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THEORETICAL PROBLEMS IN INNOVATIONS

CORRELATION BETWEEN KNOWLEDGE MANAGEMENT AND STANDARD ISO 9001
Prof. dr Jovanović J., Prof. dr Krivokapić Z., Prof. dr Vujović A., M.Sc. Avdalović P. .......................................................... 52

INDUSTRIAL MATHEMATICS – PHASE TRANSITIONS, SCATTERING, STRUCTURES
Stefan Bushev ......................................................................................................................................................................... 57

INNOVATION POLICY AND INNOVATION MANAGEMENT

INNOVATION POLICIES OF POLISH INDUSTRIAL ENTERPRISES BASED ON INNOVATION CUBE MODEL. RESEARCH RESULTS1
PhD. Paweł Mielcarek, Assistant Professor ........................................................................................................................... 64

MARKETING INNOVATIONS IN THE AUTOMOTIVE INDUSTRY GLOBALLY
Todorov V., PhD Student ............................................................................................................................................... ....... 71

ASSESSMENT OF NEEDED VOLUME OF CAPITAL INVESTMENTS IN EARLY PHASES OF INNOVATIVE PRODUCT DESIGN IN MULTI-NOMENCLATURE MECHANICAL ENGINEERING
V.G. Abrahamyan .................................................................................................................................................................. 76

INNOVATIVE SOLUTIONS

ESTIMATION OF CONDITIONS IN EXCHANGEABLE JAWS DESIGN OF PNEUMATICS GRIPPER IN MILLING MACHINE WITHIN THE MANUFACTURING – ASSEMBLING SYSTEM ICIM 3000

INNOVATIVE SOLUTIONS IN WASTE PROCESSING
Petkova-Kozovska M. S., PhD. .............................................................................................................................................. 83

DEVELOP REQUIREMENTS FOR AUTOMATED COMPLEX OF EXPRESS DIAGNOSTICS OF PIGMENTED SKIN LESIONS
Postgraduate student Rimskaya E., Ph.D. Apollonova I., Prof. dr. Nikolaev A., Prof. dr. Reshetov I., junior researcher Kudrin K. .................................................................................................................... 87

NEW METHOD AND DEVICE FOR MEASURING SLIDING FRICTION
Białasz Sebastian, Klepka Tomasz ......................................................................................................................................... 90

INFLUENCE OF INORGANIC INHIBITOR ON COPPER CORROSION IN ACIDIC MEDIUM
Sanela Božinović ..................................................................................................................................................................... 92

ENERGY BALANCE OF GREENHOUSE WITH GROUND WARMING INSTALLATION
Jovanovska V. PhD., Sovreski Z. PhD., Hristovska E. PhD., Makarijoski B. MSc. ................................................................. 95

THE APPLICATION OF VIBRATION ANALYSIS FOR DIAGNOSIS OF BEARINGS AND GEARS OF THE REAR AXLE ASSEMBLY OF THE PASSENGER CARS
Asoc. Prof. Dr. Lajqi N., Ass. Prof. Dr. Lajqi Sh. .................................................................................................................. 99

RESEARCH OF THE NEW GENERATION CHISEL PLOW
Associate professor Tverdokhlebov S.A., PhD, Parkhomenko G.G. ................................................................. 103
CORRELATION BETWEEN KNOWLEDGE MANAGEMENT AND STANDARD ISO 9001

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Abstract: Standard ISO 9001: 2015 brings some novelties which caused changes in the work of already certified organizations. Except of changes in terminology and structure of the standard, there has been a substantial change which opens up the possibility for the realization of effective quality management system. One such change is the introduction of the new standard’s requirement “7.1.6 Knowledge”, which emphasizes the obligation of establishing, maintaining and updating the knowledge of the organization.

Knowledge has become the main driving force in society and a major success factor. Knowledge of individuals integrated into a particular entity or organization, represents the highest value and intellectual capital of the organization. Since the knowledge is the main factor of organization’s success, it is necessary to adequately organize knowledge management in order to provide sustainable development of the organization. Knowledge management is a broad multidisciplinary and complex field that is constantly evolving and represents an essential driver of innovation in organizations.

In contrast of previous version of the standard, ISO 9001: 2015 has more requirements focused on providing knowledge and information, through which can be made the integration of knowledge management. Thus, the paper is focused on research of correlation between standards ISO 9001: 2015 and knowledge management. Accordingly, the paper gives an overview of identified techniques and methods of knowledge management and analysis of their correlation with the requirements of ISO 9001 standard.

Keywords: KNOWLEDGE MANAGEMENT, STANDARD ISO 9001:2015

1. Introduction

According to Ackoff, the content of the human mind can be divided into 5 categories:

- Date – unorganized and unprocessed static fact
- Information – has meaning, purpose, relevance
- Knowledge – useful information gathering
- Understanding – connects and synthesizes knowledge
- Wisdom – state of mind which comprises the treatment of conscience and morality, the code of ethics, etc.

The ratio of these categories on the basis [1] is shown in Fig. 1.

![Wisdom](https://via.placeholder.com/150)

![Understanding](https://via.placeholder.com/150)

![Knowledge](https://via.placeholder.com/150)

![Information](https://via.placeholder.com/150)

![Analysis](https://via.placeholder.com/150)

![Date](https://via.placeholder.com/150)

**Fig. 1 The path from data to wisdom.**

The fact is that from all of the above emphasized categories, the most difficult is to make a clear distinction between information and knowledge because these two categories are mutually intertwined. This is because it is debatable whether the segments of recorded information actually are "knowledge" and whether the recorded knowledge contains much information.

Knowledge is one of the terms that are difficult to define. Knowledge can be defined as the volume of information, observations or understanding that has a personality.

The most appropriate definition of knowledge is: Knowledge is data plus "knowledge" about the meaning of these data, i.e. knowledge is always associated with the procedures for its use.

Knowledge is intangible, dynamic and difficult to measure, but without it organization cannot function. The basic division of knowledge is as follows:

- Tacit knowledge. Represents inarticulate knowledge that is largely personal, experiential, specific context. Tacit knowledge is variable, increasing and constantly getting new forms, in line with recent experience of its owner. The basis for innovation and creative processes. Methods of transmission are: mentoring, apprenticeships, communities, practices.
- Explicit knowledge. It can easily be written and codified. Objectively it exist, it can be codified, clearly and formally expressed and documented and is easy to transfer, sharing and transferring.

Knowledge has become the main driving force in society and a major success factor. Knowledge of individuals integrated into a particular entity, i.e. business system, represents the highest value, and intellectual capital of the organization. Knowledge is actually the base for the realization of all the processes in the organization, therefore, the aim of knowledge management is actually the construction and use of intellectual capital in an efficient and effective manner.

Standard ISO 9001, in the new edition of 2015, provided the knowledge more importance by assigning it a special point 7.1.6. Knowledge of the organization. This requirement was introduced to protect the organization from the LOSS OF KNOWLEDGE (staff turnover, lack of knowledge sharing ...) but also to encourage organizations to acquire new knowledge. In direct correlation with the knowledge is associated and the standard requirement 7.1.2. People, 7.2 and Competence and 7.3 Awareness.

In accordance with the foregoing, the aim of this paper is to highlight the importance of the categories of knowledge and management skills and to determine their correlation with the standard ISO.


2. Knowledge management

More than 40 years 80% of the employees participated in the production (directly or indirectly). At the present time only 20% of employees are involved in the production. Thus, the organization uses on average 20% of the available knowledge while about 80% of knowledge in the organization is unstructured.

In addition to the basic division of knowledge to tacit and explicit, knowledge is still divided into individual and collective knowledge. Individual knowledge is part of the organizational knowledge that exists in the minds and skills of individuals. It is autonomous in the application and transferability between individuals.

Collective knowledge - "organizational memory" or "collective thinking of organization," depends on the way in which knowledge is spread and shared among members of the organization. It’s accumulated in the organizational rules, procedures, routines, and common standards that define ways of solving problems in practice, and the interaction between members of the organization.

The fact that knowledge is the main factor of success of the organization that’s why is necessary to manage adequately with the individual and collective knowledge in order to provide sustainable development of organization.

Knowledge management is a broad multidisciplinary and complex field that is constantly evolving and therefore there are different interpretations of its meaning. Here are given some of the older definitions of knowledge management that are still in use nowadays:

According to Birkett (1995) knowledge management represents bringing of unutterable knowledge to the surface, their consolidation into forms that are more accessible and promote their continued creation.

Davenport 1994, defines knowledge management as a process of abstraction, distribution and effective use of knowledge.

Basic components of knowledge management are:

- People. The most important and the most difficult challenge of knowledge management implementation concept is to prepare the organizational culture of (values and behavior)
- Processes. Should be adapted in a way to support the employees in creation, division and knowledge application.
- Technology. Should be adapted to people and processes of creation, division and knowledge application.

As knowledge is recognized as increasingly important "asset" of the organization's knowledge, thus that knowledge of organization must be formalized, distributed, shared and applied. Thus, the existence of knowledge in the organization is not enough that the organization becomes a highly-competent, but it is necessary to establish an effective system of knowledge management.

There have been proposed many models of knowledge management system. In Figure 2 on the basis of the paper [14] is shown a model that is in consistent with PDCA cycle.

As the PDCA cycle is the basis of ISO 9001 standard, so and the model and system of knowledge management is displayed through this cycle on the basis of five processes. Planning and organizing of knowledge are the segments of the phase P (Plan), Transfer of knowledge belongs to a phase D (Do), Application of knowledge belong to a phase C (check) and a Measurement and Analysis belong to phase A (Act). In each of the processes are defined and key activities that define them.

In knowledge management are defined the following principles [2]:

1) Knowledge management is expensive but irrelevant

2) Effective knowledge management requires a hybrid combination of people and technology
3) Knowledge management is in the hands of top management
4) Knowledge management requires knowledge managers
5) Knowledge management provides greater benefits through the plan than through the model
6) Sharing and use of knowledge is often an unnatural act
7) Knowledge management means improving of working processes that are based on knowledge

![Fig. 2 The cycle of knowledge management](image)

The knowledge management uses a variety of multidisciplinary techniques and approaches to manage with the knowledge. Some of the most popular techniques and approaches are [3]:

- Professional groups/Asynchronous communication (e-mail, bulletin board / advertising, index text and alerts, discussion themes);
- Synchronous communication (instant messages / document sharing, application and screen sharing, video and audio conferencies);
- Collaborative services (calendars and schedules, task management, voting and evaluation monitoring, labor flows);
- Management of documents and content;
- Engineering knowledge;
- Classification;
- Mapping;
- Detection of knowledge (data warehouse, data mining, expert systems);
- Depot records of learned lessons and the best practices;
- E-learning, training and mentoring;
- Locator of experts/Organizational;
- Yellow pages;
- Management of changes, agent of changes, BPR culture of change, incentives, leadership;
- Intellectual property/Oweship.

All of the above mentioned methods and techniques by the character can be classified to the linkage and the collecting. [4] Gathering techniques connect people with the information, and the other connecting people with people who have specific knowledge. Basically all the knowledge of management techniques are enabled thanks to the development of information technology.

3. Relationship of knowledge management and ISO 9001 standard

The success of the business system can be expressed on the basis of the four key factors:

- knowledge,
- quality,
competence and continuity.

Neglecting other influencing factors, that can be treated as 4 mentioned functions, the success is defined as:

\[ \text{Success} = f(\text{knowledge, quality, competence, continuity}) \]

The 4 mentioned factors, as a dependent variable, present (Figure 3):

- Precondition of success – Knowledge,
- Guarantee of success – Quality,
- Ensuring of success – Competence and
- Sustainability of success – Continuity.

In order to meet all the challenges that today is facing a business system a prerequisite of success, respectively the basis of success is the knowledge.

Fig 3 Success.

One of the principles of quality management is "Decision-making based on facts." Analyzing this principle, from the standpoint of his expedient fulfillment, are revealed two aspects of knowledge.

The first aspect relates how to provide a fact. In this case, under the fact is implied true detailed information. So this is information that is timely and topical, relevant, accurate and reliable. Information is itself a resource at which basis is the data. The data itself is nothing until it is put into context. Thus, knowledge of how to put the information into context on the basis of which leads to a fact presents the first aspect.

The second aspect is the knowledge necessary for decision-making. And in addition to providing adequate facts, unless there is a sufficient quantum of knowledge of decision-makers, there is a risk of making the wrong decision.

The requirements of ISO 9001 standard that are in direct correlation with knowledge are:

- In item 4.1, "Understanding the organization and its context," pointing out that "Understanding the Internal context can facilitate consideration of issues relating to values, culture, knowledge and organizational performance".
- Item 16.7 is specifically oriented to the knowledge of the organization. In the previous standard the knowledge is only mentioned in item 6.2.2. The work environment due to the importance now got special item.
- In Item 7.2 Competence is associated with knowledge of the organization but for expressing the importance of this item is included separately, which was not the case in the old version of the standard.
- Item 7.3 Consciousness is also associated with the knowledge of the organization because it requires the organization to develop the awareness of individuals in relation to the contribution to the effectiveness of the quality management system, including the benefits of improved performance, as well as the consequences of non-compliance with the requirements of the quality management system.

Item 7.5 refers to the documented information which clearly defines how information is created, stored, controlled, recorded, distributed, delayed …... Although between the information and knowledge is the fine line yet in ISO 9001 standard these two themes are clearly separated.

- Item 7.1.6. Knowledge of the organization is the only item of the standard ISO 9001: 2015 without any equivalent sub-items in the preceding standard and indicates the commitment of the standard of knowledge as one of the important resources of an organization.
- Item 7.1.6 defines three imperatives related to knowledge as a resource of organization, as follows:
  1) the necessity to continuously measure and determine overall knowledge that is necessary for the performance of business processes in the organization, in order to increase or retain the necessary level of quality products and services;
  2) this knowledge must be maintained at the desired level and to make available at the organization level;
  3) depending on the available knowledge, the organization has to design ways to access additional knowledge in order to innovate the existing.

Well, the standard’s requirement 7.1.6, in terms of knowledge as a resource, in some way directly promotes the use of techniques and methods of knowledge management for the fulfillment of those imperatives. Unlike this item, item 7.6. Documented information contains all the elements of a documented management system, which is one of the tools of knowledge management. Also, within the item 9 Evaluation of performance, there is a sub-item 9.1.2 Customer satisfaction, which requires that the organization must establish methods for preparing, monitoring and review of information on user satisfaction with products and services. The methods and techniques that can be used to fulfill a request by the mentioned items of the standard at the same time are and the methods and techniques in the field of knowledge management process. In Figure 4 indicates the relationship between the ISO 9001 standard and Knowledge Management.

Fig 4 The relationship between the standard and knowledge management.

Standard ISO 9001 requires from organizations the establishment of knowledge management as a support process, i.e. support through the application of techniques and methods of knowledge management. In the context of item 7.1.3 Infrastructure requires the organization to provide the equipment, including hardware and software, and information and communication technologies that are the basis for the application of methods and techniques of knowledge management. In the other direction through the application of techniques and methods of knowledge management are provided the knowledge and information necessary to meet the requirements of the standard in terms of smooth functioning of the business processes of the organization, achieving the goals of the organization and the achievement of quality in the organization.

Unlike previous versions of the standard, ISO 9001: 2015 standard has broader requirements in terms of providing knowledge and information and through which can be made with the
integration of knowledge management. In Table 1, have been identified methods and techniques of the knowledge management via which it is possible to satisfy the requirements of the ISO 9001 standard.

**Table 1: The ratio of the standard requirements ISO 9001:2015 and method of techniques of management knowledge.**

<table>
<thead>
<tr>
<th>Requirement of the ISO 9001 standard</th>
<th>Methods and techniques of management knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>The organization shall monitor and review the information to these external and internal issues;</td>
</tr>
<tr>
<td>4.2</td>
<td>The organization shall monitor and review the information of those interested parties and their relevant requirements;</td>
</tr>
<tr>
<td>4.4.2</td>
<td>a) to keep up documented information as support on function of their processes;</td>
</tr>
<tr>
<td></td>
<td>b) to keep up documented information to have confidence the processes to be carried out as it were planned;</td>
</tr>
<tr>
<td>5.2.2</td>
<td>a) to be available and maintained as documented information;</td>
</tr>
<tr>
<td></td>
<td>b) to communicate about it, to be understood and applied within the organization;</td>
</tr>
<tr>
<td>6.2</td>
<td>f) to communicate about them;</td>
</tr>
<tr>
<td>7.1.5.1</td>
<td>The organization shall keep up appropriate documented information as evidence of conveniences of resources for monitoring and measuring, for an appropriate purpose</td>
</tr>
<tr>
<td>7.1.5.2</td>
<td>a) .... must be kept as documented information;</td>
</tr>
<tr>
<td>7.1.6</td>
<td>Knowledge of information</td>
</tr>
<tr>
<td>7.2</td>
<td>Competency</td>
</tr>
<tr>
<td>7.4</td>
<td>Communication</td>
</tr>
<tr>
<td>7.5</td>
<td>Documented information</td>
</tr>
<tr>
<td>8.1</td>
<td>e) identification and management of documented information to the necessary extent</td>
</tr>
<tr>
<td>8.2.3.2</td>
<td>The organization must, as applicable, to keeps up documented information;</td>
</tr>
<tr>
<td>8.2.4</td>
<td>When request for products and services change, the organization must ensure that the relevant documented information are changed and the relevant persons are aware of changed requests.</td>
</tr>
<tr>
<td>8.3.2</td>
<td>j) documented information that are needed to be shown that the requirements for design and development are completed.</td>
</tr>
<tr>
<td>8.3.3</td>
<td>b) information stemming from previous similar design and development activities;</td>
</tr>
<tr>
<td></td>
<td>Organization shall retain documented information on input elements of design and development.</td>
</tr>
<tr>
<td>8.3.4</td>
<td>e) that on these activities to keep up documented information</td>
</tr>
<tr>
<td>8.3.6</td>
<td>Organization must keep up documented information:</td>
</tr>
<tr>
<td>8.4.1</td>
<td>Organization must keep up documented information on all activities and all necessary measures stemming from evaluation.</td>
</tr>
<tr>
<td>8.5.1</td>
<td>e) appointment of competent persons, including of all required qualifications;</td>
</tr>
<tr>
<td>8.5.2</td>
<td>When the traceability is a requirement, an organization must manage with unique identification of output elements, which are necessary to enable traceability.</td>
</tr>
<tr>
<td>8.5.3</td>
<td>When a property of a user or extern supplier is lost, damaged or is found otherwise to be unsuitable for use, organization must inform the user or extern supplier and to keep up documented information about what happened.</td>
</tr>
<tr>
<td>8.5.5</td>
<td>e) feedback from user.</td>
</tr>
<tr>
<td>8.5.6</td>
<td>Organization shall retain documented information describing the results of the review of changes, people who approve changes and all necessary measures stemming from review.</td>
</tr>
<tr>
<td>8.6</td>
<td>Organization shall retain documented information on the release of products and services.</td>
</tr>
<tr>
<td>8.7</td>
<td>Management of nonconforming output elements</td>
</tr>
<tr>
<td>9.1.1</td>
<td>Organization shall retain appropriate documented information as evidence of reults</td>
</tr>
<tr>
<td>9.2.2</td>
<td>f) to keep up documented information as evidence on the application of checks of program and results</td>
</tr>
<tr>
<td>9.3.2</td>
<td>c) information about the performance and effectiveness of the quality management system, including trends:</td>
</tr>
</tbody>
</table>
10.1 Organization must keep up documented information as evidence:

In the table have been identified exclusively those requirements of the standard which indicate directly to the application of the methods and techniques of knowledge management.

4. Conclusion

The paper describes the correlation of ISO 9001:2015 standard and knowledge management. Specifically, standard ISO 9001:2015 introduces a new requirement that is directly related to the knowledge with a view to ensuring that knowledge is maintained and therefore to make available to the necessary extent.

The correlation between knowledge management and ISO 9001:2015 standard goes in two directions. ISO 9001 sets the basis for the application of the knowledge management methods, through whose further implementation of the goals of quality and meet the requirements of the standard. It has been observed that most of the requirements of the standard, both directly and indirectly has specific requirements in terms of knowledge that allows them quality management through their methods of collecting information and new knowledge. On the other hand, meet the requirements of standards that are correlated with the knowledge management provide a good basis for the establishment of an effective and efficient knowledge management.

The paper also shows the correlation of the standard requirements of the identified methods and techniques of knowledge management, and further research may move in the direction of determining the strength of this correlation and ranking of the selected method from the aspect of knowledge management.

5. References

Abstract: Presents the basics of methodology to use the full knowledge of micro-producer (personality, micro-foundry) based on: methodology of mathematics, foundations of mathematics and mathematical physics. Example - phase transition of the first order of Stefan’s problems, scattering connection with new structures.

Key words: phase transition of firs order, Stefan’s problems and scattering connection with new structures.

1. Introduction – Mathematics in Industrial Sub branch

Machine building – Casting and Heat treatment

The processes of structures formation are: phase transitions of I-st order (casting) and II-nd order (heat treatment); elastic and plastic deformation. The type of these structures is polycrystalline grains with size of macro-scale to 1µm or micro-scale below 1µm under a lattice parameter in Å. The structure of all materials is a winner of its properties and the based interest of industries is: 1. improving the working properties of known materials; 2. creating new materials by structures design.

Mathematical description of the phase transitions [1-8, 38 and 40] presented by: the theory of thermal conductivity with the tasks of Stefan and Stefan - Schwartz; the fundamental equation of the formation of new phases of Kashchiev.

On the Fig.1 we introduced castings technologies with different velocity of solidification and science support of micro-foundry

![Diagram of casting technologies](image)

Electronic structure is origin of all properties of the metals and its alloys. For description the structures and properties of the metals and alloys are approach mathematics and mathematical physics. It will not be wrong to say that we need a nearly full knowledge i.e. tasks Stefan and Stefan-Schwarz must include mathematics and mathematical physics. This is done through mathematical tasks bridges between mathematical fields and quantum mechanics.

An example of such approach is the use of the results of the theory of scattering. In paper [2] is developed classical Stefan’s problem.

In Institute of Mathematics of Bulgarian academy of science are obtained great results about mathematical theory of scattering from Veselin Petkov [10] and Vladimir Georgiev [11].

The first base problem of scattering theory is proving existence of scattering operator. The second direction of development is inverse problem.

It is well known, that thermodynamics driving force of the nucleation at phase transitions of I-st order (crystallization: liquid (L) ↔ solid (S)) is \( \Delta \mu = \mu_L - \mu_S = Q_L \ln(T_m/T) \), where \( \mu_L(S) \) are thermodynamics potentials of base (matter) and new phases; \( T_m \) and \( T \) are temperatures of transition and supercooling of the base (L) phase; \( Q_L \) – latent heat of melting. The supercooling is \( \ln(T_m/T) = \Delta T_r + \Delta T_k + \Delta T_s \), where \( \Delta T_r \) – supercooling effect radius of curvature, \( \Delta T_k \) – supercooling for the transfer of atoms in the interface of liquid-solid phase; \( \Delta T_s \) – supercooled liquid phase, where scattering heat of the phase transition. Received development task of Stephen with scatter theory [2] and assessments of supercooled melt (\( \Delta T_s = 0, 1, 2, \ldots, \max K \)) in charge of literature [9]. Here must many investigations – measurements and theoretically; but our opinion, that \( \Delta T_s \) is a bridge to Quantum mechanics.

Aim of this paper is to show methodological need to use the full modern knowledge required by the industry examples of casting and heat treatment.

Philosophy is a science with a systematic approach and rational argument, but it does not rely on the scientific method and not strictly defined and accepted subject [17]. Scientific method (generalized) [18]: from Greek origin is "research, teaching, way of knowledge"; today is a system of principles (in development and change) to reach the objective knowledge of reality.

2.1 Philosophy – mine areas and objects research

The origin of the term is of Greek philosophy: φιλοσοφία, from φιλε ῖν - love and σοφία – wisdom; and definition: philosophy is the study of general and fundamental questions concerning man and the world [17], with mine areas and objects research.

Fundamentals of philosophy:
- **Metaphysics** – Nature
- **Ethics** – Morality
- **Logic**
- **Pseudepigraph**
- **Argumentation**
- **Science**
- **History**
- **Mathematics**
- **Physics**
- **Psychology**
- **Anthropology** etc.

Philosophical achievements and results strongly influence [17]: the development of a given society; educational institutions and practices. The results of philosophy are a way of mediation in their application in academic and scientific disciplines [17]: as the importance of logic in mathematics, linguistics, psychology and computer science; generalized the key role of the philosophy of science through scientific methodology. The philosophy has many branches and one of them is the philosophy of science [17] with branches: philosophy of mathematics; philosophy of physics; philosophy of biology, etc. Philosophy of science is divided and developed very intensive branches in the 19th and 20th centuries, which continues to this day. It is well known that mathematics is separated from philosophy in 1600year after Christ.

2.2 Philosophy of Mathematics holds a special place in the philosophy of science

The philosophy of mathematics – subject: studying philosophical assumptions, foundations and implications of mathematics; the need to present the nature and methodology of mathematics to understand the place of mathematics in people's lives [19, 20, 21, 22].

Reasons for the emergence of mathematics are the need for description of reality first appeared historically known mathematical knowledge is ~ 2500year before Christ (to new era) [26, 27, 28]. In antiquity it was gradually realized the abstract nature of mathematical objects. Mathematics differs from the humanities and natural sciences [19, 20, 21, 22] for example: 1. The objects of study in the natural sciences are located in space and in time, which is not at all clear that applies to objects in mathematics; 2. Methods of study of mathematics very different from the methods of the natural sciences. The use of mathematics in the humanities and natural sciences is due to: there are mathematical properties and regularities of reality, and any object has some mathematical properties. Therefore any theory in natural sciences is mathematized because it contained mathematical knowledge. For example, physics is heavily mathematized.

Explanatory notes on some results on the philosophy of mathematics we present according to works [19, 20, 21, 22]:
- **Mathematical realism**: there are mathematical structures, regardless of the human mind;
- **Mathematical anti-realism**: mathematical statements are true values, but they are not corresponding to a specific area of intangible or non-empirical objects;
- **Mathematical Platonism**: a form of realism, showing that mathematical structures are abstract, have no spatial and temporal or causal properties, and are eternal and immutable;
- **Platonism of Gödel** posits a special kind of mathematical intuition, allowing to perceive mathematical objects directly; Full-blooded Platonism is a modern response to the fact different sets (groups) of mathematical structures can be proven to exist according to the axioms and inference rules employed (for example, the right of excluded middle and the axiom of choice);
- **Empiricism** is a form of realism that denies that mathematics can be known a priori at all;
- **Mathematical monism** Max Tegmark’s hypothesis mathematical universe if there are any mathematical objects, they exist physically; Logicism is a thesis boils down to mathematics, logic, and hence nothing but a part of logic; Formalism argues that mathematical statements may be thought of as statements about the consequences of certain rules of strings; Conventionalism
- **Convexional, conditional; Psychologism** is the position that mathematical concepts and/or truths are based on materials derived from or explained by psychological facts (or laws); In mathematics, intuitionism is a program of methodological reform whose motto is that "there are no non-experienced mathematical truths" (L.E.J. Brouwer); Constructivism includes regulative principle that only mathematical structures that cannot be explicitly constructed in a way to be admitted to mathematical discourse; Finitism is an extreme constructivism, according to which a mathematical object does not exist, unless it can be made of natural numbers in a finite number of steps; Ultrafinitism is even more extreme version of finitism, which rejected not only infinites, but limited quantities that can actually be constructed with available resources. Structuralism is position, considering that mathematical theories describe structures and that mathematical objects are exhaustively defined by their places in such structures, therefore, has no the intrinsic properties; Embodied mind theories (perfectly realized mind theories) claim that mathematical thinking is a natural product of the cognitive apparatus of the man who is in our physical universe.

Mathematics and mathematical knowledge are used by the methodology of mathematics in a concrete science. This is achieved by applying the philosophy of mathematics in the philosophy of science for specific use of the methodology of mathematics.

Mathematical monism we believe is a heavy time for mathematicians. They require a huge amount of experimental data and described by mathematics. We think that should be used and develop multi-scales approach.

2.3 Foundations of Mathematics [23, 24 and 25]

Hallmark of mathematics is its logical rigor: it deals with precisely defined concepts and proven safe allegations. Mathematical definitions are comprehensive: they contain the necessary and sufficient conditions under which an object can be assigned to the volume of identifiable concept. This attribute mathematical concept is suitable for preparation of mathematical statements whose meaning is quite clear. About the veracity of these claims can be checked so that the resulting conclusions to be absolutely sure. Mathematical assertions, once established, are outside any possible claim. This distinguishes mathematics from both the natural and the humanities, whose allegations can be substantiated most beyond any reasonable doubt, but beyond any doubt at all. This explains the fundamental role of proof in mathematics. Like any science and mathematics is developed, which includes among other things, the existence of unresolved issues. But mathematics is very clear distinction between hypotheses (i.e., statements which may sound plausible, but still not completely certain) and theorems (i.e. statements that are proven and rigorous about their authenticity longer doubt).

In addition to establishing the veracity of claims proof has another function: with its help investigate links between
Causality or causal connection (more causalit, causality and modality) is called the relationship between one event (cause) and another event called effect, where the second event is understood as a consequence of the first. Aristotle and the topic remains on the agenda of modern philosophical discussion goes back at least since causality and modality is called the relationship between one event (cause) and another event called effect, where the second event is understood as a consequence of the first effect. Direct anything that affects an effect is a factor that effect. Everything that influences on the given effect is a factor of this effect. Direct factor called factor that achieves on effect directly i.e. without the involvement of other variables. The relationship between cause (causes) and effect is called casual or causal connection. Philosophical reflections on the issues of causality still more than a millennium. In the western philosophical tradition discussion goes back at least since Aristotle and the topic remains on the agenda of modern philosophers.

Definition [33] causation 1. the relation of cause and effect. 2. The result is the same, however differently the causality is interpreted. 3. causality 1. the action of causing or producing. 2. Anything that affects an effect is a factor that effect. Everything that influences on the given effect is a factor of this effect. Direct factor called factor that achieves on effect directly i.e. without the involvement of other variables. The relationship between cause (causes) and effect is called casual or causal connection. Philosophical reflections on the issues of causality still more than a millennium. In the western philosophical tradition discussion goes back at least since Aristotle and the topic remains on the agenda of modern philosophers.

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3. Mathematical Physics – Applied Mathematics

Principle of causality is a fundamental principle in physics, which states that any event that takes place in a physical system may influence this system in the future, but not to influence her behavior in the past. This means, that if the two events are separate, it neither can be no reason, no consequence to the other.

3.1 Phase transition of first order – thermodynamics, theory of heat conductivity

Mathematical fundamental theories are: Stefan and Stefan-Schwartz problems
- equations conductivity of liquid L and solid S phases
  \[
  \frac{\partial T_L}{\partial t} = \lambda_L \rho_L \frac{\partial^2 T_L}{\partial x^2}, \quad \frac{\partial T_S}{\partial t} = \lambda_S \rho_S \frac{\partial^2 T_S}{\partial x^2},
  \]
  (1; 2)
- initial condition of liquid phase (L)
  \[
  t=0: T_L(x, t) = T_L^0 = \text{const}_L,
  \]
  (1, 3)
- boundary conditions
  \[
  x = \infty \text{ and } t \geq 0 \quad T_L(x, t) = T^\infty = \text{const}_L,
  \]
  (1, 4)
- boundary conditions at the moving interfacial surface (or solidification (front))
  \[
  x_0 \text{ and } t \geq 0 \quad T_L(x_0, t) = T_S(x_0, t) = T_M = \text{const}_M \quad \text{(1, 5)}
  \]
  - heat balance of \( x_0 \)
  \[
  \frac{\partial T_L}{\partial x} \bigg|_{x=x_0} - \rho_L Q_L \frac{\partial T_L}{\partial t} - \lambda_S \frac{\partial T_S}{\partial x} |_{x=x_0} = 0,
  \]
  (1, 6)

The solution is for \( K, T_L, T_S \) and \( X \):

\[
T_L = T^\infty - \left( T^\infty - T_M \right) \left( 1 - \text{erf} \left( \frac{x}{2 \sqrt{a_L t}} \right) \right),
\]
\[
T_S = T^\infty + \left( T_M - T^\infty \right) \left( 1 - \text{erf} \left( \frac{x}{2 \sqrt{a_S t}} \right) \right),
\]
\[
X = K \sqrt{t} \quad \text{for} \quad t > 0.
\]

Stefan-Schwartz problem:

\[
\frac{\partial T_M}{\partial t} = \frac{\partial}{\partial t} \left[ \rho_T \frac{\partial T_M}{\partial t} \right], \quad \frac{\partial T_M}{\partial t} = \frac{\partial}{\partial t} \left[ \rho_T \frac{\partial T_M}{\partial t} \right], \quad \frac{\partial T_M}{\partial t} = \frac{\partial}{\partial t} \left[ \rho_T \frac{\partial T_M}{\partial t} \right], \quad \frac{\partial}{\partial t} \left[ \rho_T \frac{\partial T_M}{\partial t} \right],
\]
(2; 1; 2; 3)
- initial conditions liquid and mould
  \[
  t=0: T_M(x, t) = T^\infty = \text{const}_M,
  \]
  (2; 4)
- boundary conditions melt, a solid phase and contact (index C) (solid phase/mould)
  \[
  x = \infty \text{ and } t \geq 0 \quad T_C^L(x, t) = T^\infty = \text{const}_L,
  \]
  (2; 5)
- boundary conditions \( x_0 \) and \( t \geq 0 \)
  \[
  x_0 \text{ and } t \geq 0 \quad T_C^M(x_0, t) = T_S(x_0, t) = T_M = \text{const}_M \quad \text{(2, 6)}
  \]
- boundary conditions melt, a solid phase and contact (index C) (solid phase/mould)
  \[
  x = 0 \text{ and } t \geq 0 \quad T_C^L(x, t) = T_C^M(x, t) = T_C(0, t) = T^\infty,
  \]
  (2, 7)

\[
T_C = \frac{1}{B_M} \text{erf} \left( \frac{K}{2 \sqrt{a_C t}} \right),
\]
(2, 10)
\[ \rho L_m \frac{\sqrt{\pi}}{2} K = b_3 (T_m - T_{c1}) - b_4 (T' - T_m) \left( 1 - \text{erf} \left( \frac{K}{2 \sqrt{a_s}} \right) \right), \]  

\[ T_L = T_m - (T' - T_m) \left( 1 - \text{erf} \left( \frac{x}{2 \sqrt{a_s} t} \right) \right), \]  

\[ T_S = T_{c1} + (T_m - T_{c1}) \left( 1 - \text{erf} \left( \frac{x}{2 \sqrt{a_s} t} \right) \right), \]  

\[ T_M = T_{c1} - (T_{c1} - T_m) \left( 1 - \text{erf} \left( \frac{x}{2 \sqrt{a_s} t} \right) \right), \]

\[ X_F = K \sqrt{t}. \]

In tasks (1) and (2) use the following symbols, \( a_s, a_m, a_k \) and \( \sigma = \sqrt{\lambda c \rho} \) are thermo conductivity numbers and \( \lambda, c, \rho \) are thermal conductivity, heat capacity and density of liquid (L), solid (S), mould (M) materials; \( b = \sqrt{\lambda c \rho} \) and \( b_c, b_s, b_m \) are capability accumulation material (L), (S) and (M); \( K \) is coefficient of solidification; \( T_{L|M|S} \) is temperature of cast phases (L), (S) and (M); \( T_{c1} \) is contact temperature between cast and mould, and the same, but \( T_{S'}^{c1}, T_{M}^{c1} \) at \( x = 0 \); \( t \) is time; \( Q_m \) – latent heat of melting; \( x \) is coordinate.

The tasks of Stefan’s type are verified experimentally and used in the creation of mathematical models for technology phase transformations. At high cooling rates and small size of the studied open system these tasks provide huge opportunity for creating mathematical models. This methodological approach is: estimates of temperature fields and thermal balance.

This methodology based on the task of Stefan we can applied of process and the phase transition of the second order (heat treatment). It should consider the specific difference between the two phase transitions. The description of the temperature field in the phase transition of the first kind is more complicated in comparison with the temperature field of phase transition of the second order.

For example we have chosen the application of task Stephen-Schwartz for thermodynamics open system from aluminum melt and steel mould – phase transition of first order.

The thickness of cast and mould each is with a size of 100 microns. To calculate the temperature field of the rapid solidification process of molten pure aluminum in quenching steel mould is on the Fig. 2 [38] – comparative analysis between the analytical solution and numerical solution with the Finite element method of Stephen-Schwartz problem.

---

**Fig. 2** Stefan-Schwartz problem solutions of rapid solidification at high-speed quenching in open thermodynamics system of cast (C) with liquid (L) and solid (S) phases and steel mould (M) [38]. Analytical solution eq.(2): time-temperature curve 1; \( x_F \) is calculated place at the front: \( X_F^{\text{Analytical}} = 32,53 \mu \text{m line 3} \); ideal contact \( T_1^{c1} = 292,15 ^\circ C \). Numerical solution of Finite elements method: time-temperature curve 2; \( X_F^{\text{Numerical}} = 32,653 \mu \text{m line 4} \); real contact \( T_2^{c1} = 97,7 ^\circ C \) and \( T_3^{c1} = 444,1 ^\circ C \) at coefficient of heat transfer \( \alpha = 6x10^6 \text{ w/m}^2 \text{ K} \).
For the process of heat transfer from Figure 2 we compare the ideal and the real contact via the contact temperatures \( T_{1}^{\text{FC}} \) and \( T_{\text{Real}}^{\text{FC}} = \left( T_{2}^{\text{M}} + T_{2}^{\text{S}} \right)/2 \) and values of \( x_{p} \), from the analytical \( X_{p}^{\text{Analytical}} \) and the numerical \( X_{p}^{\text{Numerical}} \) solutions.

Contact temperatures: \( T_{1}^{\text{FC}} = 229.15^\circ \text{C} \) and \( T_{\text{Real}}^{\text{FC}} = 270.9^\circ \text{C} \) are different with 18.22 %.

Heat balance: \( X_{p}^{\text{Analytical}} = 32.55 \mu \text{m} \) and \( X_{p}^{\text{Numerical}} = 32.653 \mu \text{m} \) have differences 0.316 %.

Pure metals and part of the alloys solidified with one interface surface and other alloys solidified in temperature interval between two moving interface surfaces. Foundry engineering methodology: 1) Experimental measurement and numerical description of non-stationary temperature field with moving liquid/solid (L/S) interfacial surface(s) and constant temperature; 2) Microscopic measurements of the obtaining structure and a description of the crystallization (structure formation) processes.

\[
\begin{bmatrix}
\text{Summary amending} \\
\text{heat at the expense of conductivity}
\end{bmatrix} + \begin{bmatrix}
\text{Summary amending} \\
\text{the heat at the expense of moving the boundary}
\end{bmatrix} = 0. \quad (3, 3)
\]

The solidification (macro level of phase transition first order) has two typical cases on Fig. 3: 1. Equilibrium – without supercooled of metal melt; 2. Non-equilibrium – Low or High supercooled of metal melt. In both cases of solidification is released the latent heat of transition (melting) \( Q_{m} \).

![Fig. 3 Time-temperature curves pure metals solidification (macro level of phase transition first order) at according to supercooled: 1. Equilibrium – without supercooled of metal melt; 2. Non-equilibrium – Low or High supercooled of metal melt.](image)

The numerical solution of 3D task of Stefan and Stefan-Schwarz is for equilibrium phase transition of the first order independently of the cooling rate. All numerical experiments on Figures 1 and 2 not accounted for supercooling of melt but in practice the phase transition first order is non-equilibrium. For reporting in particular local processes of structure formation is necessary to take into account local conditions: 1. the local cooling rates; 2. and local supercooling of the melt.

The structure of cast pure metal or alloy is polycrystalline grains mainly in the form of cells with simple geometry or dendrites – complex geometry. The character geometrical parameters are the middle radius of grains, and primary and secondary distances. The local conditions influence on character geometry are [9]: the product of the gradient of the temperature eq.(3, 1) and the speed of the growth eq.(3, 2) (rate of cooling GR), or the duration of the local time of solidification \( t_{f} \) and temperature interval of non-equilibrium solidification \( \Delta T_{S} \) and dimensionless supercooling with (supercooling \( \Delta T \))

\[
t_{f} = \frac{\Delta T_{S}}{GR}, \Delta U = \frac{c_{S} \Delta T}{Q_{m}}. \quad (3, 4)
\]

It should be noted in equations (3, 4) we only have thermodynamic variables and time. The supercooling is very important, but it many difficult is defined. Factors that affect supercooling are many and relate to the mechanism of structure formation of each material (metal, alloy, etc.). The supercooling of eq.34 as local conditions is similar to similar to supercooling \( \ln(T_{m}/T) \) (see the introduction).

Latent heat of phase transition is scattering in volume with supercooled melt [9] i.e. connectivity between the release of latent heat of melting and its scattering in supercooled melt is applied the theory of diffusion of works [10, 11]. In [2] is a developed Stefan task considering the supercooled area, which disperses and releases latent heat \( Q_{m} \). On Fig. 4 is shown only temperature field [4] of supercooled zone of pure Al.
The maximum value of reported supercooling does not contradict the data from the literature. These data can be used for the thermodynamic driving force of crystallization \( \ln(T_m/T) \). But we recall that there is a lot of work. For the modeling of the crystallization process (the structures formation) were used other theories, such as the classical theory Kossel–Stranski–Folmer–Kaishev (atomistic approach) and the fundamental equation of new phases formation of Kashchiev generalized for variable thermodynamic driving force [7 and 8]. Finally result of Fig. 4 suggests close nano-research areas i.e. using quantum mechanics or multiscale approach in one iteration (one step in time of Stefan’s problem) use calculations of quantum mechanics.

4. Industry mathematics – Industry 4

The fundamental mathematics, mathematical physics and fundamental experimental physics lead to a revolution in physics [34]. Based on the results of fundamental research are create new technologies.

Industry 4 is a comprehensive revolutionary change of society by the advent of technology [16]: artificial intelligence, robotics, internet things, autonomous vehicle without a driver, 3D printing, nanotechnology, biotechnology, materials science, energy storage and quantum computing. These new technologies are the foundation for creating "smart factories". New technologies are related to the requirements of ecology; circulation of materials on the market - production - use - scrap for production; renewable energy and renewable energetics. Knowledge becomes a commodity and opens a permanent market for it.

Industry 4 requires a complete mathematization of everything [12, 13 and 14].

The change is exponential rate, close to many branches and released millions of jobs, which are often called subversive effect. For these reasons, society appears conditions for chaos, a huge challenge for man.

Appears acute need for training and retraining of large groups of people, and of course we have education for all life.

5. Mathematical Education – Complete orientation (talented and others)

Mathematics has become the language of science and technology based on research results. Part of the Industry 4 and math education and retraining that obliges the development of education in mathematics in the direction of maximum (almost full) orientation of the student (child or adult). In this direction, working in many educational systems scientists’ mathematicians develops new educational programs. An example is the educational system, created by the famous Bulgarian mathematician Blagovest Sendov called "Sendov’s system" [36].

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INNOVATION POLICIES OF POLISH INDUSTRIAL ENTERPRISES BASED ON INNOVATION CUBE MODEL. RESEARCH RESULTS

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Conference registration number: 31.

Abstract: Many theoretical concepts of studying innovation strategies concentrate on selected aspects and determinants of this phenomenon and dissemble cohesive and wider perspective. In result there is lack of comprehensive researches concerning innovation policies, especially covering long term, repetitive studies based on the same methodology. The main purpose of this article is to assess innovation strategies applied in Polish medium and large industrial enterprises based on three dimensional innovation activity model – innovation cube. Those dimensions are: place of creating, continuity of activity and way of innovation utilization. In result of imposition above criteria these model presents eight different variations of innovation policies. The most common innovation policy utilized in Polish industrial enterprises is individual innovator. This means that innovations were created in continuous manner, based on own resources and for own use. The test sample covered years 2007-2009 and 2012-2014. Surveys were conducted on group of medium and large Polish enterprises belonging to low-, medium- and high-tech industries. Each phase of research was based on the same methodology. From first stage 80 responses were obtained and from the second one 92.

KEYWORDS: INNOVATION, STRATEGY, INNOVATION POLICY, INDUSTRY, COMPANY

1. Introduction

Innovation is one of the key dimensions of functioning and development of the organization (Kaplan, Norton 1993:67-70). It can be perceive as decisive dilemma of company’s success due to its dual role. On the one hand innovation can be seen as a source of change that can reshape company’s competitive potential. On the other hand this requires investments and reconfiguration of key resources which raises uncertainty and is highly risky activity (Tidd et al. 2005:111). Therefore, innovation strategy must cope with both of these perspectives. Short term plan focused on orchestrating resource synergy and efficiency. However, long term perspective creates capacity and growth potential of organization. Moreover innovation strategy should also enable cohesion of wide scope of company’s activities depending of current level of its competitiveness, development of technology and market conditions.

In general view, the key goal of the innovation strategy is to assure a long-term survival of the company and growth of its competitiveness by creating revenue streams based on delivery value to customers. On a tactic level innovation strategy should designate goals, create boundaries conditions and key assumptions for innovation process. Embeddedness of and consistency of innovation process within innovation strategy and both of them in organization’s competitive strategy is crucial for achieving success in a longer perspective. These dependencies determine efficiency of innovation strategy based on achieving synergies from positive feedback between the subsystem of innovation and other subsystems of organization (Mielcarek 2016:29). Complex and multidimensional nature of this phenomenon is result of being conditioned on both, external and internal factors, as well as a need of coping operational activity with long term development.

There are many studies that emphasize one specific aspect or research perspective of innovation strategy. For instance in literature of last decades in reference to business environment and external conditions, there can be distinguished m. al.: managing relations (Ahuja et al. 2008), innovation network (Perri et al. 2006), innovation ecosystem (Jansiti, Levien 2004), business model and open innovation (Chesbrough 2006). Also in regards to organizational factors there are many concepts and research frameworks. For instance K. Zduńczyk and J. Błęchinskopp adapted idea developed by E. Martins and F. Terblanche (2003) consisting of four dimensions – strategy, structure, support mechanisms and behavior, to examine their influence on innovation (2007:25-40). In other research, to group of organizational factors researchers include financial expenditure, innovation culture, leadership, organizational structure and interorganizational relations (Assimakopoulos et al. 2011).

There are several studies and attempts of meta-analysis comparing relations of numerous factors in the context of innovation strategy (Damanpour 1991:555-590; Kimberly, Evanisko 1981:689-713). However most of those analyses are based on different scope and are focused on different level of complexity. Thus still exist a cognitive gap and need of analysis of this phenomenon that is up-to-date and based on complex research framework.

Above mentioned discourse allows to formulate main purpose of this article which is assess of innovation strategies applied in Polish medium and large industrial enterprises based on three dimensional innovation activity model – innovation cube. In specific those three dimensions are: place of creating innovation (in-house / outside), continuity of activity (continuous / occasional activity) and utilization of innovation (own usage / commercialization). In result of imposition above criteria these model presents eight different variations of innovation policies. Adoption of main goal and presented model allows derivation following research questions assuming Polish industrial enterprises:

1) in terms of diagnosis of innovation strategies:
   a. What is the distribution of each of abovementioned dimensions in cube model in both surveyed periods?
   b. What is the distribution of eight variants of innovation policies in both surveyed periods?

2) in terms of diagnosis of innovation strategies:
   a. What type of innovation (according to Oslo methodology) was dominant in both surveyed periods?
   b. How innovation importance phenomenon presents in both surveyed periods?
   c. What other effects were obtained by applying innovation policies in both surveyed periods?

2. Innovation strategy - theoretical starting points

In general main goal of business activity is creating added value for its customers in order to make profit. That is why planners must cope with several functions of strategy, extending on corresponding dimensions of company’s activity (Grant 2012). First of all strategy is way to achieve goals and ensure development of organization. Therefore it reflects to future actions and intended position that company wants to acquire. To put this vision into reality, strategy should also motivate and inspire organization members. Second dimension of strategy is to ensure cohesion of organization’s decisions, which is essential for managers acting within limited rationality. In this sense strategy reduces risk and scope of possible paths of development into a satisfactory solution that meets accepted criteria. Third one is function of coordination and communication. Strategy enables
cooperation of different units and individuals within organization. Process of strategic planning leads to exchange of views of involved parties and in result, to achieve consensus about how organization should proceed and control its actions (Grant 2012).

Literature brings many different views and perspective of defining innovation strategy (see Table 1). Despite wide scope of analysis, it is worth to notice that below list isn’t exhaustive (more criteria and variants can be proposed). At the same time presented variants describing innovation strategies aren’t alternative choices. This means that innovation strategy can be characterized by a combination of different variants, i.e. global, offensive, initiating, marketing, production and technological.

<table>
<thead>
<tr>
<th>Scope</th>
<th>Decision makers</th>
<th>Innovation character</th>
<th>Organization</th>
<th>Main concern of</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creating value</td>
<td>H. R. Greve 2007</td>
<td>Exploration / Exploitation</td>
<td>P. Doyle, S. Bridgewater 1998; Oslo Manual 2005</td>
<td>Acquisition and developing relations with entities in order to create or discount innovation.</td>
</tr>
<tr>
<td>Level of technological change</td>
<td>Incremental / Breakthrough</td>
<td>Technology push / Market pull / Coupled</td>
<td>Organizational / Market</td>
<td>Defining technology capabilities and capacities. Providing market acceptance of innovation.</td>
</tr>
<tr>
<td>Source of innovation</td>
<td>Rothwell R., Gardiner P., 1983; Rothwell R., Zegveld W. 1985</td>
<td>Initiating and driving of innovation activity depending on the relationship between technology developments and fulfilling market needs.</td>
<td>P. Drucker 2006</td>
<td>Organizational innovations: modification of internal elements of company in coherent way, i.e. structure, processes, culture.</td>
</tr>
<tr>
<td>Competition approach</td>
<td>C. Freeman, L. Soete 1997; R. G Cooper 1984</td>
<td>Offensive / Defensive</td>
<td>Technology / Marketing / Production / Human Resources / Financial</td>
<td>Balancing cost and revenue streams in perspective of market needs and competition activity.</td>
</tr>
<tr>
<td>Value chain position</td>
<td>P. Drucker 2006</td>
<td>Pioneer / Imitating / Niche</td>
<td>P. Drucker 2006</td>
<td>Possible capacity of achieving innovation rent.</td>
</tr>
</tbody>
</table>

First criterion presented in the table, perhaps most general, is decision makers approach to organization development, allowing divisions of rationalist and incremental types of innovation strategy (Whittington 1994). Rationalist approach, represented by H. I. Ansoff, is based on a formal and planned path of development that must cope, with complexity of interdependencies, in the long term perspective. It is crucial to ensure company’s capacity to endure changes and provide coherence in goals with corresponding organization’s procedures and routines. In second perspective - called incremental approach, represented by H. Mintzberg, innovation strategy comes to continuous and evolutionary adaptation to environment fluctuations based on exploring different development paths and create readiness to change strategy whenever new circumstance appears.

Different approach presents Peter Drucker, which emphasizes and relates innovation strategy to position of organization within value added chain (2006). In this perspective efficiency of innovation strategy depends on interactions with different entities such as competitors, suppliers and customers which both, directly and indirectly, determine level of expenditures, achieved income and rate of return form innovation activity. In this view expenditures are determined by cost of resources specialization, entry cost to industry, cost of access to technology or market and cost of innovation duplication. Whilst income and return rate are dependent on market scale, competition activity and possibility of achieving innovation rent.
to fragmentation of listed criteria and concept, raise a need for synthesis aim at presentation of comprehensive and consistent concept describing types of innovation strategies.

3. Variants of innovation strategies – innovation cube model

Presented model covers innovation strategy variants based on several determinants such as: scale and scope of resource base, company’s bargain power and position within its competitive environment and value added chain as well as market scope and demand. The basic assumptions that create foundation and boundaries condition of this model are as follow:

1) Each variant presents general overview of company’s innovation strategy, that predetermine use and efficiency of most of engaged resources and overall of achieved effects. However, at the same time some of innovation projects can be realized outside of selected variant (based on different approach and/or resources usage).

2) The ability to achieve goals of innovation strategy is limited by set of simultaneously affecting boundaries conditions. Most important of them are coping with competitor’s activities and simultaneously delivering value according to customer’s needs. Based on above limitations, company can choose how to realize its innovative policy. In results managers can decide if they need to cooperate or not within innovation process? Is it crucial to run continuous innovative activity or based on solely projects? What is purpose and effect of created innovation?

3) Above assumption favor covering broad variety of different configurations of individual innovative behavior of organization. In results this put pressure to extend number of variants cover by innovation cube model. At the same time it was crucial to ensure readability of the model that will determine its utility and applicability, so to limit number of variants cover by cube model.

In result of overlapping abovementioned assumptions three dimensions were selected: (1) place of innovations creation (in house or outside), (2) type of activity in terms of its continuity (continuous or occasional activity), (3) utilization of innovation (own usage or commercialization). That allows setting a three-dimensional matrix consisting of eight different variants of innovation strategy: buyers, collectors, individual innovators, occasional innovators, brokers, guerrillas, seller and casual sellers (see Figure 1).

First of dimensions is a place of innovation creation. Companies that build own research and development resource often meet several limitations hindering efficiency of innovation operations. That is why some of organizations build relationships with other entities within innovation process. The main reasons for this is reduction of transaction costs, division of labor and specialization of activities, access to technology, markets and know-how, or sharing the risk in the project (Bae, Chang 2013:968). However collaboration within innovation activity can bring several negative effects, such as knowledge spillovers, strategic drift, unnecessary diversification, raises cost of cooperation and relationship management, lowering efficiency and product quality or creates cultural conflicts (Tidd et al. 2005:292).

Second of dimensions is a type of activity in terms of its continuity of operation. Constant running of innovation activity enables fast and flexible reactions for changes appearing in the environment and within the organization. Moreover continues operation foster control and coordination, as well as favor process of innovation management. In result, it creates the conditions for synergy, which contribute to raising the efficiency of innovation activities. Also potential advantages can be gained by implementing constant improvement of activity due to business process orientation (Harrington 1991:16–21). But the realization of innovative activity in a constant manner is also costly and not always adequate to market demand or given competitive environment.

Third of dimensions is innovation utilisation. Entities that implement innovations for their own use are usually driven by two different causes. First one is aimed at building and securing the leader position in a market. In this approach it is crucial to ensure long enough period of discounting incurred investment due to innovator rent. Second approach is to reduce the distance between the company and the market leader, which usually leads to create imitation of innovation or by providing lower cost of operation, in order to avoid risk carried out by leader (Tidd et al. 2005:121). In group of companies that aim at sales of innovations,
it is possible to distinguish few types of approaches. First of them is implemented by large companies while introducing new-generation of innovation. After successful entry to new geographical market they may decide to sell previous innovation to other, less advanced markets (Bennett 1995:273-275). Other approaches based on commercialization as innovation strategy, can aim at achieving advantage in market position due to monopoly or niche occupancy. According to M. Porter’s five forces concept, along with increasing advantage in market position due to monopoly or niche occupancy, commercialization as innovation strategy, can aim at achieving markets (Bennett 1995:273 -275). Other approaches based on they may decide to sell previous innovation to other, less advanced of innovation. After successful entry to new geographical market it is possible to distinguish few types of approaches. First of them is potential and create framework for assessing innovation policies. The analysed data are the result of nonprobability sampling procedure carried out on a group of medium and large Polish industrial companies. In specific, research covered six industries - two of each: low, medium and high technology. The twosteps research procedure was conducted in 2010 (the collected data cover years 2007-2009) and repeated in 2015 (the collected data cover years 2012-2014). Then responses were rejected from entities that do not establish innovation or have provided incomplete questionnaires. Altogether from a first stage of research 80 responses and from second 92 responses were collected. The methods used in research were survey with a structured questionnaire including 17 closed questions. The questionnaire includes auto check questions in order to ensure the reliability of answers. Half of the responses were gathered via traditional mail questionnaire survey and half were achieved by CATI method (computer-assisted telephone interview). The questionnaires were delivered to managers or specialists involved in innovation activity and R&D within companies.

4. Effects of innovation strategies in Polish industrial enterprises - research results

Characteristics of the research sample

The methods of research were survey with a structured questionnaire including 17 closed questions. The questionnaire includes auto check questions in order to ensure the reliability of answers. Half of the responses were gathered via traditional mail questionnaire survey and half were achieved by CATI method (computer-assisted telephone interview). The questionnaires were delivered to managers or specialists involved in innovation activity and R&D within companies.

**Research results**

First step of innovation strategies diagnosis was analysis of the three dimensions characterizing innovation policies of Polish industrial enterprises. In general in both surveyed periods most of responders were creating their innovations in house, based on continuous manner and for own use (see Figure 2). This kind of orientation of innovation policy is typical for closed innovation model, which seems to be less effective in highly dynamic and competitive environment.

However there can be indicated changes in patterns in both analyzed periods that mark new trends. Including dynamic perspective there tendencies between 2007-09 and 2012-14 were noticed. 1) There was raise of concentration on endogenous potential and own resource base in creating innovation (from 61% to 95% of companies). This change can be interpreted as further closing of company innovation process within organization boundaries. As advantages of this orientation are economics of scale and rise of resource efficiency but at the same time there is strong dependency of current resource base and limitation of stimulus of development. 2) There is decrease of continuity and regularity of innovation activity (drop from 67% to 54% of companies). This can mean that more enterprises turn towards use of project orientation instead of consistent innovation process. So it can reflect raise of dynamic and discontinuity of environment, especially customer’s needs. 3) There is also growth of company’s percentage that creates innovation for commercialization (raise from 13% to 37%). This also support view of innovation policies focused on customer’s needs.

<table>
<thead>
<tr>
<th>Place of innovations creation:</th>
<th>2012-2014</th>
<th>2007-2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>in house / outside</td>
<td>95%</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>61%</td>
<td>39%</td>
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<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>continuous / occasional</td>
<td>54%</td>
<td>46%</td>
</tr>
<tr>
<td>activity</td>
<td>67%</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>63%</td>
<td>37%</td>
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<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>own usage / commercialization</td>
<td>87%</td>
<td>13%</td>
</tr>
</tbody>
</table>

Figure 2. Three dimensions of innovation policies in Polish industrial enterprises Source: own work.

Despite some changes and observed tendencies in innovation policies, still the most common type of strategy is based on close innovation model. More than one third of surveyed companies were using individual innovator (35%), then seller (28% of respondents), occasional innovator (18%) and casual seller (14%). Rest four variants represent 5% of company’s behavior (see Figure 3). Two variants: individual innovator (creating based on own resource, continuous manner and for own use) and casual innovator (creating based on own resource, in discontinuous manner and for own use) are covering 53% of all innovation policies in Polish industrial enterprises in 2012-2014. This also reflects and confirms domination of close innovation model. Next innovation policies in term of distribution are seller (creating based on own resource, continuous manner and for sell) as well as occasional seller (creating based on own resource, in discontinuous manner and for sell). Both of those variants represent 42% of innovation policies in Polish industrial enterprises. This emphasis importance of marketing orientation in adopted strategies.

According to changes between analyzed periods there is significant growth of market orientation policies (raise about 17% of those two variants) in comparison to decrease in adoption of close innovation policies (drop about 10%).
Second part of analysis refers to effects of innovation policies. In this area there was analyzed innovations activities for each of innovation type (product, process, marketing and organizational) in refer to its geographical scope/importance of created innovation (see Table 2). There was assumption that the wider the geographical scope of created innovation the greater is its importance and novelty level. Innovation activity was presented as percentage (values shown in below table response number of companies that introduce at least one innovation in given period).

In general most of surveyed companies were creating product innovation, then process innovation, marketing innovation and lastly organizational innovation. In comparison between two analyzed periods more companies were carrying innovation activity in regards to all of four innovation’s types. The average values rise from 29% in 2007-09 to 35% in 2012-14.

In terms of innovation importance most common are in house innovations (implemented within company so can be interpreted as imitations in regards to their competitors) that were created in more than 50% of surveyed companies. On the second place there were innovations with country scope, next innovations with regional scope and lastly with global scope. It is worth to emphasize that innovation characterized with global scope, which are assumed with the highest novelty level, had raised from 12% in 2007-09 to 23% in 2012-14. This almost doubles the amount of companies that created breakthrough innovation. Observed tendencies confirm raise of efficiency of innovation policies in Polish industrial enterprises.

Table 2. Innovation activity of Polish industrial enterprises – breakdown of innovation type

<table>
<thead>
<tr>
<th>Innovation type</th>
<th>In house innovation</th>
<th>Innovation with regional influence</th>
<th>Innovation with country influence</th>
<th>Innovation with global influence</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product innovation</td>
<td>58%</td>
<td>74%</td>
<td>23%</td>
<td>49%</td>
<td>58%</td>
</tr>
<tr>
<td>Process innovation</td>
<td>63%</td>
<td>44%</td>
<td>15%</td>
<td>28%</td>
<td>25%</td>
</tr>
<tr>
<td>Organizational innovation</td>
<td>56%</td>
<td>46%</td>
<td>2%</td>
<td>25%</td>
<td>19%</td>
</tr>
<tr>
<td>Marketing innovation</td>
<td>40%</td>
<td>44%</td>
<td>15%</td>
<td>22%</td>
<td>40%</td>
</tr>
<tr>
<td>Average</td>
<td>54%</td>
<td>52%</td>
<td>14%</td>
<td>31%</td>
<td>36%</td>
</tr>
</tbody>
</table>

Source: own work.
Besides innovation activity also other effects of innovation policies were analyzed. Respondents could choose any answer out of ten propositions: brand building, cost reduction, gaining competitive advantage, income rise, fulfilling law and polices, new market entry and rise of market share, reduction of environmental hazards, rise of production flexibility, rise of production capacity, rise of production flexibility (see Figure 3). In both surveyed periods most common effect of innovation strategies was enter on new market or rise of share on current market (respectively 62% in 2007-09 and 79% in 2012-14). Next there were achieving competitive advantage and rise of production capacity. Less common response from all effects was fulfilling law and polices.

![Figure 3. Distribution of effects of innovation policies in Polish industrial enterprises](source: own work)

5. Conclusions
The main purpose of this article was to assess innovation strategies applied in Polish medium and large industrial enterprises based on three dimensional innovation activity model – innovation cube. In refer to the main goal two research fields were indicated: innovation strategies diagnosis and effects assessment.

In terms of diagnosis of Polish industrial enterprises the most common adapted strategy was individual innovator (creating innovation based on own resources, in continuous manner and for own use). Second most popular variant is seller (creating innovation based on own resources, in continuous manner and for sell). Next two are occasional innovator and occasional seller. Those four variants out of eight altogether represent 95% of adopted innovation policies in surveyed companies. It is worth to emphasize, that despite some ongoing changes, still most popular is closed innovation model that designate and create framework of companies behavior as rather self-sufficient and independent entities.

These finding might be surprising especially in contrary to one of key theoretical paradigm and widely comment open innovation model. Partly the reason of this state might be found on macroeconomic level in refer to Poland i.e. low interpersonal trust that transfer on interorganizational trust, complex and illegible law and tax system, underfunded research institution and lack of incentives for business – since cooperation. Those factors hindered building relationships and innovation networks which are one of crucial elements of open innovation strategies.

To gathered full view of innovation strategies, indicted policies were assessed by criterion of achieved effects. Namely distribution of four types of innovation was presented as well as innovation scope in terms of its geographical influence. In general, since first research phase more companies attend to innovation activity (growth from 29% in 2007-09 to 35% in 2102-14). Most of surveyed companies were creating product innovation, then process, marketing and lastly organizational innovation. In comparison between two analyzed periods innovation activity rise in regards to all of four innovation`s types. In terms of innovation importance most common are imitation changes however between two surveyed periods there was significant rise of global innovation that can be identify with breakthrough and highly novelty of introduced solutions.

Obtained view of innovation policies of Polish industrial enterprises is rather complex and hard to explain with a few regularities. One of observed trends is change towards market orientation between both surveyed periods (rise of share of seller and occasional seller as well as enter on new market and increase market share as the effect). Also despite some gaps in environment embeddedness and innovation networks building (open innovation
model) there is consistent rise of innovation activity as well as growth of importance and novelty level of created solutions.

Conducted research also has some limitations. First one is lack of financial results of each of implemented strategy as well as no precise information about profitability of created innovations. This is commonly found obstacle in all of innovation research due to tangible/intangible and complex character of this phenomenon as well as rather long and hard to defined scope of investment return. Second group of limitations is result of sample size and characteristics. It would be preferred to carry out more research based on probability sampling and wider scope of selected industries (services, agriculture e.t.c.) as well as to provide some multinational comparisons for analysis.

References


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MARKETING INNOVATIONS IN THE AUTOMOTIVE INDUSTRY GLOBALLY
ИНОВАЦИИ В МАРКЕТИНГА НА АВТОМОБИЛИНАТА ИНДУСТРИЯ ПО СВЕТА
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Abstract: In the center of the development of the new cars marketing tendencies in the next decades lay the innovations in few industries which interact between. This leads to the appearance of the autonomous vehicles, connected vehicles – between themselves, with the infrastructure and with the other personal smart belonging, incl. home; the strategic approach towards smart vehicles, shared vehicles, electric vehicles and finding ways this technology to become mainstream. These are now priority for the largest car manufacturers. The technology, Internet of Things, the environment and the change in the consumer behavior will create new types of products – smarter, more intelligent, more connected and integrated into connected ecosystems between the industries and businesses.

Keywords: MARKETING, AUTOMOTIVE INDUSTRY, AUTONOMOUS VEHICLES, ELECTRIC VEHICLES, FUTURE MOBILITY, MARKETING TRENDS, INNOVATIONS

Introduction
The desire for travel has its consequences: the cities become noisy, congested and polluted. (Bouton S, Knuffer S, Mihov I, Swartz S, 2016, McKinsey). People spend hours in the traffic and the air pollution is inevitable. The mobility becomes critical for the economy, because of the movement of goods and services. Everybody is moving around with some purpose – to school, to the office, going see friends and family. However moving form A to B is safe, ecological, affordable and reliable on very few places.

It is expected that the way people travel in the cities will change dramatically. (Neuman C-S, 2015, McKinsey). New business models, such as Uber, already change the traditional ways of travel. The technological innovations such as electrification, connectivity, Internet of things (IoT) and autonomy are already in place. The increased urbanization of the megacities (Dobs R, 2010) with more than 10 million citizens, offers opportunities for change.

The mobility systems will differ than current ones. In the center of this evolution is going to be the individual traveller, and the consumers should be opened to new technologies and services. The public and the private sector are the ones to pave this way. Of course the innovation and the communication strategy should be always synchronized. (Chernatony, 2003)

Innovation trends
In the next 10-15 years, lots of trends – from decentralizing the energy sector up to the IoT, are going to connect and will create drastic changes in the mobility systems. There are two main factors for going this direction. (Hannon E., McKerracher C., Orlandi I., Ramkumar S, 2016, McKinsey). First, some key tendencies in the mobility – electrification, shared driving and the autonomous vehicles, are about to happen. The prices of the lithium-ion batteries will drop in the next decade. The shared driving and hailing services are happening on some big cities around the globe, due to the smartphones evolution and solid financial resources. Almost all big automotive and technological companies form partnerships or alliances, in order to provide human-less mobility. The second factor is that the tendencies in connected areas are boosting one another. The urbanization is expected to increase the average population density in the cities with 30 % by 2030. The sustainability will become more important for the individuals and the managers of the companies. The increase connectivity begins to reveal lots of opportunities for the shared mobility, as well as the autonomous driving, safety on the road and the potential services which to be offered inside the vehicles.

The combined impact of both factors will be significant. The more shared mobility will impact the sales of electric vehicles, because of the more intense usage of these shared vehicles, improving the economies of ownership. The bigger manufacturing of electric vehicles will decrease the cost of the batteries development. It will provide usage in the close areas such as distributed storage. The decrease cost of the the electricity could improve impact of the greenhouse effect by the electric vehicles as they will have more charge by low-carbon resources. There is powerful dynamics based on the strong interaction.

Today not many cities have effective mobility infrastructure – developed and working public transport, ecological ways to move around and stimulating them, or to have managed to limit congestion and pollution. It is recommended to combine shared mobility, autonomous cars and transport electrification with integrated energy systems, public transport and the infrastructure. It is expected that the future will be radically different, based on three models of advanced urban mobility, which to be achieved by 2030 (Hannon E., McKerracher C., Orlandi I., Ramkumar S, 2016, McKinsey). Each will be appropriate for the specific type of metropolis depending whether it has dense, it is developing, or it is spread with suburbia. The cities will be able to demonstrate the effects of the mobility innovation on everything – from electrical systems up to the usage of public spaces, thus creating new dynamics. (Bouton S, Knuffer S, Swartz S, 2016, McKinsey).

The new ways of transportation will cause changes in other sectors which will have to find new solutions and opportunities. The electric vehicles could represent 3% of power demand worldwide, and almost 4% in Europe by 2030. Various electricity supply plans could leverage the negative effects coming from the charging of the cars. The electric vehicles could support the increased usage of alternative energy resources for charging. (Hannon E., McKerracher C., Orlandi I., Ramkumar S, 2016, McKinsey).

The automotive industry is about to change fundamentally in the future, and the car ownership models should be reconsidered in the direction of range of transportation services provision. The electric vehicles are direct competitor of the conventional ones. The gas stations network should consider various ways to benefit from the new future technologies and to be able to provide to give value and new experiences to their customers, i.e. charging infrastructure, shopping centers, shared ride stations etc. There are huge opportunities for the technological companies as well, because with the growth of the smart vehicles and the connectivity, there will be bigger demand for software and sensors.

The new innovative technologies change the ways the companies develop and manufacture the vehicles too. Electric powertrains and fuel-cell powertrains offer better performance, with less investment at lower emission levels. (Consumer reports, 2014). The new lighter materials allow for the manufacturers to lower the weights of the cars without sacrificing the safety and to provide better fuel economy and lower emissions too. The customers could even invest more in their current vehicles because of the new customization era. (Corwin S., Vitale J., Kelly E., Cathles E, Deloitte 2016). This will change the options and the design of the existing vehicles. This new maret segment could offer lighter, smarter vehicles, with very different design.

The most important trends and findings are those connected with the introduction and launching the autonomous vehicles. The connected vehicles are developing rapidly – all the innovations which are integrated, the communications technologies and IoT – in order to ensure important services for the drivers. (Ninah et al.)
The autonomous technology and opportunities will result in more shared vehicles, more autonomous taxi cars and more sharing of the priately owned vehicles. (Fagnant D. and Kockelman K. 2013; Schoenberger and Gutmann 2013). The possibility of one household vehicle to serve many users, could decrease the ownership with 43% and to increase the mileage with up to 75% (Sivak M. and Schoettle B., 2015). The potential benefits which the advocates of autonomous technology foresee are the significant convenience, safety, congestion reduction, fuel efficiency, energy savings pollution decrease. Human mistake causes 93% of the road accidents and the autonomous vehicles will decrease these accidents by 90% (KPMG 2013; Fagnant D. and Kockelman K., 2015), incl. the system errors ("death by computer"), cyberterrorism (Bilger B., 2013), and will compensate the risk of the human behavior on the road and the side effects such as increased traffic caused by the fastest or more cost-effective way of travel. (Ecenbarger W. 2006: Fung B., 2015; Kockelman, et al. 2016; Lin P., 2013; Ohnsman A.,2014). The decrease of privately owned vehicles will decrease the parking issues. The necessity of conventional public transport services will also decrease. To have clear and visible benefits of the self-driving cars, dedicated autonomous vehicles lanes will be required, which will change the infrastructure of the cities. (Litman T., Victoria Transport Policy Institute, 2017) The autonomous vehicles will solve the parking issues, but they will reduce the the important incomes for the cities by parking. Besides the drives, other professional occupations will disappear. If the accidents on the road are reduced, then industry working on this will be seriously changed. This includes insurance business, aftersales, repair shops and workers, spare-parts suppliers etc.. (Anderson J. et al. 2014, Rand.org)

It’s the main trend in the new cars marketing – the transformation of the traditional conventional cars into autonomous, with sharing between many consumers, with smart options for management, e-hailing, and providing personal and customizable services inside, thus transforming it into new type of media. When the autonomous vehicles become bigger part of the fleet on the road and most of the transits are autonomous, they could reduce significantly the risk on the road, congestions, parking issues, as well as to ensure energy savings and reduction of the CO2 emissions. (Litman T., Victoria Transport Policy Institute, 2017).

The autonomous driving

This innovative technology can be understood in five ways of driving, proposed by National Highway Traffic Safety Association (NHTSA, www.nhtsa.gov), which provides various benefits, depending on the autonomy level:

- Level 0: the human drive does everything;
- Level 1: an automated system on the vehicle can sometimes assist the human driver conduct some parts of the driving task;
- Level 2: an automated system on the vehicle can actually conduct some parts of the driving task (e.g. wheel and acceleration), while the human continues to monitor the driving environment and performs the rest of the driving task;
- Level 3: an automated system can both actually conduct some parts of the driving task and monitor the driving environment in some instances, but the human driver must be ready to take back control when the automated system requests;
- Level 4: an automated system can conduct the driving task and monitor the driving environment, and the human need not take back control, but the automated system can operate only in certain environments and under certain conditions (or fully automated driving);
- Level 5, the automated system can perform all driving tasks, under all conditions that a human driver could perform them (or driverless operation)

The autonomy could increase the mobility of those who are not able or don’t want to drive. At level 4 there the technology will be
able to give a ride to disabled people, blind, or those who are too young to drive. This will give independency, reducing the social isolation and access to public and private services.

Level 3 or higher, could be reduced the congestion costs, as the occupants can perform various tasks within the vehicle – work, have a rest, watch TV, read etc.

Level 3 could also increase the longer commuting. This could make the people to settle at far distance from the main part of the cities. The autonomous vehicles could lead to higher spread of the population and usage of less populated areas around big cities. However inside the metropolis areas it could lead the population density due to the reduced need of parking space. At Level 4 the authomons vehicles could just leave the occupants at their destination and to drive to satellite parking zones, leading to potential decrease of car ownership. (Litman T., Victoria Transport Policy Institute, 2017).

Litman T. continues to argue on other potential benefits of the autonomous technology. The overall effect on the energy usage and pollution is still not clear, but it seems both will be decreased. The autonomous vehicles will allow fuel efficiency, allowing acceleration and breaking 4-10% smoother than by humans. The other improvements could include lesser distance between the vehicles leading to road capacity incremental. The platooning suggests less stops or speed changes. It allows slower speed (meaning fuel economy), but more effective overall speed, meaning improved time for travel. As the accidents suppose to be reduced with time, the cars and the trucks will have lower weight, which will increase fuel efficiency. The autonomous vehicles would decrease the air pollution by using alternative fuels and powertrains. If the accidents reduction allows lighter vehicles, then this will solve lots of the issues with the electric vehicles range, resulting into higher demand. At Level 4, the vehicles could drop off their occupants at the given destination and continue to the charging station or to the gas station by themselves. Still it is a disadvantage the lack of developed charging infrastructure for the alternative fuel vehicles.

Litman T. argues on potential disadvantages as well. Many of the disadvantages exist in the benefits themselves. As the autonomous vehicles would decrease the congestion cost and would improve fuel efficiency, they would decrease the personal cost for driving. Due to this fact and increased mobility of people who are not able to drive, the total vehicle-travel would increase leading to negative external effects like congestion and increased fuel economy. However, despite of the congestions, the technology could could increase the road permeability due to the mobility of the vehicles leading to road capacity incremental and the overall delay due to decreased. The autonomous driving capability will probably increase vehicle purchase prices by thousands, and may require hundreds in annual subscription fees for special assistance, navigation and mapping services. The analysis suggests that effects which increase vehicle travel are more numerous and significant than those that reduce vehicle travel, so self-driving vehicles are likely to increase total vehicle travel, although these impacts are difficult to predict and will depend on specific autonomous vehicle implementation, such as their performance, technical matters, user costs, fuel and road prices.

A research (Burns L., Jordan W., Scarborough B., The Earth Institute, Columbia University 2013) presents three different scenarios to evaluate the personal mobility. They combine mobile internet, autonomous vehicles, shared automotive systems, specific-purpose vehicle design and advanced powertrains. The results show that this new mobility system has the potential to provide better overall performance at lower cost at varius conditions. It provides significant benefits for sustainability through improved rpd safety, reduced congestions, energy savings, lower emission levels, efficient space and land use and equal rights for travel and access. It suggests several models which define the connection between the geographical regions and the cost and performance of the coordinated shared autonomous mobility systems.

It is possible now to be provided better ways for mobility at lower cost for the consumers and society. This opportunity is a result of combination of five technological and business enablers:

- “Mobility internet” does for the movement of people and goods, what Internet has done for the movement of information by coordinating large amounts of real-time data.
- Self-driving vehicles operate without human control, allowing to occupants to spend their time in the vehicle as they please, without endanger themselves or the others on the road.
- Shared vehicles are by several people throughout the day rather exclusively by individual drivers who leave them parked 90% of the time during the day.
- The specific-purpose vehicle design is developed to respond to the type of mobility and the number of occupants they serve, which makes them efficient to energy, space and cost compared to the conventional vehicles.
- The new advanced powertrains allow the usage of alternative sources to move the cars and trucks. This includes electric drive, electric motors and electronic and digital control in addition or separately to the regular combustion engines. Individually each of these are significant advantage to the contemporary transport infrastructure. Combined in a new innovative way to enhance the customers’ experience in the vehicles, they bring drastic improvements and transformational changes.

The new mobility system can improve people’s life which is shown via three examples and analytics models, give by the authors. The new system combines the existing developments in the autonomous vehicles with the emerging of the mobility internet, which could coordinate the movement of the vehicles in space in time. The new mobility could work if optimally sized shared fleets of driverless, coordinated, specific-purpose vehicles are available. The customers could request a ride via app on their smartphone. An autonomous vehicle arrives at their door within few minutes and gives them a ride straight to their destination. During this trip the occupants can use their time as they are pleased. (reading, eating, talking on the phone, working, sleeping, watching a movie, listening to music). Futhermore, personalized playlists could be offered to the custumers based on their entire mobile experince, browsing and made choices during their previous trips. Upon arrival, the vehicle leaves the passangers and continues to its next destination for next client, without any need to park anywhere.

The authors conclude that, by combining the five business and technological factors, could be achieved much better performances at lower cost. This new mobility system is more attracted in comparison to the other ways for public transport, due to its potential to be more convenient, more energy- and resources efficient, more cost-effective, and much safer and cheaper. The shared vehicles bring this efficiency, which lead to cost-saving. The economy of scale could be reached rapidly, the autonomous vehicles are comfortable for the consumers. The results are similar in the different types of cities. The benefits for sustainable growth are significant with the autonomous shared vehicles.

The autonomous vehicles can impact also flying experiences. (Schwab K., 2017). It is foreseen that 54 million autonomous vehicles will be on the road by 2035 and it is projected that nearly every vehicle will be autonomous by 2050 (IHS Automotive, 2014). The ease and convenience of using a self-driving car for six or seven hours while working remotely or sleeping could mean fewer short-haul flights. The convenience of self-driving cars could force airports to rethink their entire experience design – baggage, check-in, security lines. To compete with self-driving cars, the airlines will have to shift the services they’re offering. Most importantly, they may need to offer door-to-door service, picking up customers from their homes or convenient pick-up locations and delivering them directly to the airport. That’s something that
already happens in luxury travel. Plane manufacturers are thinking about autonomous vehicles as well. In collaboration with Italdesign, Airbus recently released a concept vehicle that’s part self-driving car, part self-drivingstone.

Self-driving cars will likely fundamentally alter the nature of the airport itself. They could eliminate the need for parking structures, since people’s cars can drop them off and simply drive back home. When the parking structure is not longer needed, airports will have a large chunk of real estate that could be turned into hotel conferencing rooms.

The rise of the self-driving cars will have serious impact on the society. It can be identified ten developments in three eras, in connection with the self-driving cars. (Bertoncello M, Wee D., 2015 McKinsey&Company). These vehicles are serious innovation for the automotive industry, but their potential influence as time, adoption and penetration are not clear. The self-driving vehicles could really play crucial role for the economies, businesses, industries, mobility and society. To clarify these issues, the authors interview 30 experts globally and then the information is combined with data by Automotive & Assembly and High-Tech Practices, to be proposed relevant point of view for the impact of the new type of vehicles.

First era is focused on the conditions before the autonomous vehicles being on the market for use by the consumers, or at the phase of development and new mobility models begin to emerge. The second era argues on the autonomous vehicles at the phase of early adoption, and the last era projects the changes which could follow when the autonomous vehicles become primary means of transportation.

- The travel costs fall, due to the higher utilization of the assets, i.e. shared driving and economy of scale;
- The infrastructure is financed by fees for the actual real consumption and use, as the connected vehicles technology allows precisely the personal costs for usage of the roads;
- The parking spaces disappear, as the rise of the the autonomous vehicles and shared rides eliminate them. The land and the space inside the cities could be used in favour of citizens and green strategies for sustainable development.;
- The authorities stop dealing with the traffic matters, because the autonomous vehicles are programmed not to break the rules and the traffic laws;
- The speed of deliveries increases, and the costs are reduced, due to the rise of fully autonomous networks for truck travels and/or platooning, which operate longer and with less human interaction
- The seamless multimodal transport is becoming mainstream, as the improved system interactions allow the consumers to travel from A to B via multiple connected ways of transportation at fixed price, charged by unified payment system.
- New business models and alliances rise between automotive industry and tech industry creating new supply and value chains in order to provide new mobility, transforming the vehicles into service, and bringing additional value models for the customers, i.e. provision of personal and customizable services inside, thus transforming it into new type of media

First era is focused on the conditions before the autonomous vehicles being on the market for use by the consumers, or at the phase of development and new mobility models begin to emerge. The second era argues on the autonomous vehicles at the phase of early adoption, and the last era projects the changes which could follow when the autonomous vehicles become primary means of transportation.

**Fig.1: Self-driving vehicle revolution. Source: McKinsey& Company**

**Conclusion**

Both automotive and tech industries are working to present something radically different and innovative than the current existing vehicles. The tendency fully autonomous, shared, electric, vehicles on demand is about to happen, bringing additional innovative business models and services, which to be researched and analysed from now on. It is expected a world in which:

- The vehicles do not crash. Autonomy eliminates the cause for almost all accidents – the human mistake; Connectivity between the vehicles themselves and real time data and connectivity with infrastructure allow communication about potential danger on the road too;
- The congestions happen rarely, due to the sensors integrated in the vehicles, which allow less space between them, as well as integrated communicational systems for traffic management with real time data and information about the congestions;
- The energy demand is less as the smaller and lighter vehicles allow compact, fuel-efficient and eco-friendly powertrains;
- The energy demand is less as the smaller and lighter vehicles allow compact, fuel-efficient and eco-friendly powertrains;

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ASSESSMENT OF NEEDED VOLUME OF CAPITAL INVESTMENTS IN EARLY PHASES OF INNOVATIVE PRODUCT DESIGN IN MULTI-NOMENCLATURE MECHANICAL ENGINEERING

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Abstract: Economic-mathematical models have been developed and proposed to determine the amount of funds required in early stages of a new product design. This will allow reducing the volume of operations in the pre-production stage and will help structurally optimize the innovative product lifecycle.

Keywords: innovation, new product, design, funds, capital investment.

To assess the effectiveness of the innovation process alternatives being developed, in early stages of design work a comparative analysis and selection of innovation ideas are being carried out it is necessary to determine the types and quantity of new technological equipment needed for a new product introduction, for the acquisition whereof the needed amount of the nonrecurring funds makes up 60-70% of the costs envisaged for the implementation of the technical preparation activities of a new product introduction.

An effective solution to the issue in question will enable the manufacturing organization to project the amount of nonrecurring funds needed for the implementation of the innovation processes in early stages of new product design. This, in its turn, will provide the manufacturing organization with an opportunity to better determine the productivity level of the innovation processes being carried out, assess the chances of their implementation, make an informed decision on their implementation direction and optimize the product lifecycle structure timewise.

The utilization of economic-mathematical models (EMM) can greatly contribute to the successful resolution of this issue. The application of those models in early stages of design work makes it possible to define with great precision the labor intensity of a new product launch in various manufacturing stages (structural and technological labor intensity) as well as the material output ratio and the manufacturing costs thereof.

Defining the structural and technological labor intensity of a new product in the early design stage provides a scope for determining the quantity of all technological equipment and machinery needed in various stages of the manufacture thereof when carrying out technological processes.

This approach is successfully employed in multi-nomenclature mechanical engineering. The application of economic-mathematical models allow determining with great precision the structural (as per the basic stages of manufacturing) technological labor intensity of a new product manufacture in the early design stage which serves as a basis for defining the quantity of the technological equipment and machinery as well as the
The economic-technological models introduced for determining the structural technological labor intensity enable to, in the early stages of a new product design, define the quantity of the technological equipment necessary for the product manufacture in the basic phases thereof as well as the size of the production surface area for product assembly. Based on the data obtained it is possible to determine the amount of nonrecurring funds (capital investments) needed for a new product introduction in the given design stage.

In the preparatory stage of production, the volume of capital investments necessary for incorporating technological processes with regard to a new product introduction can be defined by the following formula:

$$K_1 = a_1 P_1^{x_1} \left( \frac{m_{ij}}{K_{ij}} \right)^{x_2}$$

(2)

where $P_1$ refers to the preform production volume (pc/yr), $a_1$ indicates the constant term, $x_1$ and $x_2$ represent the exponents.

The coefficient taking into account the impact of the preform complexity level is defined by the following formula:

$$K_2 = a^{c-1}$$

(3)

where $c$ denotes the number of the groups specifying the preforms complexity level, $a$ is a positive integer ($a > 1$).

In the production processing stage the technological labor intensity can be defined with great precision by the following formula:

$$T_2 = e^{a_2} \left( \sum_{j=1}^{K} \sum_{i=1}^{N_j} \frac{m_{ij}}{K_{ij}} \right)^{x_2} e^{a_2} K_{ITT}$$

(4)

where the first constituent element of the formula ($e^{a_2}$) is the constant term ($e=2.71828...$), $X_2$, $Y_2$, $Z_2$ represent the exponents, the second constituent element is the total mass of the component preforms being developed in the organization, the third constituent element is the coefficient of the technological equipment necessary for the product manufacture in the early stages of a new product design, define the quantity of the technological equipment, the fourth constituent element takes into account the impact of the years of product launch in a given organization (excluding the design stage), the fifth constituent element is the coefficient of the advancement level of processing technologies [1,3].

The economic-technological models for the introduction of technological processes with regard to a new product introduction can be defined by the following formula:

$$K_2^E = \sum_{j=1}^{k} \left[ U_j \sum_{i=1}^{N_j} t_{ij}^{0} P_{1ij} \right]$$

(7)

where $U_j$ represents the costs relating to the acquisition and exploitation of new technological equipment necessary for the implementation of the $j$ technological processes, $t_{ij}$ is technological labor intensity of the $i$ component preform manufacture through the $j$ technological process, $P_{1ij}$ refers to the volume of the $i$ component preform launch in case of the $j$ technological process, $K_{ij}^{b}$ denotes the time standards of the $i$
component preform manufacture in case of the \( j \) technological process, \( F_{ij}^0 \) the annual labor time reserve of the equipment exploitation in the \( j \) technological process in case of the \( i \) component preform manufacture [1,3].

In the production processing stage the volume of capital investments necessary for incorporating advanced technological processes with regard to a new product introduction can be determined by the following formula:

\[
K_2^{E} = \sum_{\varphi=1}^{F} \frac{U_{2\varphi} P_{2\varphi} T_{2\varphi}}{K_{2\varphi}^{b} F_{2\varphi}^{0}}
\]  

(8)

where \( U_{2\varphi} \) refers to the costs relating to the acquisition and exploitation of new equipment necessary for the implementation of the \( \varphi \) technological operations of processing, \( P_{2\varphi} \) denotes the launch volume of the components processed during the \( \varphi \) technological operations, \( T_{2\varphi} \) represents the technological labor intensity during the \( \varphi \) technological operations of processing, \( K_{2\varphi}^{b} \) denotes the time standards of the \( \varphi \) technological operations of processing, \( F_{2\varphi}^{0} \) the annual labor time reserve of the equipment exploitation during the implementation of the \( \varphi \) technological operations of processing[1,3].

In the early design stage determining the amount of the nonrecurring costs (capital investments) necessary for a new product introduction will enable to assess the efficiency level of the innovation processes implementation alternatives, find out the level of the organization's capacity to carry them out on its own and make an economically efficient selection.

References
ESTIMATION OF CONDITIONS IN EXCHANGEABLE JAWS DESIGN OF PNEUMATICS GRIPPER IN MILLING MACHINE WITHIN THE MANUFACTURING – ASSEMBLING SYSTEM ICIM 3000

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Abstract: The paper deals with the design of replaceable jaws on pneumatics gripper on the CNC milling machine EMCO Concept MILL 105, which is part of the iCIM 3000 like as manufacturing and assembly system. The current shape and size of the replaceable jaws is not suitable for the new component base. When designing replaceable jaws to allow firm and safe clamping of rotating and non-rotating parts, it was based on limiting factors such as parameters of the pneumatics gripper, dimensions, shape and material of the clamped parts and the like.

Keywords: MILLING, NEW COMPONENT BASE, CHANGEABLE JAWS, PNEUMATICS GRIPPER, DIMENSION, ROTATING

1. Introduction
In the complete design of the preparation takes into account several requirements such as technological operation, shape and dimensions of the component, material of the components, splinters. There are also clamps with replaceable parts such as pneumatic gripper, where only replaceable jaws are designed.

The EMCO Concept MILL 105 CNC milling machine, which is part of the iCIM 3000 production and assembly system, is a pneumatic gripper from GRESSEL Ecopos with replaceable jaws. The paper deals with the individual steps of designing the replaceable jaws for a new component base.

2. Current state in the milling machine
At present, the EMCO Concept MILL 105 CNC milling machine machining of rotating parts with diameter ø 30mm and ø 40mm. These rotating parts are clamped in clamping jaws, which also serve to clamp a plate-shaped component with dimension 80x150x14.8mm (Fig.1). All machined parts are made of aluminium. Replaceable jaws are clamped on a pneumatic spindle with a maximum clamping length of 70mm and a jaw width of 72mm. This size is also adjustable for jaws.

3. New component base
The milling machine is designed to produce rotating components with a diameter of 32-35mm and a non-rotating components with dimensions 60x140x14.8mm (Fig.2). New rotary parts and plates are also made of aluminium.

4. Design of replaceable jaws in the pneumatics gripper
For the new component base, replaceable jaws are designed to allow firm and secure clamping of rotating and non-rotating components. At the same time, the jaws of the pneumatic gripper cannot clamp the new parts because their dimensions and shapes are different. The clamping of the rotating parts will be up to 8mm in height, which ensures a firm and reliable clamping at a total height of 35mm. The insufficient maximum clamping length of the pneumatic gripper affects the shape of the replaceable jaws.

When designing replaceable jaws, the dimensions are suggested: • of the clamping parts of the replaceable jaws to the gripper, • of the clamping parts of the replaceable jaws for the base plates, • of the prisms of the replaceable jaws.

4.1 Dimensions design of fixture parts of replaceable jaws to the gripper
The clamping parts of the replaceable jaws consist of the design of two groups of dimensions. These are the diameters of the jaws
for clamping the jaws with screws and the spacing between holes for clamping the jaws through the screws (Fig. 3). These dimensions are influenced by the pneumatic sprocket.

![Fig.3 Fixture part of jaws to the pneumatics gripper](image)

a) left jaw, b) right jaw

The most important parameter that affects the dimensions $L_1$ and $L_2$ is the maximum clamping length of the pneumatic gripper, which is 70 mm and the clamping stroke of the pneumatic gripper, the value of which can be selected in the range of 1 to 5 mm.

The clamping stroke determines the distance that the jaws move when they are snapped and tipped. In this case, the distance of 7mm jaws (Fig. 4a) and 11mm jaws (Fig. 4b) was determined. Thus, the clamping stroke is 4mm. Dimensions $L_1$ and $L_2$ can be determined on the basis of the opening and clamping stroke of the pneumatic gripper. The total width of the left and right jaw represents 59mm. Based on the design, the width of the left jaw was $L_1 = 25mm$ and the width of the right jaw $L_2 = 34mm$.

![Fig.4 Mutual dimension of replaceable jaws which are fixture in pneumatics gripper](image)
a) closed jaws, b) opened jaws

4.2 Design dimensions of fixture part of replaceable jaws for base plates

Clamping of plates 60x140x14.8 mm is high up to 5mm. The dimensions $l_1$ and $l_2$ are given by the length of the plate from which the distance between the closed jaws is deducted. The sum of the lengths of the clamping parts of the left and right jaws for clamping plates is 133 mm. On the basis of the design, the length of the clamping portion of the left jaw was $l_1 = 66.5mm$ and the length of the right jaw clamping length $l_2 = 66.5mm$ (Fig. 5).

The width of the left and right jaw clamps was determined to be 77mm (Fig. 6) based on the base plate width of 60mm.

![Fig.5 Lengths of fixture parts of replaceable jaws](image)

4.3 Dimensions design of prisms of replaceable jaws

Prismatic jaws are designed to clamp the rotary workpieces. The angle $\alpha$ is $60^\circ$, $90^\circ$ to $120^\circ$. Most often prisms are used with a $90^\circ$ angle. In this case, the prism angle $\alpha = 90^\circ$ was also selected.

The prism design (Fig. 7) was based on the diameter of the clamped work piece $D$ and the distance $h$, which represents the length of the prism, in this case determines the dimension of the clamping part for clamping the plate, i.e. $h = l_1$. The distance $h$ is an important value for determining the $H$ value, which represents the distance of the edge of the clamping portion of the base plate from the component axis. The $H$ value is defined by:

$$H = h + 0,707 \times D - 0,5 \times C \ [mm] \quad (1)$$

where:

- $h$ – flexible part dimension for fixturing of base plate [mm]
- $D$ – workpiece diameter [mm]
- $C$ – width of prism [mm]

If the value $C$ is not known, it can be based on the $L_{zc}$ value, which represents the distance between the clamped jaws and its value is 7mm. In this case, the relation for $H$ is determined as:

$$H = h + \frac{L_{zc}}{2} \ [mm] \quad (2)$$

where:

- $L_{zc}$ – dimension between closed jaws [mm]

Based on the previous relationship (1) it is possible to derive the relationship for determining the prism width $C$ in the form:
\[ C = 2 \times (h - H + 0.707 \times D) \text{ [mm]} \]  \hspace{3em} (3)

Dimensions SA and SB (Fig. 7) are defined by relationships:
\[ SB = \frac{D}{2} \text{ [mm]} \]  \hspace{3em} (4)
\[ SA = \frac{SB}{\sin \frac{\alpha}{2}} \text{ [mm]} \]  \hspace{3em} (5)

where:
\[ \alpha \text{ – angle of prism \text{[°]}} \]

According to previous relations, the basic prism dimensions for the rotary components with diameter ø32mm (Tab. 1) have been calculated. The designed replaceable prisms are shown on (Fig. 8).

<table>
<thead>
<tr>
<th>Diameter of fixed workpieces D [mm]</th>
<th>α [°]</th>
<th>h [mm]</th>
<th>H [mm]</th>
<th>C [mm]</th>
<th>SB [mm]</th>
<th>SA [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ø 32</td>
<td>90</td>
<td>66.5</td>
<td>70</td>
<td>38.3</td>
<td>16</td>
<td>22.6</td>
</tr>
</tbody>
</table>

For each prism, the range of possible clamping diameters can be determined. \( D_{\text{min}} \) and \( D_{\text{max}} \) are designated, representing the minimum and maximum possible clamping diameters. Workpieces with a larger or smaller diameter cannot be fixture and clamped when determining the minimum and maximum possible clamping diameter. These distances are important to take into account when calculating the limits. In this case, the distance between the jaws is 7 mm and the cutting state is 11 mm. The new rotary components are designed to be reliably clamped at the minimum jaw distance, i.e. \( D_{\text{min}} \). The determination of \( D_{\text{max}} \) is based on the formula (2), where the distance of the broken jaws 11 mm is obtained after the value \( L_{\text{zč}} \), thus the value H is changed to 72 mm. This value is given in the following relation (12). The value h, which represents the prism length, in this case determines the dimension of the clamping part for clamping the base plate, i.e. h = 1. From formula (3), the relationship is determined for the maximum workpiece diameter \( D_{\text{max}} \):

\[ D_{\text{max}} = 2 \times \frac{C}{2} - h + H \times 0.707 \text{ [mm]} \]  \hspace{3em} (12)

The minimum possible clamping diameter is ø32mm. The maximum possible clamping diameter is ø34.8mm. (Fig. 10)
4.4 Selection of suitable material for removable jaws

Steel with a minimum tensile strength about 450MPa, is one of the most commonly used materials for the jaws' jaws. The chosen material was therefore the E360 (11 700) structural steel, suitable for machine parts that have higher resistance to wear and tear (Tab. 2).

<table>
<thead>
<tr>
<th>Marking according to STN standard</th>
<th>11 700</th>
</tr>
</thead>
<tbody>
<tr>
<td>New marking EN</td>
<td>E360</td>
</tr>
<tr>
<td>Carbon content %</td>
<td>0,65</td>
</tr>
<tr>
<td>Lower yield point $R_y$ [MPa]</td>
<td>461 - 834</td>
</tr>
<tr>
<td>Tensile strength $R_m$ [MPa]</td>
<td>324 - 637</td>
</tr>
<tr>
<td>Hardness HB</td>
<td>max. 290</td>
</tr>
</tbody>
</table>

5. Determining the size of the clamping force

The size of the clamping force is an important parameter for machining. The clamping force must be greater than the cutting force so that the workpiece is not displaced or vibrated. The pneumatic sprocket used has a maximum clamping force of 3000N, which means that the cutting force must be smaller.

Determining the size of the cutting force consists of the following steps:

- Select a suitable cutting tool
- It depends on the dimensions, shape and quality of the surface of the milled surface, also from the machined material. The selected cutting tool gives the parameters necessary to determine the cutting force, that is, the diameter of the cutting tool, the number of teeth, and the geometry of the cutting tool. Determines the number of teeth in engagement.
- Determination of cutting conditions
  - For a given milling surface and the selected tool, the depth of cut, the number of shots, is determined. From catalogs or standards, it is cutting speed, rotational speed, feed to the tooth. Specify the type and method of cooling.
  - Calculation of the cross section of the fragments taken
  - For milling, it is important to determine the width and maximum thickness of the chips to be sampled, from which the cross section of the chips is calculated.
- Determination of cutting resistance
  - The cutting resistance is calculated for the machined material, i.e. aluminium and the maximum thickness of the chips removed.
- Calculate the cutting force size
  - The cutting force is calculated as the product of the cross section of the chips and the cutting resistance. If there is more teeth than one, the cutting force is determined for each tooth individually. Subsequently, the individual cutting forces are added together to calculate the resulting cutting force.
- Determination of the safety factor
  - Security factor $K$ ensures sufficient clamping of the workpiece at any operating force. When selecting a low security factor, there may be little clamping reliability. Determination of large $K$ can result in unnecessarily large clamping force $F_u$. The size of the safety clamping coefficient $K$ is determined by adding the individual coefficients. (Chvála, B.)
  - Determining the size of the clamping force

The size of the clamping force $F_u$ can be determined by:

$$F_u \geq \frac{K \times F_c}{f} \quad [N]$$

(13)

The coefficient of friction $f$ between the workpiece and the clamping surfaces of the preparation. Its value depends on the surface of the preparation and the machining of the workpiece.

The clamping forces required to clamp the rotating components and plates have been calculated. All values were below max. The clamping force which the pneumatic claw is able to clamp.

6. Conclusion

The aim was to design replaceable jaws on the GRESSEL Ecopos pneumatic gripper clamped on the EMCO Concept MILL 105 CNC milling table. Before the design, it was necessary to evaluate the current state of the jaws. Replaceable jaws ensure clamping of diameters $\phi$ 30mm and $\phi$ 40mm and 80x150x14.8mm (wxdxh) plates made of aluminium. The new jaws have been designed to ensure firm clamping and setting up of newly-formed rotating components with $\phi$ 32mm diameter and a 60x140x14.8mm (wxdxv) baseplate.

The design of jaws was based on limiting factors, such as the parameters of a pneumatic gripper as a maximum and minimum cutting, maximum clamping force, maximum clamping stroke, clamping screw spacing and others. Another important design factor was also the size, shape and material of the parts. For the versatile use of the pneumatic gripper, the shape of the designed jaws has been adapted to the gripper parameter. When designing replaceable jaws, their dimensions were proposed, which were divided into three groups. These groups consist of the dimensions of the clamping parts of the replaceable jaws, the clamping part of the replaceable jaws for the base plates and the dimensions of the jaws of the replaceable jaws.

Designed jaws have calculated the minimum and maximum diameter of parts that can be safely clamped into the jaws. Also, the minimum and maximum diameter of the parts that can be clamped into the jaws on the pneumatic gripper was calculated. With the jaws clamped on the pneumatic gripper, the minimum and maximum possible clamping diameter was limited by the maximum opening of the pneumatic gripper. The chosen material was E360 structural steel (11 700). For design components and base plates, it was necessary to determine the size of the clamping force. The required size of the clamping force must be less than the maximal clamping force of the gripper. After calculating the clamping forces, it was found that all the components and base plates could be securely clamped on the pneumatic gripper.

7. References


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INNOVATIVE SOLUTIONS IN WASTE PROCESSING
ИНОВАЦИОННИ РЕШЕНИЯ ПРИ ПРЕРАБОТВАНЕТО НА ОТПАДЪЦИ

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Abstract: The current report aims to provide insight into the different innovative solutions in waste processing. It outlines that the new technologies for solving the waste issue should be consistent with the current requirements for saving resources and minimizing the waste going to landfills. First, the paper discusses that one of the most serious challenges of the modern world is linked to the daily disposal of hundreds tonnes of waste. They are not only a national, but a global problem, the uncontrolled disposal and accumulation can cause serious pollution of the environment and lead to worsening health. That is why the issue of their effective management is of utmost importance. The report gives special attention to the global problem with waste collection and disposal that imposes an urgent need for innovations. Next, different innovative solutions in waste processing are also analyzed in the paper. A new, better model of waste management needs to be created and innovative methods (instruments) for disposal and treatment of municipal solid waste are needed. The author identifies that scientific progress allows for the implementation of new waste management technologies such as radio-frequency identification (RFID), GPS systems, underground waste treatment facilities, multistage waste recycling system, etc. Finally, on the basis of the analysis, recommendations for waste management on a global level are outlined. A conclusion is made that when choosing a new and effective waste management technology, the ecological (safety and ecological risks) and economic (efficiency, capital and operational expenses) factors should be considered.

Keywords: INNOVATIVE SOLUTIONS, INNOVATIVE TECHNOLOGIES, ENVIRONMENTALLY FRIENDLY TECHNOLOGIES, WASTE MANAGEMENT, WASTE PROCESSING, RECYCLING METHODS, ENVIRONMENT

1. Introduction

Global systems of production and consumption continue to impose considerable consequences on the environment and public health. Most of the used natural resources return to the environment in the form of waste, which in most cases is toxic and unsuitable for recycling. Waste is a global issue and if not properly dealt with, waste poses a serious threat not only to the biosphere, but also to public health. It is a growing issue linked directly to the way society produces and consumes. Meanwhile, global trends such as population growth, urbanization and the emerging ‘consumer middle class’ in many developing countries are expected to drive steady growth in global competition for resources in coming decades. The problem is further exacerbated by the consequences of the enhanced technological progress which leads to generation of more waste products which do not dissolve.

Addressing these challenges will require fundamental changes in global systems of resource use and economic growth. That is why one of the pressing issues for developing countries will be a shift away from a linear (take-make-dispose) model of resource consumption towards a circular economy where nothing is wasted. Proper waste management is one of the most important contributions humanity can make to reducing its impact on the natural world. Environmental sustainability is the core issue that will need to be addressed for development to focus on human well-being and yet stay within the limitations of planet’s capacity. Environmentally sound waste management is one of the key elements for sustainable development. The first priority is to bring wastes under control but that on its own is not enough – it is also necessary to move from waste management in a linear economy to resource management within a circular economy.

New technologies for solving the waste issue should be consistent with the current requirements for saving resources and minimizing the waste going to landfills. Eco-innovation also has a crucial role, enabling producers to reduce their resource use or shift to less harmful or scarce substitutes (for example in the transition from fossil fuels to solar or wind power). When choosing a new and effective waste management technology, the ecological (safety and ecological risks) and economic (efficiency, capital and operational expenses) factors should be considered. In many cases, the shortage of funds for waste management leads to further deepening of the problem especially in the least developed countries.

2. Preconditions and means for resolving the problem

In the past, the municipal waste management is limited primarily to the collection, disposal, landfill or incineration. Over time, however, the environmental awareness of the population has increased, caused by various reasons such as technological development and interest in activities that pollute and harm health. Along with this the problem of limited resources comes to the fore and the conclusion is made that only landfilling and incineration are not sufficient to cope with the ever-increasing amount of waste worldwide. All these issues and the emergence of the concept of sustainable development give impetus to the idea of recycling as a way to reduce the amount of waste.

“[Despite different assessments global generation of municipal solid waste (MSW) is estimated at about 2 billion tonnes per annum. MSW generation rates vary widely within and between countries. They depend on income levels, socio-cultural patterns and climatic factors, factors such as population expansion, urbanization, economic and technological development. MSW generation per capita is strongly correlated with national income. In high-income countries, MSW generation rates are now beginning to stabilize, or even show a slight decline, which may indicate the beginning of waste growth ‘decoupling’ from economic growth. However as economies continue to grow rapidly in low- and middle-income countries, it can be expected waste generation per capita to rise steadily.]”

The volume of waste is mainly determined by two factors – the size of the population and the structure of consumption. “[According to the United Nations’ data, the current world population of 7.3 billion is expected to reach 8.5 billion by 2030, 9.7 billion in 2050 and 11.2 billion in 2100. Most of the projected increase in the world’s population can be attributed to a short list of high-fertility countries, mainly in Africa, or countries with already large populations. With the highest rate of population growth, Africa is expected to account for more than half of the world’s population growth between 2015 and 2050. During 2015–2050, half of the world’s population growth is expected to be concentrated in nine countries: India, Nigeria, Pakistan, Democratic Republic of the Congo, Ethiopia, United Republic of Tanzania, United States of America (USA), Indonesia and Uganda, listed according to the size of their contribution to the total growth.”] However, the concentration of population growth in the poorest countries imposes

83
challenges on the success of the global sustainable development. Population growth will inevitably lead to higher rates of urbanization (on a global scale it is projected that urban population will be around 65% of the total) and the formation of large areas filled with poor people in the big cities and in their surroundings. As a result, the number of people in poor blocks will double by 2025 and will reach 1.5 billion people. According to the other estimates, some 80% of this growing population will live in cities, most of which are yet to be built. Of this projected almost 9 billion people, 3 billion will belong to the middle class, with sufficient disposable income to purchase the consumer goods that others enjoy elsewhere in the world, further draining the planet’s already strained natural resources. Moving to a circular development model – which works to reduce waste before it is produced by which treats waste as a resource when it is – is essential, and holistic and integrated sustainable waste management will be crucial.

“The considerable growth in population and the upsurge in global GDP will inevitably trigger an increase in the amount of waste. It is estimated that a 1% rise in national income leads to an increase by 0.69% in solid waste.” Nonetheless, there are positive prospects for the future. It is a well-known fact that the larger the GDP of a country, the more complicated and efficient its waste management system is. Against this background, it can be claimed that GDP growth will certainly force governments of the new members of the group of developed countries to take measures for enhancing waste collection and management. The current economic situation, however, shows that it is cheaper for developed countries to export their waste to third world countries rather than to spend large amounts of money on recycling waste on their own. Thus, there are fears that technology advance without supporting measures will not resolve this problem. This also raises the question to what extent new technologies will be accessible for the developing countries. Therefore, one of the most serious challenges of the modern world is linked to the daily disposal of hundreds of tonnes of waste. They are not only a national, but a global problem, that is not only still increasing, but also has a potential to cause damage to the environment and lead to worsening health. That is why the issue of their effective management is of utmost importance.

In addition to population growth, globalized markets and increasing consumption of materials, rising energy prices and increasing commitment worldwide to reduce greenhouse gas emissions and landfill drive the development of new approaches to waste management. More and more countries restrict or even prohibit landfilling, heading towards alternative solutions for waste to combinations of maximum recycling and alternative energy production. The concept of integrated waste management now emerges as a mature strategy that can cope with ever-increasing complexity of processing large volumes of waste. The global problem with waste collection and disposal imposes an urgent need for innovations. In recent years it has become clearer that the existing waste management systems cannot handle that task. The 2008-2009 world financial and economic crisis has further worsened the situation – waste processing has always been expensive and the worsening economic environment drove many processing enterprises out of business, especially in developing countries. At the same time, the volume of waste is rapidly increasing and as a result the huge landfills in many countries inevitably cause environmental disaster.

Recently, one of the most pressing environmental issues in the world is related to the recycling and utilization of the so-called electronic waste. Waste electrical and electronic equipment (WEEE) is currently considered to be one of the fastest-growing waste streams. WEEE contains a number of hazardous substances and at the same time valuable materials. The revised EU WEEE Directive (2012/19/EU) sets out measures to reduce generation of WEEE, and enhance collection, reuse, recycling and recovery, applying producer responsibility as key implementing mechanism. “This kind of waste includes all types of high-technology electronic devices, from mobile phones and music players to computers and television sets. The increasing amount of old electronics raises concerns as these products contain a number of substances which are harmful for both people and nature. They contain a large quantity of cadmium which can be found in semiconductors, resistors, and all sorts of transmitters. There is mercury in the fuses and commuters, chromium in the hull, and bromine in the power and connecting cables.” “[It is a well-known fact that batteries are made of nickel, cadmium, lithium, and other harmful chemical substances. The problem is worsened by the fact that the quantity of e-waste in the world is growing.” “[According to several studies, the volume of high-tech waste, including only computers, mobile phones, and TVs, will enhance to 9.8 million tonnes. In addition, it is projected that the rapid development of nanotechnologies and the emergence of new types of materials will increase the quantity of hazardous waste which is not naturally degradable.”]

The reduction of hazardous substances in newly produced electronic and electrical equipment taking place currently is an important step in reducing the environmental and health risks from disposal, also in the countries of destination. In addition, it is however, necessary also to incorporate in the overall consideration the risks from the use of auxiliary products from the handling (e.g. leaching agents, cyanide), as well as the emissions from handling and recycling processes (e.g. PCDD/F emissions from thermal processes, wastewater, secondary wastes such as, for example, sludge). Separate collection of WEEE and its subsequent recovery and recycling is an environmentally sound manner will help achieve not only reduction of environmental impacts, but also better resource efficiency.

The abovementioned trends in waste management will be present in the future, as well. The rising quantity of waste cannot be stopped because of the increase in the global population. Furthermore, consumerism will continue spreading among the society along with bigger progress achieved by some developing countries with huge population. The current economic system requires constant growth which can be achieved with a constantly rising consumption. Ignorance in consumption and thus in growth will lead to the collapse of many economies, to unemployment, and to famine. This creates a vicious circle which cannot be broken without innovations which will change dramatically the way resources are utilized as well as waste management and recycling.

As regards the changes in waste composition, prospects are once again far from optimistic. The attempts to replace plastics with easily degradable materials have failed to produce any significant results. A lot of artificial materials cannot be replaced and in those which can the costs for producing environmentally-friendly substitutes are 4 to 5 times higher.

3. Results and discussion

Innovation is always a good thing, improving the recycling process is constantly welcome and thankfully there are individuals and organizations who are dedicated to doing just that. As waste management climbs the political and environmental agenda, bright sparks in the industry respond with innovation. These are some of the ideas that have changed our industry over the past few years, and given us potential answers to global problems.

We are continuing to see new developments, innovations, and even new problems in sustainability ventures and recycling efforts. To get a better sense of where we are headed in the near future, for good or bad, we have to know the forthcoming trends and expectations. All organisations must deal with their waste appropriately, but they shouldn’t stop at compliance. Smart organisations innovate by setting targets that drive them towards best practice.

Waste management generally comprises operations related to collecting, transportation, sorting, and treating of waste, but the active work with the population, government authorities, and business organizations is also part of it. Numerous issues in the field of waste management need to be resolved. They include, among others, creating effective waste management system, providing financing, and defining the right government instrument
and steam. A plasma gasification plant uses plasma torches which convert organic waste into syngas – which is produced during gasification – and monoxide and hydrogen. The gas is then burnt to produce electricity.

For years scientists have developed and tested various kinds of technologies for treatment of that kind of waste and to create new ways to process them with the aim to make residue less hazardous. Some of the most interesting developments in the field of nuclear waste management need to be considered. Different standards and limitations might hinder the introduction of new technologies. Another important condition for successful waste management is the relationship between the public and the private sector, between institutions, organizations, and society. A new, better model of waste management needs to be created and innovative methods (instruments) for disposal and treatment of municipal solid waste (MSW) are needed.

"[Anaerobic digestion came about as the result of a long process of people searching for the best way to deal with biowaste. Even before awareness of climate change came to the fore, we had problems with leachate and gas. So, early technologies found ways to convert organic waste into compost and fertilizer instead. The process works quickly and the remainder can be used as fertilizer. Biogas, which is a product of anaerobic digestion, is produced not only as a waste management process but also as a source of renewable energy.]"

The manufacture of biogas from organic waste has the following advantages: biogas with high saturation can be used to produce both power and heat; the anaerobic treatment of materials from plants and animals facilitates the manufacture of mineral fertilizers which are high in nitrogen and phosphorus (unlike the conventional production of natural fertilizers by composting waste where between 30-40 % of the nitrogen is lost); all pathogenic microorganisms are removed and the residue fully complies with the environmental requirements after the anaerobic treatment is completed; biogas production facilities can easily be installed in any region and they do not require expensive and complex pipe infrastructure. These facilities can fully replace the small steam generators which produce heat and power in rural areas.

Given the oil crisis and the ever-increasing price of fossil fuel, turning waste into fuel is a fantastic solution. Biofuel is the most common form, and the term encompasses a range of different fuels derived from organic matter, including biowaste. Biofuel can be solid, liquid or gas and be used to power vehicles or used to enhance other types of fuel. Biogas is a product of anaerobic digestion – and syngas – which is produced during gasification – are both types of biofuel. Landfill gas also has an up-and-coming role in this field. Most landfill-gas-to-energy projects involve turning otherwise harmful emissions into electricity to power homes. But it is also being increasingly used as a vehicle fuel or as a substitute for mains household gas supply.

Recycling waste oil in a safe and environmentally friendly way by using the right technologies is one of the most pressing issues of today. Given the difficulties in the recycling of heavy oil in Western Europe and the USA, the technology to treat waste oil with sulfuric acid was rarely used. Instead, it was replaced with modern selective hydrogenation and cleaning solvents. There are almost none environmentally friendly industrial technologies for treatment of acid tars as they are burned in the thermal power plants to generate heat which has an adverse impact on the environment. The most rational way to treat heavy oil is the controlled thermal destruction of saturated hydrocarbons. The high temperature, the high pressure, and the little time for thermocracking allow for the production of asphalt and resin from the saturated hydrocarbons. In industry, the thermal cracking of heavy oils is used to produce tar, coke, and bituminous materials. The prospects for implementing this technology are supported by the thin film deposition of heavy oil in the composition of the original structure. The technologies and facilities for heavy oil processing might be used in refineries which already have huge quantities of heavy oil.

Despite all negatives, nuclear power makes up a significant part of total power output in the world. As a result, the treatment of hazardous waste from nuclear power plants is a significant problem. Nuclear waste could be used to fuel the reactors of the rising number of alternative energy companies in the future. At that moment, however, it is stored in underground nuclear waste dumps. Scientists from various organizations strive to improve the technologies for treatment of that kind of waste and to create new ways to process them with the aim to make residue less hazardous and toxic. According to one of the latest works in this field, nuclear fuel will be converted into very dense solid-glass blocks which will make it easier and safer to store.

For years scientists have developed and tested various kinds of technological approaches to convert nuclear waste into solid glass. The new method comprises mixing of frozen plutonium with furnace...
slag with the aim to produce glass. Currently, the nuclear waste is contaminated under concrete but in the future it might be used in glass production. It is noteworthy that for now the method of the scientist from the University of Sheffield is applied with cerium instead of plutonium because they are very similar. If tests prove successful, then the mankind will have a simpler and safer way to treat nuclear waste.

“[Scientific progress allows for the implementation of new waste management technologies such as:  

- Radio-frequency identification (RFID) which is used to gather information on the transportation and disposal of waste in towns and cities. Collected data are used to develop new types of waste containers for recycled raw materials, recycle bins, among others. The essence of this technology is the automatic identification of the objects which is done by using radio signals. Thus, data is received and analyzed by the so-called RFID tags. In fact, each RFID system includes a reader device.  
- GPS system used primarily for transportation of waste which has already been sorted. GSP (Global Positioning System) is a satellite navigation system which measures the distance and the time necessary to reach specific point. The system can be used in almost every spot on the Earth (excluding the polar regions) in all weather conditions. The GPS system was developed by the United States Department of Defense.  
- Underground waste treatment facilities. In contrast to conventional burning appliances, this device is a semi-round container with a tube that reaches a depth of 3.5 meters. It is equipped with a special waste compaction mechanism which reduces the volume of the waste five times. Thus, the container can hold a total of 50 m3 of waste. More than fifty devices of that type are already installed in Finland where they are becoming increasingly popular.  
- Multistage waste recycling system – this type of technology derives from the traditional sorting and recycling systems in Western Europe, the USA, and Japan. For other countries, however, it still remains innovative and quite expensive. Usually, waste is treated in a facility which is very close to the waste source (or potential source of waste) which makes this technology quite useful for consumers as it requires minimal effort and capital.”

4. Conclusion

The analysis of new waste management technologies in the world focuses the attention on the following trends in the process of modernization in this sphere:

- environmental safety – nearly all new technologies focus, albeit to different extents, on minimizing resource use and the harm on the environment;  
- economy – the innovative technologies in this sphere largely contribute to the reduction (minimization) of waste treatment and disposal costs. Costs of using these technologies are usually much lower than costs incurred in implementing traditional technologies;  
- saving resources and energy efficiency – minimizing the quantity of resources used in waste recycling and treatment;  
- automation which is expressed in increased use of new technologies in the recycling with the help of innovative, high-tech tools: computer programs, satellite communication, etc;  
- information transparency and publicity. This trend is typical for the developed countries where the waste management process is increasingly open, democratic, and covered by the media. State agencies and local authorities present plans and forecasts in this sphere, inform the society about events, run active campaigns promoting waste minimization, encourage the population to have social responsibility for waste disposal and treatment, express the public opinion, and conduct effective exchange of information between the authorities and the civil society.  
Using waste management as a way to combat GHG and climate change is one of the most innovative and common-sense concepts in waste today. The role that the waste industry can play in helping to avert climate change must not be underestimated. Given the correct legislation to work to the technologies which are already making great leaps in this area will show how much good they can really do. Although the costs of implementing these processes is often seen as prohibitive, the cost to the planet and the resulting financial cost of dealing with this, make all of these moves more than worthwhile.

5. Literature

DEVELOP REQUIREMENTS FOR AUTOMATED COMPLEX OF EXPRESS DIAGNOSTICS OF PIGMENTED SKIN LESIONS

РАЗРАБОТКА ТРЕБОВАНИЙ ДЛЯ АВТОМАТИЗИРОВАННОГО КОМПЛЕКСА ЭКСПРЕСС-ДИАГНОСТИКИ ПИГМЕНТНЫХ НОВООБРАЗОВАНИЙ КОЖИ

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Abstract: The work contains the main results of the development of a non-invasive method for the early diagnosis of skin pigmented lesions. The risk factors for the development of melanoma, their influence on the formation, development and degeneration of benign pigmented lesions in malignant ones are considered. Noninvasive methods for early diagnosis of pigmented skin lesions, their advantages and disadvantages, and informative indicators of diagnostic methods for early detection of lesions have been analysed. Diagnostic signs for the development of an automated noninvasive method for the early diagnosis of pigmented skin lesions have been formulated. And also formulated technical requirements for an automated complex for express diagnosis of pigmented skin lesions.

KEYWORDS: MELANOMA, MELANOMA RISK FACTORS, CLINICAL SIGNS, DIAGNOSTIC FEATURES, TECHNICAL REQUIREMENTS.

1. Introduction

Melanoma among other lesions occupies a special position, since it has aggressive properties. To date, skin melanoma remains the leading cause of death in patients with oncodermatology, with a steady increase in the incidence of skin melanoma all over the world[1].

In this regard, the questions of melanoma clinic remain extremely relevant. In order to automate the system and develop a complex for express diagnostics of pigmented skin lesions, it is necessary to consider the features of the origin, development and degeneration of benign pigmented skin lesions into malignant ones.

For the emergence of any tumor disease, in particular melanoma, it is necessary to combine the effects of the main causal factor with the conditions both surrounding the environment and the internal environment of the human body. Recently, it has been possible to identify a significant number of factors whose effect statistically significantly increases the likelihood of melanoma. To do this, exogenous and endogenous risk factors for melanoma development were analysed[2].

2. Melanoma risk factors

Scientists managed to separate risk factors for melanoma development into exogenous and endogenous ones[3].

Melanoma risk factors:
1 Exogenous risk factors are physical, chemical, biological agents of the environment that have a direct effect on the skin.

1.1 Physical factors:
1.1.1 Ultraviolet radiation
1.1.2 Ionizing radiation
1.1.3 Electromagnetic radiation
1.1.4 Fluorescent lighting
1.1.5 Trauma of the skin

1.2 Chemical factors:
1.2.2 Contact with benzene, polyvinyl chloride, plastics, pesticides and radioactive materials

1.3 Biological factors:
1.3.1 Food habits
1.3.2 Skin diseases
1.3.3 Viral infections
1.3.4 Medications

2 Endogenous factors are divided into two groups: biological factors and melanoma precursors.

2.1 Biological factors:
2.1.1 Racial and ethnic predisposition

2.2 Predictors of melanoma:
2.2.1.2 The level of pigmentation
2.2.1.3 Hereditary (family) factors
2.2.1.4 Anthropometric indicators
2.2.1.5 Immune disorders
2.2.1.6 Endocrine factors
2.2.1.7 Reproductive factors in women

Risk factors for developing melanoma cause "damage" to normal cells and tissues. As a result of such damage, necrosis of cells or tissues occurs with subsequent proliferation, regeneration and restoration of normal tissue structures. However, prolonged proliferation under the influence of these factors can lead to a violation of cell differentiation, a change in their membrane antigenic structure, and hyporeactivity to the effects of regulatory factors in the body. Thus, under the influence of risk factors, normal cells and tissues are transformed into tumor cells. Also, in the case of primary damage, changes in the DNA of the cell can immediately occur, followed by a violation of its protein structure and differentiation (Fig.1).

Fig. 1 Changes in pigment lesions under various effects

In connection with the frequency of melanoma from benign pigment neoplasms, as a rule, 70% of melanomas develop from the previous pigmented growth, and 30% arise on clean skin, it is necessary to know the clinical manifestations of their malignancy:
• growth of the nevus, its compaction or ulceration;
• change in color (strengthening or weakening);
• occurrence of hyperemia or stagnant halo around its base;
• development of radiating growths of a pigment or non-pigmentary nature around the primary formation;
• the appearance of an exophytic component on the surface of the nevus;
• formation near the nevus pigmented or unpigmented daughter nodules - satellites.

Therefore, pigmented skin tumors can be characterized by the following complex of clinical signs:
1 Color
2 Pigmentation uniformity
3. Methods of early non-invasive diagnostics of melanoma

Methods of early non-invasive diagnostics are divided into two types: primary diagnosis and secondary diagnostics, which is of a more precise nature in case of suspected melanoma (Fig. 2)[4].

The analysis of the examined non-invasive methods of early diagnosis of skin melanoma made it possible to determine the main indicators of the informative value of the diagnostic methods: accuracy, sensitivity and specificity presented in Table 1.

According to the data in Table 2, the following conclusions can be drawn: the sensitivity and specificity of dermatoscopy for the diagnosis of pigmented skin lesions are very high, therefore it is a good diagnostic tool for diagnosis, which avoids extensive traumatic surgeries in the treatment of pigmented skin lesions with a low risk of malignancy. However, despite the high sensitivity of the method of digital dermatoscopy in the early diagnosis of skin melanoma and benign melanocytic neoplasms, this method has so far limited application in Russia. In Russia, until now, doctors use a conventional manual dermatoscope, assessing visually every birthmark [6].

Fluorescent diagnostics helps to actively search for hidden, small tumor lesions on the skin surface [9].

The coincidence of thermometric and histological diagnoses occurs in 94.8% of cases with skin melanoma and in 67.9% in benign skin tumors. The accuracy of the thermometric method is limited by the fact that not all skin melanomas have hyperthermia properties [10].

From all of the above, it follows that the development of an automated, non-invasive method of early diagnosis based on the
advantages of all known methods of diagnosing skin pigmented lesions is undoubtedly relevant.

After analysing all the data obtained, the following diagnostic features were formulated for the development of an automated non-invasive method for early diagnostics[11]:

1. Color
2. Pigmentation uniformity
3. Pigmentation intensity
4. Size: diameter, area
5. The border of lesions
6. Border sharpness
7. Form

As well as formulated the main requirements for the technical system:

1. The system should have a high degree of accuracy, at least 90% detect pigmented skin lesions on the image;
2. The system should automatically perform segmentation of pigmented skin lesions;
3. The system should have a high degree of accuracy, at least 90% recognize the boundaries of skin pigmented lesions;
4. The system should automatically calculate parameters of skin pigmented lesions with an accuracy of at least 80% (maximum, minimum diameters, area, pigmentation uniformity, pigmentation intensity, color, border sharpness, shape);
5. The system should display the detected boundaries and calculated parameters of skin pigmented neoplasms;
6. The system should monitor the dynamics of changes in parameters of skin pigmented lesions, storing the data in the database;
7. The system should save the current result of calculating parameters of skin pigmented lesions in the form of a file.pdf;
8. The system should have a high degree of accuracy, sensitivity and specificity, at least 90%, of an automated method for early diagnosis of skin pigmented lesions;
9. The system should have a working wavelength range of 420-640 nm;
10. The system must have a resolution of at least 320 dpi;
11. The system should scan the areas of the surface of a person's body with an area of at least 50x50 mm;
12. The system should have a photodetector array with a resolution of at least 5 megapixels.

4. Conclusions

As a result of the analysis of risk factors for the development of skin melanoma, clinical signs of skin pigmented lesions were formulated.

1. The results of a comparative analysis of non-invasive methods of early diagnosis of skin pigmented lesions allowed to formulate the advantages and disadvantages of each method, as well as to determine the informative indicators of diagnostic methods for early detection of lesions.
2. Based on a comparative analysis of early diagnostic methods, diagnostic features were developed to develop an automated non-invasive method for early detection of skin pigmented lesions.
3. As a result of the analysis of all data, technical requirements were formulated for an automated complex for express diagnostics of skin pigmented lesions.

5. References

1. Introduction

Friction is a very common phenomenon in daily life and industry, which is governed by the processes occurring in the thin surfaces layers of bodies in moving contact (Fig. 1). The simple and fruitful idea used in studies of friction is that there are two main non-interacting components of friction, namely, adhesion and deformation. Measurement of the molecular forces acting between solids is one of the most difficult experimental tasks. Since the forces are small and distances at which they act are short the measuring instruments should meet the specific requirements. One of the main problems arising when measuring the molecular forces is that the latter increase rapidly with decreasing the distance between the specimens under testing. Hence, the measurements should be carried out at a very small speed that cannot be done using the design of the common balance. The frictional force is attributed to deformation taking place when the asperities of two sliding surfaces come into contact with each other. The surface asperities experience elastic, plastic or viscoelastic deformation depending on material behavior. At initial application of load to polymer, the deformation will be mainly plastic if polymer is in glassy state or mainly viscoelastic (or even viscoplastic) if polymer is in highly elastic state. Therefore mechanical properties of contact materials should be taken into account at any scale level but also in their physical interpretation. This deformation is accompanied by dissipation of mechanical energy depending on deformation mode, sliding conditions, rubbing materials, scale level of mechanical properties, environment, and other factors.

2. The sliding layers manufacturing

During the technological process of extrusion or co-extrusion the duct or catheter we can received the high sliding top layers. Manufacture of this kind of coatings can be obtained from different polymers materials conducted with use of a modernized process during the technological line. New constructions of cables or ducts with modified coatings can significantly change the existing assumptions of cable installation, significantly increasing lengths installed. However, there is no methodology for examining frictionless layers for systems that work slidingly over longer distances, with relatively low pressure forces, such as for cable-duct pairs [1,2].

Fig. 1. Example of elements in sliding interaction: a) the duct for telecommunication cable, by catheters in to the human body

3. Measure method of the friction factors

The method and the device for testing elements, particularly the polymers, with one-sided sliding contact which moves in a plane motion. Therefore the method for testing elements with their sliding interactions have been known and described in a several publication [3]. Their characteristics is that the motion of structural element made in a sliding system by a tested sample is reciprocating with an external contact with another structural element, i.e. the tested counter-sample. The contacting elements, i.e. the sample and counter-sample, especially made for the tribological tests, frequently in compliance with the standards, are rigid and little-deformable and have various shapes and relatively small sizes [4].

The essence of testing the elements (fig. 2), particularly the polymers with sliding interactions, whose tested elements having various shapes of small sizes, while the sample and counter-sample are pressed onto each other with various forces of different values and move in relation to each other in different directions, consists in that the tested polymer element, i.e. a sample and being the fragment of a finished product, like a tube or section, with elements of geometric macrostructure or a sliding layer on the tested area, is fixed in the handle of the device [5,6]. Next the sample is contacted with another structural polymer element with a counter-sample, possibly of a cylinder or non-cylinder external surface, such as a section, a tube of small diameter, rod, cable, conductor or a line. The counter-sample is fixed into the driving-measuring unit which ensures a uniform plane motion and facilitates the measurement of a resisting force that develops during the contact with the tested sample. The counter-sample is moved with a uniform plane motion in vertical direction up with a constant linear speed. The sample and counter-sample are contacted on one side with each other, with a constant pressure.

Fig. 2. The scheme and the laboratory test machine to measure coefficient of friction on specifically length with one-sided sliding
The next innovative machines which is constructed in our Department of Technical University (fig. 3) make it possible to measure precisely and reproducibly the friction resistance force between the outer surface of the fiber optic cable and inner surface of the duct [7,8].

During the tests it’s possible to conduct simulation of the installation process in laboratory conditions. We can change some input factors such as: length of contact, duct curve angle, speed of fiber optic cable movement, load during the measure etc. Measurements of maximum friction resistance force (F) enable to make it easy to analyse on the base of received diagrams (fig. 4.) the contact of cooperation bodies cable and duct.

![Fig. 3. The scheme and the laboratory test machine to measure coefficient of friction](image)

The value of sliding coefficient of friction was calculated according to the Eytelwein’s formula, relates the hold-force to the load-force if a flexible cable is wound around a cylinder with requirement wrapped angle with an equivalent mathematical relation:

\[ \mu = \frac{1}{\alpha} \ln \frac{F}{G} \]

where: \( \mu \) - sliding coefficient of friction, \( F \) - maximum friction resistance force, \( G \) - load on the free end of cable, \( \alpha \) - the total wrapped angle of duct around the drum.

![Fig. 4. The sample of diagram of the friction resistance force as the function of distance L](image)

The new modified test method [9] can be applied to products with very small dimensions cooperating with each other in the slide system. The invention enables friction measurements to be carried out and sliding friction coefficients to be determined for elements such as tubes and inner ducts housing fibre optic micro-cables, catheters, cannulas or stents.

The essence of the invention is the fact that the section of interest is introduced into the innerduct, etc. with a constant linear velocity. The jacket is fixed to grips and wrapped around a cylinder with the radius R. In measurement mode, the fixtures move away from each other with a constant velocity V2. Consequently, the actual radius of belting changes. The fixture of the measured elements allows for their independent movement against each other and controlled modification of the radius of their belting on the cylinder.

![Fig. 5. An example of test stand to measurements sliding friction in medical devices catheter and guide](image)

4. Conclusion

Interaction of duct and cable (or guide in medical application) during installation process is a very complicated research problem. The reason is that, there are many different measurements methods of tribological properties [9]. The test machines which are constructed in different research laboratories, have different value of characteristic factors and technical conditions of measure depends of geometrical dimensions and specific function.

The presented inventions allows scientific research to be carried out, novel materials to be designed and new materials for sliding layers to be effectively selected. The application of the invention reduces costs of analyses of innovative products by 55%-70% in relation to those used at present.

Owing to the measurement of particular values, obtaining lower friction coefficients between working elements will be possible. In addition, the invention will enable more effective and less invasive diagnostic procedures to be carried out, energy consumption for scientific work to be reduced, interactions improved and tooling time shortened.

The universal character of the invention is manifested in its ability to be applied in opto-telecommunication (FTTH broadband internet), medicine (vascular surgery), microbiology and agriculture, among others.

In addition, the device expands the scope and means of standardization regarding analyses of sliding friction carried out independently in various R&D institutions in the EU, USA, Canada, China and Japan.

References:

INFLUENCE OF INORGANIC INHIBITOR ON COPPER CORROSION IN ACIDIC MEDIUM

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Summary: In this paper behavior of inorganic compound (2-amino-5-ethyl-1,3,4-thiadiazole) as inhibitor of copper corrosion in acidic medium (HCl solution) was examined. In addition to examination the effects of different concentrations of the inhibitor on the corrosion processes, research also included investigation of influence of immersion time of copper electrode in 2-amino-5-ethyl-1,3,4-thiadiazole (AETDA) solution on protective film formation on electrode surface (copper electrode). During this study next experimental methods are used: open circuit potential measurements (OCP), linear voltammetry measurements (LV) and cyclic voltammetry measurements (CV). Shift of open circuit potential toward negative values indicate that on copper surface comes to formation of corrosion product sand adsorption of molecule inhibitor. Copper oxidation is consequence of existing defect in structure layer and layer dissolution on electrode surface. Results show that inhibition efficiency depend on inorganic inhibitor concentration and immersion time of copper electrode in inhibitor solution (azole derivatives solution). Inhibition mechanism of AETDA is explained by forming compact protective film on copper surface. Adsorption of 2-amino-5-ethyl-1,3,4-thiadiazole on copper surface in 0.05M HCl solution obeys the Langmuir adsorption isotherm. The value of adsorption energy amount: \( \Delta G = -39.52 \text{ kJ/mol} \).

Key words: copper, HCl, oxidation, corrosion inhibition, inorganic inhibitor, acidic medium, AETDA

Introduction
Copper has been one of more important materials in industry owing to its high electrical and thermal conductivities, mechanical workability, and its relatively noble properties [1, 2]. Thus, corrosion of copper and its inhibition in a wide variety of media, particularly when they contain chloride ions, have attracted attention of a number of investigators [1, 3]. Azole derivatives like benzotriazole, mercaptobenzothiazole, benzimidazole, and imidazole are well-known corrosion inhibitors for copper [1, 4]. The present paper reports on the behavior of 2-amino-5-ethyl-1,3,4-thiadiazole (AETDA) as an inhibitor for copper corrosion in HCl solutions. Based on structure (Figure1), can be expected that in acid medium, this compound show high inhibition efficiency for copper corrosion. In addition, it is nontoxic and inexpensive compound [1].

![Figure 1. Molecular structure of 2-Amino-5-ethyl-1,3,4-thiadiazole (AETDA)[1](1)](image)

Experimental
Electrode preparation
Copper electrode was used as working electrode.

Reagents
HCl solution (0.05 M) was used during experiment. 2-Amino-5-ethyl-1,3,4-thiadiazole (AETDA) was used as inhibitor in the wide range of concentrations \( 1.0 \cdot 10^{-6} \text{ M} \) - \( 1.0 \cdot 10^{-2} \text{ M} \). Also, immersion time of copper electrode in inhibitor solution \( 1.0 \cdot 10^{-2} \text{ M} \) was studied.

Electrochemical measurements
The electrochemical characteristics of copper in HCl solution, in the presence of inhibitor was investigated in the following way:

| Electrode potential measurements; Cyclic potentiodynamic measurements; Electrode was immersed for a certain time (5, 15, 30 and 60 min) in \( 1 \cdot 10^{-2} \text{ M} \) AETDA; The electrode was immersed for a certain time 5, 15, 30 and 60 min, in \( 1 \cdot 10^{-2} \text{ M} \) AETDA solution.

| Results and discussion |

Open circuit potential
Change of open circuit potential values was followed in 0.05 M HCl with and without addition of various concentration of inhibitor during 10 min and results are showed in table 1

<table>
<thead>
<tr>
<th>Table 1. Open circuit potential of copper in 0.05 M HCl with and without addition of various concentration of AETDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_{inh} [\text{M}] )</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>/</td>
</tr>
<tr>
<td>( 1.0 \cdot 10^{-6} )</td>
</tr>
<tr>
<td>( 1.0 \cdot 10^{-5} )</td>
</tr>
<tr>
<td>( 1.0 \cdot 10^{-4} )</td>
</tr>
<tr>
<td>0.087</td>
</tr>
<tr>
<td>( 1.0 \cdot 10^{-2} )</td>
</tr>
</tbody>
</table>

Change of OCP indicate direction of the corrosion processes in the examined solutions[1, 5]. Based on the OCP values shown in the table it can be assumed that comes to adsorption of inhibitor molecule on copper surface [6].

Polarization measurements
Cyclic voltammetry

92
Cyclic voltammogram of copper obtained in a hydrochloric acid solutions without and with the addition of 2-amino-5-ethyl-1,3,4-thiadiazole is shown in Figure 2.

**Figure 2.** Cyclic voltammogram of copper recorded in 0.05M HCl in the presence of various concentrations of 2-amino-5-ethyl-1,3,4-thiadiazole. Scan rate 10mV/s

CV curves shown in figure 2 indicate that on 0.2 V vs. SCE comes to rapid increase of current density pointing on more intensive copper oxidation. In acid chloride nature aerated solution, process of copper dissolution can be shown by following reactions [1, 9]:

\[
2 \text{Cu} + \frac{1}{2} \text{O}_2 + 2 \text{H}^+ \rightarrow 2 \text{Cu}^2+ + \text{H}_2\text{O} \quad \text{............................(1)}
\]

\[
2\text{Cu}^2+ + \frac{1}{2} \text{O}_2 + 2 \text{H}^+ \rightarrow 2 \text{Cu}^{2+} + \text{H}_2\text{O} \quad \text{.............................(2)}
\]

Increase of concentration Cu^{2+} ions causes further copper dissolution by following reaction:

\[
\text{Cu}^{2+} + \text{Cu} \leftrightarrow 2 \text{Cu}^{+} \quad \text{...........................(3)}
\]

Also, in HCl solutions come to reaction between copper and Cl- ions by following reactions [8]:

\[
\text{Cu} + \text{Cl}^- = \text{CuCl}^{ads} + e^- \quad \text{...........................(4)}
\]

\[
\text{CuCl}^{ads} + \text{Cl}^- = \text{CuCl}^{2ads} \quad \text{...........................(5)}
\]

\[
\text{CuCl}^{2ads} = \text{Cu}^{2+} + 2\text{Cl}^- + e^- \quad \text{...........................(6)}
\]

**Figure 3.** Cyclic voltammogram of copper in a 0.05M HCl solution after immersion in 1·10^{-2} M AETDA solution for various periods of time (5, 15, 30 and 60 min). Scan rate 10mV/s

From figure 3 was noticed that on potential 0.1 V exist anode current peak which indicate that after electrode immersion in inhibitor solution and during potentiodynamic measurements in 0.05 M HCl come to dissolution of copper. Inhibition mechanism of azole compounds can be explains by following reactions [10]:

\[
\text{Cu} + \text{inh} = \text{Cu(inh)}^{ads} = \text{Cu}^{n+} + ne^- + \text{inh} \quad \text{...........................(7)}
\]

\[
\text{inh}^{aq} + n\text{H}_2\text{O}^{ads} = \text{inh}^{ads} + n\text{H}_2\text{O}^{aq} \quad \text{...........................(8)}
\]

**Linear voltammetry**

Besides the cyclic potentiodynamic measurements, for a complete understanding of corrosion processes and mechanisms of action of AETDA linear potentiodynamic measurements were performed.

**Figure 4.** Potentiodynamic polarization curves for copper in 0.05 M HCl with and without addition of various concentrations of AETDA. Scan rate 1 mV/s.

According to polarization curves present in figure 4 it can be seen that corrosion potential moves toward positive values with increase inhibitor concentrations. Besides that current density decreases with increasing AETDA concentration indicating that AETDA acts as anode inhibitor in examined conditions. The values of inhibition efficiency (IE%) were calculated from polarization data according to the equation [1, 2]:

\[
\text{IE}\% = \left(\frac{j_{\text{Corr}} - j_{\text{Corr (inh)}}}{j_{\text{Corr}}} \right) \times 100 \quad \text{...........................(10)}
\]

where \(j_{\text{Corr}}\) and \(j_{\text{Corr (inh)}}\) - are the corrosion currents in absence and presence of AETDA, respectively.
Table 3. Electrochemical parameters of copper in 0.05 M HCl in absence and presence of inhibitor

<table>
<thead>
<tr>
<th>Solution</th>
<th>Immersion time [min]</th>
<th>Ecorr [V vs. SCE]</th>
<th>jcorr [μA/cm²]</th>
<th>bc</th>
<th>ba</th>
<th>θ</th>
<th>IE [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 M HCl</td>
<td>/</td>
<td>-0.183</td>
<td>48 200</td>
<td>-0.318</td>
<td>0.164</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>1.0 x 10⁻⁵ M AETDA</td>
<td>/</td>
<td>-0.118</td>
<td>11 200</td>
<td>-0.088</td>
<td>0.073</td>
<td>0.7676</td>
<td>76.76</td>
</tr>
<tr>
<td>1.0 x 10⁻⁴ M AETDA</td>
<td>/</td>
<td>-0.088</td>
<td>10 600</td>
<td>-0.106</td>
<td>0.085</td>
<td>0.7801</td>
<td>78.01</td>
</tr>
<tr>
<td>1.0 x 10⁻³ M AETDA</td>
<td>/</td>
<td>-0.104</td>
<td>10 500</td>
<td>-0.070</td>
<td>0.061</td>
<td>0.7822</td>
<td>78.22</td>
</tr>
<tr>
<td>1.0 x 10⁻² M AETDA</td>
<td>/</td>
<td>-0.085</td>
<td>7 900</td>
<td>-0.083</td>
<td>0.061</td>
<td>0.8361</td>
<td>83.61</td>
</tr>
<tr>
<td>1.0 x 10⁻¹ M AETDA</td>
<td>/</td>
<td>0.119</td>
<td>7 500</td>
<td>-0.188</td>
<td>0.142</td>
<td>0.8444</td>
<td>84.44</td>
</tr>
</tbody>
</table>

It is clear from table 3 that increase of concentrations of AETDA increasing inhibition efficiency. Also increase of AETDA concentration leads to decrease of corrosion current density. Nevertheless, according to results presents in table 3 it can be said that with longer immersion time, values of IE increase and jcorr decrease.

Adsorption isotherm

Primary information about interaction between inhibitor and metal surface can be obtained from adsorption isotherm. Lengmuir adsorption isotherm obtains from equation [4]:

\[
\frac{C}{1-C} = \frac{A\exp\left(-\frac{\Delta G}{RT}\right)}{K_C} \quad \text{........................................(11)}
\]

\[
\Delta G = -\ln K - \frac{1}{55500} RT \quad \text{........................................(14)}
\]

The value of adsorption energy amount:

\[
\Delta G = -39.52 \text{ kJ/mol}
\]

The negative value of the free energies of adsorption indicates strong adsorption of AETDA molecules on copper surface [4].

Conclusions

Shift of open circuit potential toward negative values indicate that on copper surface comes to formation of corrosion product sand adsorption of molecule inhibitor. Cyclic and linear potentiodynamic measurements indicate that in presence of inhibitor come to copper dissolution lower intensity compared to copper dissolution in bare HCl solution. In the presence of AETDA comes to formation protective layer on copper surface which prevents further intensive dissolution of metal. Adsorption of 2-amino-5-ethyl-1,3,4-thiadiazole on copper surface in hydrochloric acid solution obeys the Langmuir adsorption isotherm.

References

ENERGY BALANCE OF GREENHOUSE WITH GROUND WARMING INSTALLATION

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vangelicaj@yahoo.com

Abstract: Geothermal energy, solar energy, industrial thermal effluents, etc. mainly offer low-temperature waters. Heating installation or system, originally developed for one of the alternative energy source. The problem of low-temperature heating of greenhouses is not characteristically only for direct application of geothermal energy but is connected to the problem of all the "alternative" energies use for that purpose. Calculations determine the losses of heat transfer, losses from the application of heat and benefit from the use of hot water. Calculated is necessary and permissible temperature of the floor, the recommended speed of the fluid and plan for layout of pipes in the ground of greenhouse.

Keywords: ENERGY BALANCE, GREENHOUSE, INSTALLATION, GEOTHERMAL ENERGY;

1. Introduction
Main advantages of alternative energies is that they are free of charge or much cheaper than the fossil fuels. Their main disadvantage is that in most of the cases heating fluids are available with rather low temperatures.

The problem of low temperature greenhouses is connected with all alternative energies that is use for that purpose. But heating installation that is originally developed for one alternative energy source is or can often be convenient for use of the other.

The choice of a technically, technologically and economically feasible heating system for concrete greenhouse and plant culture is one of the most difficult technical design problem. When taking in account all the influencing factors it is not possible to define with a strict methodology which gives straight answers for concrete situation. Therefore, the solution is in the definition and listing of influencing factors and by estimation of the importance of each one of them for concrete case to determine possible optimal solutions.

2. Flow of heat in the greenhouse
The indoor climate in greenhouse differs from the outside due to the impact of these active participants on the heat balance (Fig.1)
- Sun's energy flux of radiation;
- Atmosphere with radiation;
- The surrounding area also with radiation;
- External air by convective heat transfer to (or from) the greenhouse located;
- Construction of greenhouse by radiation, convection and conduction heat transfer to (or from) the environment;
- Internal air, with convective and latent heat transfer;
- The roof of the greenhouse and the heat transfer through radiation, convection and conduction;
- The ground and its heat transfer through convection, conduction and evaporation;
- Installations for heating and cooling by convection, radiation and latent heat transfer, depending on the type of used heat exchangers;
- Ventilation with latent heat transfer caused by the filtration of the outside air entering the greenhouse;
- Irrigation with latent heat transfer caused by changes in the interior humid air and wet ground;

3. Installation of ground heat

Fig. 2 Simplified scheme of installation for heating in the ground

Fig. 3 Vertical temperature profile in the heated greenhouse with installation in the ground
4. Calculation of greenhouse

Fig. 4 Vertical temperature profile in the heated greenhouse with installation in the ground

- predicted internal temperature 20°C;
- predicted outside temperature 5°C;
- predicted wind speed 40 km/h;
- double-layered roof \( U = 14.9 \text{ kJ/m}^2\text{°C} \);
- walls of fiberglass \( U = 21.6 \text{ kJ/m}^2\text{°C} \);

The values for \( U \) are adopted from next Table 1:

<table>
<thead>
<tr>
<th>Material</th>
<th>Change of the air (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single glass</td>
<td>2.5-3.5</td>
</tr>
<tr>
<td>Double glazing</td>
<td>1.0-1.5</td>
</tr>
<tr>
<td>Fiberglass</td>
<td>2.0-3.0</td>
</tr>
<tr>
<td>Single layer roof</td>
<td>0.5-1.0</td>
</tr>
<tr>
<td>Dual-layer roof</td>
<td>0.0-0.5</td>
</tr>
<tr>
<td>Single roof / fiberglass lower side</td>
<td>1.0-1.5</td>
</tr>
<tr>
<td>Double roof / fiberglass lower side</td>
<td>0.5-1.0</td>
</tr>
<tr>
<td>Single roof / fiberglass larger side</td>
<td>1.5-2.0</td>
</tr>
<tr>
<td>Dual-layer roof / fiberglass larger side</td>
<td>1.0-1.5</td>
</tr>
</tbody>
</table>

- Volume of greenhouse \( 36 \times 13 \times 2.5 + 0.165 \times 13^2 \times 36 = 2174 \text{m}^3 \);
- heat loss AC/H \( \cdot B \Delta T \cdot 1.21 \times 1.5 / h \cdot 2174 \text{m}^3 \cdot (20-5) \text{°C} \times 1.21 \text{kJ/m}^3 \text{°C} \times 59187.5 \text{kj/h} = 16.44 \text{ kW} \)

4.3. Total loss of heat

Total: \( q = 207039 + 59187 = 266226 \text{kj/h} \approx 266000 \text{kj/h} \approx 74 \text{ kW} \)

4.4. The products of combustion are used through the heat exchangers with \( t = 120^\circ \text{C} \) and exit with \( t = 70^\circ \text{C} \), and water from greenhouse enters in heat exchangers with \( t = 50^\circ \text{C} \) and exit with \( t = 60^\circ \text{C} \) shown in Fig.5.

4.1. Losses of Heat Transfer

Two layers: \( A \cdot \Delta T \cdot U = 490 \times (20-5) \times 14.9 = 109505 \text{kJ/h} = 30,42 \text{kW} \)
- fiberglass: \( A \cdot \Delta T \cdot U = 310 \times (20-5) \times 21.6 = 97524 \text{kJ/h} = 27,09 \text{kW} \)

Total: 207039 kJ/h = 57,51 kW

4.1. Losses of conducting heat

Data on the change of the air in various materials (AC / H) are taken from next Table 2.

Table 2. Change of the air in various materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Change of the air (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single glass</td>
<td>2.5-3.5</td>
</tr>
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</tr>
<tr>
<td>Single layer roof</td>
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<tr>
<td>Dual-layer roof</td>
<td>0.0-0.5</td>
</tr>
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<td>Single roof / fiberglass larger side</td>
<td>1.5-2.0</td>
</tr>
<tr>
<td>Dual-layer roof / fiberglass larger side</td>
<td>1.0-1.5</td>
</tr>
</tbody>
</table>

- Volume of greenhouse \( 36 \times 13 \times 2.5 + 0.165 \times 13^2 \times 36 = 2174 \text{m}^3 \);
- heat loss \( AC/H \cdot B \Delta T \cdot 1.21 = 1.5 / h \cdot 2174 \text{m}^3 \cdot (20-5) \text{°C} \cdot 1.21 \text{kJ/m}^3 \text{°C} \cdot 59187.5 \text{kj/h} = 16.44 \text{ kW} \)

4.3. Total loss of heat

Total: \( q = 207039 + 59187 = 266226 \text{kj/h} \approx 266000 \text{kj/h} \approx 74 \text{ kW} \)

5. Warming soil

5.1 Calculation of the required temperature on the floor to determine the thermal load on the floor surface (reduced by 10%) = 13.36 0.9 = 421 \text{ m}^2

- Required flow

\[
Q = \frac{266000}{15040 \cdot (60-50)} = 177 \text{ m}^3 / \text{day}
\]

5.2 Calculation of the IST (internal temperature area)

Dual-layer roof:

- IST lower side: \( \text{IST}_l = \text{IDT} - (0.0291 \cdot U \cdot \Delta T) \)
- IST larger side: \( \text{IST}_l = 20^\circ - (0.0291 \cdot 14.9 \cdot 15 ) = 13.5^\circ \text{C} \)

IST - planned internal temperature
Single layer fiberglass: IST₂ = 20° - (0,0291 * 21,6 * 15) = 10,8°C
AUST - average temperature of the unheated areas in greenhouse (walls, roof)

\[ AUST = \frac{A_1 \cdot IST_1 + A_2 \cdot IST_2}{A_1 + A_2} = \frac{490 \cdot 13,5 + 301 \cdot 10,6}{490 + 301} = 12,4°C \]

**Fig.6. Circulation of water through the floor area of greenhouse**

Required flow:

\[ Q = \frac{q}{(15040 \cdot \Delta T)} = \frac{266000}{15040 \cdot (60 - 50)} = 1,77 \frac{ℓ}{s} = 106 \frac{ℓ}{min} \frac{m^3}{den} \]

5.3. Calculation of the floor surface temperature -Tp (°C)

\[ T_p = \frac{q}{A} \left[ \frac{1,8 \cdot T_p + 492}{100} \right]^4 - \left( \frac{1,8 \cdot AUST + 492}{100} \right)^4 + 7,87 \cdot (T_p - T_o) \]

To - the internal air temperature (°C)

\[ T_p = 33,3°C \]

The maximum allowable temperature is ≈ 30 °C, and calculated 33,3°C is high, but can afford by bringing the smaller heat loading per m².

So for 30°C is brings only 524kJ / hm², respectively 0,146kW/m² or (0,146 / 0,1755) 100 = 83% of predicted load.

5.4. Average water temperature

\[ \Delta T = \frac{q}{15040 \cdot Q} = \frac{266000}{15040 \cdot 1,77} = 10°C \] (60° C enter and 50° C exit)

\[ AWT = T_S - \frac{\Delta T}{2} = 60 - \frac{10}{2} = 55° C \]

5.4.1. When using surface temperature of 30°C (used 83% of the thermal load) and AWT = 55°C, the temperature difference tube-surface is ΔT=(55-30)=25°C. On the next Fig.7 can be read output heat from pipe with inner diameter (ID) = 19mm, when its placement at a depth of 100mm and is 9,00 kJ/hm²C=2,510 kW/m°C.

The tube with ID = 25mm is used the ratio of external diameters to determine the heat output of the tube or

\[ 9,00 \cdot (\frac{33,0}{26,7}) = 11,1 \text{ kJ/hm}°\text{C} = 3,08 \times 10^3 \text{kJ/m²°C} \]

where:

(25mmID has 33mmOD and 19mmID has 26,7mmOD).

**Fig.7. Heat output of radiation floor system**

5.4.2 Thus, heat output per meter is (for 19mmID), respectively

\[ Q = \frac{266000}{15040 \cdot 1,77} = 106 \frac{ℓ}{min} \frac{m^3}{den} \]

Since the interspace to pipes used 0,146kW/m², obtained 0,146/0,0625 = 2,33m²/m² or 12,33 = 0,425m from the center.

5.4.3 Correction heat loss with safety factor of 10%

- calculation the distance from the center: 0,429/0,90 = 0,476 m
- calculation the total distance: (2,33/0,90)3613=0,09 = 1090 m

5.4.4 Using the recommended fluid velocity of 1 m/s through a pipe volume ID = 19mm to determine fluid flow

\[ V = \frac{0,019 \cdot 1,0}{0,000284 / s} = 0,284 \frac{ℓ}{s} \]

- flow required for a ΔT=(60-50)=10°C and 83% load.

\[ Q = \frac{266000 \cdot 0,83}{15040 \cdot 1,77} = 147 \frac{ℓ}{s} \]

So the number of required circles is:1,47/0,287 = 5,17 or 6 to total flow, each with 1090/6 = 182 m length. Because ΔT = 10°C > 8°C it recommended or used equipment with double serpentine tube shown in the next Fig.8.

**Fig.8. Single and double serpentine tube**

182m long tubes, placed on surface with 12m width and 35m length. 182m/6=30,33 circles, and because it's a double serpentine tube has ≈16 steps on the floor.

[Corrected area: 35m / (16 * 16) = 0,365m]
Note: For others (100 - 83 ) = 17% thermal load, must be set as heating system above the ground (warming units or fine tubes).

5.4.5 Plan the layout of the floor

6. Conclusion

This type of heating system is suitable for controlling the temperature of the root and to cover the minimum temperature requirements. This makes it suitable for very moderate climatic conditions if used as a single installation in greenhouse. But on the other hand very well suited in combination with other types of heating installations also for moderate and cold climates. Simple disassembly can be a good and cheap solution for the group of crops. The part of the base used obligatory must be processed. Expensive regulation set is economically justified only if it is part of the regulation set for full climate control (i.e. if other heating installations are present in greenhouse). For Mediterranean climate plants are not economically justified.

7. References

9. Vadiee, A., Martin, V.: Energy management in horticultural applications through the closed greenhouse concept, state of the art, Renewable and Sustainable Energy Reviews, 2012;
THE APPLICATION OF VIBRATION ANALYSIS FOR DIAGNOSIS OF BEARINGS AND GEARS OF THE REAR AXLE ASSEMBLY OF THE PASSENGER CARS

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(*Corresponding author: shpetim.lajqi@uni-pr.edu)

Abstract: Predictive maintenance of machines, also known as Condition Based Maintenance, is based on monitoring operating parameters, and comparison with corresponding values of parameters obtained for the new equipment.

All machines with moving parts give rise to sound and vibration and each machine has a specific vibration signature related to the construction and the state of the machine. If the state of the machine changes the vibration signature will also change and a change in the vibration signature can be used to detect incipient defects before they become critical. The condition monitoring technique is based on detecting the presence of a fault, diagnosing the root cause of the fault, assessing its level of severity and making arrangements for its correction. A broad of condition monitoring and fault diagnosis techniques has been carried out for improving the accuracy and ability of condition monitoring and prognosis systems for bearing and gear components.

This paper introduces the method for diagnostic of the rear drive axle for the passenger cars without its demounting. The objective method of diagnosing the rear drive axle is done by vibrometer. Application of diagnostic method greatly would be contributed in quickly localization of the rear drive axle fault where diagnostic process of the servicer will done faster.

Keywords: Condition monitoring; vibration; fault diagnosis; bearing, gear;

1. Introduction

The rear axle assembly is used on rear-wheel drive vehicles. This assembly is the final leg of the drive train. It is often called the final drive or rear end. The rear axle assembly includes the differential assembly, the rear drive axles, and the rear axle housing. A typical rear axle assembly is shown in Figure 1.

In a rear axle assembly, engine power enters the drive pinion gear from the drive shaft assembly and differential pinion yoke/flange. The drive pinion gear, which is in mesh with the ring gear, causes the ring gear to turn. Power from the ring gear flows through the differential case, spider gears, and side gears to the drive axles. The drive axles transfer power from the differential assembly to the rear wheels.

The bearings and rear axle housing are components of the rear axle assembly. They are designed to support and align the differential assembly and the drive axles.

All moving parts of rear axle give rise to sound and vibration and each parts has a specific vibration signature related to the construction and the state of the rear axle assembly.

If the state of the machine changes the vibration signature will also change and a change in the vibration signature can be used to detect incipient defects before they become critical. This is the basics of vibration based condition monitoring methods. The condition monitoring technique is based on detecting the presence of a fault, diagnosing the root cause of the fault. A broad review of the state-of-art of condition monitoring and fault diagnosis techniques has been carried out for improving the accuracy and ability of condition monitoring and prognosis systems for bearing and gear components.

Early fault diagnosis of gears and bearings may prevent unnecessary failures of most of the parts and thereby increase operational reliability and availability of rear axle assembly. Fault diagnosis techniques are important for monitor the conditions in bearing and gear. Currently available fault diagnosis techniques have a variety of limitations. An effective and method has to be researched and automated system has to be developed for industrial machinery component health diagnostic activities. (Taylor, 1995) discussed the dynamic performance of the rotating components is highly influential in the performance of any rotating machinery. (Endo and Randall, 2007) gave the importance of gear and bearings in the industrial rotating and transport machinery applications. Fault detection is the process of observing the measured system data and system status information and comparing them with a normal range of observed attributes to determine whether some measurements fall outside the range representing the healthy condition of the system. Unfortunately, no one technique is able to detect all machine faults. However, it has been suggested that vibration measurement, which is the most widely used condition monitoring technique in industry, can accurately identify 90% of all machinery failures by the change in vibration signals which they produce and the level of signal can give an accurate prediction of future failure (Randall, 2011). The task is to diagnose the fault at an early stage so corrective action can be taken as early as possible to extend the life of the machine (Latino, 1999).

Tandon and Nakara, (1992) compared the most commonly used vibration analysis methods for mechanical fault diagnosis such as time domain analysis, frequency domain analysis; time frequency analysis for defect detection in bearings.

In this work is presented condition monitoring of: ring and pinion gear, two side bearing and pinion bearing of the rear axle based on vibration analysis, through two parameters: frequency and amplitude of the vibrations.

In vibration analysis, measuring the vibration amplitude is made in broadband measurement. Broadband or overall measurement of the vibration amplitude is a measure of the total energy of all components of the machine vibrations. Generally accepted frequency range for broadband measurements is 10...10000Hz. An overall vibration measurement is a single value that is relatively easy and cheap to collect, process, analyzes and trend. Scales factors used to characterize the amplitude of vibration are: Peak value (Ppk), Peak to Peak value (PpP) or Root Mean Square value (RMS).
2. Methodology for diagnostic of bearings and gears of the rear axle assembly for the passenger car Mercedes 190D

The preparation of the passenger car Mercedes 190 D to measure vibrations velocity, vibrations displacement and vibrations acceleration of the rear drive axle is presented in Figure 2. The vehicle is raised from the ground with crane and placed into two supports on both sides in order that during rotations of the wheels do not come into contact with the surface of the earth.

In the absence of the tachometer for measuring engine speeds, the measurements were made in the fourth gear of gearbox transmission (direct transmission ratio). In this case the vehicle speed is 100 [km/h], which corresponds to engine speed, respectively the speed of input drive pinion gear of rear axle assembly at 3000 rpm (Figure 3).

During the test part of the handbrake is activated to simulate the rear axle load. The braking force is the same for both the left and right rear axle assemblies in order to simulate the straight movement of the vehicle.

Used tools to measure vibration have improved significantly in the past 25 years. The sensor of choice for most vibration data collection on industrial machinery is an accelerometer. As the name implies, the output is proportional to acceleration; however, it is normally integrated to display in units of velocity and displacement. Measurements of vibrations in the rear axle assembly of the passenger car Mercedes 190 D are made with vibrometer MANUAL PCE-VT 3000. Technical specification of vibrometer MANUAL PCE-VT 3000 is presented in Table 1.

Table 1. Technical specification of vibrometer MANUAL PCE-VT 3000

<table>
<thead>
<tr>
<th>Technical Specifications</th>
<th>Measuring Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of acceleration</td>
<td>0.1...... 392 m/s² (Peak); (39.95 g force)</td>
</tr>
<tr>
<td>Range of Velocity</td>
<td>0.01..... 80 cm/s (RMS)</td>
</tr>
<tr>
<td>Range of Displacement</td>
<td>0.001....10 mm (Peak – Peak)</td>
</tr>
</tbody>
</table>

3. Results of vibration measurements for rear drive axle of the passenger car Mercedes 190

Measurements of the vibration are done in five specific points, which are presented in Figure 4. The measuring sensor with needle shape is used for measurements in points 3 and 4, while the measuring sensor with electromagnet is used in other measurement points.
In Figures 5, 6 and 7, are shown the measured values for the vibration velocity, vibration displacement, and vibration acceleration at the five specific points for rear axle assembly of passenger car Mercedes 190 D, when the input speed of the drive pinion gear is 3000 rpm (50 Hz).

**Figure 5.** Graphic presentation of the vibration velocities at the five specific measuring points

**Figure 6.** Graphic presentation of the vibration displacements at the five specific measuring points

**Figure 7.** Graphic presentation of the vibration acceleration at the five specific measuring points

Figure 8 shows the measured values for displacement, speed and vibration acceleration on the display of the measuring device MANUAL PCE-VT 3000.

4. Vibration analysis

After measuring the vibration is necessary to evaluate the vibration severity. At the first method is compared the measured values with the vibration severity charts. Depending on the recorded values of the vibrations speed (RMS values) and the size of equipment, the ISO 10816-1995 standard evaluates the vibrations severity as in the Table 2. The ISO 10816-1995 standard is the most common example of absolute criteria and is a good guide for engineers who do not have any historical data on a machine.

**Table 2: Vibrations Severity Chart – ISO 10816-1995**

<table>
<thead>
<tr>
<th>Vibration velocity ( v_{\text{max}} ) [mm/s]</th>
<th>Type of machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I ( P_e &lt; 15 ) [kW]</td>
<td>Area A</td>
</tr>
<tr>
<td>Class II ( 15 \leq P_e &lt; 75 ) [kW]</td>
<td>Area A</td>
</tr>
<tr>
<td>Class III ( P_e \geq 75 ) kW</td>
<td>Area A</td>
</tr>
<tr>
<td>Class IV</td>
<td>Area D</td>
</tr>
<tr>
<td>0.00 ( \leq ) 0.28</td>
<td>A</td>
</tr>
<tr>
<td>0.28 ( &lt; ) 0.45</td>
<td>A</td>
</tr>
<tr>
<td>0.45 ( &lt; ) 0.71</td>
<td>A</td>
</tr>
<tr>
<td>0.71 ( &lt; ) 1.12</td>
<td>A</td>
</tr>
<tr>
<td>1.12 ( &lt; ) 1.80</td>
<td>A</td>
</tr>
<tr>
<td>1.80 ( \leq ) 2.80</td>
<td>A</td>
</tr>
<tr>
<td>2.80 ( \leq ) 4.50</td>
<td>B</td>
</tr>
<tr>
<td>4.50 ( &lt; ) 7.10</td>
<td>B</td>
</tr>
<tr>
<td>7.10 ( \leq ) 11.20</td>
<td>C</td>
</tr>
<tr>
<td>11.20 ( &lt; ) 18.00</td>
<td>D</td>
</tr>
<tr>
<td>18.00 ( \leq ) 28.00</td>
<td>D</td>
</tr>
<tr>
<td>28.00 ( &lt; ) 45.00</td>
<td>D</td>
</tr>
<tr>
<td>45.00</td>
<td>D</td>
</tr>
</tbody>
</table>

Note:
- **Area A** - Good condition of machine,
- **Area B** – Operation of machine is satisfactory,
- **Area C** - Operation of machine is unsatisfactory, and
- **Area D** – Operation of machine is unacceptable (to repair).
At the second method is compared the measured values with the Blake chart. Depending on the recorded values of the vibrations displacement, speed and acceleration, and the frequency, the Blake chart evaluates the vibrations severity as in the Figure 9 (Eshleman, 1999).

After measuring, the rear drive axle is disassembled and its components are observed carefully, where components are in good condition (haven’t shown any damage).

4. Conclusion
The presented paper introduces diagnosing method for the gear mesh pinion gear and ring gear, two side bearing and pinion bearing of rear axle condition monitoring based on vibration analysis.

During the condition monitoring technique are made vibration measurements of the vibration velocity, vibration displacement and vibration acceleration by vibrometer device MANUAL PCE-VT 3000, when the vehicle speed is simulated to be 100 [km/h], which corresponds with speed drive pinion gear 3000 [rpm].

Obtained results for the vibration velocity, vibration displacement, and vibration acceleration measuring for five points in the rear drive axle are:

- In Area A - good condition (according to ISO),
- Greater values of vibration velocity are appeared in the side bearing differential case (points 3 and 4 of measurement),
- Vibration velocity and acceleration have similar behavior compared with vibration displacement.

The obtained results are suitable because after disassembling, the condition of the component of the rear drive axle are good (don’t shown any damage) after measuring.

5. References
Eshleman, Ron, Basic Machinery Vibrations, Chapter 5, Machine Condition Evaluation, VI Press, IL, 1999
RESEARCH OF THE NEW GENERATION CHISEL PLOW

ИССЛЕДОВАНИЕ ЧИЗЕЛЯ НОВОГО ПОКОЛЕНИЯ

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Abstract: The article presents the chisel plow of the new generation developed on the basis of the systematic approach and adaptability of technological impacts from soil-climatic and agro-landscape conditions. The principle of the use of the alternating movement of working elements for the destruction of the layer in the so-called lines of the least connections was built into the basis of the chisel plow construction. The chisel plow is multipurpose: it performs the present technological process of soil processing of fields on different depth and spaces between rows of perennial plants on the depth which is differentially changed distancing from the bole due to the architectonics of the root system disposition. Working elements of the chisel plow contain the fastened clutches on hinges, the angle of the mounting is determined by the action of soil resistance forces but the destruction of the layer is executed by differently directed deformations. Researches showed that the chisel plow qualitatively fulfills the present technological process and corresponds to agro-technical demands. The amount of agronomically valuable aggregates increases in the arable layer under the processing of soil by the chisel plow. The chisel plow is fairly aggregated with the T-150K according to energetic indexes. The decrease in traction resistance (by 12.27%) and specific energy consumption (1.14%) when using the working elements with self-centered clutches have been observed. There was set the reasonability of the application of the type without clutches at the deeper tillage, and it is necessary to use the chisel plow with self-centered clutches under the soil treatment on small and medium depth. To treat soil in arid conditions there was developed the construction of the combined chisel plow presenting the combination of the chisel plow with a roller. The comparative analysis of technological process indexes testifies increasing the quality under function of the chisel plow with a roller and unimportant increase of power inputs in normal ranges. According to the acceptance tests on the South-Caucasian MIS, chisel plow is recommended to the application in agricultural production.

KEYWORDS: CHISEL, SOIL, WORKING ELEMENTS, DEFORMATION, TECHNOLOGICAL PROCESS, TRACTION RESISTANCE

1. Introduction

Modern trend of mechanization of agricultural production provides for the creation of a new generation of machines and aggregates to treat soil developed on the basis of the systemic approach and adaptability of technological effects from soil-climatic and agro-landscape conditions. The solution of the present problem must be based on the analysis of interaction of working elements with soil, the choice of optimal parameters and regimes of functioning allowing us to execute the present technological process with required qualitative rates under the least power inputs.

2. The problem of the discussion

Under designing the soil-cultivating machines it is necessary not only to eliminate fluctuations leading to the loss of stability but to use the alternating movements of working elements to destruct the layer by the so-called lines of the least links. This method is based on the principle of operation of working elements of the chisel plow (CDA-3,6) which is versatile, it executes the specified technological process of field soil tillage at different depths and between rows of perennial plants in the depth which is differentially varying as the distance from a tree (shrub) respectively to architectonics of the root system disposition.

The working elements of the chisel plow contain the hinged fastened clutches whose angle of mounting, relatively to the bay with chisel in cross-vertical plane, is determined by the action of soil resistance forces but the destruction of the layer is implemented by differently directed deformations at the expense of alternating movable elements (clutches). The hinged assembly of clutches with the bay promotes fluctuations of a working element not worsening the stability of a machine.

The object of researches is the technological process of soil tillage by the chisel plow with options of working elements: clutches are fixed in position "flat cutter"; clutches are not fixed and self-mounted in the cross-vertical plane under the action of soil resistance forces transforming the "flat cutter" into the "chisel"; clutches are absent (Figure 1).

3. Purpose and methods of research

It is known that the energy consumption for basic soil processing can be around 40% of the total costs on the cultivation of a crop. That is, these studies are to examine the possibility of reducing the traction resistance of a machine, and hence the energy costs of tillage. The reduction of energy inputs is possible with the impact on soil by differently directed movement of working elements when the
layer is destructed along lines of the least links. All possible options (in general type) of working elements for deeper tillage: transforming with full range of change of the mounting angle (0-90°) of its movable elements (clutches) in the cross-vertical plane as well as the flat-cut (mounting angle of clutches 0°) and chisel (mounting angle of clutches 90° or their absence) are exposed to the comparative analysis on results of agro-technical, energetic and dynamic assessments.

4. Results of researches

The chisel plow effectively carries out the present technological process (Table 1) and corresponds to agro-technical requirements.

The deviation of the depth from given one (2,03-2,16 cm) is in normal range (to 3cm). Some overstated irregularity at depth 19 cm (11% at admitted to 10%) is conditioned to multifocal uptakes of the process (Table 1) and corresponds to agro-technical requirements.

The chisel plow provides the stable depth of coverage with fluctuation 20%.

The experimental studies of energy rates of the chisel plow are comparative analysis on results of agro-technical, energetic and dynamic assessments.

Table 1 – Agrotechnical indexes of the chisel plow

<table>
<thead>
<tr>
<th>Index title</th>
<th>Value of working element option</th>
<th>Technological operation</th>
<th>Depth of treatment</th>
<th>Coverage, m</th>
<th>Stubble preservation, %</th>
<th>Degree of weed trimming, %</th>
<th>Crumbling of the layer in fractions, mm, %: - above 50</th>
<th>Blocking %</th>
<th>Sealing and blockage of working elements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clutches are not fixed</td>
<td>Subsurface tillage with slight cut of layer in the depth of coverage (chisel plowing)</td>
<td>- average, cm</td>
<td>3,2±1%</td>
<td>60...70</td>
<td>100</td>
<td>35</td>
<td>8</td>
<td>not observed</td>
</tr>
<tr>
<td></td>
<td>Clutches are fixed</td>
<td></td>
<td>- average square deviation, cm</td>
<td>3,2±1%</td>
<td>60...70</td>
<td>100</td>
<td>35</td>
<td>8</td>
<td>not observed</td>
</tr>
<tr>
<td></td>
<td>Clutches are absent</td>
<td></td>
<td>- coefficient of variation, %</td>
<td>3,2±1%</td>
<td>60...70</td>
<td>100</td>
<td>35</td>
<td>8</td>
<td>not observed</td>
</tr>
</tbody>
</table>

Ridging with the increase of depth treatment practically is not changed (5,4-5,5 cm). The absolute value of ridging slightly exceeds the norm (to 4 cm), but the relative value determining in percentage from the depth of treatment is within the tolerance. 60-70% of plant residues (stubble) at admitted 60% and more remain on field surface after soil treatment by the chisel plow. Weeds were cut entirely.

The chisel plow provides the stable depth of coverage with irregularity 1% at admitted 2%.

The fixations of clutches in position “Flat-cutting” does not influence significantly the change of agro-technical indexes characterizing the quality of technological process of the chisel plow. At all models of the working element (fixed, non-fixed and absent clutches) the chisel plow effectively makes the subsurface tillage with slight cut of the layer in coverage and corresponds to agro-technical requirements.

Data of comparative analysis of the structural soil content before and after chisel processing with different models of working elements (Table 2) testify to the increase of agronomically valuable aggregate content in layers 5-15 cm and 15-25 cm on 8,2-8,6% using the working element with non-fixed clutches.

Table 2 – Data of structural content of soil

<table>
<thead>
<tr>
<th>Depth of sampling, cm</th>
<th>Content of fraction in % from absolutely dry soil</th>
<th>Before treatment</th>
<th>After treatment</th>
<th>Difference in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;10mm</td>
<td>10-5mm</td>
<td>5-3mm</td>
<td>1-0.5mm</td>
<td>0-0.25mm</td>
</tr>
<tr>
<td>Black soils simple weak humus vigorous light-clayey on loess-like clays</td>
<td>104</td>
<td>104</td>
<td>104</td>
<td>104</td>
</tr>
</tbody>
</table>

At soil treatment by chisel plow with missing clutches, on the contrary, in the layer of 5-15 cm a sharp decrease in the content of agronomically valuable aggregates (from 72.0 to 41.0%) takes place, in the layer of 15-25 cm – it remains the same (and 64.9 and 66.9%), and increases by 8.4% in the layer of 25-35 cm at the depth of the chisel plow’s passage.

So, it can be marked the increase of amount of agronomically valuable aggregates in layers 5-15 cm and 15-25 cm under treatment by the chisel plow with non-fixed clutches in the layer 25-35 cm – at missing clutches.

Therefore, it is advisable to use the option with missing clutches at the deepest tillage, and to use a chisel plow with non-fixed clutches at the tillage on small and medium depth.

The experimental studies of energy rates of the chisel plow are shown in Table 3, calculated on the basis of experimental values of traction resistance.

The analysis of data testifies to the increase of traction resistance consumed output and specific power intensity with increase of depth treatment [1, 2, 3].

It follows that from the analysis:

- increasing the speed of the aggregate from 6,67km/h (1st gear of the tractor T-150K) to 8,57km/h (3rd gear) traction resistance increases in 1,5 times;
- traction resistance with the increase of depth increases more intensively than with the increase of speed. So, with the increase of soil treatment depth in 1,4 times by the chisel plow with non-fixed clutches the traction resistance increases in 1,7 times.

At soil treatment depth in 27 cm and the option of working on with non-fixed clutches the traction resistance of the chisel plow is close to the nominal traction force of the tractor of traction class 3T, which indicates to the rational consumption of power with specified operation mode.

In the result of researches there was determined that the traction resistance of the chisel plow with non-fixed clutches on the depth in 34 cm with clutches insufficient to the capacity of the tractor T-150K. So, the way of soil treatment with option of a working
element without clutches is rational to use at the deeper tillage (34 cm and more).

On the depth in 19 cm the traction resistance of the chisel plow is quite less than at 27 cm, the consumed power is lower, the speed is 6,67; 7,35 and 8,57km/h on 1, 2 it 3 gears, that corresponds to the norm at maximum traction capacity of the tractor of the tractor class 3T.

Based on the foregoing, we can conclude that the traction resistance of the chisel plow satisfactorily is aggregated with the tractor T-150K.

The comparison of energy characteristics of the chisel plow (Table 4) indicates to the decline of traction resistance (by 12.27%) and decrease of specific energy intensity (1.14%) when using the working elements with non-fixed clutches, it supports the hypothesis that the destruction of the layer along the path of the least resistance by self- mounting of clutches at the angle of natural soil cleavage. The increase of traction resistance is conditioned by the increase of pressure of the soil layer on the surface of working elements in the option with fixed clutches [4].

### Table 4 – Comparative assessment of chisel plow energy rates

<table>
<thead>
<tr>
<th>Rate title</th>
<th>Value for option of working element</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>non-fixed clutches</td>
</tr>
<tr>
<td>Work rate: - speed, km/h</td>
<td>6,10</td>
</tr>
<tr>
<td></td>
<td>27</td>
</tr>
<tr>
<td>Traction resistance, kN</td>
<td>32,52±3,2</td>
</tr>
<tr>
<td>Decrease of traction resistance, %</td>
<td>12,27</td>
</tr>
<tr>
<td>Specific energy intensity, kWt/h/ha</td>
<td>33,21</td>
</tr>
<tr>
<td>Decrease of specific energy intensity, time</td>
<td>1,14</td>
</tr>
</tbody>
</table>

So, the angle of soil deformation on the sides of the chisel plow, under which the clutches are mounted to loosen the layer, is determined by the physico-mechanical properties of the treated medium (humidity, hardness, etc.), we can assume that under other circumstances, the reduction of traction resistance, and, consequently, specific energy consumption in the process is more important than the results of field experiments.

Analyzing the obtained deviation of traction resistance from the average one (Table 3), it follows to note the decrease of irregularity with the increase of treatment depth conditioned by the miter of dynamic influences of the top layer of soil. So the coefficient of variation of traction resistance at the depth of 19 cm in average amounts for 14.06%, at the depth of 27 cm – 10.02%, at the depth of 33-34 cm – 8,67%. In this case the average deviation of traction resistance is not practically changed from speed, depth, and type of a working element of the garden chisel plow and is in the limits of tolerance (in average about ±3 kN).

Despite the fact that the great cut plant residues remain on the surface, the topsoil does not have sufficient erosion resistance, as plant residues are badly crushed, there are areas with large clots of soil, thereby mulch surface I not provided. These disadvantages can be eliminated by means of application in the construction of disk working elements to crumble the plant residues and adjustments to improve the soil crumbling (rollers). It is necessary to apply the compaction of the top treated layer by the roller in arid areas, because the blowing of fertile soil is decreased and moisture is preserved better because of decrease of intensity of convection-diffusion flow of vaporous water, the intensity of which will be higher in loose soil. In combination with disks the rollers create the insulating layer on the soil surface decreasing the moisture evaporation.

On the basis of researches there was worked out the construction of the combined chisel plow presenting the combination of the chisel plow with a roller, whose general form is presented on the fig.2.

The technological process of the chisel plow with a roller is implemented in the following way: during the moving of the aggregate across the field the clutches with a bit cut soil on a given depth, which is crumbled and then is subjected to additional tillage and crumbing of large soil clots by a roller-ripper with simultaneous leveling of surface.

Agro-technical indices of the chisel plow with a roller were obtained [5] at tillage of black soils along stubble of winter wheat. Relief and microrelief of fields are smooth. Humidity and soil solidity on the background 2 is in normal range, the background 1 is characterized by increased solidity and low soil humidity in a treated layer (Report №11-64-12 (1010032) North-Caucasian MIS).

### Table 5 – Agro-technical indices of the chisel plow with a roller

<table>
<thead>
<tr>
<th>Depth of treatment:</th>
<th>Value for a working element</th>
</tr>
</thead>
<tbody>
<tr>
<td>- average, cm</td>
<td></td>
</tr>
<tr>
<td>- deviation, ±cm</td>
<td></td>
</tr>
<tr>
<td>- coefficient of variation, %</td>
<td></td>
</tr>
<tr>
<td>Soil crumbling, %:</td>
<td></td>
</tr>
<tr>
<td>- size of fractions to 50 mm</td>
<td></td>
</tr>
<tr>
<td>- size of fractions more 50 mm</td>
<td></td>
</tr>
<tr>
<td>Ridging of soil surface, cm</td>
<td></td>
</tr>
<tr>
<td>Stubble preservation, %</td>
<td></td>
</tr>
<tr>
<td>Change of erosion-hazardous soil particles in the layer of 0...5 cm, %</td>
<td></td>
</tr>
</tbody>
</table>

The quality of soil crumbling is good, the number of fractions up to 50 mm made of 57.51...76,49%, which meets the agronomic requirements (not less than 25% in fallow field). During almost at all operation modes the number of fractions up to 50 mm accounted for more than 60% with the exception of the variant with clutches on

![Figure 2 – Chisel plow with a roller](image-url)
the depth 27.56 cm (of 57.51%), due to the increased soil hardness in the treated layer on the given background.

Blocking of soil layer amounted for 3,25...5,88 cm, it meets the requirements (not more than 30% from depth of treatment).

The preservation of stubble on the background of normal moisture and solidity meets the agro-technical requirements (not less 85%) and amounted for 85,12...85,88%. However, this rate does not exceed 50,52% on the background of increased solidity and low moisture, as far as the stubble got spilled in the crack between dry soil clots.

After the passage of the aggregate the amount of erosion-hazardous particles in the top soil layer decreased to 2,40...5,19%, it corresponds to agro-technical requirements (it must not increase).

So, at soil tillage by the chisel plow with a roller without options of working elements on all regimes the aggregate’s work on all agro-technical characteristic corresponds to requirements excluding the preservation of stubble with increased solidity and low humidity that is connected with arid soil-climatic conditions [5].

The analysis of energetic characteristic testifies to the increase of speed and depth of treatment the traction resistance consumed the capacity and specific power inputs are increased.

The most traction resistance 41,7 kN at 6,67 km/h and depth 27 cm is explained by the increased soil solidity of the background 1 and by low soil humidity of treated layers that led to the remultiplex of the layer.

The analysis shows that the chisel plow with a roller due to traction and capacity rates is satisfactorily aggregated with the tractor T-150K.

During the operation of the chisel plow with a roller the soil tillage technological process damages (blockage and sticking) were not noticed on all regimes, it testifies to the stability of technological process operation, the coefficient of reliability is 1.0, and it meets standard requirements (not less 0.99).

5. Conclusion

Researches show that the chisel plow with a roller meets the requirements due to rates of technological process of soil treatment and is recommended to the application in agricultural production on the results of tests on North-Caucasian MIS.

The comparative analysis of agro-technical rates testifies to increase the quality of crumbling and decreasing of height of ridges on the surface of treated soil under functioning the chisel plow with a roller (Table 1 and Table 5), that is the power inputs will slightly increase (Table 3 and Table 6) and are in normal range. From above mentioned we make conclusions on reasonability of the chisel plow modernization.

6. References


