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<table>
<thead>
<tr>
<th>Foreign Members</th>
<th>Country Code</th>
</tr>
</thead>
<tbody>
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<td>Prof. Adel Mahmoud</td>
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<td>PL</td>
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<td>KZ</td>
</tr>
<tr>
<td>Prof. Marco Boccioleone</td>
<td>IT</td>
</tr>
</tbody>
</table>
## CONTENTS

### MACHINES

**FOURTH INDUSTRIAL REVOLUTION. ROBOTS AND PRODUCTION AUTOMATION WITH ELEMENTS OF ARTIFICIAL INTELLIGENCE**  
Prof. Pavlov, V, Phd, Avishay, D. Phd, Pavlova, G ................................................................. 507

**PATH PLANNING AND COLLISION AVOIDANCE REGIME FOR A MULTI-AGENT SYSTEM IN INDUSTRIAL ROBOTICS**  
MSc. Ivan Gochev, MSc. Gorjan Nadzinski, Prof. DSc Mile Stankovski .................................................. 511

**PRINCIPLES OF DESIGNING AND DEVELOPING INTELLIGENT MANUFACTURING SYSTEMS OF PACKAGING**  
Prof. dr. Palchevskyi B., PhD. Krestyanpol O., PhD. Krestyanpo L. .................................................. 515

**VEHICLES AND EXHAUST EMISSION: A REVIEW OF THE TECHNOLOGICAL IMPROVEMENTS**  
assistant professor dr. Angelevska B., full professor dr. Atanasova V. .................................................. 520

### TECHNOLOGIES

**ANALYSIS OF MANUFACTURING SYSTEMS WITH USE OF SIMULATION SOFTWARE**  
doc. Ing. P. Košťál, PhD. & doc. Ing. Š. Václav, PhD. & Ing. D. Michal & Ing. Š. Lecký .................................................. 525

**INFLUENCE OF FRICTION COEFFICIENT ON MECHANICAL PROPERTIES IN PROCESS OF COLD BULK FORMING**  
Ass. Prof. dr. Leo Gusel, Ass. Prof. dr. Rebeka Rudolf ........................................................................ 529

**IMPROVEMENT OF TECHNOLOGIES FOR THE DEVELOPMENT OF MODERN RAIL AUTOMATION SYSTEMS**  

**PERFORMANCE OF GARMENT SEAMS STRENGTHENED WITH THERMOPLASTIC STITCHED RAINFORCED TAPE**  
Ph.D stud. Ass. M.Sc Golomeova S., Prof. Dr. Demboski G. ................................................................. 537

**ANISOTROPY OF THE MECHANICAL PROPERTIES OF HOT ROLLED STEEL COILS FOR WELDED PIPES**  
Prof. Dr. Maksuti Rr. ......................................................................................................................... 541

**DATA COLLECTION AND ANALYSIS TO IDENTIFY THE TRAFFIC PROBLEMS OF THE EXISTING NETWORK AND APPLICATION OF SOFTWARE FOR SOLUTION PROPOSALS, A CASE STUDY**  

### MATERIALS

**STRENGTHENING OF SURFACE LAYERS OF STEELS AND ALLOYS BY BORIDE COATINGS FORMED UNDER THE CONDITIONS OF AN EXTERNAL MAGNETIC FIELD**  
Prof. Dr. Chernega S., Grinenko E., Krasovskiy M. ................................................................. 549
FOURTH INDUSTRIAL REVOLUTION, ROBOTS AND PRODUCTION AUTOMATION WITH ELEMENTS OF ARTIFICIAL INTELLIGENCE

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Abstract: The present research is devoted to the coexistence and communication of a person with machines, equipment and robots that possess elements of artificial intelligence. The new conditions lead to revolutionary changes in the automation of various activities in and outside the industry. Changes are multifaceted and the disclosure of trends allows planning and protecting of legal long-term activities to achieve useful outcomes effectively.

KEYWORDS: INDUSTRIAL REVOLUTION, ROBOT, AUTOMATION, EDUCATION, SELFTRAINING

1. Introduction

1.1. Motives for the Human Society Development and Revolutionary Steps

The evolution of human society creates tools of labor to satisfy ever-increasing needs of the people. The man king are forced to create tools that initially were driven by the energy of their muscles. Subsequently, the mental development is directed to the use of other kinds of energy – directly the natural (the power of water, fire, wind) and later - other types (electricity and other). The essence of satisfying human needs (consumption) most accurately and briefly is defined in the theory of Abraham Maslow [1], an American scholar psychologist in the publication „A Theory of Human Motivation“. He defined the needs of humans as a hierarchical pyramid (fig. 1).

![Distribution of needs according to Maslow's pyramid](image)

According to Maslow, if the lower-level needs are not met, the person can not focus on fulfilling higher level needs. If the hierarchical structure of the pyramid is considered in detail, the importance of technological evolution with appropriate tools could be determined. As we progress to higher levels in the pyramid it could be seen how consumption increases. The hard to satisfying human nature drives him from what he has got, to what he has not or has not yet achieved. Passion for prey and survival tolerates violence The warriors have created and perfected instruments (armaments) for years and centuries. When neighbors are conquered, the distant countries become a next/new goal. Expanding their territories and conquering the peoples, the economically developed countries - conquerors, draw resources and goods from conquered territories and increase their wealth. As a result, a society with distributed functions and migration of the Earth population from poorer to richer countries is created. The number of people in the world is increasing and most often in less developed countries and the basic needs of these people are growing. Economically, the society is oriented towards change and modernization. The purpose of change is to give hope for the future. Society has reached its inflexion point. The change is revolutionary. The revolution comes to satisfy the increased consumption and is based on one or a group of discoveries.

1.2. Characteristic features of industrial revolutions

As a beginning of the industrial revolution (IR) is considered:

- for the first IR - invention of the steam engine, as well as improvement of the weaving and spinning looms;
- for the second IR - invention of electricity, the internal combustion engine, the radio and the production line;
- for the third IR - the emergence of electronics, robotics, computer chip (microprocessor), flexible automation, new materials, information and communication technologies, Internet.

Recently there is a change in economic reality and political authority [2,3,4], which is considered as the fourth industrial revolution. The “country and market behavior” is the main topic that was discussed at the World Economic Forum in Davos in 2016. There is growth of convergence between three spheres - the techno-sphere (the digital world and everything materially created by humans), the natural world (the eco-sphere) and the human sphere (socio-informational, everything not material created by people). A new point in the interconnection and interaction between man and machinery accrues – people and robots are allowed to work together in one job (place), as well as different machines (robots) and people from different cultures (multicultural). The relationship between physical, digital and biological systems (bioengineering) is developing. This new stage of the economic development is based on: new technologies, AI robots, 3D printing (4D printing, for now is modestly mentioned, but in the near future it is expected to create structures, that can “grow in time”, by analogy with biological ones), nanotechnologies (including nanorobots), big data processing (super intelligence), and AI-based automation. The speed with which the world is developing is unprecedented. The future comes soon and this imposes new demands on education and training of people [8,9] because of coexistence and action with robots with artificial intelligence.

2. Artificial intelligence and robots

The first obstacle encountered by technological revolutions is the need for qualified specialists for the new type of work. The new professions set different conditions from the previous ones. The intellectual human potential, allowing quick adaptation to the new, is still limited.

This gives the opportunity of biological species to survive (providing food and nutrition, surviving in a dynamically changing environment, and procreation through breeding), and people and human society, that in addition to the three activities for survival also needs spiritual life, to reach the current stage of development.
Figure 2. Architecture of robot with artificial intelligence

By analogy with the natural intelligence of humans and living creatures, inhabiting our planet, artificial intelligence (AI) is created due to increased abilities of computer technologies to solve complex tasks not only in the industry but also in the intangible sphere. The new digital environments are constructed by analogy to the biological world and are defined as artificial intelligence systems (AIS). In the architecture of the robots with AI (Figure 2), units for perception of the external environment must be included by analogy with the human brain and sensory organs, that allow solving tasks using global databases and knowledge (cloud technologies and super computers) [10]. This makes it possible for people and robots to work together (at the same workstation without collisions), which on the other hand reveals new opportunities in automation in the industry and beyond.

Robots nowadays are a product based on the latest physical theories, mechanical and physico-chemical technologies, theories and techniques for assessment of their own state and perception of external environment, technologies and techniques for collecting and processing of information and forming controlled behavior, including elements of AI. But in the near future, a qualitative change in intellectual capabilities is expected. New means for obtaining and transforming energy are expected. Such a product implies a need for knowledge in many scientific fields. Bionics and cybernetics are the theoretical basis of robotics. Biomechatronics (integration of biology, mechanics and electronics) is the future of robotics. This integration has appeared in the form of "Biologically Inspired Robots". For entrepreneurs, the dilemma "man or robot" will stand, as their qualities will get closer and in most cases the comparison will be in favor of the robots.

On one hand, human uses biological (zoological) analogies to improve the robots, and on the other hand man (and in the future, animals) has to be artificially "repaired" by implanting (including "added intelligence"). While, on the one hand, scientists (biologists and doctors) are progressing rapidly on the way of "humans robotisation", scientists-engineers are running along the same way striving to "humanize the robots". While the "artificial man," replacing human parts with artificial ones is creating, robotics aims to create a robot with artificial intelligence. The result of these efforts will occur at the so-called singularity point. According to the latest forecasts, a complete "technical singularity" will occur in 2045, i.e. the Turing test will be passed by computer, although according to some authors [7, 8], now there are partial cases of passing the test.

Thus, two tendencies are emerging for the future development of robotics: fear (robo-fear) and hope (robo-hope). What are the aspects of "human fears"? A lot of researchers believe that the three leading technologies for the 21st century are now unpredictable - robotics, genetic engineering and nano technologies. They may be far more dangerous than previous technologies in the 20th century because a 20th-century bomb may explode "only once", but for example a reproductive robot may "get out of control" and to reproduce through multiplier technology "countless" copies of himself. The danger of the new technologies of the 21st century is that they are based exclusively on knowledge and do not require heavy equipment, rare raw materials and large capital investments. For this reason, both positive (beneficial) and negative (harmful and dangerous) technological products could be created by a smaller group of people. However, humans and, above all, the government elite of the states have to be prepared to avoid of harmful products and the negative consequences of the development of the leading technologies of the 21st century. Actually, as the bombs of the 20th-century have failed to destroy population, human society and the nature of the Earth, the negative consequences of new technologies in the 21st century could be possible also to be prevented. Since the fourth revolution concerns the highly developed countries (there are places on the Earth where they have not passed the first three stages), we must hope that they will not allow human society to be restarted from the beginning (from the primitive).
What are the optimistic forecasts?

- Robots have a great merit in the development of industrial technologies and technology in turn contribute to development and improvement the quality and ability of the robot;
- Robots gradually become indispensable and excellent assistants in the lifestyle of people, for example in the performance of precise and complex surgical operations (telecontrolable robot Da Vinci, cyber knife, etc.);
- Robotics provides modern adaptive and intelligent dentures, orthoses (mechanical compensator for physical disabilities), artificial limbs and artificial organs;
- It is possible to implant the robot-technical components in a person's body, which is related to the idea of turning people into "robot people", i.e. cyborgs;
- Robots help people and society to fight terrorism, crime and road accidents;
- Robots create new jobs - directly and indirectly.

3. What kind of changes could be expected in automation

Modern society is at a stage of immense automation, that undoubtedly increases the productivity and quality of human activity. Essential criteria for modern automation in industry is flexibility - the ability without reconstruction to produce new products. Productivity and versatility are the antithetic features. The highest productivity can be obtaine when the versatility is low (zero) and vice versa. The highest productivity comes from a fully-organized work environment that accurately determines all the elements involved in the manufacturing process (machines, basic and auxiliary equipment, robots, billets, details, assemblies and finished products) in space and time. The rhythm of production, if it is not the same or continuous, imposes intermediate storage in specialized facilities (intermediate warehouses). In order to shorten the transport times, the ordering is by the sequence of the technological process (less often by group technology). The efficiency of all devices for the highest productivity is when they are developed for the specific production, which is contrary to the flexibility.

The flexibility is imposed due to the individualization of consumption and, in particular, due to the constantly increasing requirements for the realization of the production on the market. The competitive environment requires offering new products with improved quality and competitive price. That is why an optimal and dynamic ratio between productivity and flexibility is needed and the change is in favor of flexibility.

The digitization of machinery and equipment, the new technologies, newly discovered materials and modern science dynamize industry and modern society. Metaphorically, the automation could be presented as an "orchestra with conductor artificial intelligence" to obtain a finite intelligent product. The robots in industry called "industrial" or "stationary robots" are used to fulfill their assigned functional task - to perform both technological (welding, painting, cutting, etc.) or ancillary (moving of blanks and finished parts, tools, equipment) operations. Therefore, the movements, actions and intellect that they have to possess are related to the respective task. They replace a man-worker with a robot-worker, and it is logical for these robots to be called "technological robots." The next higher level of robots, which will have a more developed AI, will cover a certain specialization like human engineers and will be a robots engineer-specialist. This class of specialized robots could be used not only in industry, but also in the automation of all human activities, which will ensure high quality and precisinity of the execution processes. All this is a prerequisite for a new organization of automation - from a fully organized environment that requires a large number of auxiliary equipment, specific for each product to semi-organized one, where the production object (another type of product) occupies one of the possible stable positions and the position could be changed over the time.

There are still hypotheses about the spheres and / or segments where the fourth revolution will find a field of expression and to what extent the production will change. Bold is the forecast of Chief Executive Officer of AutoDesk, Carl Bass, "future factories will have only two employees: one man and one dog. The work of a man will be to feed the dog, and that of the dog - to prevent the person from touching the equipment."

Of course, it should be haven in mind that AI (for now elements of AI are considered) can not fully cover the creative abilities of the human individual.

4. Education of people and robots in the new situation

4.1 A mix between traditional education and open education methods of people

Nowadays there are no boundaries for information due to the internet, so the need for education in general could be reconsidered and organized in different way. The physical boundaries are no longer barriers for education dues to the nationally and globally enlargement of networking services.

A modern approach in education is open education, which is one of the greatest challenges for future of learning. One of such type of education is Massive Open Online Courses (MOOCs). Except traditional course materials such as filmed lectures, readings etc., MOOCs provide interactive user forums among students, professors, and teaching assistants. The number of participants has doubled in 2015 from 16-18 million students to 35 million students across all MOOC providers.

The mix between MOOCs and traditional education methods in the future can provide higher education institutes and universities the opportunity to expand services to offer credentials using the experiences of the lecturers and teachers from all over the world.

4.2 Education of robots

Training of specialists in robotics is conducted nowadays. Here is payed attention of the need for another type of training for robots and people who train robots. Robots will receive hardware and basic knowledge from manufacturers, but they will not be enough for effective usage. Both people and robots have to go through specialized training to solve "class problems". At this stage, a bold prognosis is to talk about "schools and teachers for robots" but in the near future the need of such schools will grow up. The robots that could reproduce themselves will have very high basic capabilities of their "memory", which have to be "filled with knowledge", according to the needs of using the newly created product. By "image and likeness of its creator," the robots will have to resemble their "parent", but the knowledge about the surrounding environment and what is its job to do, the robots must acquire these knowledge through education and self-education. A rough analogy for this process can be made with modern computers. The manufacturer installes only the basic software and each user adds software and knowledge (accumulates knowledge) according to what they need to solve a certain set of tasks. If necessary, the hardware of the computer is upgraded, but the activity of the computer is mostly determined by the specificity of the software and by the knowledge of its full use, which so far remains only for the humans. It is often necessary to use the services of specialists when something unusual happens to particular computer, both with its software and hardware. The memory of robots in the near future, as well as of future computers, will probably be built on another basis (physical, biological, or a combination of both), and will be with grater abilities.
By analogy with education of people, robot training stations can once again be called “schools”, and specially educated people will be called "teachers" or "roboteachers". It is not possible for the robots to adopt the other analogue referring to the conventional modern technique. The places where the technique is repaired are called "repair shops," and people who carry out this activity are called "masters" so far. The reproductive robots will need not only simple repairs but also for obtaining new knowledge that will not only be done by changing programs, but in ways that resemble human learning, such as MOOCs modules.

5. Conclusion

The development of human society is becoming more dynamic. The future comes soon and often people are unprepared in many directions. People have long been cohabiting with machinery and equipment, but in the near future these devices will have intellect and communication should be realized in a different way. This is large extend concerns communication between a human and a robot in jointly performing different activities within and without of the industry. That is why it is necessary to create united creative teams for project development, preparation of new type of specialists with higher and secondary qualification. Legislative changes will be needed to avoid conflicting situations during design and usage of innovations to solve the problems for the benefit of man and human society.

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Path Planning and Collision Avoidance Regime for a Multi-Agent System in Industrial Robotics

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Abstract: Industry 4.0 which creates “smart factories” present a recent trend in development. The area represents a merge of cyber-physical systems and Internet of Things, which aims to improve manufacturing technologies. Industry 4.0 strives to boost the algorithms and technologies used in industrial processes during the production processes, process preparations, and products delivery. Our intention is to improve the robotics transport system in factory floor. There are a lot of different research approaches in this area for further improvement. Our approach is to deal with multi-agent systems control, because of the great potential it has in practical applications in industrial robotics. The strive for minimizing the work time and maximizing the efficiency can be satisfied through the usage of multiple coordinated agents to achieve the end goal. The use of Automated Guided Vehicles (AGVs), combined with concepts for task planning of multiple agents broadened during the late 20th century. In this paper, the multi-agent system consists of several mobile robots, in other words platforms, which need to transport materials in a workhouse. The goal of each mobile platform is to carry the specified object to a set position. These appointed goals are not predefined and can be changed according to the needs of the user. Working in a dynamic environment, numerous agents with different tasks to complete can be exposed to many obstacles which may be the cause of accidents. For this reason, a careful path planning is required in such environments. The suggested path planning algorithm for this system is A*. A* is a fast path finder, which can navigate quite well in a planar environment, but it is not favorable for dynamical settings. Therefore, a combination of the A* algorithm with a collision avoidance method is proposed for overcoming these difficulties. By doing this, the A* algorithm is expanded to work in dynamical situations and can assure the convergence of any agent towards their goal. This fusion of both, the path finding algorithm and the collision avoidance method, can aid the cooperation of the agents and improve the efficiency of the system as a whole.

Keywords: Industry 4.0, smart factory, factory floor, multi-agent systems, mobile robotics, A* algorithm, collision avoidance.

1. Introduction

Recent technological advances indicate that we are witnessing the dawn of an era of Internet of Things [1]. Internet of things is broadening its possibilities in industry as well, providing more flexibility and maneuverability in production. Intelligent agents creating multi-agent systems provide better performance instead of single agents completing different tasks. Not only that, but multi-agent systems can even found themselves in a situation to complete tasks which other individual agents would not be able. The control of multi-agent systems is presented in [2]. The industry strives to create manufacturing systems that would be fully autonomous, in order to increase the time and capacity of production. The first step to automate the environment is to plan the trajectory that each robot has to follow to reach the end goal. A* is one of the most used algorithms for finding optimal paths [3] [4].

In this paper, a small representation of a smart factory is presented where automatic guided vehicles (AGVs) are accomplishing different tasks. The main idea is to design an autonomous warehouse, where mobile vehicles (agents) deliver packages. For that very reason in this paper path planning in the environment and preventing collisions between agents of the multi-agent system is accentuated the most. In section 2, the environment (warehouse) layout and the multi-agent system working in those settings are presented. The following sections, Section 3 and Section 4 explain the planning and control algorithms used to create the autonomous work of the whole system, and the avoidance rules of agents and static environment obstacles. Section 5 briefly shows the function of the different aspects of in the whole project and the results from the implemented algorithms. In Section 6 a conclusion is given, as well as the outlook for future work.

2. Environment settings and Multi-agent system

V-REP and factory settings

The multi-agent system along with the environment in which it operates is represented in the programing package V-REP (Virtual Robot Experimentation Platform), a program for prototyping robotics systems. V-REP is the first step for system design and algorithm testing, because it offers a flexible program with a lot of possibilities. The free open source educational version of the robotics toolbox is provided by Coppelia Robotics. Robotic simulators represent the connection between artificial creatures’ theory and robotics. They provide an additional guarantee that cognitive framework developed can be applied to real robots, with need of minor adjustments needed [5].

Fig. 1: V-REP Simulation interface

The simulator is running from Python code where most of the main algorithms are written. The basic idea is that the hardware aspects of the system are realized in the V-REP simulation interface, whereas the logic is implemented in Python, V-REP is the server side, and Python is the client side. Both programs are communicating through an Application Programming Interface (API). The remote API modus operandi represent a set of functions, subroutines, protocols and tools for building application software.

Multi-agent system

The multi-agent system consists of automatic guided vehicles (AGVs), which are by definition the agents of the system. They are equipped with 16 ultrasonic sensors and 10 force sensors. The end goal of each mobile robot of the multi-agent system is to hand out a specific object to the correct position in the warehouse. They need to navigate in a time differing and dynamic environment. The system is made up of N automatic guided vehicles which distribute certain goods in a warehouse and the best way to automate that is to implement some kind of planning logic. Having an optimal planning
algorithm would enhance the performance of the system as a whole and therefore a heuristic pathfinding algorithm is proposed. The suggested algorithm is A* (A-star) and this is only the first step in designing the whole factory floor. To ensure the convergence towards the final objective of the whole project, the pathfinding algorithm is enhanced with a collision avoidance regime, which prevents any accidents that might occur.

A multi-agent system is a system composed of multiple interacting intelligent agents in a specific environment. The agents of the system are small mobile robots generated in V-REP called the “Pioneer” model. (Fig. 2)

![Pioneer robot model](image)

The mobile robot is equipped with ultrasonic and force sensors. Based on the information from the ultrasonic sensors the specific agent will either enter a collision avoidance regime or it will continue finishing the designated task. When the force sensors are activated, the agent will know that a specific object to transport is given to it and will start completing the task. The algorithms are tested for two agents in the environment, but there are no restrictions on how many agents can be involved if the hardware can endure.

The mobile robots work in a warehouse which is 60 meters long and 20 meters wide. The map of the environment is represented as a grid with 120x60 elements. One cell of the grid is 0.5x0.5m². Each vehicle has information about all other objects in the environment, including the other agents, all seen as rigid bodies. A rigid body in space is defined by 3 positions (x, y, and z coordinates) and 3 angles (α, β, γ) which give the orientation of the body around a specific coordinate system. When the position of the agent is known the cell coordinates can be obtained through the following equations:

\[
\begin{align*}
    i &= \left\lfloor \frac{x}{\text{cell length} + \text{environment length} - 1} \right\rfloor \\
    j &= \left\lfloor \frac{y}{\text{cell length} + \text{environment width}} \right\rfloor
\end{align*}
\]

(1)

where x and y are the agent coordinates, cell_length is the length of each cell in the grid, environment_length and environment_width are the length and width of the whole factory floor (an offset of the grid), and i and j are the obtained cell coordinates. Having the environment mapped as a 120x60 grid, and translated to a graph, the pathfinding algorithm can easily navigate in it and find the optimal trajectory [3].

### 3. Path planning

One of the most used algorithms for finding an optimal path in an environment is the A* (A-star) algorithm. This is a heuristic search algorithm for graph traversal. It minimizes a cost function for each neighboring node and expands to the nodes with the smallest function value. The algorithms’ efficiency depends on the defined heuristic function. The heuristic function is the main decision maker in how the algorithm goes over the vertices of the graph. Because of the grid like representation of the environment, the chosen heuristic is the Manhattan heuristic, given with the equation:

\[
h = |x_1 - x_2| + |y_1 - y_2|
\]

(2)

The two parts which construct the A* algorithm are the heuristic and distance between the points in the graph. To complete the whole algorithm, it is needed to get the distance between the points. The distance is calculated as Euclidean with the equation:

\[
d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}
\]

(3)

To sum up everything, the A* is storing each neighbor in a priority queue and is looking for the nearest node with minimal f, where f is:

\[
f(n) = d(n) + h(n),
\]

(4)

where n is a neighboring node of the current node in the graph. Fig. 3 shows the generated path from the algorithm for specific settings.

However, there is a possibility for the A* algorithm to generate two or more trajectories for different agents that can intersect, leading to a collision between them. To avoid this the algorithm is enriched with a force model collision and obstacle avoidance regime presented in the following section.

### 4. Collision avoidance

To increase the certainty of the operation of the multi-agent system in the specific environmental settings, the planning algorithm is augmented with a collision avoidance method. The regime is divided into two parts: prevention of collision between the agents of the system and obstacles avoidance. In the following subsections the proposed methods are shown.

**Collision avoidance between agents**

Every agent of the system is equipped with ultrasonic sensors which construct a reaction zone around each agent. As soon as another agent is detected in the safe zone, both of them activate the code for collision avoidance. This upgrade enables the agents to quickly react when they are nearing each other and create a roundabout along the generated trajectory, instead of stepping back and changing directions which would be more time consuming. The collision avoidance is based on the force and momentum models of the agents seen as a rigid body [6]. This way the control rule is a whole of a fast path planning algorithm and a quick method for reaction if a potential collision is detected.

As said before, the method is based on the force and momentum models of the agents seen as a rigid body. This means that as soon as two or more agents enter each other’s safe zones they become “risky neighbors”, and based on the force vectors the new trajectory for the agents is updated with the following equation:

\[
\text{new position} = \text{current position} + C \times \text{new direction}
\]

(5)

where the current position of the agent are the x and y coordinates. The new direction vector is determined from the direction of the force vector needed to be applied in order for the agent to reach the goal. The amount the new position is updated relies on the weight factor C, which is tuned by the user. Two force vectors are needed to complete the control law. Those are the external force vector and the force vector needed to reach the goal. The external force vector represents a sum of the force vectors of all agents in the reaction zone (risky neighbors).

To define whether a force or momentum model will be used, the formulated external force vector and the goal force vector are used to calculate the similarity between them. This similarity states how the agents are set in the environment and how they are moving. Having this information, both agents can move in a linear direction (force model) or rotate around each other (momentum model).

**Obstacles avoidance**

The obstacle avoidance rule is based on the Braithaenberg approach for mobile robot navigation. This method can also be used instead of...
the force and moment models for constructing a roundabout between
agents, but both algorithms are implemented since the first method
preserves the movement of the agents. The deviations from the
original path with the first method do not have a large impact on the
performance of the system, whereas the Braitenberg method would
completely change the direction of the agents, leading to the need
to regenerate a new path. The Braitenberg method is used for obstacle
avoidance between an agent and other static objects in the
environment, such as: walls, boxes, and conveyor belts. The outputs
of the ultrasonic sensors directly affect the movement of the vehicle.
When the detected obstacle is different than another agent, this part
of the control code is activated. The measured distance affects the
vehicle motors speeds proportionally to specific weight coefficients.
The coefficients can be tuned in order to make the avoidance faster
or slower. Although higher coefficients will make the avoidance
greater, it will also make the movement of the vehicle more oscillatory.
The motor speeds are modified as in the following equation:

\[ v_m' = v_m + B_c \cdot s, \]  

where \( v_m \) is the motor speed, \( B_c \) is the braitenberg weight coefficient,
\( s \) is the normalized data from a specific ultrasonic sensor. The
normalization is a function of the minimum safety distance and the
maximum detection radius.

5. Simulation

There are 3 aspects that have to be taken into consideration,
which are: path planning, obstacle avoidance and agent avoidance.
In Fig. 3 we can observe the generated path which the vehicle has to go
over. It can be seen that the algorithm correctly finds the optimal
path.

Fig. 3: Generated path from the algorithm

As it can be seen the mobile robot needs to reach the fourth cell
in the bottom row. The A* algorithm generates the correct shortest
path, instead of a longer one which would make the vehicle circle
around the terrain.

Fig. 4 presents the Braitenberg algorithm for obstacle avoidance,
where a vehicle switches the direction in order to escape the obstacle.

Fig. 4: The vehicle avoids the barrier in front of it

The graph shows that the mobile robot successfully changes the path
and avoids the static obstacle.

The avoidance between agents is shown on Fig. 6, where if two
agents are moving in a direction they construct a roundabout each
other and continue moving.

Fig. 5 shows the \( x, y, \) and \( z \) coordinates of the vehicle when it avoids
the obstacle.

The next figure (Fig. 7) shows the symmetry between the \( x, y, \) and \( z \)
coordinates of the agents.

The graph shows that the mobile robot successfully changes the path
and avoids the static obstacle.

6. Conclusion and outlook for future work

In this paper a prototype of a smart factory is presented with
accent put on the path planning in the specific environment settings.
The environment is mapped as a 2D grid represented as a graph
where the objects are stationed and the automatically guided vehicles
can operate. The proposed path planning algorithm is A*, a heuristic
search algorithm which is used for graph traversal. The algorithm
generates a path for each vehicle on factory floor, to the end position
the vehicle needs to reach. To ensure the operation of the whole
multi-agent system the A* algorithm is implemented together with a
collision avoidance and obstacles avoidance rules.
Future work in this area consists of further upgrades of the proposed algorithms, or switching to dynamical pathfinding algorithms which can significantly improve the multi-agent systems’ performance and even replace the collision avoidance regime. Another idea includes finding a way to modify the graph vertices which represent the environment in such a way that the generated path will avoid the static obstacles [7]. The Braitenberg algorithm used for obstacle avoidance can be upgraded to be used in agent avoidance as well, which would lead to less computational power used if there are two algorithms instead of three. This can be achieved if the Braitenberg algorithm is modified so that the sensors values influence the actuators in a symmetrical way, which would lead to the same outcome as the force and moment model method. Furthermore, a wide variety of data can be obtained in the environment in which the multi-agent system operates. The information from those data sets can be used to improve the performance of the multi-agent system.

ACKNOWLEDGMENTS

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PRINCIPLES OF DESIGNING AND DEVELOPING INTELLIGENT MANUFACTURING SYSTEMS OF PACKAGING

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Annotation: Manufacturing facilities employing the elements of intellectual technologies can be encountered in various industries. The given paper provides examples of intelligent devices of manufacturing packaging systems. It shows how to maintain operational performance in case of unforeseen changes in the properties of an intelligent manufacturing system by changing the operation algorithm, changing the program behavior or searching for optimal or effective solutions and states during operation.

KEY WORDS: INTELLIGENT TECHNOLOGY, EXPERT SYSTEM, TECHNOLOGICAL COMPLEX, ADAPTIVE MANAGEMENT

1. Introduction

The development and use of advanced information technologies at all levels of manufacturing management allows you to go to the intellectual of the technological equipment. Any manufacture task, for which there is an unknown algorithm for its solution, can be attributed to the intellectual. To solve this problem it is necessary to create an appropriate knowledge base and apply mean of artificial intellectual [1, 2, 4, 7].

Summarizing the arguments of many researchers [3,6,7], it can be argued that the manufacturing system becomes intellectual, if decision tasks of manufacturing, it operates without having an exact algorithm for solving the problem. It adapts for work in external conditions varying with time, based on the appropriate knowledge base that allow you to create the adaptation algorithm.

2. Prerequisites and approaches for the task

The development and use of advanced information technologies at all levels of manufacturing management allows you to go to the intellectual of the technological equipment. Any manufacture task, for which there is an unknown algorithm for its solution, can be attributed to the intellectual. To solve this problem it is necessary to create an appropriate knowledge base and apply mean of artificial intellectual. Summarizing the arguments of many researchers, it can be argued that the manufacturing system becomes intellectual, if decision tasks of manufacturing, it operates without having an exact algorithm for solving the problem. It adapts for work in external conditions varying with time, based on the appropriate knowledge base that allow you to create the adaptation algorithm. For this automatic control systems (ACS) must be suitable for working with knowledge bases, that is to become intellectual ACS (Fig. 1).

3. The features of the intelligent production systems

It follows that intellectual manufacturing system can be divided into two modules - "mechanical" and "intelligent".

As rule, under the mechanical module refers to flexible manufacturing system that implements the physical actions on product and has potential capabilities to adapt when changing function conditions. Intellectual module of intellectual manufacturing system should include knowledge base and provide adjustments of program functioning when changing external conditions. It allows you to modify, based on the use of artificial intelligence as parameters of the functioning of intellectual manufacturing systems, and their structure.

Combining mechanical and intelligent modules provides getting intellectual flexible manufacturing system (IFMS).

First intellectual ACS, what combining the methods of traditional systems of automatic control and knowledge engineering, became expert systems (ES). The simplest intellectual ACS can, for example, consist of a conventional ACS and base of productive rules.

Since the formation of management program must take into account possible manufacturing situations, the intellectual subsystem ACS must compensate for the change external conditions by making some changes in the management algorithm to achieve the optimal parameters of the functioning of the IFMS. It's evident, that such ACS must first of all, evaluate the external conditions in order to make the necessary changes in the algorithm of functioning. Therefore, intellectual ACS implements three management functions.

1. Identification of the manufacturing system, which consists in obtaining an estimate of the instantaneous quality of the process of its functioning by defining some indicator, which can be compared with its specified value.
2. Decision making, which is the search direction changing the functioning program of IFMS in the direction of improving the quality of the production process by changing its structure or modes.
3. Setup, which involves a physical or mechanical change of algorithm the functioning of IFMS.

Functional interaction of processes in of IFMS is shown in Fig.2.
For implement these processes the structure of IFMS includes the executive subsystem, the subsystem of automatic control and intellectual (creative) subsystem (Fig.3).

The executive subsystem of IFMS implements a physical process that needs to be automated.

The automatic control subsystem creates at its output the control commands of IFMS and signals IGUS and visualization signals depending on the results of reporting on the physical process and the results are consistent with the specified instructions.

Intellectual subsystem provides the formation algorithm of functioning depending on the influence of external (for example, changing a production task, the use of other semi-finished products, etc.) or internal (for example, failure of some mechanisms) factors.

For example, the intelligent flexible manufacturing module (IFMS) on the basis of CNC machine includes an executive part actually the machine and its basic mechanisms with drives soft ware management system and intelligent subsystem.

The executive system of the CNC machine implements technological operation from the conversion the work piece in the processed detail with the commands given control system. Thanks to reporting of executive system (instrument position, moving speed, the resulting size after processing, etc) the control system monitors the technological elementary operations. In addition to exchange of commands and reports system performance, the control system communicates with external systems (user, operator, etc.), receiving instructions and reporting back for help with a light or sound means. For this, in the structure of the machine is provided, for example, an expert system condition diagnosis of the machine and adjust the cutting conditions depending on the sensor readings.

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On technological process is influenced by external conditions \( Z \) (random disturbance) and \( V \) (change of production tasks) that changing. The control system determines the current values of input \( X \) and output \( Y \) of system parameters and determines the quality of the process \( u' \). The decision about changes in the establishment \( u \) (reorganization of the algorithm operation and technological regimes), which are necessary to ensuring the quality of functioning of a technological machine.

In the solution of intellectual tasks, the system operates without accurate algorithm for solving the problem. Tasks associated with search algorithm to solve them, will be intellectual. Then any task, for is unknown the algorithm, will be referred to the intellectual, for which it is necessary to use the tools of artificial intelligence. As see, the intellectual tasks have two distinctive features:

- using of information in symbolic form (words, symbols, drawings), what distinguishes artificial intelligence systems from traditional computer systems, that processing only numerical data;
- availability of choice - the absence of a decision algorithm determines only those, that it is necessary to make a choice between many of their variants.

The main feature of intelligent systems is that, they are based on knowledge, or rather, on some of their performance. Knowledge here is understood as saving (using a computer) information, formalized according to some rules, which computers can use with logical deduction by certain algorithms.

**Technological process design** - is the creation of functional description the technological complex. If this description is created from known operations, then the technological process is formed by synthesis. The synthesis of technological process the question is solved number of technological operations, their level of concentration, consistency of execution. To expand the field of search variants of technological process it is necessary to generate the greatest number of possible variants of its structure. For creation of ES, which can carry out synthesis technological process with changing the route for different operating conditions of IFMS, need to create a knowledge base, which defines the sequence of processing of surfaces of details and type of necessary equipment. The results of this analysis will set the set of possible variants of processing routes. It is desirable in the first step is to carry out optimization of the synthesized technological process.

Show by example, how the building of knowledge base and model, which includes a plurality of alternative processing routes. Let task is processing the details made of cast iron – housing support (Fig. 5).

The following machines are located on the site:
- CNC lathe,
- long,
- vertical milling,
- CNC horizontal milling
- CNC drilling
- CNC boring.

In case of failure or busy processing another part, any of the selected machine tools, in of IFMS should be changing the processing route.

**Knowledge base formation.** For a formal definition the sequence of creating surfaces, let's introduce the concept of a binary precedence relation \( \pi \). Consider, that in more general case, on sequence of the creation a product at formation its quality parameters influence the functional, design and technological constraints, which allows it possible to distinguish three groups relation of anxiety, namely:

- **functional precedence relations**, which are imposed by the conditions of operation of the product;
- **design precedence relations**, which are imposed by the conditions of spatial location the details and the individual surfaces in product design;
- **pre-treatment of other surfaces**, that is, the column dependence \( BO \), which indicates the degree of technological dependence of the processing of this surface from other surfaces of the part. Summing unit in each column of the matrix, write their sum, which characterize the technological degree of imitation of the surfaces, that their influence on the processing of other surfaces.

To determine the total number of such links for each of the surfaces, which is necessary to process, sum the unit in each row of the matrix, and the amount is written in the column \( BO \), which indicates the degree of technological dependence of the processing of this surface from other surfaces of the part. Summing unit in each column of the matrix, write their sum, which characterize the technological degree of imitation of the surfaces, that their influence on the processing of other surfaces.

Determining the processing sequence will be guided by the following:

1. The first treated surface is processed, which requires no pre-treatment of other surfaces, that is, the column dependence \( BO \) zero value (no precedence relations).
2. When processing this surface all the connections are forwarded, which are in the column of the surface subtracted from
the values, shown in the column total degrees of dependence BO. The resulting values describe the new state of the part after the first stage of processing – B1. To determine the next surface for processing the repeating stage 1, whereupon, the procedure is repeated.

3. In the presence of multiple surfaces with zero degree of dependence, they can be processed in one step.

We got with help of formalized procedure, the sequence of technological transitions surface treatment details, which creates three stages of processing, specified by the precedence graph Gz.

Fig. 6. Model of the set of routes for handling the support casing

Marking vertices of the graph is performed, starting from the last operation, as follows: on each vertex, note the minimum value of technological cost, which meets the minimum path to it from the end of technological process (vertex 2-3-6). The value of other ways that have the highest total the cost of technology, down. After the reverse run graph model minimum path is remembered and celebrated. The resulting sequence of operations 2-3-6 is the optimal technological process, which ensures the lowest cost of processing.

In order to realize the concept of intellectual production, the main components of IFMS (machines, their functional modules and control units in the machines, etc.), must be converted into intellectual device with systems of diagnosis, that are real-time processing main hole. and completely main hole.

Rule № 40. The work piece is fed to the drilling machine 3 and, if he is free and healthy, which processes 2 basic and one of the threaded holes.

Rule № 50. If machine 3 is engaged, the process stop.

Rule № 60. The work piece is fed on the lathe machine 6 and, if he is free and healthy, processing two the ends and rough and completely main hole.

Rule № 70. If the machine 6 is busy, the work piece is fed to boring machines 7, which processes two ends and rough and completely main hole.

Rule № 80. If the boring machines 7 busy, the work piece is fed to horizontal milling machine 4, which processes two ends.

Rule № 90. If the machine 4 is busy, the process stop.

Rule № 100. The work piece is fed to the drilling machine 5 and if he is free and healthy, treated main hole roughly.

Rule № 110. If the machine 5 is busy, the process stop.

Rule № 120. The work piece is fed to a prolonged machine 8 and if he is free and working properly, then clean processing main hole.

Rule № 130. If the machine 8 is busy, the process stop.

The following is the algorithm of IFMS, that can be programmed in any language (Delphi, C++ or PROLOG, LISP, etc.).

For ease of analysis of functioning the IMS, the influence of environment is divided into two groups:

• Determined change given conditions of production (nomenclature, time of delivery, that is, calendar-production planning)

• random vibration conditions for the functioning - disturbances in the system such as cracks.

Then IMS is structurally divided into two generalized level, ordered according to the theory of intellectual machines: the organizational level, depending on the conditions of production and executive level, depending on the conditions of functioning manufacturing system.

4. Conclusions

1. It should be determined two areas of building intellectual manufacturing systems – first, top-down, by attaching a new component to an existing intellectual system, and, secondly, from the bottom up, by providing intellectual properties grassroots components, for example, as is typical for mechanic units.

2. Any production task, the algorithm of solution of which is unknown in advance or which is created on the basis of incomplete data, and systems, programs which perform the actions for the solution of this problem can be attributed to artificial intelligence, if the result of their work will be similar to the result of human activities in solving the same problem.

3. For technological systems the concept of artificial intelligence can be applied in their using of the subsystems, which change their algorithm operation depending on changes in external or internal conditions.

5. References


VEHICLES AND EXHAUST EMISSION: A REVIEW OF THE TECHNOLOGICAL IMPROVEMENTS

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Abstract: Vehicles growth has continuous negative influence on air pollution problem especially in urban areas. Exhaust emissions from vehicles contribute for a significant amount of toxic air polluters, harmful both for the environment and health. This underlines the need for development and implementation of technological measures aimed towards emission control and reduction. Technological measures are under continuous research and innovative development, and as a result vehicles have the opportunity to be equipped with different solutions for emission control. Used technological measures at the moment, as well as the next generation measures are all included in the categorized review presented in this paper. Also, a suitable kind of technological measures for countries like Macedonia without industry for car production and with older vehicle fleet are presented.

KEYWORDS: TECHNOLOGICAL MEASURES, EXHAUST EMISSIONS

1. Introduction

Constantly increasing number of vehicles continues to increase air pollution problems especially in urban areas [1]. With the increase of the number of vehicles, it becomes very important for pollutant emissions to be kept at the acceptable levels.

Concerns for the exhaust emission impact on the environment and health have stimulated the development of the technological measures for air pollution reduction. The aim of technological measures built in the vehicles is to achieve required performances of the system for fuel management and system for control and reduction of exhaust emissions. For example, control of the preparation of the fuel-air mixture and control of the burning process, post-treatment of the exhaust emissions, usage of the computerized devices for the control of the catalysts are just a part from all the available and effective technological measures that have a potential to reduce exhaust emissions.

Today’s modern vehicle is a result of several technological improvements, which will continue further with a purpose to satisfy the requirements for better performances referring exhaust emission and fuel consumption. Also, at the same time, they should provide effective power transmission, increased comfort and safety of the vehicle. The main focus of technological development for exhaust emission control is reduction of hydrocarbons, particles and nitrogen oxides, as the most harmful polluters from exhaust emissions.

The aim of this analysis is to present a categorized review of technological measures that have potential to contribute for emission control. At the same time, measures suitable for developing countries, like Macedonia, without car industry and older national vehicle fleet are recommended.

2. Systematic approach in the definition of the technological measures

There are several directions for the development of the technology available for car manufacturers, in order a lower emission levels to be achieved. For this, a systematic approach comprising the following activities should be used (Fig. 1):

- improvement of the engine technology and improvement of the burning process
- development of the devices for emission control (catalysts)
- development of sensors for control of the catalysts
- increase of the fuel quality through modification of its chemical content.

Fig. 1: A systematic approach of the technologies for exhaust emission control

Source: [2]

The main aspects in achieving decreased emissions using different technological measures are [3]:

- preservation of the close relation between vehicle’s technologies and fuel quality (needed for accomplishing real improvements in the fuel quality)
- application of advanced technology at several systems in the vehicle (ignition system, fuel system, exhaust emission system etc.)
- improvement of the technological measures for control of the process for exhaust emission reduction and the condition of the catalysts.

Today, development of the vehicle’s engine is directed to the decrease of the toxic exhaust emission at the needed level and decrease of the fuel consumption, keeping its good performances at the same time.

3. Categorization of the technological measures

Introduction of the Euro standards for exhaust emissions and their constant aggravation have contributed for the improvement of the technological measures for vehicles, for example, better engine design and fuel efficiency. Hence, emissions per vehicle are decreased as a result of advanced engine design and introduction of computerized controlled technologies for reduction of fuel consumption and control of exhaust emission [2].

Categorization of technological measures for the control of the vehicle’s toxic emissions is presented at the fig. 2.
New engine characteristics for emission reduction, although contribute for its higher complexity, include direct injection system, as well as the systems for emission control with electronic surveillance and adjustment of the engine under different operational conditions [3]. Additional devices are added to the engine for dealing with the air and fuel intake and exhaust emission release, as well as for computerized surveillance and control of its performances.

At the same time with the development of the technological measures for exhaust emission reduction, an improvement of fuel quality is taking place. Reformulated fuels have modified chemical structure designed to improve exhaust emissions. For example, at the gasoline, lead is removed and sulfur level is reduced, which improved the efficacy of the three-way catalyst. Additional improvements in the gasoline include reduction of the evaporation (especially of hydrocarbons) and wide spread use of special additives [3].

For identification of high polluting vehicles, good support provide OBD systems (On-Board Diagnostic Systems). These are systems for diagnostics built in the vehicles and sensitive to the performances of the system for exhaust emission control. OBD identifies malfunctions of particular components and informs the driver through the display at the instrumental board. These capabilities of OBD had stimulated big car manufacturers to start with their massive application in the vehicles. In Europe, since 2000, every new vehicle is equipped with OBD [4]. Today, OBD systems have durability of 16000 km with minimal maintenance [3].

The challenge for environmental protection from exhaust emission is serious. For this, numerous additional technological systems for emission control will be used in the future, from which a higher durability and resistance during the life time of the vehicles will be required [3]. These solutions will comprise modern engine technologies and equipment for post-treatment of exhaust emissions, and for their optimality in the usage, a high quality fuels should be introduced. Measures for exhaust emission reduction during the cold starts should be especially aggravated, as well as the measures for reduction of fuel evaporation [3].

However, the changes in the engine design will reduce some of the components in the exhaust emissions, but will contribute for increase of the other [3]. This, from the other side, makes it more difficult to precisely predict the harmful environmental effects. All designed measures cannot be accepted as rational and justified from an engineering point of view, especially if low fuel consumption is expected.

4. National vehicle fleet in Macedonia

4.1. Characteristics of the trend of passenger vehicles

The trend of the passenger vehicles depends of the national economical and political circumstances under which transport sector works. The number of passenger vehicles in Macedonia in the last decade continuously is changing with an increasing trend. For example, the number of registered passenger vehicles in 2013, compared with 2012, has increased for 12,9% [5]. The increasing trend of the number of passenger vehicles is a good indicator for the extent of air pollution problem in urban areas.

<table>
<thead>
<tr>
<th>Table 1: Registered road transport vehicles</th>
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<tr>
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<tr>
<td>Total</td>
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<td>Motorcycles</td>
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<td>Passenger cars</td>
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<td>Buses</td>
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<td>Goods vehicles</td>
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<td>Road tractors</td>
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<td>Tractors</td>
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<tr>
<td>Work vehicles</td>
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<td>Trailers</td>
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Source: [5]
**Table 2: Road vehicles per fuel type (data for 2013)**

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<tr>
<th></th>
<th>Total</th>
<th>Motorcycles</th>
<th>Passenger cars</th>
<th>Buses</th>
<th>Goods vehicles</th>
<th>Work vehicles</th>
<th>Road tractors</th>
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<tr>
<td><strong>Total</strong></td>
<td>403 339</td>
<td>8 093</td>
<td>346 798</td>
<td>3 022</td>
<td>30 167</td>
<td>585</td>
<td>4 934</td>
<td>9 740</td>
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<tr>
<td><strong>Gasoline</strong></td>
<td>230 283</td>
<td>7 681</td>
<td>213 808</td>
<td>287</td>
<td>7 661</td>
<td>88</td>
<td>498</td>
<td>260</td>
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<tr>
<td><strong>Diesel</strong></td>
<td>161 143</td>
<td>249</td>
<td>122 443</td>
<td>2 671</td>
<td>21 818</td>
<td>482</td>
<td>4 274</td>
<td>9 206</td>
</tr>
<tr>
<td><strong>Mix</strong></td>
<td>521</td>
<td>150</td>
<td>272</td>
<td>7</td>
<td>81</td>
<td>1</td>
<td>3</td>
<td>7</td>
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<tr>
<td><strong>Gasoline-gas</strong></td>
<td>11 341</td>
<td>10</td>
<td>10 241</td>
<td>54</td>
<td>597</td>
<td>14</td>
<td>185</td>
<td>367</td>
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<tr>
<td><strong>Electric energy</strong></td>
<td>51</td>
<td>3</td>
<td>34</td>
<td>3</td>
<td>10</td>
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**Source:** [5]

**Table 3: Average age of the passenger vehicles**

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<td><strong>Total /000</strong></td>
<td>300</td>
<td>310</td>
<td>308</td>
<td>300</td>
<td>249</td>
<td>253</td>
<td>242</td>
<td>249</td>
<td>263</td>
<td>282</td>
<td>310</td>
<td>313</td>
<td>302</td>
<td>347</td>
</tr>
<tr>
<td>&lt;=2 years %</td>
<td>6.3</td>
<td>4.2</td>
<td>2.6</td>
<td>2.3</td>
<td>4.6</td>
<td>5.4</td>
<td>6.9</td>
<td>8.3</td>
<td>9.4</td>
<td>7.8</td>
<td>4.3</td>
<td>3.3</td>
<td>2.3</td>
<td>1.7</td>
</tr>
<tr>
<td>&lt;=5 years %</td>
<td>9.3</td>
<td>8.4</td>
<td>9.4</td>
<td>8.3</td>
<td>7.3</td>
<td>5.1</td>
<td>7.0</td>
<td>8.0</td>
<td>9.8</td>
<td>11.0</td>
<td>12.2</td>
<td>11.2</td>
<td>9.3</td>
<td>5.8</td>
</tr>
<tr>
<td>&lt;=10 years %</td>
<td>15.0</td>
<td>14.8</td>
<td>20.8</td>
<td>21.7</td>
<td>23.1</td>
<td>21.8</td>
<td>18.4</td>
<td>16.7</td>
<td>13.6</td>
<td>13.0</td>
<td>11.9</td>
<td>13.4</td>
<td>15.2</td>
<td>17.3</td>
</tr>
<tr>
<td>&gt;10 years %</td>
<td>69.4</td>
<td>72.6</td>
<td>67.2</td>
<td>67.7</td>
<td>65.0</td>
<td>67.7</td>
<td>67.7</td>
<td>67.0</td>
<td>67.2</td>
<td>68.2</td>
<td>71.6</td>
<td>72.1</td>
<td>73.2</td>
<td>75.2</td>
</tr>
</tbody>
</table>

**Source:** [5]

There aren’t available data for the participation of passenger vehicles without catalysts or with improper catalysts function, although assumptions could be made according to the categories of vehicle age (table 3). Newer passenger vehicles are much cleaner and have lower emissions, but older and most polluting vehicles (Euro 1 vehicles, especially passenger gasoline vehicles without three-way catalyst), are still in a significant number on the roads in Macedonia [1].

### 4.2. Changes in vehicle fleet: import of used vehicles

The stagnation in the supply with new vehicles and the import of old vehicles contributed for the ageing of the national fleet of passenger vehicles. From the environmental point of view, this is highly unfavorable, because old vehicles that prevail on the roads, as well as the bad maintenance of the vehicles, contribute for multiple higher exhaust emissions compared with new vehicles.

In the period between 2010-2014 when a privileged import was allowed a total of 158.512 used vehicles were imported in Macedonia. The biggest import happened in 2010, when 51.399 old vehicles were imported. Every next year, an import of old vehicles is decreasing (table 4).

**Table 4: Imported old vehicles per year**

<table>
<thead>
<tr>
<th>year</th>
<th>number of vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>51 399</td>
</tr>
<tr>
<td>2011</td>
<td>34 326</td>
</tr>
<tr>
<td>2012</td>
<td>28 546</td>
</tr>
<tr>
<td>2013</td>
<td>29 560</td>
</tr>
</tbody>
</table>

The import of the Euro 1 and Euro 2 vehicles had contributed for the social issues to be accomplished (every family to afford a car), but from the other side, those vehicles are the highest air polluters.

At the same time when this kind of import of old vehicles was allowed, a sale of new vehicles decreased. In the period from March 2010 (when privileged import was allowed), until July 2014, a total of 20.784 new vehicles were imported. Before, the yearly sale of new vehicles was three times bigger than the current one.

**Table 5: Imported new vehicles per year**

<table>
<thead>
<tr>
<th>year</th>
<th>number of vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>10 574</td>
</tr>
<tr>
<td>2010</td>
<td>7 183</td>
</tr>
<tr>
<td>2011</td>
<td>5 795</td>
</tr>
<tr>
<td>2012</td>
<td>4 021</td>
</tr>
<tr>
<td>2013</td>
<td>3 288</td>
</tr>
</tbody>
</table>

However, according to the legislation changes, Euro 3 vehicles were imported until 30 June 2014. Since 1 July 2014, the vehicles import is possible only if the vehicle belongs at least to Euro 4. The purpose of this is to renew the national vehicle fleet.

These terms for import of passenger vehicles are more acceptable than the previous ones. Hence, it is expected that will have:

- positive effect for the improvement of age structure of the vehicle fleet
- direct contribution for air pollution reduction.

522
5. Recommendations for Macedonia

Having in mind that Macedonia doesn’t have automobile industry, technological measures that can be recommended for our fleet can be grouped in two groups: programs for technical inspection and maintenance and limitations in the national legislation.

5.1. Regular programs for technical inspection and maintenance

Effective programs for regular technical inspection and maintenance could identify the problems and provide their timely repair. Providing a good preventive maintenance practice, these programs remain as the best proved way for protection of the investments in the technology for emission control.

Regular servicing of the vehicles is needed in order to keep the efficiency during the exhaust emission reduction. Hence the contribution of this program for better air quality. Not sufficiently maintained vehicles spend more fuel and emit higher levels of particles, hydrocarbons and nitrogen oxides compared with those vehicles with a regular maintenance. The real experiences show that high-quality programs for regular technical inspection and maintenance could reduce exhaust emission of hydrocarbons and carbon monoxide approximately for 20-30%. These programs have need of minimal investments [6].

For the countries with insufficient emission control or without any control, the simple programs for regular technical inspection and maintenance could be a good starting point for the emission control, during which even a vehicles without built-in system for emission control could profit.

5.2. Limitations in national legislation

This kind of measure isn’t strictly in the group of technological measures, but has indirect connection with it through the definition of laws based of the technological condition of the vehicle.

Macedonia doesn’t have an industry for car production, meaning that technological measures cannot be directly implemented at the vehicles. But, indirectly, the technological characteristics of the national vehicle fleet could be maintained and controlled by introduction and aggravation of national laws. For example, the process of renewing the national fleet has began with limitation of the maximal age of vehicle (Euro 4), allowed to be imported. Additionally, for supporting the import of new vehicles, lower import and customs taxes should be introduced, joined with national subsidies. Also, higher registration taxes could be introduced for older vehicles, or taxes for using these vehicles in the urban traffic.

In parallel, the legislation should support the use of high quality fuel through strictly defined chemical content. This could help vehicles to maintain the built technological measures for emission control at a good level.

6. Summing the effects of the technological measures for exhaust emission reduction

Decrease of the exhaust emissions is a result of the improved vehicle performances, i.e., implementation of new technologies and improvement of the fuel quality. Application of catalysts and other technological measures at the gasoline and diesel vehicles has significantly reduced pollutant emissions. For example, the decrease of the emissions was around 24-35% in the period between 1990-2001, mostly as a result of the technological development and introduction of cleaner fuels as a response to the European emission legislation [7].

The continuous development and implementation of the technological measures for emission control will result with additional air quality improvement [1]. Still, in large part of Europe, the current European standards for air quality are exceeded [8]. Although the emissions per vehicle will further decrease as a result of the improved technology and severe emission standards, the traffic growth, increase of the number of diesel vehicles, high number of short urban journeys and frequent traffic jams could reduce the benefits from the technological improvements [1].

Wide usage of previously categorized technological measures and equipment may provide a cleaner air in the next 10-15 years, although doesn’t represent long-term solution for air pollution problem in urban areas [3]. Some of the measures have success – for example, introduction of catalysts brought significant improvements of air quality in the last 20 years [3]. However, it should be considered that equipping the vehicles with these measures will newer produce a completely not-polluting vehicle. It’s necessary that these technological measures are combined with the schemes for traffic management and control in urban areas, as well as with the efforts for stimulating the drivers to use their vehicles less than usual [1].

The future programs for emission control from the vehicles will be directed to the reduction of hydrocarbons, nitrogen oxides and particles. Hence, an indirect reduction in the ozone will be achieved [3]. Apart of this, considering the impact that carbon dioxide has on global warming, significant importance will be dedicated to the technological solutions for emission control that would effectively decrease the greenhouse gasses, without increasing the problems in urban air pollution [9].

7. Conclusion

Vehicles are significant source for urban air pollution, and as such would probably remain in the next decades [3]. Maintenance of the needed air quality imposes the implementation of technological innovation, directed to the achievement of adequate performances of the vehicle’s engine and devices for exhaust emission reduction and control during the vehicle life time period.

Technological development has high influence on the current state of the vehicle’s engine and systems for control of exhaust emission, contributing for their continuous evolution into the new and more advanced design. Therefore, the future progress would be directed to the continuation of the exhaust emission reduction and fuel consumption, at the same time improving the engine power and efficiency [3].

Use of the technological measures for emission control, especially different kinds of catalysts and sensors, as well as the use of high quality fuels, has resulted with significant decrease of vehicle exhaust emission [3]. However, despite the achieved fall in the levels of vehicles exhaust emission, the quality of urban air didn’t significantly improve, mostly because of the vehicle’s increasing trend [1]. Therefore, the intention of development and effective implementation of technological measures for reduction of toxic exhaust emission continues.

Technological measures implemented in vehicles at the moment, as well as the next generation measures, are systematically categorized in this paper. A bigger durability and resistance during the vehicle life time period from all of them would be expected. Measures comprise modern engine technologies and post-treatment equipment for exhaust emissions, and for their optimality, fuel quality should be improved. Especially would be necessary to aggravate the measures for exhaust emission reduction during the cold starts and measures for reduction of fuel evaporation. Additionally, measures like programs for regular maintenance and legislative changes are proposed for countries without car industry and with old vehicle fleet, like Macedonia.

Today, emissions per vehicle are decreased as a result of the advanced development in the engine design and introduction of computerized technologies for reduction of fuel consumption and exhaust emission control [3]. But, benefits made per vehicle are overshadowed by the increased number of the vehicles. Improved performances of advanced technology for emission control currently are insufficient for dealing with the growth of transport systems. Improvements in air quality and emission reduction are lower than expected - the vehicles will remain a dominant source of pollution.
air pollution. Therefore, it becomes clear that there isn’t a smallest chance for reaching the levels of pollution before several decades ago [3]. Hence, a success will be even the minimal decrease of the damage and deceleration of the pollution process.

References


ANALYSIS OF MANUFACTURING SYSTEMS WITH USE OF SIMULATION SOFTWARE

Abstract: Knowledge gained from the Digital factory field needs to be expanded and further disseminated. The use of the Digital factory concept is mainly in laboratory conditions. It is essential for new knowledge to be made more accessible for further experiments and for acquiring new knowledge for faster and easier deployment. The visualization of machines, devices, and entire manufacturing systems allows for almost faultless design of such systems. It is an expense saving and time-efficient solution. The article represents an experiment aimed at exploring simulation methods used in design and development of production systems by use of simulation digital tool. Comparison of the results obtained by examining the simulation model and real model will be made for acquisition of deviation between virtual model and real model. The task of optimization is, in this case, to create an optimal timetable for individual production lines by increasing flexibility and lowering costs, with prediction that the conditions are met and all orders will be made on time, minimize downtime, reduce production of waste and consider the efficient use of electricity.

Keywords: SIMULATION, MANUFACTURING, TECNOMATIX,

1. Introduction

Among the current priorities in the field of production is the effort to shorten product cycle cycles, to increase the usability of production systems and to reduce the complexity of production, which requires changes in the technical preparation of production as well as in the realization of production. Optimizing these and other areas is geared to the main goal of increasing efficiency, saving costs, increasing productivity. Maintaining the right to maintain high quality and production stability is a matter of course. The scope and scope of workplace optimization is given by sufficient flexibility, which is achieved using appropriate technologies already at the design of the workplace itself. With increasing demands for production efficiency, reliability and the quickest start-up, an important part of the design of production and assembly lines is the computer simulation.

Empirical experience confirms that the most expensive decisions to change production and products are those that arrive late in the last stages of product development and the process of putting products and production systems into operation. It can be stated that any change introduced into production needs to be prepared and reliably tested in all aspects of production in the early stages of the design and development of production systems. Testing the production process in production systems is one way of preventing late changes in production systems. Simulating new models, as well as the virtual introduction of production systems into the digital enterprise concept, are a tool that verifies the functionality of the individual models together with the systems and verifies the functionality of the elements of automation technology in the early stages of product development and manufacturing processes. The current way of introducing new production systems has its drawbacks, and by means of new software tools for simulation and modeling of process systems, the time needed for the preparation and deployment of real systems will be shortened and thus considerable savings will be saved. Start of production or the introduction of new production, the production line is time-consuming. With these tools, there is a significant reduction in the start-up time of production. The virtualization of production systems by virtue of the future of technology and the "Industry 4.0" concept.

Computer simulation enables virtual verification of plans and assembly lines before the start of production, thus helping to mitigate risks, whether in terms of cost or real-world safety. It is a comprehensive tool that can verify the feasibility of the assembly process by controlling the reachability and eliminating possible collisions. This process is performed by simulating the whole assembly procedures of the product and the required tools and their interaction. Using computer simulation, it is possible to design the most optimal way of these processes and to incorporate all the necessary means necessary for the planned production process. The main advantages of computer simulations include, in particular, the possibility of early detection of errors in the design phase and optimization of production, the possibility of making analyzes of the feasibility of a given solution or examining ergonomics of manual works.

2. Literature analysis

At present, a large part of the production is realized in medium and small-lot or piece production. Many ranges of flexible assembly of manufacturing machines and handling equipment from production cells to flexible production systems (hereinafter referred to as PVS) are designed for these production series. The efficiency of the work of such flexible clusters of production and handling technology does not achieve the efficiency of mass production. The lower efficiency is particularly evident in the higher percentile of bypass and non-production times due to the frequent change in production. As a result, the Lean Manufacturing requirement has grown in recent years, i.e. the slimming of production strategies and the design of products and equipment itself. These requirements will need to be implemented in new production strategies, product design support and production facilities. [1]

CAx technologies have become self-evident in the design process of manufacturing systems and processes. These technologies make it possible to streamline the process of designing and designing production systems with a view to improving quality through virtual simulation and testing of individual kinematic patterns. However, these kinematic models need to be integrated and integrated into the process control itself within the simulation. On the basis of the analysis, it can be stated that the process of decontamination of the production system and its processes is often lengthy and not always predefined solutions are right. This process is demanding, costly and increases the total time needed to complete the project. The big advantage for the implementation of this process is the ability to use new technologies that allow engineers to build a complete production equipment and also they realized processes in an interactive virtual 3D environment, which are implemented as complete mechanical, electrical, hydraulic and pneumatic systems and include the production process the process into operation weeks or months before building a real production system. By creating a simulation model in a virtual environment within the Industry 4.0 concept, it is possible to simultaneously control and monitor material flow that can be tested and optimized by means of simulation tools. The expected benefit of using virtual simulation tools is to shorten the time to redeploy production systems to operational status at the planning stage. The author (Lee Ch.G. and Park S.C., 2014) addresses the idea of linking the virtual model of a production system with a real-time control system to achieve virtualization of systems. [2]

Based on the information from published works by authors (G. Kovács and S. Kot, 2017; Hoffmann et al, 2010; Reinhart, G. and...
it is possible to conclude that simulation tools have high application in the design and the design of new production systems, but it is important to evaluate methodologies interaction between platforms, a new production system in the simulation environment and verification of production equipment in a real environment and compare the simulation model with the real environment of the production system. [3, 4, 10]

Innovating current solutions emphasizes the development of fully integrated and interoperable manufacturing systems that can respond in real time to conditions and requirements changing in real time. [5]

Simulation software enables simulation of all activities from product creation, manufacturing processes, production planning, operational management, component manufacturing, inspection, assembly, packaging to shipping, to reduce material and energy demands, increase work productivity, reduce inventory, shorten ongoing development and production times, increase time and power utilization of production facilities, and increase product quality. The potential of using simulation software is high. To select the software, you need to have a clear idea of the usability and suitability of the selected software, and it is necessary to correctly define the criteria and the objective of the project.

Problems and Errors Detected During Simulation:

- large transport points,
- small storage capacity,
- insufficient storage capacity,
- excess or shortage of workers,
- poor layout of workplaces,
- downtime,
- high caries,
- insufficient maintenance,
- unusable workplaces during breaks,
- verification of functionality, reliability and performance,
- poorly planned progress of individual operations in the project.

There are models that are built for single use only (eg when analyzing processes to confirm the correctness of our hypotheses). Next are the models whose use is repeated. These are, therefore, simulation models of production and logistics systems that are still available to the user. Such models are used, for example, to verify the availability of system capacities, production plans, and the number of workers depending on the plan. An important part of the reuse of the model is its updating. The user not only changes the production plan but needs to constantly update the basic process data in the simulation model (eg machine failure, cycle times, sorting times). Today's simulation software can communicate with different databases or spreadsheet editors. Therefore, process data can be maintained in MS Excel spreadsheets or automatically downloaded from the enterprise information system. This greatly reduces the simulation model user's expertise. Although the construction of the model is performed by an expert, it can also be used by a scheduler in the production, and may not be able to control the programming language. [6]

### 2.1 Tecnomatix Plant simulation

Tecnomatix Plant Simulation of workplaces and assembly systems helps in planning new systems or improving current systems. It is also often used in decision-making processes such as return of investment, cost of planned changes, project confirmation, production process analysis, and so on. Simulation in assembly systems facilitates the design phase and enhances the smoothness of project design and execution through its outputs. At present, simulations are up to 99% accurate. Of course, it depends on the input parameters and the validity of the model.

**Benefits of simulation:**

- testing innovative strategies in risk-free virtual environments,
- maximum use of production resources,
- reducing investment risk through rapid simulation,
- optimizing the size of systems and storage space,
- rapid identification of sources of problems in logistics and production spheres,
- 20-60% reduction in inventory due to system size,
- 5 - 20% reduction in investment costs for the new system,
- reduction of capacities for personnel and handling equipment,
- quickly achieve positive results and identify impacts [7].

![Integration of simulation in designing of production cells](image)

**Fig.1 Integration of simulation in designing of production cells [11]**

#### 2.2 Tecnomatix Process Simulate

It is a comprehensive tool that can verify the feasibility of the production or assembly process and eliminate possible collisions. This process is carried out by simulating the entire assembly or production procedures of the product and the required tools and their interaction. Its task is to design the most optimal solution of the processes and to involve all the necessary means necessary for the planning of the production process. [8]

**Main functions:**

- 3D simulation.
- static and dynamic detection of collisions,
- 2D and 3D view,
- 3D measurement,
- scanning operations
- planned assembly operation.
- 3D geometry and kinematics. [7]

Process Simulation is the solution to minimize the risk of changes in the production and launch of new production system. It allows to verify the plans from design concept to start of production. It helps allay these risks. Ability to use 3D data makes easier virtual validation, optimization and commissioning of production processes. This results in faster launches and better production quality. Tecnomatix - Process Simulation can verify the feasibility of the assembly process by verifying reachability of the robot or human, and collisions between moving devices or between
man and machine. This is done by simulating complete assembly sequence of the products and their working tools. Tools such as measurement and detection of collisions allows detailed control and optimization of assembly processes. The software is fully integrated with the platform Teamcenter. Technology can be reused and can verify the production processes. Makes easier simulation of assembly processes, human operations and mechanical methods of tools, devices and robots [7, 8].

Advantages:

• reduce the risk in the production system,
• shortening the planning of new production systems,
• reduce the cost of change thanks to the early detection of errors,
• analysis of ergonomic process.
• choice of the best production variant[7].

3. The example of Tecnomatix application

At first, we need to define what kind of research question we are going to solve by simulation.

Research question:

How does the impact / insufficiency of information gained from simulation with respect to real-process operation?

In this study, the proposed digital model is used to represent the production and transport system. Dynamic simulation data can be used to verify the layout of individual production machines, conveyors, industrial robots and to determine the working range of the workers.

In addition, it is possible to verify the selection of the industrial robot and to verify its working range. It is necessary to verify the collisions and the reach of the industrial arm. From Fig.1 "Collision warning of industrial robotic arm with CNC milling machine doors" it is obvious that a collision state arises. It is necessary to review the time sequence of the event and at the same time to change the choice of the industrial robot due to the inaccessibility of the robotic arm.

Among other things, I know to gain the load characteristics and speed characteristics of the industrial robot joints. In figure 2, "Joint value", it is possible to see the characteristics of the rotation of individual joints in relation to time, where it is possible to check the applicability of the range of joints. We can use the information to make it easier for the production system to be put into real operation.

4. Results and discussion

Simulation is suitable tool for experimenting with the structure of work and modernization of the production system. Simulation allows detection and the subsequently reducing collision situations in the design of the production system in the digital space and the help to find unfeasible and dangerous situation.

Fig.4 Designed production system

Same production system made in Tecnomatix Plant simulation can be analyzed for bottlenecks or throughput, labor time management, conveyor usage etc. On figure below is shown 3D model visualized in Tecnomatix Plant Simulation software.

Fig.5 Designed production system in Tecnomatix Plant Simulation (3D view)

By analyzing this model, we can get resource statistics about each station. Based on that production line stations can be managed or time management on stations can be adjusted.

Fig.6 Designed production system in Tecnomatix Plant Simulation (2D view)
Fig. 7 Resource statistics before implementation of changes

Between figure seven and eight we can see difference in productivity of stations. In figure eight is much better productivity and working time on stations because of adjustments to model based on simulation results.

Fig. 8 Resource statistics after implementation of changes

5. Conclusion

The use of simulation tools in the design and implementation of production systems is highly sought after by the professional public and in the field of design and design of production systems and by the automatic service, and the results of the research will be expected from the point of view of the transfer. The creation and more frequent introduction of simulations of various processes in manufacturing, logistics or other industries is an integral part of the Digital Factory concept, which falls under the Industry 4.0 strategy. Simulation facilitates decision making when designing new and optimizing existing production systems.

Simulation methods are used for evaluation different aspects of production systems or subsystems. Repeatability is important and basic attribute of computer simulation. Because of exact values and parameters which have their own values assigned to them can be the same process executed many times. In real life, this is not possible [9].

Production planning ensures the efficient use of material resources, production capacities of the company and external cooperation with a view to meeting the deadline by the customer in the required quantity and quality. Data is very important for production planning. These are input data, which are usually output from the majority of processes in individual departments, which are then joined and evaluated. Further research in this field is the possibility of integrating available information from the simulation model to automate the generation of mechanisms and the automatic selection of production facilities or decision-making solutions.

Software solutions allow you to create simulations across the range of tasks from simple object availability testing within the robot workspace to virtual plant simulation including process, production, logistics, product, and more.

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References


INFLUENCE OF FRICTION COEFFICIENT ON MECHANICAL PROPERTIES IN PROCESS OF COLD BULK FORMING

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Abstract. Bulk forming is one of the most effective and efficient manufacturing processes. Mass production of many of the items without any defects has been possible because of the advancements in cold bulk forming. The characteristic of a lubricant, especially coefficient of friction influences the interfacial friction during the forming process. This friction causes defects and many difficulties and has to be kept within limits so the proper choice of lubrication is very important for the quality of the formed product. The influence of lubricant's coefficient of friction on different mechanical and electrical properties of cold extruded material has been investigated and described in this paper by performing many different tests and measurements for mechanical properties and electrical conductivity of the formed material. Coefficients of friction for four different lubricants were first obtained by ring test, and then these lubricants were used in cold extrusion process. The obtained experimental results describing the effect of lubrication on material properties were presented in a form of diagrams and have shown that choice of lubrication could influence some material properties.

Keywords: BULK FORMING, FORWARD EXTRUSION, LUBRICANTS, FRICTION COEFFICIENT, RING TEST, MECHANICAL PROPERTIES

1. Introduction

Mass production of many of the products without any defects, in different fields has been possible because of the advancements in cold bulk forming, extrusion for example. During extrusion process, there is a relative movement between the tool and die setup, and the billet formed; Due to this friction arises in the interface between them. [1]

This friction causes defects and difficulties like inadequate filling up of metal in the cavity, cracks and porous surfaces, subsurface defects in the formed part, premature wear and tear of the tool and die setup, increased energy requirements [1]. Therefor the interfacial friction has to be kept within limits, though cannot be eradicated. The lubrication problems are one of the most delicate problems in cold forming. The influence of lubrication on wear, friction, forming force, temperature, material and geometrical properties and finally costs are very important [2]

In a bulk metal forming, the characteristic of a lubricant (especially coefficient of friction) influences the interfacial friction during the process. It is generally expressed in two terms, coefficient of friction, μ and shear friction factor, m. In metal forming analysis, two friction models namely Coulomb friction model and Tresca friction model are used to describe friction. In Coulomb’s theory, frictional shear stress, \( \tau \) is expressed as follows [1]:

\[
\tau = \mu \sigma_n
\]

where \( \sigma_n \) is the normal stress or pressure that acts perpendicular to the surface and \( \mu \) is the coefficient of friction.

Tresca’s friction model relates the shear stress to a constant shear friction factor, \( m \) as given below [1]:

\[
\tau = m \sigma_t / \sqrt{3}
\]

where \( \sigma_t \) is the flow stress of the material.

The flow stress, a property of the material, in turn depends upon the strain, strain rate and temperature of the billet.

The value of shear friction factor varies from 0 to 1, where \( m = 0 \) represents frictionless interface and \( m = 1 \) represents sticking friction.

In the majority of metalworking processes the material is deformed by means of a contacting die. The pressure required for deformation generates a normal stress to the die surface, and movement of the specimen relative to the die surface generate a shear stress at the interface [3, 4]. Thus a classical tribology situation arises, with friction at the die-specimen interface, and with potential for wear of both die and specimen materials. The first step in controlling this friction is to quantify it, and then properly apply a suitable lubricant for the extrusion process [5, 6].

The success or failure of such lubrication has important consequences on the quality of the issuing product, and also on pressures, forces and on the mechanical properties as well as some other properties of the product. The choice of the right lubricant and its proper application is very important. There are some articles describing new lubrication technologies [6, 7, 8] with new lubricants and also optimization of application of known and widely used lubricants [9, 10]. Authors in [11] describe numerical analysis of lubrication while in papers [12] decreasing of friction during cold forming by using a nano-molecular layer or adding a nano particles [13] was investigated. Despite the extremely wide range of conditions under lubricants must function, some systematic approach to selection can be made.

Final selection is almost always a matter of compromise, but there exists some fairly general, desirable attributes which must be taken into account when choosing the optimal lubricants for bulk forming processes [14]:

- separation of die and specimen surfaces,
- prevention of cold welding (pressure welding),
- controlled friction,
- control of surface temperature,
- easy handling, safety,
- low costs, ecological friendly.
2. Experimental work

In the frame of the experimental work the process of cold forward extrusion of a cylinder from the copper alloy CuCrZr was analysed. This is a copper-chrome-zirconium alloy with high electrical and thermal conductivity and excellent mechanical and physical properties also at elevated temperatures. It is used as electrode material in spot, seam and butt resistance welding of low carbon steel sheets. Further it is used for manufacture of various components for resistance welding equipment.

The cylinders of dimension $\Phi 22 \text{ mm} \times 32 \text{ mm}$ were extruded in a special tool for forward extrusion (Fig. 1) at $20^\circ \text{C}$ temperature and four different lubricants coefficients of friction ($\mu = 0.05, 0.07, 0.11$ and 0.16). The effective strain was in all cases $\varepsilon_e = 1.29$. The measurements of coefficient of friction for each of the four different lubricants were carried out by using the ring-compression test. It is a very simple test. There is no need for load measurement or knowledge of material yield stress. This test is most suitable for processes with low effective strains. A ring-shaped billet is compressed by two plates in several increments. Deformation of diameter and height is measured after each increment [15]. Friction is evaluated by comparing obtained results (curve) with friction calibration curves given in literature [16, 17, 18, 19]. Increasing friction presents increasing resistance to free expansion of the ring, resulting in a decrease of the ring internal diameter (Fig. 2).

Thus lubricants can be ranked simply by measuring the change in internal diameter and height of the ring. For each lubricant three ring tests were performed and then average values of coefficients of friction were calculated. The results of the ring-compression test for all four lubricants gave us these average values:

- Lubricant No. 1 (oil) $\mu = 0.05$
- Lubricant No. 2 (oil) $\mu = 0.07$
- Lubricant No. 3 (oil) $\mu = 0.11$
- Lubricant No. 4 (grease) $\mu = 0.16$

To determine the influence of the coefficient of friction on mechanical and electrical properties of cold forward extruded specimens, tensile tests, Brinell hardness measurements and electrical conductivity measurements were carried out.

Tensile strength, yield stress, reduction of area and elongation were determined with the tensile tests. Brinell hardness was measured using the measuring instrument WPM, electrical conductivity of extruded specimens was measured by the Sigmatest instrument. Many experiments were done to provide reliable results.

3. Results and discussion

The diagrams on the Fig. 3 and Fig. 4 present the change of tensile strength $R_m$, yield stress $R_{p0.2}$, reduction of area $Z$ and elongation $A_5$ as a function of lubrication friction factor $\mu$ at the constant tool speed $v_{\text{tool}} = 12 \text{ mm/s}$. The results at different coefficients of friction are very similar but the difference between them range from 2% to 7%.

Although this difference in mechanical properties could be of importance in some specific cases, in general it is possible to say that the value of lubricant’s coefficient of friction does not affects significantly the measured mechanical properties of the cold extruded alloy. Of course this conclusion can be made only for lubricant friction factor interval from $\mu = 0.05$ to 0.16.
Fig. 4. Influence of coefficient of friction $\mu$ on reduction of area ($Z$) and elongation $A_5$

If we compare the results for tensile stress $R_m$ and yield stress $R_{p0.2}$ measured at different values of coefficient of friction very interesting thing can be observed. By using lubricator with the lowest coefficient of friction ($\mu = \text{for lubricator Nr.1}$) the highest tensile strengths and yield stresses were measured. With increasing coefficient of friction ($\mu = 0, 07$ and) both, tensile and yield stress decreases, although insignificantly. The biggest difference in yield stress measurement was obtained when we compared results for lubricant’s coefficient of friction $\mu = 0, 05$ and $\mu = 0, 11$. The yield stress measured at $\mu = 0, 11$ was 7% lower compared to yield stress at $\mu = 0, 05$. We could expect a further decrease of both stresses when using lubricant with the highest value of coefficient of friction ($\mu = 0, 16$). But tensile strength and yield stress increase for about 2% to 4% compared with stress values when lower coefficient of friction was used.

The same phenomenon can be observed with elongation $A_5$ and reduction of area $Z$ on Fig. 4. But the change of values for elongation and reduction of area measured at different coefficients of friction is even smaller (less than 4%) than the change of tensile strength and yield stress.

By means of Brinell hardness measurements in several measuring points of the cold extruded part (Fig. 5), it was possible to determine the influence of the strain and lubricants coefficient of friction factor on the hardness. Fig. 5 presents the measuring points on the extruded alloy CuCrZr.

Fig. 6 shows the influence of lubricant friction factor to Brinell hardness of the extruded alloy, measured at points according to Fig. 5.

According to diagram on Fig. 6 the influence of lubricant friction factor on Brinell hardness has no big importance but it is obvious that with increasing coefficient of friction there is an increase of hardness (especially in measuring points T1, T3 and T5, which are all in the middle axis of the specimen) although this increase is relatively small.

The differences between values of Brinell hardness in the same measuring point of the extruded alloy but at different lubricant coefficients of friction $\mu$ are less than 4%. Of course, this conclusion can be made only for lubricant’s coefficient friction interval from $\mu = 0,05$ to $0,16$.

Measurement of the electric conductivity was performed on the cylinders taken from the root of the cold extruded alloy. Dimension of these cylinders was $\Phi 11 \text{mm} \times 16 \text{mm}$ and the conductivity was measured by special Sigmatest instrument with measuring frequency of 120 kHz. Many measurements were done to provide reliable measuring results of electric conductivity. The influence of coefficient of friction on the electrical conductivity of the cold extruded material is presented in Fig. 7.

Electrical conductivity is decreasing with higher strain. When measured on the specimen which was extruded with lubricant’s coefficient of friction $\mu = 0,05$, the electrical conductivity is about 20% lower than the electrical conductivity of unformed material (0 on x-axis in the Fig. 7). It is obvious that the electrical conductivity increases with increased lubricant’s coefficient of friction, the difference between electrical conductivity values when using smallest ($\mu = 0,05$) and highest ($\mu = 0,16$) coefficient of friction is less than 6%.

Fig. 5. Measuring points for Brinell hardness

Fig. 6. Brinell hardness HB measured in different points T as a function of lubricant’s coefficient of friction $\mu$ (sr. = unformed alloy)
Friction is a very important parameter in all metal forming processes. It affects in unfavourable way all main process parameters and product quality. The magnitude of friction needs to be known for several reasons. Pressures, forces and energy requirements can be calculated only if interface conditions can be described by shear strength or friction factor. For this, a numerical value must be established. In most cases reduction of friction by lubrication has a beneficial effect by lowering the forces required for a given operation. This reduces the stresses imposed on tooling and may allow the use of smaller and less costly equipment. Effective lubrication can also improve product quality by eliminating surface defects such as scoring or cracking through the reduction of metal-to-metal contact and avoiding harmful residual stresses and internal defects through promoting more homogeneous deformation conditions.

The values of lubricant’s coefficient of friction can also have effects on the material properties during and after forming process. Although this influence is in general not very significant, it could be of importance when very precise information of mechanical and other properties of the extruded specimen is necessary. One of the reasons for small difference in measured mechanical properties when using different lubricators with different coefficients of friction could be the fact that we have done our experiments with lubricants with rather low coefficients of friction. By using lubricants with higher coefficients of friction, the influence on the mechanical and electrical properties of the formed material could be more significant.

4. Conclusion

Friction is a very important parameter in all metal forming processes. It affects in unfavourable way all main process parameters and product quality. The magnitude of friction needs to be known for several reasons. Pressures, forces and energy requirements can be calculated only if interface conditions can be described by shear strength or friction factor. For this, a numerical value must be established. In most cases reduction of friction by lubrication has a beneficial effect by lowering the forces required for a given operation. This reduces the stresses imposed on tooling and may allow the use of smaller and less costly equipment. Effective lubrication can also improve product quality by eliminating surface defects such as scoring or cracking through the reduction of metal-to-metal contact and avoiding harmful residual stresses and internal defects through promoting more homogeneous deformation conditions.

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5. References

Abstract: Until currently in the countries of Europe there is an intensification of the introduction of modern microprocessor systems of railway automation and the increase of their functional capabilities. The introduction of additional functions of control and monitoring systems, tightening of the requirements for the safety of their operation, mutual integration and unification of systems for various purposes, the complication of the implementation of processing of logical dependencies require fundamentally new approaches to the development of software and hardware of a new generation. In this regard, scientific and applied research aimed at the development of appropriate technologies is being conducted, based on the common methods and tools used in the formation of control and monitoring systems for various objects of the railway transport infrastructure. The proposed material contains the main results of such studies conducted over the past five years, as well as the main directions for further improving the development of microprocessor-based rail automation systems.

Keywords: railway automation, development, technology, integration, logical dependencies, control system, transport infrastructure.

1. Introduction

Currently, in Europe, there is an intensive development of rail automation systems involved in the management and regulation of train traffic, as well as the implementation of shunting work. Modern systems are built on a microprocessor-based element base with application of programmable logic. Several generations of such systems have already changed. Systems of the first generation, which appeared in the late 70's - early 80's of the last century, used symbiosis of the microelectronic and relay-contact element base, laying on the latter almost 100% of the responsible functions. Those. full responsibility for ensuring the conditions of traffic safety is assigned in such systems to relay-contact logic elements and finite state machines. The second generation of transport automation systems (90s of the last century), similar to the first generation, also represented a combination of a microprocessor and a relay-contact logic component. However, unlike the previous generation, there is a division of responsibility for the safety of the functioning of systems between relay and microprocessor components. The degree of distribution depends on a number of factors, among which: the functional purpose of the system, the type of technological control object, the type of microelectronic components used, the way of reserving information-control channels, etc. The third generation of rail automation systems (late 90s - early 2000s) is characterized by the fact that all the logic of functioning in them is programmable, while the switching of power circuits is performed by means of relay components connected to the windings and contacts of the modules O and input. In such circuits, the relays perform the function of exclusively contactors, without participation in the implementation of the dependency logic. In the systems of the fourth generation (2000s - present), all the logic of the functioning and implementation of the execution of commands are performed on programmable microprocessor components - without the use of relays. In such a system, the implementation of the dependency logic is performed by a separate subsystem, and the execution of commands by specialized object controllers [1–3].

The most interesting are the systems of the fifth generation, which began to develop actively after 2010. They are characterized by mutual integration and unification of systems for various purposes on the basis of a single core of management and control [4, 5]. For automation systems of different generations, fundamentally different approaches to the preparation of the turnkey management complex are applied, including design, production, safety proofing and commissioning. At the same time, it is the design and proof of security that, in the opinion of most experts in the field of knowledge, are the most important components of the technology for developing such responsible systems. At the same time, for systems of the last two generations, which are the most economical and efficient from the point of view of performance indicators, many aspects of the above components are fundamentally unresolved. The task of the conducted research is to form preliminary bases for the subsequent solution of an important scientific and applied problem of improving technologies for the development of modern rail automation systems.

2. Preconditions and means for resolving the problem

2.1. Methodological and practical basis for the development of methods and design tools

Automated design of modern railway automation systems involves the following main areas: software design (configuration) and design of technical documentation. For these purposes, specialized application packages of CAD systems are used. The basis for the development of such systems used for transport infrastructure facilities is the principle of their territorial distribution. In [5], experimental-static models of distributed process objects were proposed as a mathematical basis for improving methods and tools for computer-aided design. They are based on the graphic and analytical representation of the initial design object with the subsequent block decomposition of the graphic model. As a result, the implementation of the design scheme using this method looks like the diagram shown in Fig. 1.

The disadvantage of this approach is the excessive complexity for the user, primarily due to the inconvenience of the user interface and the need for specialized knowledge in the field of graph theory and matrix analysis.

At the same time, classical methods and means of computer-aided design are not in all cases acceptable for rail automation systems, taking into account their specificity. Thus, combining the method of forming a design object using experimental-static models and classical graphical shells (human-machine interfaces) is a method of solving this problem in the field of computer-aided design.

2.1. Methodological and practical basis for the development of methods and design tools

The main methods of proving the safety of railway automation systems are: methods of expert evaluation, calculated, experimental and calculation-experimental methods.
3. Solution of the problem under consideration

3.1. Synthesis of the method and interface of computer-aided design

The solution of the problem of computer-aided design is the synthesis of the user's shell (user interface) with the means of forming the experimental-static model of the design object (the subsystem for processing logical dependencies, technical documentation, software, etc.). For this, a graphic editor with an external interface of an acceptable CAD package is created. This editor forms a modified graph of the experimental-static model, which together with the editor represents the custom shell of the advanced CAD system (Fig. 3).

Together, the solution of the two agreed problems in the direction of improving the technologies for the development of modern railroad automation systems of the fourth and fifth generations should increase the economic and technical efficiency of their creation. The evaluation of the corresponding effect depends on the purpose and specific modification of the control system.

Fig. 3. The scheme of computer-aided design taking into account the synthesis of the graphic shell and the experimental-static model

In contrast to the classical experimental-static model proposed in [5], the proposed approach does not presuppose the preliminary formation of the components of graphs and blocks of parametrically-topological matrices in explicit form. Instead of them, files File 1 - File n, reproducing data blocks are generated directly on the basis of the modified graph. After composing these files, the synthesis of the design object is performed - similar to how it is done when using the classical experimental-static model. The most important advantage of the proposed approach is the maximum adaptability to a user who does not have a special mathematical preparation, and the use of standardized human-machine interfaces. The most promising environment for automated design, which is taken as the basis for the formation of the user's shell, is a CAD-type E-plan. The advantage of such an application package is maximum user adaptability, the ability to accelerate the design of large-scale objects, the use of convenient tabs and links, a sufficiently high speed. Taking as a basis the shell of this CAD will make it possible to create a universal means of automated design of railroad automation systems of any complexity. Thus, the issue related to the effective use of graphic models and their analytic interpretations (in the form of matrices) in the problems of computer-aided design is solved.
3.2 Creation of self-learning system of automated tests

As it was noted earlier, the most important advantage of imitation and bench tests is the possibility of their maximum automation - with the exception or minimization of human participation in the trial process. At the same time, however, the human factor is not completely excluded under the existing approach (Figure 2) in connection with the design of the program and the test procedure followed by its interpretation into a test script by a test engineer (a group of engineers). In this regard, at least it is not guaranteed to provide 100% of the test coverage of the functions, conditions and properties of the control system.

The solution to this problem is the implementation of self-learning test scripts (Fig. 4).

Fig. 4. The procedure of automated tests with self-learning test script

With this approach, the procedure for performing automated tests is generally similar to the original version (Fig. 5). However, in the scheme (Fig. 4) it is stipulated that only the basic (initial) test script is formed on the basis of the program and the test procedure by the test person. It is formed and used only before the first test cycle.

On subsequent cycles, the test automation tool generates a corrected test script, taking into account the actual coverage of the functions, conditions and properties of the control system. For this test script, feedback is provided to the test automation facilities, in accordance with which the technological information of this script is written to the memory devices of these means. Thus, a system is formed in which the automation tools independently form a test scenario using some initial data (the initial test script) and dynamic test coverage results.

In turn, the evaluation of the test coverage is formed on the basis of information obtained on the basis of the dynamic (test) analysis of the test object (control system) through the information channels of feedback. Only when determining the complete (100%) coverage of all functions, conditions and properties of the system is the feasibility of testing determined. This is done by a special algorithm (Fig. 5).

The initial data in this algorithm are the sets of input signals of the control system, on the basis of which, in turn, the sets of output signals and internal states are formed. On the basis of these sets, sets of combinations of functions, conditions and properties of the system are formed, which actually represents a test coverage without taking into account the reaction of the system to such combinations. After the initial test script is formed, the above combinations are cycled through according to their indexing. Only after this is done, the test coverage is checked (branch operator in Figure 5). Only after the positive test results is formed a dynamic test script. Otherwise, the cyclic operation is repeated until a complete test coating is provided.

Fig. 5. Algorithm for generating a dynamic test script, taking into account testing of the test coverage

Performing the process shown in Fig. 5 of the cyclic procedure is realized during the direct execution of automated tests with subsequent testing of the test coating. Thus, the first few test cycles serve not to reveal the properties of the system (including failures and failures), but to provide self-learning test scripts. The number of these cycles depends, first of all, on the scale of the transport infrastructure object, which is subject to testing. For control systems for various purposes and for a particular application, this number of cycles can vary within fairly wide limits.

However, however, the methodology (procedure) for evaluating the test coverage, which is performed on the basis of combinatorial analysis, remains unclear. The algorithm for its implementation is shown in Fig. 6.

Fig. 6. Algorithm of combinatorial evaluation of test coverage

The algorithm works as follows. At the first stage, the union of the sets of all functions, conditions and properties of the system \( \bigcup_{i=1}^{n} F_i \).

After that all their possible combinations are determined \( \bigcup_{i=1}^{n} F_i \).

The completeness of the test coverage is determined on the basis of a one-to-one correspondence of the specified combination of sets and combinations of functions, conditions and properties of the system. In fact, the algorithm in Fig. 6, is an embedded algorithm for Fig. 5. Completely executed test coverage is a guarantee of
verification of all functions, conditions and properties of the system. However, even as a result of the procedure in Fig. 6 the test coverage problem is not completely solved, which may be due to the identification of additional system properties in the testing process. These properties should also be taken into account in the assessment of the test coating. The corresponding algorithm is shown in Fig. 7.

**Fig. 7. Algorithm of combinatorial evaluation of test coverage, taking into account the identification of new systems**

Initially, the initial set of combinations of functions, conditions and properties of the system \( \{F\} = N^\mathbb{F} \). In the process of testing, an additional set is formed, identified during their conduct \( \{F'\} \). As a result, a set of initial and additional (revealed in the test) properties of the control system is formed \( F'' = \{F\} + \{F'\} \). The subsequent operations with the resulting set are carried out in a manner analogous to the algorithm in Fig. 6.

Another important aspect of carrying out automated tests in conditions of self-learning test scripts is the correction of the original program and the test procedure taking into account changes in these scripts. The fact is that according to the current normative and technical documentation for testing, it is the program and methodology that is the guiding document, according to which the order and conditions of testing are regulated. This is especially true for the certification of control systems, in which the technical documentation for the system (including the program and test procedure) is an integral attribute of the object of certification. In such circumstances, the guidance document must necessarily be aligned as an updated test script, and in accordance with the current regulatory technical documentation. However, adjusting the program and test methodology only on the basis of the test script does not guarantee unambiguous compliance with regulatory requirements, since certain aspects and results of self-learning test scripts may not correspond to these requirements. At the same time, these discrepancies must be taken into account both in the guidance document and in the script itself. This should be taken into account in the final test cycle. The algorithm for performing the corresponding check and making corrections based on it is shown in Fig. 8.

**Fig. 8. Algorithm for adjusting the program and test methodology, taking into account changes in the test script and regulatory requirements**

The resulting electronic test report must be consistent with the final versions of both the test program and methodology, and the test script.

### 4. Conclusion

Thus, in the technology of the development of modern systems of rail automation there are two main problems - the automation of design and automation of safety tests. Within the framework of solving the first problem, an approach based on the synthesis of the graph-analytic design method and the graphical user shell is proposed. To solve the second problem, an approach based on self-learning test scripts is proposed. Additionally, a set of procedures for verifying the correctness of the results of self-study is proposed. The results of the research are practically applied in the conditions of the development and implementation of a microprocessor system for the electric interlocking of pointers and signals at a number of railway stations.

### 5. Literature

PERFORMANCE OF GARMENT SEAMS STRENGTHENED WITH THERMOPLASTIC STITCHED RAINFORCED TAPE

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²Faculty of Technology and Metallurgy, University “Ss.Cyril and Methodius”- Skopje, Macedonia

Abstract: The purpose of this study was to evaluate the possibility of increasing seam performance by insertion of thermoplastic stitched reinforced tape in seam construction. The seam quality was evaluated by seam slippage, seam strength and seam efficiency. Two groups of specimens were investigated to determine the effect of thermoplastic stitched reinforced tape on seam quality. Specimens sewn according the standard were in the first group and specimens sewn by the industrial practice were in the second group. The obtained results show that with the insertion of thermoplastic stitched reinforced tape in the seam construction seam slippage strength increases in both groups of specimens, but the percentage of seam slippage increasing is higher for the group of specimens sewn according to the industrial practice. Seam efficiency is increased in the group of specimens sewn according to the industrial practice.

Key words: SEAM STRENGTH, SEAM SLIPPAGE, SEAM EFFICIENCY

1. Introduction

Seam slippage, seam strength and seam efficiency are the seam quality criteria which define a seam stability. There are various factors that can affect seam strength and seam efficiency. Many previous studies [1, 2] showed that seam strength and seam efficiency depend on the interrelationship of fabrics, threads, stitch and seam selection, and sewing conditions, which include: needle size, stitch density, appropriate operation, sewing machine setup etc. [3-10].

Many researchers have investigated seam slippage in order to determine the causes of this phenomenon and to find techniques to reduce or eliminate it. The obtained results show that, higher weft density, cover factor, yarn count of fabric yarns and lower weaver factor lead to seam slippage decreasing [11-13]. Seam slippage may also be affected by stitch type, stitch density, width of seam allowance, fabric’s sewing direction, seam type and size, type of sewing thread and thread tension.

In most of previous studies, researchers in their experiments were focused on increasing fabric resistance on seam slippage and seam breaking by fabric structure modification. A lesser number of studies were focused on seam slippage and seam breaking decreasing in garment production process by sewing parameters optimization and seam characteristics adaptation.

Investigation of techniques to reduce seam slippage and increase seam strength and seam efficiency in the garment during production process is very important for the development of high quality textile products. For this purpose, we used stitched reinforced tapes for fabric structure strengthening in the sewing area. These tapes are support materials from the group of thermoplastic interlining, which are used to increase the stability of textile materials and support the form of garment. Also, they can be used to improve the garment seam performance. The purpose of this paper is to examine the impact of thermoplastic stitched reinforced tapes on the performance of the seams.

2. Experimental part

In this study, 3 lightweight woven fabrics were investigated. The characteristics of fabrics used are given in Table 1.

<table>
<thead>
<tr>
<th>Tape T₁</th>
<th>Tape T₂</th>
<th>Tape T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composition</td>
<td>100% PES</td>
<td>100% PES</td>
</tr>
<tr>
<td>Surface density of thermoplastic interlining</td>
<td>45 g/m²</td>
<td>45 g/m²</td>
</tr>
<tr>
<td>Reinforcement</td>
<td>Stitches parallel to seam</td>
<td>Stitches in bias direction</td>
</tr>
<tr>
<td>Additional reinforcement</td>
<td>None</td>
<td>Chain stitch</td>
</tr>
</tbody>
</table>

The surface density was measured according to the standard MKS BS EN 12127: 1998 yarn count according to the standard ISO 7211-5:1984 and MKS EN 1049-2: 2007 was used to determine yarn density. In the test, three thermoplastic stitched reinforced tapes produced by “Vantela”- Turkey were used, Figure 1. The first tape T1s is a lockstitch reinforced tape in sewing direction, and the other two tapes have lockstitches in bias direction. The tape T2 is additionally reinforced with a chain stitch and the tape T3 is additionally reinforced with a weavingle.
seam slippage strength for fixed seam opening from 2-6mm. The measurement of seam slippage strength for 3mm seam opening was chosen as more rigorous criteria for high quality garment. If seam slippage strength is higher than 200N, then the result is reported as “no seam slippage”. All measurements were made with the tensile testing machine “Timuous Olsen” HSKT.

Because the sewing parameters from the standard ISO 13936-1 do not correspond with the sewing parameters used in industrial practice, the seam slippage and the seam strength in two groups of test specimens were measured. In the first group, specimens were sewn according to the standard, and in the second group specimens were sewn according to industrial experts instructions. According to standard, all type of fabrics were sewn together using the same sewing parameters, but according to the expert’s instructions, pieces of the testing fabric were sewn with different thread size and needle size number, in coordination to the weight and the composition of the fabrics, as shown in Table 3.

### Table 3. Sewing parameters for specimens from the two test groups

<table>
<thead>
<tr>
<th>Seams</th>
<th>Fabric</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yarn count, tex</td>
<td>45±5</td>
<td>45±5</td>
<td>45±5</td>
<td></td>
</tr>
<tr>
<td>Needle size, metric</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Stitch density, thread/100 mm</td>
<td>50±2</td>
<td>50±2</td>
<td>50±2</td>
<td></td>
</tr>
<tr>
<td>Yarn count, tex (Tkt)</td>
<td>18 (180)</td>
<td>21 (150)</td>
<td>30 (100)</td>
<td></td>
</tr>
<tr>
<td>Needle size, metric</td>
<td>60</td>
<td>65</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Stitch density, thread/100 mm</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

Legend: Tkt- thread ticket number

The only common parameter for these two groups was stitch density. Specimens were sewn in warp direction with a high speed sewing machine Juki DDL 9000b-s using polyester core-spun sewing threads.

### 3. Results and discussion

Thermoplastic stitched reinforced tapes were fused onto the seam area of testing specimens. Under the same conditions, specimens without thermoplastic tapes were prepared and tested. Obtained results for seam slippage strength, fabric strength, and seam strength and calculated results for seam efficiency are shown in Table 4 and Table 5, for two test groups of specimens. The results shown in Table 4 and Table 5 are mean values calculated from five specimens.

### Table 4. Fabric strength, seam slippage strength, seam strength and seam efficiency for specimens sewn according to standard

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Fabric strength, N</th>
<th>Seam-slippage strength, N</th>
<th>Seam strength, N</th>
<th>Seam efficiency, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>88.7</td>
<td>28.46</td>
<td>25.0</td>
<td>65.54</td>
</tr>
<tr>
<td>F1/T1</td>
<td>34.39</td>
<td>18.9</td>
<td>21.5</td>
<td>61.78</td>
</tr>
<tr>
<td>F1/T2</td>
<td>30.75</td>
<td>20.0</td>
<td>18.9</td>
<td>57.02</td>
</tr>
<tr>
<td>F1/T3</td>
<td>30.24</td>
<td>21.5</td>
<td>21.5</td>
<td>54.47</td>
</tr>
<tr>
<td>F2</td>
<td>16.08</td>
<td>11.5</td>
<td>11.5</td>
<td>37.68</td>
</tr>
<tr>
<td>F2/T1</td>
<td>24.64</td>
<td>8.00</td>
<td>8.00</td>
<td>51.36</td>
</tr>
<tr>
<td>F2/T2</td>
<td>24.96</td>
<td>10.2</td>
<td>10.2</td>
<td>50.80</td>
</tr>
<tr>
<td>F2/T3</td>
<td>27.68</td>
<td>10.5</td>
<td>10.5</td>
<td>42.32</td>
</tr>
<tr>
<td>F3</td>
<td>182.4</td>
<td>83.8</td>
<td>9.3</td>
<td>167.28</td>
</tr>
<tr>
<td>F3/T1</td>
<td>94.76</td>
<td>23.3</td>
<td>23.3</td>
<td>171.04</td>
</tr>
<tr>
<td>F3/T2</td>
<td>95.16</td>
<td>11.9</td>
<td>11.9</td>
<td>167.04</td>
</tr>
<tr>
<td>F3/T3</td>
<td>91.72</td>
<td>22.9</td>
<td>22.9</td>
<td>161.88</td>
</tr>
</tbody>
</table>

Legend: F-fabric, T1, T2, T3- thermoplastic stitched reinforced tape

According to the results obtained for fabrics specimens, there is seam slippage at all three fabrics in both groups of specimens. The group of specimens sewn according to the standard has higher seam slippage strength, seam strength and seam efficiency compared to the group of specimens sewn according to the industrial practice, for all three fabrics.

When the seam is under transversal load the seam deformation occurs, in fact, the stitch and the fabric are deformed and seam slippage occurs due to fabric deformation. In a standardized group of specimens, the sewing thread has higher yarn count and it needs higher extension force for seam deformation.
With insertion of thermoplastic stitched reinforced tape in seam construction seam slippage strength increases in both groups of specimens (Fig. 3).

In the fusing process, substrate of interlining is fused onto the fabric by thermoplastic polymer. One part of the polymer remains on the fabric surface, fuses the substrate and the fabric, and the other part of polymer migrates into the internal fabric structure through the interspaces of warp and weft yarns. The result of the fusing process is a fabric with higher bending rigidity, thickness and more closed structure. Warp and weft fabric yarns are fused together, the fabric structure consolidated and yarn slippage resistance increases. On the other hand, from the literature review we have knowledge that higher bending rigidity and thickness have positive impact on seam slippage reduction [14].

Generally, fused specimens sewn according to the industrial practice have higher seam slippage strength. In order to make a comparison between the two test groups, we calculated the percentage of seam slippage strength increasing of fused specimens. Table 6. Results in Table 5 show that the percentage of seam slippage strength increasing is higher for fabrics of lower cover factor. The fabric F2 has the lowest cover factor $C_f = 0.40$ and the highest percentage of seam slippage strength increasing is 9.3 - 13.55% in the standard test group of specimens and 97.59 - 105.42% in the group of specimens sewn according to industrial practice.

The percentage of seam slippage strength increasing of fabric F1 with cover factor $C_f = 0.54$ is 6.25 - 20.8% in the standard group of specimens, and 31.38 - 86.02% in the group of specimens sewn according to industrial practice. The fabric F3 has the highest cover factor $C_f = 0.82$ and the percentage of seam slippage strength increasing is 9.3 - 13.55% in the standard group of specimens, and 2.23 - 31.76% in the group of specimens sewn according to industrial practice. Fabrics with higher cover factor have greater coverage of the total fabric area with yarns [15], so a bigger part of thermoplastic polymer stays on the fabric surface and a smaller part migrates into the internal structure of fabrics. As the result of this, there is smaller mutual weft and warp yarns fusing and they have a greater ability to slip, while fabrics with smaller cover factor have a more open structure and gaps between warp and weft fabrics yarns through which the thermoplastic polymer migrates into the internal structure of fabrics and fuses weft and warp yarns together. Therefore, the effect of thermoplastic stitched reinforced tape is higher for fabrics with a lower cover factor.

With the insertion of thermoplastic tapes in the seam structure, results show that seam efficiency is increased in the group of specimens sewn according to industrial practice. In the standard group of specimens there is seam efficiency increasing for fabric F2 and fabric F3 fused with tapes T1 and T2 and seam efficiency decreasing for fabrics F1 and F3 fused with the tape T1. The results of seam efficiency are shown in Figure 4.

The increase in seam efficiency is due to the strengthening of the fabric structure in the seam area. The percentage of seam efficiency increasing is shown in Table 7. The group of specimens sewn according to industrial practice has a higher percentage of seam efficiency increasing compared with the group of standardized specimens.

By increasing the fabric thickness and bending rigidity by fusing a thermoplastic tape, the needle penetration force (NPF) also increases during sewing. Also the needle penetration force increases proportionally with the needle size. A fabric with high needle penetration force and low fabric yarn mobility is more susceptible to damage during the sewing process. Because of the high fabric thickness and high needle penetration force, higher sewing thread size in the standardized group is subjected to greater friction during stitches formation, which conditionally reduces its strength. Fabric damage during the sewing process and lower thread strength causes seam efficiency decreasing of the fabric F1 in the standardized group. F1 is silk, lightweight fabric with lowest strength and in sewing it is susceptible to damage. Another indicator that the fabric F1 is subject to damage during the sewing process is a very low percentage 1.32-2.40% of seam efficiency increasing in the group of industrial practice.

**Legend:** F1, F2, F3- fabrics; i-specimens sewn according to industrial practice; s- specimens sewn according to standard; T1, T2, T3- tapes.

**Table 6. Percentage of seam slippage strength increasing**

<table>
<thead>
<tr>
<th>Fabric</th>
<th>$C_f$</th>
<th>Method</th>
<th>Seam with tape T1</th>
<th>Seam with tape T2</th>
<th>Seam with tape T3</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>0.54</td>
<td>S</td>
<td>20.8</td>
<td>8.04</td>
<td>6.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>31.38</td>
<td>83.62</td>
<td>86.02</td>
</tr>
<tr>
<td>F2</td>
<td>0.40</td>
<td>S</td>
<td>53.23</td>
<td>55.22</td>
<td>72.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>97.59</td>
<td>100.30</td>
<td>105.42</td>
</tr>
<tr>
<td>F3</td>
<td>0.82</td>
<td>S</td>
<td>13.07</td>
<td>13.55</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>2.23</td>
<td>13.69</td>
<td>31.76</td>
</tr>
</tbody>
</table>

**Legend:** s- specimens sewn according to standard; i-specimens sewn according to industrial practice

**Figure 3. Seam slippage strength of the fabrics with and without tape**

**Legend:** F1, F2, F3- fabrics; i-specimens sewn according to industrial practice; s- specimens sewn according to standard; T1, T2, T3- tapes.

**Figure 4. Seam efficiency of fabric with and without thermoplastic tape**

**Legend:** F1, F2, F3- fabrics; i-specimens sewn according to industrial practice; s- specimens sewn according to standard; T1, T2, T3- tapes.

**Table 7. Percentage of seam efficiency increasing**

<table>
<thead>
<tr>
<th>Fabric specimen</th>
<th>Seam with tape T1</th>
<th>Seam with tape T2</th>
<th>Seam with tape T3</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F1 i</td>
<td>1.32</td>
<td>2.40</td>
<td>1.41</td>
</tr>
<tr>
<td>F2 s</td>
<td>36.34</td>
<td>34.88</td>
<td>12.39</td>
</tr>
<tr>
<td>F2 i</td>
<td>319.14</td>
<td>349.42</td>
<td>391.00</td>
</tr>
<tr>
<td>F3 s</td>
<td>2.25</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>F3 i</td>
<td>3.06</td>
<td>7.5</td>
<td>8.7</td>
</tr>
</tbody>
</table>

**Legend:** s- specimens sewn according to standard; i-specimens sewn according to industrial practice
From aforementioned explanation we can conclude that thermoplastic stitched reinforced tapes has greater effect for the seam slippage strength increasing than for the seam efficiency.

The influence of the thickness on the seam quality of fused specimens can be seen from the lower percentage of seam slippage strength increasing in the group of specimens sewn according to standard practice compared with the group of specimens sewn according to industrial practice.

4. Conclusion

In this study the effect of three types of thermoplastic stitched reinforced tapes on seam slippage and seam strength/seam efficiency were investigated. Three woven fabrics were tested and two test groups of specimens were prepared. In the first group specimens were sewn according to the standard, and in the second group specimens were sewn according the industrial practice.

According to the results obtained for fabrics specimens, seam slippage occurs at all three fabrics in both groups of specimens. The group of specimens sewn according to the standard has higher seam slippage strength, seam strength and seam efficiency compared with the group of specimens sewn according to the industrial practice. With the insertion of thermoplastic stitched reinforced tape in the seam construction seam slippage strength increases in both groups of specimens, but the percentage of seam slippage increasing is higher for the group of specimens sewn according to the industrial practice. The effect of thermoplastic stitched reinforce tapes on seam slippage is higher for fabrics with lower cover factor.

With the insertion of thermoplastic tapes in the seam structure, seam efficiency is increased in the group of specimens sewn according to the industrial practice. The percentage of seam efficiency increasing is from 1.32- 2.40 % for fabric F1, 319.14-391 % for fabric F2 and from 3.06-8.7% for F3, depending from type of tape used. In the standard group of specimens there is increasing of seam efficiency 12.39- 36.34% for fabric F2 and 2.25% and 0.22 % for fabric F3 fused with tapes T1 and T2, while seam efficiency was decreased for fabrics F1 and F3 fused with the tape T1. The effect of thermoplastic stitched reinforced tapes on seam slippage increasing is higher for the group of specimen sewn according to the industrial practice due to the selection of correct sewing parameters, seam thread and needle size. Generally, the results of measured properties for the group of specimens sewn according to the industrial practice have lower coefficients of variation, which means that these seams are more homogeneous and have higher quality.

All three tapes have the same effect, increase the resistance of fabrics to seam slippage, but the percentage of seam slippage strength increasing is different due to the different structure of the tapes. This will be the subject of further research.

5. References:

ANISOTROPY OF THE MECHANICAL PROPERTIES OF HOT ROLLED STEEL COILS FOR WELDED PIPES

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Abstract: Hot rolled steel coils, as a result of the history of production, respectively processing, shows anisotropy of the mechanical properties, i.e. different mechanical properties in different direction. Therefore, the mechanical properties of hot rolled steel coils should be known in advance, respectively prior to its use as raw material for the production of various final products, particularly for spiral and longitudinal welded steel pipes, where mechanical anisotropy of hot rolled steel coils even more appears during the formation of hot rolled coils into the pipe. Mechanical testing of the hot rolled steel coils in transversal (T) and longitudinal (L) direction related to the rolling, were conducted.

The aim of this paper is to investigate anisotropy of the mechanical properties of the hot rolled steel (S355 EN 10025:2004) coils, used for the production of spiral and longitudinal welded steel pipes.

Keywords: ANISOTROPY, MECHANICAL PROPERTIES, STEEL COILS, WELDED PIPES.

1. Introduction

Rolling is one of the most important bulk plastic deformation processing of metals, passing between rolls, that rotate in opposite direction, where the raw material is deformed by compressive force applied by the rolls, (Fig. 1). Mostly, rolling is done at high temperature, above the recrystallization temperature and called hot rolling [1, 2].

Deformation during the rolling process causes significant change of the microstructure in terms of size of crystal grains, and in their orientation view in certain directions, depending on the direction and intensity of deformation. Microstructure evolution processes in this case, during and after hot rolling, (Fig. 3) are key factors for mechanical properties of hot rolled coils [3].

During deformation, crystal grains rotate as well as elongate, causing certain crystallographic directions and planes to become aligned with the direction in which stress is applied. Consequently, preferred orientations or textures develop and cause anisotropic behavior. The properties of a rolled sheet or plate depend on the direction in which the property is measured [4]. In processes such as rolling, grains become oriented in a preferred crystallographic direction and plane, giving a sheet texture. The properties of a rolled sheet or plate depend on the direction in which the property is measured [4].

A typical microstructure in a hot rolled low alloy steel coils is illustrated in (Fig. 4). There are planar patches of ferrite and pearlite bands parallel to the rolling plane, or banding oriented microstructure in the longitudinal (L) and transversal (T) direction [5]. Microstructural banding is more pronounced in the rolling direction (longitudinal-L) than in the transverse direction (transversal-T).

This ferrite/pearlite banding microstructure is responsible for mechanical properties of hot rolled coils used for spiral and longitudinal welded steel pipes.
Preferred orientation of the microstructure is known as deformation texture [6, 7, 8], while in this specific case it is called the rolling texture. As a result of this kind of microstructure orientation (rolling texture) it comes to:

- changes in mechanical properties,
- changes in optical properties,
- changes in magnetic properties,
- changes in thermal properties,
- changes in electrical properties,
- changes in resistance to corrosion, etc.

The phenomenon of occurrence of different properties in different directions is known as anisotropy.

Anisotropy derives from the Greek words: aniso, which means change (difference) and tropos, which means direction, so different properties in different directions [8]. The concept of anisotropy is very important, because it reflects the properties of the material, respectively the part depending on the direction. In case of rolling, high intense textures are formed in the transversal (T) and longitudinal (L) direction of rolling, which may lead to significantly different mechanical properties.

The mechanical properties of hot rolled steel coils like resistance to deformation (strength) and ability to deformation (ductility), are in correlation with the metallurgical properties like microstructure, grain size, etc. [9].

It is worth mentioning that except in rare cases where it can show beneficial effect, anisotropy of the mechanical properties always shows harmful effects. Although its full elimination is very difficult, we should follow and analyze the intensity of the harmful effect of anisotropy of mechanical properties.

At hot and cold rolled products there comes to the appearance of anisotropy of mechanical properties, respectively the appearance of different mechanical properties in different directions.

Taking this into consideration, this paper takes a look at the anisotropy of mechanical properties of rolled coils, used for the manufacturing of spiral and longitudinal welded steel pipes.

## 2. Experimental procedure

### 2.1. Material

In this paper it is reviewed the effect of anisotropy of mechanical properties of hot-rolled coils from steel S355 according to EN 10027:2003, (Fig. 5) which is used as raw material for the manufacturing of welded steel pipes with spiral and longitudinal seam. This steel is produced in the shape of hot-rolled coils.

The chemical composition and mechanical properties of hot rolled steel coils S355 (EN 10027:2003), according to the manufacturer's Certificate are presented in Tab. 1, respectively 2.

<table>
<thead>
<tr>
<th>Chemical composition of used steel coils S355</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel coils</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>S355</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mechanical properties of used steel coils S355</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel coils</td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td>S355</td>
</tr>
</tbody>
</table>

### 2.2. Mechanical testing

With the aim of monitoring the anisotropy of mechanical properties of the hot-rolled coils, the following tests were conducted:

2.2.1. Tensile testing were conducted in order to determine yield strength (Re), ultimate tensile strength (Rm), ratio (Re/Rm) and elongation (A).

2.2.2. Impact toughness testing were conducted to determine Charpy-V notch impact toughness (Kv), at temperature (-20°C).

2.2.3. Hardness testing were conducted to determine Vickers hardness (HV30/15).

To conduct all these tests, samples were taken from the hot-rolled coils, according to the scheme given in (Fig. 6).
3. Results and discussion

The tensile testing was conducted in the universal testing machine, MOHR-FEDERHAFF-LOSENHAUSEN and the obtained results are presented in Tab. 3.

Table 3: Results of tensile testing

<table>
<thead>
<tr>
<th>Samples</th>
<th>Transversal direction - T</th>
<th>Longitudinal direction - L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Re</td>
<td>Rm</td>
</tr>
<tr>
<td></td>
<td>MPa</td>
<td>%</td>
</tr>
<tr>
<td>S1.</td>
<td>442</td>
<td>540</td>
</tr>
<tr>
<td>S2.</td>
<td>405</td>
<td>517</td>
</tr>
<tr>
<td>S3.</td>
<td>430</td>
<td>540</td>
</tr>
<tr>
<td>Average</td>
<td>426</td>
<td>532</td>
</tr>
</tbody>
</table>

The impact toughness testing (ISO-V-5) was conducted in the Charpy pendulum, MOHR-FEDERHAFF-LOSENHAUSEN, at temperature (-20°C) and the obtained results are presented in (Fig. 7).

The hardness testing, respectively Vickers hardness (HV30/15) was conducted in the hardness tester Shimadzu.
The average value of the yield strength in the transversal direction ($Re_T=426$ MPa) is bigger than the average value of the yield strength in the longitudinal direction ($Re_L=396$ MPa), for 7.57%, while the ultimate tensile strength in the transversal direction ($Rm_T=532$ MPa) is also bigger than the ultimate tensile strength in the longitudinal direction ($Rm_L=520$ MPa), for 2.30%.

Impact toughness in the transversal direction ($Kv_T=52.4$ J/cm²) is smaller than impact toughness in the longitudinal direction ($Kv_L=166$ J/cm²), for 3.16 times and this is the biggest difference which appears at the ho-rolled coils and it must be taken into account when using the hot-rolled coils as semi-product, respectively as raw material for the production of finished products in general and for the production of spiral and longitudinal welded steel pipes in particular, used for line pipes, tubing, casing and for other applications.

The distribution of hardness values (HV30/15) in the longitudinal (L), transversal (T) and surface layer shows slightly difference ($\Delta HV = HV_{max} - HV_{min} = 188-165=23HV$). Maximum hardness, (Fig. 9) is measured in the surface layer-S ($HV_{max}=188$), while minimum hardness is measured in the longitudinal-L ($HV_{min}=165$).

4. Conclusion

Based on the literature review of relevant field and based on the experimental results, it can be concluded that:

Anisotropy of mechanical properties of the hot-rolled coils is emphasized both in terms of the resistance to deformation (yield strength-Re, ultimate tensile strength-Rm, ratio-Re/Rm, hardness-HV) and also in terms of the ability to deformation (elongation-A), but in this case it is not very pronounced and can be neglected

Anisotropy of impact toughness ($Kv$) of hot-rolled coils is significantly emphasized, so in this case impact toughness in longitudinal direction-L is nearly three times (3X) greater than the impact toughness in the transversal direction-T. This is the biggest difference between these two directions of hot rolled coils and necessarily must be considered when using the hot-rolled coils for manufacturing of spiral and longitudinal welded steel pipes.

5. References

DATA COLLECTION AND ANALYSIS TO IDENTIFY THE TRAFFIC PROBLEMS OF THE EXISTING NETWORK AND APPLICATION OF SOFTWARE FOR SOLUTION PROPOSALS, A CASE STUDY

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Abstract: The development of information technologies are taking part in all spheres of human lives. In the traffic engineering shows a big need for application of advanced computing tools.

Softwares for traffic analysis except that allow precise, visual and multifactor analysis of the imagined or proposed traffic solutions, they save time and money as opposed to the site testing. For proper development of the traffic, it is needed detailed and comprehensive planning of the process that will contribute to improving the traffic infrastructure.

One of the crucial steps before using any software for traffic analysis is the collection of data with purpose to establish the relevant traffic loads for the examined area. Namely, to get the real realistic picture of the traffic situation, it is necessary recording the traffic to get of the process that will contribute to improving the traffic infrastructure.

In the present work will be shown simulation of the most critical crossroads in the town of Gostivar in the two versions of existing and newly-condition situation using the software tool PTV VISSIM 7. Here will be analysed the most important parameters of the current traffic flow - the time losts in order to indicate the need of change the way of the traffic management of this intersection.

Keywords: SOFTWARE, SIMULATION, TRAFFIC ANALYSIS

1. Introduction

All human activities and mobility directly depend on the traffic areas. The main factor for the development of each territory is the existence and connection of quality traffic infrastructure with the surrounding areas. Quality traffic network contributes to the development of all spheres of human life.

Traffic planning is coordination between the providing of transport, land use, economic development and social planning, which are forming a cyclic process. Planning and implementation are an integral system.

For proper traffic development, it is needed detailed and comprehensive planning process that will contribute to improving the traffic infrastructure.

In any taking of measures, activities, wearing a conclusion or implementation of an idea, to get a real realistic picture of the traffic situation, as the first and basic step is to present the current status of traffic and getting the hour, daily, monthly and yearly imbalance on traffic intensity of the investigated location.

2. Determination of traffic imbalance

Obtaining a relevant data that will objective show the situation on the ground is an essential step in any activities on traffic network. For that purpuse, it is made a recording of the traffic to determine the daily, weekly, monthly and annual imbalance.

2.1. Determination of daily traffic imbalance

To determine the daily imbalance of traffic and the establishment of the rush hour, it is made a daily traffic recording on 13.04.2015 (Tuesday) with a duration of 12 hours (06:00 to 18:00 pm) at the junction 1 (JNA – Ginoski brothers). Counting papers were made so that the intake of each vehicle that passes is recorded in the appropriate category where it belongs, certainly on approaches and directions. Filming was done in twenty minute intervals, for getting a clearer picture of real hourly intensities, as well as consideration of the traffic load.

The next figure shows the locations of which were located the counters.

The counting is performed on three approaches from a total of 4 - because the fourth approach is one-way - only out of the junction.

The table below shows the traffic load of the research crossroad.

Table 1: Total traffic load for the crossroad Ginoski brothers - JNA.

<table>
<thead>
<tr>
<th>from</th>
<th>to</th>
<th>App. 1</th>
<th>App. 2</th>
<th>App. 3</th>
<th>Total junction (20 min.)</th>
<th>Total junction (hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H.</td>
<td>M.</td>
<td>H.</td>
<td>M.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>6</td>
<td>20</td>
<td>29</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>6</td>
<td>40</td>
<td>43</td>
<td>36</td>
<td>24</td>
</tr>
<tr>
<td>6</td>
<td>40</td>
<td>7</td>
<td>0</td>
<td>138</td>
<td>78</td>
<td>53</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>7</td>
<td>20</td>
<td>128</td>
<td>87</td>
<td>44</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>7</td>
<td>20</td>
<td>118</td>
<td>78</td>
<td>34</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
<td>7</td>
<td>40</td>
<td>165</td>
<td>92</td>
<td>67</td>
</tr>
<tr>
<td>7</td>
<td>40</td>
<td>8</td>
<td>0</td>
<td>149</td>
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<td>8</td>
<td>20</td>
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<td>20</td>
<td>192</td>
<td>32</td>
<td>80</td>
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<td>8</td>
<td>40</td>
<td>9</td>
<td>0</td>
<td>216</td>
<td>117</td>
<td>114</td>
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<tr>
<td>9</td>
<td>0</td>
<td>9</td>
<td>20</td>
<td>164</td>
<td>140</td>
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<td>9</td>
<td>20</td>
<td>9</td>
<td>40</td>
<td>132</td>
<td>132</td>
<td>75</td>
</tr>
<tr>
<td>9</td>
<td>40</td>
<td>10</td>
<td>0</td>
<td>150</td>
<td>121</td>
<td>73</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>173</td>
<td>129</td>
<td>79</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
From the table was obtained daily imbalance of traffic, shown below.

Chart 1: Daily traffic imbalance

With proper analysis of the data from the tables and the diagram can be seen that we have extended rush hour with the greatest intensity between 11:00 and 15:00.

2.2. Determination of weekly traffic imbalance

The weekly imbalance of traffic over a single authoritative week is shown in the following diagram.

Chart 2: Weekly traffic imbalance

Predictably, the minimum intensity of the traffic occurs on Sunday. The biggest traffic movement in turn, has on Tuesday (open market day).

2.3. Determine the monthly traffic imbalance

In determining the monthly imbalance in traffic in Gostivar, as a prevail month was taken August, in consultation with experts in the field. The reason for this is that quite a number of residents from Gostivar are emigrants who spend summer vacations in their home areas. They contribute to the most intense agitation exactly in August.

The distribution of traffic for the month August is shown in the diagram that follows.

Chart 3: Monthly traffic imbalance

The values for current vehicles of the adequate junction (JNA – Ginoski brothers) vary about 1200 vehicles / hour, with the largest deviations of 18 August.

2.4. Determination of annual traffic imbalance

The annual traffic imbalance is obtained based on recordings of the traffic made on the same junction (JNA – Ginoski brothers) where is done the filming for daily, weekly and monthly traffic imbalance.

During the traffic recording are taken into account all types of motor vehicles (passenger cars, buses, heavy goods vehicles and motorcycles).

In order to get a relatively accurate data on the annual imbalance of traffic, the team with the previously specially designed counting apers, has executed the recording of the traffic. Filming was done over one year (one day per month), starting from April - 2015 to March - 2016 in the most congested day of the week (Tuesday).

The traffic recording was done in period with duration of two hours (10:00 to 12:00 am), in twenty minute intervals, getting clearer realistic picture of the intensity of movement at the
crossroad JNA – Ginoski brothers (where is performed the recording for daily, weekly and monthly imbalance).

Chart 4: Annual traffic imbalance

The greatest traffic intensity occurs in June.

3. Simulating of the current traffic situation with the collected data and proposed solutions: A case study

The obtained data on traffic intensity is used to visually display the traffic situation and to evaluate the level of service on the crossroad. The following figure shows the current traffic situation on the crossroad (JNA - Ginovski brothers) designed in the software PTV VISSIM 7.

Fig. 1: Current situation at the crossroad JNA – Ginoski brothers

From the entered data of the number of vehicles that passed thorough the given intersection with a 10 minute simulation that enables the PTV VISSIM 7, as output was obtained analysis for the stalled vehicles depending on their direction and frequency.

Chart 5: Time delay pro vehicle depending on their direction and frequency

The red pillars of the diagram represent the time delays, while blue columns - the number of vehicles. From the results can be seen that the approach JNA (West) - occurs the longest time delay for turning left (41 seconds), while the smallest, and in certain periods there is no time delay is for the vehicles from JNA (right). These time delays are varying significantly with the time of other streets that are included in this intersection.

The only one-way street has a major role in the reducing of traffic density. The proposed solution that is offered to reduce time losses of intersection, and the reduction of traffic accidents is building a roundabout.

The reconstruction of four-legged intersection in an appropriate roundabout by setting the appropriate road signs and rules is build in the software PTV VISSIM 7 and is shown in the following figure.

Fig. 2: Appearance of the new designed roundabout JNA – Ginoski brothers

Following are shown the time delays with the new roundabout according to approaches and directions of movement.

Chart 6: Time delay pro vehicle in roundabout depending on their movement and frequency

We already know that the maximum time loss in the current situation at the intersection is 41 seconds. Here we see that with the existence of roundabout, the time delays will be reduced to 25 seconds.

A comparison of time delays at the current intersection and construction of roundabout in the same simulation period (10 min) is given in the graph below.

Chart 7: Comparison of time delays pro approach and direction between classic crossroad and roundabout for the intersection

The construction of roundabouts would balance the approaches in terms of time losses. Thus, the direction Brothers Ginoski (north) - right, gets certain time losses at the expense of other approaches, what results with smoother traffic flow at this intersection.

Conclusion

The detailed, concise and comprehensive data collection about the traffic situation is the basis for a quality traffic project. The collected quality data reflects real the traffic situation, and based on the same evaluates will be decided which steps need to be taken to increase safety, ease of road traffic flows and improving the traffic conditions of the investigated area.

To achieve these important goals in traffic planning, there are several software tools that make the work of traffic engineer easier - that gives him the opportunity virtually to see if his decision will result in better results, or need to take into account some other solution.
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STRENGTHENING OF SURFACE LAYERS OF STEELS AND ALLOYS BY BORIDE COATINGS FORMED UNDER THE CONDITIONS OF AN EXTERNAL MAGNETIC FIELD

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Abstract: It was dedicated to solution of scientific and technical problem to increase the level of physical and mechanical and operational properties of the surface of steels by forming strengthened layers diffusion boriding and complex saturation boron and copper in a magnetic field.

KEYWORDS: BORON, BORIDING, BORON LAYER, COPPER, STRUCTURE, DIFFUSION, MICROSTRUCTURE, MICROHARDNESS, EXTERNAL MAGNETIC FIELD.

INTRODUCTION
Diffusive multicomponent boriding quite energy consuming process, therefore to reduce energy consumption necessary to use methods for intensification the process saturation. One of these methods is the application of an external magnetic field (EMF), the so-called magnetic thermo chemical treatment [1-3].

To solve this problem, we used a complex diffusive saturation of the surface layer of carbon steel boron or boron and copper at simultaneous action of EMF.

The aim of this work was to study diffusive boride coatings and coatings obtained after saturation with boron and copper on carbon steel,

MATERIALS AND EXPERIMENT
The paper presents the results of the study of the influence of external magnetic field (EMF) on the structure, phase and chemical composition, microhardness, growth kinetics, roughness, crack resistance and wear resistance of boride coatings obtained with complex boron or boron and copper saturation.

RESULTS AND DISCUSSION
It was found that the use of EMF in diffusion saturated for 2 hours allows to increase the thickness of the diffusion boride layer in 1.5-2 times, compared with the coatings obtained without the action of EMF with a saturation time of 2 hours. So for 2 hours of diffusion saturation with EMF on medium carbon steel the thickness of the coating reached up to 200 μm (Fig. 1, c), compared with the boron layers obtained without EMF - up to 110 microns (Fig. 1, a). It has been shown that the use of EMF can reduce the duration of saturation of steels and alloys by 2 times. So the thickness of the diffusion boride layer on medium carbon steel without the action of EMF grows to 160 μm for 4 hours of diffusion saturation.

The same pattern is observed for boride coatings obtained with complex boron and copper saturation. So with a whack for a while For 4 hours without EMF, coatings with a thickness of 165 - 200 μm are formed (Fig. 1, r), whereas, when diminished under the action of EMF, 2 hours of diffusion saturation, borate phases grow in the thickness 180 – 225 μm. Investigation of the microhardness of the boride phases after boring at the simultaneous action of EMF showed that the microhardness of the phase of FeB is 19-20 GPa, and the FeB2 phase is 17 - 18 GPa, without the action of a magnetic field, FeB - 17 - 18 GPa, FeB2 - 15-16 GPa. At complex saturation with boron and copper using EMF, we obtain boride layers with a microhardness - for phase (Fe, Cu) B - 17 - 18 GPa, and for phase (Fe, Cu) 2B - 15-16 GPa, without magnetic field action (Fe, Cu) B - 15.5 - 16.5 GPa, and for the phase (Fe, Cu) 2B - 13.5 - 14.5 GPa. Thus, there is an increase in the microhardness of FeB, FeB2 and (Fe, Cu) B, (Fe, Cu) 2B phases at 1.5-2 GPa, obtained under magnetic field conditions, which is probably due to the shredding of the block structure boride grains up to 38.3 nm compared to 66.1 nm for the FeB phase obtained without the action of EMF. At complex saturation with boron and copper, we observe a decrease in the microhardness of boride layers compared to boring.

The study of the phase composition of boride coatings obtained in different physical and chemical conditions was carried out. It was shown that in the case of boronization without EMF in the surface layer of boride coating to 15 - 20 μm, the FeB phase (Fig. 2, a), and with complex boron and copper saturation without the action of EMF - the FeB, Fe2B, and Cu phases (Fig. 2, b).

Fig.1 Microstructures of complex boride coatings on steel 45 obtained in different physical - chemical conditions: a – boriding without action EMF, the duration of saturation 2 hours, x200; b – boriding in EMF, the duration of saturation 2 hours, x200; c – complex saturation with boron and copper without action EMF, the duration of saturation 2 hours, x200; d – complex saturation with boron and copper with simultaneous action of EMF, the duration of saturation 2 hours, x200, (thermal etching)

Fig.2. X-ray diffraction picture taken from the surface of the carbon steel 45 with boride coatings obtained without action EMF after: a – boriding, the duration of saturation 2 hours; b – complex saturation with boron and copper, the duration of saturation 2 hours complex saturation with boron and copper without action EMF, the duration of saturation 2 hours
The research of roughness of complex boride layers obtained in various physical and chemical conditions has shown that the lowest level of roughness \(Ra = 0.0553\) is achieved at the complex boron and copper saturation using EMF, compared with \(Ra = 0.0650\) with dimming without EMF. When pounding in EMF \(Ra = 0.0855\), compared with \(Ra = 0.0961\) in the absence of EMF.

### CONCLUSIONS

The investigation of the crack resistance of diffusion boride coatings obtained in various physical and chemical conditions was carried out. It has been established that the highest cracking strength is achieved in the boride phases obtained in powder environments with the use of copper powder when applied to EMF, and on steel 20, respectively, is \(2.22 \text{ MPa} \cdot \text{m}^{0.5}\), with the shearing stress of 345 MPa. Then, when scattering without the action of EMF, the crack resistance of the steel is \(20 - 1.24 \text{ MPa} \cdot \text{m}^{0.5}\), and the stresses of shearing - 181 MPa. An increase in the magnitude of the stresses in the complex boride layers is due to the formation of phases of greater viscosity, for which the crack resistance \(K_{1C}\) in 1.4 - 1.7 times higher than the output boridephases (FeB, Fe2B).

The study of wear resistance of boride coatings obtained in various physical and chemical conditions was conducted. It has been established that diffusion boride coatings obtained with the use of an external magnetic field have higher tribotechnical characteristics. Thus, the average linear wear in the boride coatings obtained in the EMF is reduced by 2.4 times, and the coefficient of friction is 0.63 versus 0.66. In the case of the production of gloomy coatings obtained in EMF, the average linear deterioration is reduced by 1.8 times, the coefficient of friction decreases to 0.60 compared with 0.64 for gloomy coatings without EMF.

### REFERENCES
