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DETERMINATION OF AERODYNAMIC COEFFICIENTS NECESSARY FOR THE CONTROL OF MAVs

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Abstract: The present paper examines the use of free software to determine the aerodynamic coefficients of the selected MAVs. The resulting ratios and aerodynamic forces and momentums are tested for their applicability in the controlling of this type of aircrafts.

Keywords: MINI AIR VEHICLES (MAVs), AERODYNAMIC COEFFICIENTS, AERODYNAMIC FORCES AND MOMENTUMS, FREE SOFTWARE, CONTROL OF MAVs

Error! No sequence specified.

Introduction

For each specific task related to the use of unmanned aerial vehicles (UAV), different planar designs and algorithms for automatic control are applied. In intelligence and reconnaissance missions, the proper construction of the UAV is in the field of mini air vehicles (MAVs). Frequently used structure is in the shape of a flying wing.

When there are templates of complete flyer structures, it is necessary, together with their assembly, to carry out theoretical researches on the possibility of reaching the target of the mission. The main problems come from the fact that nothing can be learned about the flying characteristics and operational capabilities of the chosen MAV from the templates. For these characteristics, it is necessary to examine the profiles from which the MAV is built, as well as the aerodynamic coefficients entering the expressions for finding the aerodynamic forces and the momentums acting in the rigid body MAV. The forces and momentums thus found are involved in the complete mathematical model [4], [8] of the MAV, from which the appropriate control is synthesized [3], [5].

A suitable solution for the chosen case is the use of specialized software for studying in a profile and plan of a flying wing type MAV. Many such software platforms are available on the market, ranging from free to fairly expensive. All of them have their advantages, but particularly suited for the purpose, in terms of price and functionality, is the software product XFLR5 [7], [9], [11].

2. Examination of aerodynamic characteristics

For the purpose of the study, a flying wing type MAV was selected with the corresponding profile and plan dimensions [6]. After the wing has been fabricated, the dimensions of the obtained profiles are taken and the MAV is drawn in the middle of the XFLR5. The result is shown in Fig.1.

The profiles from which the MAV is constructed are three and after the measurement and interpolation, in relative dimensions they have the shapes shown in Fig.2.

1. The main profile named Osnoven profil - Max thickness 11.6% at 29.7% chord; Max camber 4.5% at 31.9% chord;
2. the middle profile named Mejdinen Profil - Max thickness 8.1% at 27.2% chord; Max camber 3.2% at 25.2% chord;
3. The end profile named Kraen Profil - Max thickness 15.8% at 47.5% chord; Max camber 6.2% at 54% chord.

For the study of the profiles from which the wing is made, the speeds for which the MAV is designed are set, and they are in the range V = 1 ÷ 20 m/s (3,6 ÷ 72 km/h). Also, the attack angle of the profile α = -50 ÷ 90 °is set. Fig.3 shows the results of the virtual air moving tunnel of the obtained profiles in the XFLR5 environment.
at three selected speeds: \( V_1 = 1 \text{ [m/s]} \); \( V_2 = 10 \text{ [m/s]} \); \( V_3 = 20 \text{ [m/s]} \) at specified attack angles \( \alpha \).

The results show (Fig. 3) that the lifting force for all three profiles is greatest for attack angles \( \alpha = 20 \div 40 ^\circ \), and the drag force is small at attack angles \( \alpha = 0 \div 20 ^\circ \). The aerodynamic quality of the angles of attack profiles is greatest at about \( \alpha \approx 20 ^\circ \). The polar graph shows the same trend for all profiles when changing the speed and angle of attack. On Fig.3 it is seen that the main profile manifests a flow collapse at maximum speed, and for the end profile such a collapse is still observed at intermediate speeds.

For the profile to be stable in the airflow, the pitch momentum coefficient should be \( c_m = 0 \). For the profiles thus obtained, this coefficient is zero at negative attack angles.

On the basis of these profiles and the selected geometry in the plan of the flying wing MAV type, the planer is developed (Fig.1). In the XFLR5 environment at different velocities and angles of attack (Fig. 4) the dependencies for the coefficients of the aerodynamic forces (Fig.5) and momentums (Fig.6) are obtained.

For additional balancing of the plane, it is necessary to relocate the load masses to the geometric dimensions of the planer or to put the altitude control surfaces in the appropriate position. In this case, a balance is selected by changing the angle of the control surfaces with \( \delta_\alpha = 5 ^\circ \). Fig. 6 shows the result of this control surfaces' adjustment, with the pitch momentum equal to zero at an angle of attack \( \alpha = 1,14 ^\circ \). The control surfaces' adjustment also influences the aerodynamic coefficients as shown in Fig.7.

It can be seen from Figure 7 that the lifting force is greatest at attack angle \( \alpha = 57 ^\circ \), and the drag coefficient is greatest at an angle of attack \( \alpha = 70 ^\circ \). It is noted that both factors are smaller in amplitude following the change of the angle of the control surfaces. The angle of attack at zero lift force \( \alpha_{cy0} = -0,34 ^\circ \), which is the expression of the coefficient of non-inductive resistance. It is evident from the graph of the polar in Fig.7 that after deflection of the rules, the quality of the MAV deteriorates slightly due to the displacement of the graph to the right and also to the slight increase of the inductive resistance. However, the maximum qualities of the wing are close (Fig.7).
tendency for the MAV to change its vertical speed when changing the horizontal at a fixed lift.

The asymmetry and the behavior of the polar in the half-plane of the negative force coefficients (Fig. 7) enables the MAV to perform inverted flights, and also provide information regarding the difference in the execution of figures in normal and inverted flight. It shows that the figures in the inverted flight are limited by the angle of attack.

Fig. 8 The ability of an MAV to climb or descend at different angles of attack.

Three characteristic points are also defined on the MAV’s polar. The first one is for the critical angle of the attack - \( \alpha_{cr} \). The critical angle of attack (Fig. 7) \( \alpha_{cr} = 59\,^\circ \), at this angle the aircraft is held in the air at the minimum possible speed, which is useful for the landings. For the constructed MAV at weight \( G = 0,609 \, [\text{kg}] \), the lifting force in the vertical plane is obtained at a linear velocity \( V_x = 3,714 \, [\text{m/s}] \) (Fig.9a). The safe lifting force must be less than the critical lifts at critical attack angles. It is obtained in the flight tests and lies within the limit of the lift coefficient when starting the transition and the maximum lifting force.

Fig. 9 The ability of the MAV: a) to fly at critical attack angles; b) to fly at maximum speed.

The next one is for the economic angle of the attack - \( \alpha_{econ} \) (the most advantageous) in which the drag coefficient is minimal but different from zero, at this angle of attack, the inductive resistance is a half of the resistance of the airplane and the aircraft can fly at maximum speed (Fig. 9b)). At this angle, the deviation of the full aerodynamic force from the air flow direction is maximal. To find this polar point, the aerodynamic quality chart of the MAV is used (Fig.7). It shows that the most advantageous angle of attack is \( \alpha = 2.5^\circ \). For this angle, the lifting force significantly exceeds the drag coefficient and the linear velocity is \( V_x = 14,15 \, [\text{m/s}] \) (Fig. 9b)). With this speed, the MAV can fly at a fixed lift.

The last polar point is for the most favorable angle of attack (Fig. 7) \( \alpha = 24^\circ \). At this angle, the quality of MAV is the maximum \( K = 9.3 \). Then, only at this angle of attack for a certain height, it flies the farthest (windless) because the lift force is 9.3 times greater than the drag, and for 1 meter altitude the airplane will fly 9.3 [m] (if the air is still).

The polar of wing and its derivative - the aerodynamic quality, show virtually all the basic planning properties of the developed MAV. In order for this to happen, the wind speed needs to be 0.00 [m/s] (calm atmosphere), the airplane should not change its planning speed and its engine must be off. This feature of the MAV is useful when the engine shuts down into the air or when the battery capacity is exhausted.

Aside from the fact that the polar (Fig. 7) shows the planning properties of the MAV, it also determines the angle of planning, which is also the angle of the slope of the trajectory. From formula (1), it can be seen that the planning angle depends only on the aerodynamic output of the MAV.

\[
\tan \Theta_{pl} = \frac{1}{K_{aer}},
\]

where \( \Theta_{pl} \) is the angle of slope of the trajectory, \( K_{aer} \) is the aerodynamic quality of the wing.

From formula (1), it is clear that the minimum planning angle is reached at the most favorable attack angle when the aerodynamic quality of the MAV is greatest. Any other planning angle is achieved either by a small angle of attack and a high velocity or at a great angle and low speed, or these are the first and second planning modes.

The polar of the speeds (Fig.8b) is also an indicator of the glide path. It defines the angle of the trajectory slope, the planning speeds and the vertical descent in a steady rectilinear flight. It is especially useful when the engine shuts down in flight. This graph also determines the most economical speed and the most favorable speed, which is \( V_x = 4.7 \, [\text{m/s}] \).

In the presence of wind, the planning distance changes because of the change in the flight speed of the flight and the angle of wind direction reference. If the graph of Fig. 8 (b) is shifted with the wind indicators, the characteristics of the current flight conditions are obtained for the MAV. Only the maximum, minimum, economy and best flight speeds are not changed.

Unlike the minimum flight speed, the maximum speed is limited by the thrust of the propelled engine propulsion system. For the determination of the maximum and minimum flight speeds it is assumed that the flying wing model is absolutely smooth and the thrust does not depend on the flight velocity, which is practically valid for the electric motor driven screws.

For the thrust of the engine-propeller system used [2], the graph in Fig.10 is valid. It was taken experimentally and processed with mathematical methods for smoothing.

Fig. 10. The thrust of the engine-propeller system depends on the engine speed in function of the control.

The static thrust of the engine-propeller system is taken at zero speeds of the air flow. A propeller (9*3.5) has been selected for the engine-propeller system operation. This propeller at maximum speed has a thrust of 760 grams or 7,453054 [N] at a flow rate of 9.5 [m/s].

Starting from the assumption that the propeller rotates at the same speed for the entire speed range, it results that for propeller 9*3.5 at zero flight speed the thrust will be 760 grams or 7,453054 [N], and at speed 9.5 [m/s] flight, the propeller will be screwed into the air and will not pull it back in any way, so the thrust will be zero.

This is the basis for Zhukovski's curves for the available and necessary trust. First, the graph of the dependence of the force of the linear drag on the linear velocity of the flight is constructed. In the MATLAB system then is imported the thrust data of the selected engine-propeller system and the overall graph shown in Fig.11 is drawn.
As can be seen from the graph in Fig.11, the model thus created will fly in a horizontal flight at \( V_x = 9.43 \) [m/s] and 99% thrust (Fig.10).

**Fig. 11 Zhukovsky curves for the available and needed thrust.**

For more accurate calculations of the engine-propeller system, simulations need to be made in specialized software products such as Qblade or MotoCalc.

The last speed of the flight is the cruise speed at which the MAV travels one kilometer with minimal fuel consumption. This speed allows for a maximum mileage with a fixed fuel volume where the ratio between the required thrust and the flight speed has a minimum value. At this speed, the MAV usually flies to the point of execution of the main mission, during reconnaissance missions, etc. This velocity (Fig. 11) is \( V = 9.5 \) [m/s].

### 3. Completing the mathematical model of MAVs

For the aerodynamic forces and momentums acting on this aircraft, the dependencies are shown in Fig.12 and Fig.13 (a). Fig. 12 depicts the dependencies for respectively: (a) the lift force; and (b) the drag force. Fig.13 shows respectively a) the pitching momentum and the developed MAV.

**Fig. 12. The aerodynamic forces of lift and drag.**

**Fig. 13. The momentum of the pitch and the developed MAV.**

The aerodynamic forces and momentums obtained in this way are designed to work with a mathematical model of motion of the MAV [10]:

- changing the amount of movement:
  \[
  \frac{dV}{dt} + \omega \times V = \sum F
  \]

- to change the kinetic momentum:
  \[
  \frac{d\omega}{dt} + \omega \times \omega = \sum M
  \]

where \( V, \omega \), are main momentums of inertia; \( I_x, I_y, I_z \) are main momentums of inertia; \( \sum M, \sum M, \sum M \) are the sum of the projections of the moment in the rigid body.

The model thus synthesized is designed to work in the flying-navigation complex of the MAV [1]

### 4. Conclusions and results

1. The profiles that are obtained after the assembly of the finished templates from which the MAV was made are studied.
2. Survey of the planner of the MAV was made. The results are described in the report.
3. The angular-speed restrictions for the MAV created were obtained.
4. Validation of the results which will be obtained in the aerodynamic tube and in real-life flights is pending.

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DESIGN OF STUD ENDS AND THEIR INFLUENCE ON LOAD OF MACHINE HOUSINGS

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Abstract: The article discusses a calculation procedure for determining the load and stress conditions in stud joints. There are considered two basic types of stud fixing: with a circular rim and with an abutting end. There are given the equations for calculation of tightening torques for both types of studs. It is shown the load distribution in joined parts and by help of experimental research is shown that studs with the circular rim are a bit stronger than the studs with the abutting end.

Keywords: CONDITION OF COMMON DEFORMATIONS, LOAD DISTRIBUTION, STUD, CIRCULAR RIM, ABUTTING END

1. Introduction

Studs are widely used for joint of machine housings and frames made of light alloys and cast iron and sometimes made of steel and titanium alloys. Components with studs can for example be some joints, covers, frames, or cylinders. In some designs, when it is necessary to dismount the parts very often, is not recommended to use the screws, which must be screwed into the frame because the internal thread can be broken. In these cases, the studs are usually used. To eliminate the rotation during tightening, the stud must be fixed into the frame enough tightly. There are various methods of stud fixing into the frame [1], which can be evaluated, based on the efficiency of stopping, stability of the tightening and the reliability of joints.

Let us consider a case when both threaded parts are stretched. From the equilibrium condition of the forces acting on the screw, can be obtained

\[ \int_0^H q(z)dz = F_1 - F_4 \] and for the nut

\[ \int_0^H q(z)dz = F_3 - F_2. \] (3)

The forces \( F_B(z) \) and \( F_N(z) \) acting on any cross-sections \( z \) of the screw and the nut will be

\[ F_B(z) = F_4 + \int_0^z q(z)dz \] and \( F_N(z) = F_3 - \int_0^z q(z)dz \). (4)

In this work is considered changing of the maximal load on the thread by some methods of stud fixing in the frame. The frame is presented as a nut with the external diameter \( d_e = 4d \) since the stress on the external surface of the nut accounts only for 1/16 of the maximal stresses [3].

2. Condition of common deformations

Studs usually are loaded by more complicated loading schemes than classical bolt-nut joints. Therefore, it is necessary to analyze load distribution in common case of joint loading before of considering of load distribution into studs.

Condition of common deformations has a usual form

\[ \Delta_1 + \Delta_2 = [\delta_1(z) + \delta_2(z)] - [\delta_1(0) + \delta_2(0)]. \] (1)

where \( \Delta_1 = \int_0^1 \sigma_1(z)dz \) and \( \Delta_2 = \int_0^1 \sigma_2(z)dz \) are stud elongation and frame contraction, accordingly. Hereinafter index 1 and index 2 will be used for the stud and for the housing accordingly. \( \delta_1(0) + \delta_2(0) \) and \( \delta_1(z) + \delta_2(z) \) are axial displacements of the threads along the pitch diameter \( d_z \) in cross sections \( z = 0 \) and \( z \). \( \sigma_1(z) \) and \( \sigma_2(z) \) are stresses in the cross section \( z \). \( E_1 \) and \( E_2 \) are modulus of elasticity of the materials.

Commonly, four forces may act on a threaded joint. These forces are (Fig. 1)

\[ F_1 + F_2 = F_3 + F_4. \] (2)

Let us consider a case when both threaded parts are stretched. From the equilibrium condition of the forces acting on the screw, can be obtained

\[ \int_0^H q(z)dz = F_1 - F_4 \] and for the nut

\[ \int_0^H q(z)dz = F_3 - F_2. \] (3)

The forces \( F_B(z) \) and \( F_N(z) \) acting on any cross-sections \( z \) of the screw and the nut will be

\[ F_B(z) = F_4 + \int_0^z q(z)dz \] and \( F_N(z) = F_3 - \int_0^z q(z)dz \). (4)

In this work is considered changing of the maximal load on the thread by some methods of stud fixing in the frame. The frame is presented as a nut with the external diameter \( d_e = 4d \) since the stress on the external surface of the nut accounts only for 1/16 of the maximal stresses [3].

The deformations of the screw shank and the nut body can be determined as follows

\[ \Delta_1 = \frac{1}{E_1A_1} \int_0^1 F_B(z)dz = \frac{1}{E_1A_1} \int_0^1 [F_4 - \int_0^z q(z)dz]dz, \] (5)

\[ \Delta_2 = \frac{1}{E_2A_2} \int_0^1 F_N(z)dz = \frac{1}{E_2A_2} \int_0^1 [F_3 - \int_0^z q(z)dz]dz, \] (6)

where \( A \) – area of cross-section, \( q \) – intensity of load distribution.

Let us substitute these equations into the Eq. (1). The value of \( \Delta_2 \) is accepted with \((-\) -) since the nut is stretched. Differentiating Eq. (1) with respect to \( z \) can be obtained

\[ \beta \int_0^1 q(z)dz + \frac{F_4}{E_1A_1} - \frac{F_3}{E_2A_2} = \gamma \cdot \hat{q}(z) + \xi \cdot \tilde{q}(z), \] (7)

where

\[ \delta_1(z) = \delta_1'(z) + \delta_1''(z), \] \( \delta_2(z) = \delta_2'(z) + \delta_2''(z), \)

\[ \delta_1'(z) = \frac{p(z) \cdot P}{E_1} \lambda_1, \quad \delta_2'(z) = \frac{p(z) \cdot P}{E_2} \lambda_2, \]
The lower signs correspond to the scheme of loading when the compressing force act on the screw.

3. Analysis of load and torque

It is a usual practice to induce force of preliminary tightening $F_0$ initially upon the assembly of the parts before the external load $F_e$ on the stud is applied. After screwing of the stud into the frame, the axial force $F_0$ arises. The resultant force that is carried by the stud screwed into the frame may be written as $F = F_1 + F_0 + \chi F_e$, where $\chi$ is a coefficient of the external load, $\chi = 0.2 \ldots 0.4$ [2].

![Diagram of the stud fixing with the circular rim.](image)

b) The load distribution on the threads:

$I$ – force $F_e$ in the section $a - a$ is applied,

$II$ – force $F_e$ in the section $b - b$ is applied;

$I$ – from $F_0$, $2$ – from $F_0$, $3$ – from $\chi F_e$, $4$ – from total load.

The initial stress is established according to the conditions of joint tightness. It can be decreased due to the squeeze of thread roughness, stress relaxation etc. and increased due to hydraulic impact, works on resonant mode etc. Therefore, the initial stress can be changed by $\eta$ times. Then the axial tightening force can be expressed as $F_0 = \eta F_e (1 - \rho)$, where the safety factor $\eta = 1.25 \ldots 4.0$ [2]. After assembling of the stud joint is necessary to apply the torque $M_0$ to create a sufficient axial force $F_0$ to provide joint tightness. The tightening torque must be

$$M_0 = \eta \cdot F_e \left( 1 - \rho \right) \frac{d_1^2}{2} \frac{P}{\pi \cdot d_z^2} + f_1'$$
where $f'_1 = f_1 \cos \frac{\alpha}{2}$, $f_1$ is the friction factor in the frame and stud zone.

At the same time, the torque $M_0$ is equal to the sum of the friction moment in the threads $M_t$ and the friction moment $M_r$ between the stud and frame supporting surfaces, i.e.

$$M_0 = M_t + M_r.$$  \hfill (11)

Let us consider stud fixing into the frame with a circular rim (Fig. 2). The fixing of the stud causes the axial force $F_t$ in the stud and frame contact zone. Then

$$M_t = F_t \frac{d^2_3}{2} \left( \frac{P'}{\pi d_2} + f'_2 \right)$$

and

$$M_r = F_t f_3 \frac{D^3_r - (d')^3}{3 D^2_r - (d')^2},$$  \hfill (12)

where $f'_2 = f_2 \cos \frac{\alpha}{2}$, $f_2$ is the friction factor in the stud and frame zone, $f_3$ is the friction factor on the supported surface of the rim.

From Eqs. (10) – (12) the necessary axial force $F_t$ can be obtained as follows

$$F_t = \eta \cdot F_e (1 - \chi) \left( \frac{d^2_3}{\pi d_2} \left( \frac{P'}{\pi d_2} + f'_2 \right) + \frac{2 f_3 D^3_r + (d')^3}{3 D^2_r - (d')^2} \right).$$  \hfill (13)

From Eqs. (13) and (14) it follows that the force $F_t$ is identical in both methods of stud fixing if $d_a = \frac{D^3_d + (d')^3}{D^2_d - (d')^2}$. In this case $d_a > d'$, however, it is structurally impossible. Therefore, the force $F_t$ will be always higher at stud fixing with the abutting end than at fixing with the circular rim (with other things being equal).

The forces $F_0$ and $F_e$ have an identical influence on load distribution in both methods of stud fixing. The force $F_0$ stretches the stud and compresses the frame. The force $F_e$ compresses the frame and stretches the stud if it is applied to section $a - a$ and stretches both the stud and the frame if it is applied to section $b - b$.

The force $F_t$ stretches the stud and compresses the housing at fixing with the circular rim. At fixing with the abutting end this force compresses the stud and stretches the housing. It means that the difference of the maximal load value on the thread takes place only due to the action of the force $F_t$.

Qualitative diagrams of the $q(z)$ are shown in Figs. 2 and 3. More frequently are used studs M8 and M10 [1]. In Table 1 are shown the results of load calculation in critical sections for such joints.

![Table 1. The load on stud and frame threads, % of $F_t$ (the stud made of steel, $f = 0.15$, $n = 10$)](image)

<table>
<thead>
<tr>
<th>Case material</th>
<th>Thread</th>
<th>Type of fixing</th>
<th>circular rim</th>
<th>abutting end</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>cross-section</td>
<td>$z = H$</td>
<td>$z = H$</td>
</tr>
<tr>
<td>Steel</td>
<td>M8x1.25</td>
<td>34.60</td>
<td>1.36</td>
<td>0.48</td>
</tr>
<tr>
<td></td>
<td>M10x1.5</td>
<td>33.58</td>
<td>1.53</td>
<td>0.55</td>
</tr>
<tr>
<td>Cast iron</td>
<td>M8x1.25</td>
<td>28.98</td>
<td>2.44</td>
<td>1.31</td>
</tr>
<tr>
<td></td>
<td>M10x1.5</td>
<td>28.08</td>
<td>2.67</td>
<td>1.46</td>
</tr>
<tr>
<td>Aluminum alloy</td>
<td>M8x1.25</td>
<td>27.53</td>
<td>2.82</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>M10x1.5</td>
<td>26.66</td>
<td>3.06</td>
<td>1.76</td>
</tr>
</tbody>
</table>

Table 1 shows that most of load $F_t$ is applied to section $z = H$ on fixing with the circular rim and to section $z = 0$ on fixing with the abutting end. Then the complete loading $F'(i) = F_t(i) + F_0(i) + \chi \cdot F_e(i)$ in section $z = H$ (critical section of the stud) will be higher on fixing with the circular rim than with the abutting end. It means that the reliability of the stud with the abutting end should be higher than the stud with the circular rim for an ideally made and fixed joint. In practice, because of inaccurate manufacturing and fixing of threaded parts, in the thread a bending moment arises, decreasing the stud’s reliability. The circular rim (Fig. 3) allows a decrease in the influence of the bending moment and an increase in the joint reliability [2].

The section $z = 0$ is the critical section for the frame. Total load $F(i)$ in this section will be greater for stud fixing with the abutting end than with the circular rim. It should be remembered that the value of force $F_t$ is also greater for such type of fixing. It means that on joining the frame and parts by the studs with a small number of working threads, fixing with the circular rim should be preferred.
4. Experimental research

Tests of stud specimens were made on a tensile machine. Two methods of stud fixing in the frame were investigated: with circular rims and with abutting ends. Studs had the thread M10x1.5 and M8 with pitches $P = 1.25$, 1.0 and 0.75 mm. Studs were made of medium-carbon steel. Nuts were made of the same steel and of cast iron. The number of working threads was equal for both types of studs. The frame was present by nuts with the external diameter $d_e = 4d$. The torque was equal to 14 Nm for the thread M10 and 8 Nm for the thread M8.

Experimental results have shown that studs with the circular rim are about 6% ... 8% stronger than studs with the abutting end. It agree with the results of fatigue tests [2]. All studs are broken on section $a–a$ (Figs. 2 and 3). Studs with the circular rim are stronger owing to a decrease in bending in the critical section of the stud.

Frame material (medium-carbon steel and cast iron), does not influence stud reliability, difference is less than 1%. Studs reliability increases with a decrease in thread pitch explained by an increase in the stud cross-section not by the leveling of load distribution. Circular rims allow a decrease in the influence of the bending moment and an increase in joints reliability. The reliability of the frame also increases when the stud is fixed with the circular rim.

Conclusions

The force of preliminary tightening and external load on the joint have an identical influence on load distribution in stud joints at stud fixing with a circular rim and an abutting end. The difference in load distribution on the working threads takes place only due to the action of axial load arisen after stud fixing in the frame. The total load in the stud critical section will be more on fixing of the stud having a circular rim but owing to manufacturing inaccuracy and fixing of threaded parts, the bending moments lowering the stud reliability occurs. The circular rim allows to decrease the influence of the bending moment and to increase the reliability of the joint. The reliability of the housing also increases at stud fixing by help of the circular rim.

Acknowledgments

The author would like to thank Department of Mechanical and Industrial Engineering (TTÜ) for supporting this research activity.

References

Patency and safety of self-propelled wheeled machine are
critical indicators of its quality, which will depend on the
performance of its properties and performance of road conditions.
When assessing the passability and safety of self-propelled
machines, the issues of redistribution of tractive forces (or
slippage) on their wheels when moving along a curve are
practically not considered. The machine is a one-piece structure,
considering only the greatest load when assessing the movement
of machines on the ground and on a paved road on a turn is not
sufficient. Therefore, when assessing the complex indicators of
the quality of patency and machine safety, it becomes necessary to
take into account also the redistribution of their skidding.
Controllability and rotatability, are characterized by kinematic
(taujectory, turning radius, etc.) and power (torque on driving
wheels, reactions, etc.) parameters [1].

With the movement of self-propelled wheeled vehicles in
general, and at the turn in particular, the question arises of
determining the loss of the speed of the machine, that is, the
question of determining their skidding. Usually, under the
skidding of a wheeled vehicle, we mean the loss of speed of the
center of the driving bridge, that is, the skidding of some fictitious
wheel having a free radius equal to the radius of the driving
wheels and located in the middle of the drivetrain. This definition
of skidding is acceptable for cases of rectilinear motion. The
movement of the wheeled vehicle in the turning mode is estimated
from the movement of its center of mass. Therefore, the skidding
of the wheeled vehicle in the turning mode will be defined as the
loss of its center of mass velocity.

\[ \delta = \frac{V_{TC} - V_C}{V_{TC}}, \]  (1)

\[ V_{TC}, V_C - \text{respectively, the theoretical and actual speeds of the} \]
\[ \text{center of mass of the machine.} \]

The object of the study is a self-propelled machine with a 4x4
wheel arrangement with two controllable drivetrain and an
onboard blocked transmission [2, 3, 4]. In this case, the angular
velocities of the driving wheels and the dummy wheel located at
the center of the machine's masses are the same \( w = w_1 = w_2 \).

Let us express the angular velocities in terms of linear
velocities and the radii of the rolling of the wheels . Considering,
that \( r_{ki} = r_{ki}^0 (1 - \delta_i) \), where \( r_{ki}, r_{ki}^0 - \) valid and free rolling wheel
\( i; \delta_i - \) Wheel slippage \( i \), we get

\[ \frac{V_C}{1 - \delta_H} = \frac{v_2'}{1 - \delta_2} = \frac{\dot{v}_1'}{1 - \delta_1'}; \quad \frac{V_C}{1 - \delta_H} = \frac{v_2''}{1 - \delta_2''} = \frac{\dot{v}_1''}{1 - \delta_1''}, \]  (2)

\( v_1', (\delta_1'), v_1'', (\delta_1'') \) - speed (skidding) of the lagging and running wheels of the front drivetrain; \( v_2', (\delta_2'), v_2'', (\delta_2'') \) - speed (skidding) of the lagging and running wheels of the rear drivetrain;

Taking into account the equality of the projection of the absolute velocities of the points of the machine onto the line passing through them, we obtain

\[ V_C \cos(\alpha_2 - \eta_M) = v_2' \cos(\alpha_2' + \alpha_2''), \]

\[ V_C \cos(\alpha_2 + \eta_M) = v_2'' \cos(\alpha_2' + \alpha_2''), \]  (3)

\[ V_C \cos(\alpha_1 + \eta_M) = \dot{v}_1 \cos(\alpha_1' + \alpha_1''). \]

\[ V_C \cos(\alpha_1' + \eta_M) = \dot{v}_1'' \cos(\alpha_1' + \alpha_1''). \]  (4)

\( \alpha_1', (\alpha_2') \) and \( \alpha_1'', (\alpha_2'') \) - angles of rotation of the lagging and running wheels, respectively, of the front (rear) drivetrain; \( \alpha_1 \) and \( \alpha_2 \) - angles that depend from the design of the machine; \( \eta_M \) - the angle that makes up the velocity vector of the center of mass \( V_C \) with its longitudinal axis.

These angles are determined by formulas [5]

\[ \alpha_1 = \arccos \frac{a}{\sqrt{a^2 + (0.5B)^2}}, \]  (5)
\[ \epsilon_2 = \arccos\left(\frac{b}{\sqrt{b^2 + (0.5B)^2}}\right), \]  
(6)

\[ \eta_M = \arctg\left(\frac{btg\alpha_1 - atg\alpha_2}{Ltg^2\alpha_1}\right), \]  
(7)

\(a, b\) – distance of the center of mass of the machine, respectively, to the front and rear wheels; \(B\) – track; \(L\) – longitudinal base; \(\alpha_1, \alpha_2\) – average rotation angles of the front and rear axles.

Knowing the tractive forces on all wheels, you can determine the slip coefficients on each wheel, using formula [2]

\[ \delta = \frac{l}{Gr_c}\left(Gf - \sqrt{Gf(Gf - P_T)}\right). \]  
(2.21)

\(l\) - half the contact length of the machine wheel with support; \(G\) - the weight falls on the wheel; \(r_c\) - static wheel radius; \(f\) - coefficient of friction rolling wheels; \(P_T\) - tractive power of the wheel.

From equations (3) and (4), we find the velocities of the centers of mass of the front and rear drivetrain, and taking into account (2), (5), (6), and (7) we obtain

\[ \delta_B = 1 - \left(1 - \delta_i^1\right)\cos(\epsilon_1 - \alpha_i^1) + \left(1 - \delta_i^2\right)\cos(\epsilon_2 - \alpha_i^2) \]
\[ \cos(\epsilon_2 - \eta_M) + \cos(\epsilon_1 + \eta_M) \]

\[ \delta_H = 1 - \left(1 - \delta_i^1\right)\cos(\epsilon_1 + \alpha_i^1) + \left(1 - \delta_i^2\right)\cos(\epsilon_2 + \alpha_i^2) \]
\[ \cos(\epsilon_2 + \eta_M) + \cos(\epsilon_1 - \eta_M) \]

\(\delta_B, \delta_H\) - coefficients of slipping by the inside (lagging) and outside (running) sides of the machine with a rigid frame.

As is known, at a given angle of rotation of the bridges, the corresponding angles of rotation of the inner and outer wheels of a self-propelled wheeled vehicle with a rigid frame relative to the center of rotation are different. This difference is calculated by formulas [5]

\[ tg\alpha_i^1 = \frac{Ltg\alpha_i}{L - 0.5B(tg\alpha_1 + tg\alpha_2)} \]  
(10)

\[ tg\alpha_i^2 = \frac{Ltg\alpha_i}{L - 0.5B(tg\alpha_1 + tg\alpha_2)} \]  
(11)

\(\alpha_i\) and \(\alpha_i\) - angles of rotation of the inner and outer wheels of the \(i\)-th drivetrain.

Proceeding from this in the article, in the final analysis, expressions are derived for the calculation of the slipping along the inner and outer sides of the self-propelled machine relative to the center of rotation.

Thus, it is possible to make a theoretical estimate of the redistribution of wheel slippage along the sides for various designs of self-propelled machines with a rigid frame, respectively, to make a comprehensive assessment of both the passability and safety of the machine and its efficiency.

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SCIENTIFIC SUBSTANTIATION OF IMPROVED METHOD OF THE DIAGNOSIS OF HYDRAULIC DRIVES USED ON COMBINE HARVESTERS

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Abstract. Maintaining of the combine harvesters in an efficient condition throughout the harvest season is an important task of technical service. The most important elements in the work of combine harvesters are their steering mechanisms, the performance of which must have a high degree of availability, especially of their hydraulic drives. The purpose of this study is to increase the operational reliability of the steering drives of the combine harvesters, based on the development of an improved method for diagnosing of their hydraulic drives. During the research, the methods of theoretical and experimental research were used, based on the theory of machine operation, hydraulics, as well as modern methods of experimental studies of hydraulic equipment. The data of the experimental studies were processed by statistical methods using a PC. Theoretically and experimentally, an improved method for diagnosing of the hydraulic drives has been developed with the aim to increase the technical readiness of combine harvesters and reduce the costs of their maintenance and repair. A new methodical approach and results of studies on the creation of a diagnostic system for the hydraulic drive of the combine harvester's power steering have been developed.

KEYWORDS: HYDRAULIC DRIVE, COMBINE HARVESTER, DIAGNOSINGS, VOLUMETRIC EFFICIENCY, RELIABILITY, DIAGNOSING TIME

1. Introduction

As established by basic observations and studies [1], the optimal duration of harvesting of small grain crops, in which the loss of grain of grain crops should not exceed 2.5% of the harvested crop, should be no more than 7-10 days. Prolongation of the harvesting time can lead to significant losses, which can sometimes reach 20-30% of the crop yield [2]. Works on the preparation of feed and harvesting of root crops should also be carried out at the optimum time to prevent deterioration of the quality of harvested products and losses. One of the reasons for increasing the duration of harvesting is the insufficiently high reliability of combine harvesters, which leads to their downtime due to trouble shooting. The duration of combine harvesters downtime due to the maintenance and troubleshooting works reaches, in average, 0.5-0.6 hours per hour of net harvester work [3, 8,]. A significant part of the downtime is associated with the elimination of faults in the hydraulic drives of combine harvesters.

About 24% of failures, from the total number of failures on the combine harvesters, falls on hydraulic drives [4, 10, 11]. The reliability of the work of combine harvesters largely depends on the level of technical service [5, 6].

2. Results and Discussion

As a main aim of the study was to increase the technical reliability of combine harvesters and reduce the costs of their maintenance and repair.

Increasing the reliability of the hydraulic drives of combine harvesters is affected by timely detection at early stages of development and troubleshooting. This is achieved by creating and implementing of a system for the technical diagnosis of hydraulic drives, which ensures the interaction of the facility and diagnostic tools with the solution of the following issues: the determination of the type and purpose of the diagnostic systems; analysis of physical processes that take place in the object of diagnosis in order to establish the mechanisms of occurrence and signs of manifestations of injuries and defects; establishment of a list and normative values of diagnostic parameters that characterize the technical station of hydroelectric units; development of diagnostic tools and algorithms for troubleshooting. Such methodical approach was implemented when creating a diagnostic system for the hydraulic drive of the combine harvesters steering. The most expedient, at this stage, for hydraulic steering is the use of a functional type of diagnosis with the determination of both the general technical state and locally individual units using a portable set of mechanical external diagnostic tools.

The main purpose of the diagnostic system is to search for malfunctions and determine the technical condition of hydraulic units and predict the period of their further operation. An analysis of the physical processes that occur during the operation of the hydraulic drive is carried out by using the diagnostic model (Fig. 1).

To do this, a specific hydraulic power steering is conventionally divided into structural units, which can be as follows: a working fluid tank (T); power supply pump (CP); pump-dozer (DP); hydraulic cylinders (C); controlled wheels (KK). The structural-functional model is built for the following modes of operation of the steering: the movement of the combine harvester in straight direction or curvilinear with a fixed turning radius; rotation of controlled wheels at different speeds with a movable and immovable combine harvester; turning of the combine harvester with the pump running and in idle working regime.

Each block of the structural-functional model is characterized by the action of external and internal input and initial parameters. Each of the parameters presented in the diagnostic model for a particular operating mode of the hydraulic drive meets the quantitative value according to the technical requirements for the manufacture of hydraulic units and their components. Changing these parameters during the operation of the hydraulic drive leads to a disruption in the working process, which is characterized by different types of faults.

Experimental studies have been carried out to establish the nature of the changes in the structural parameters of hydraulic units and their effect on the operational performance of the steering of a combine harvester. The sets of hydraulic units of the steering with different degrees of wear were selected. With the complete sets of hydraulic units, tests were carried out according to the parameters with regard to the technical requirements for manufacturing. After the tests, the hydraulic units were dismantled and a there was done the determination of the change in the structural parameters (dimensions) of the surfaces of the parts, which were worked out during operation. The results of the measurements (micrometer) were processed according to existing methods.
The volumetric efficiency of the NSh-10 pump was determined as a result of dividing the actual supply of the working fluid by the theoretical feed at the appropriate speed of the drive shaft, the nominal pressure and temperature. The wearing of the surfaces of the parts leads to an increase in the gaps in the clearances, which also causes a decrease in the volumetric efficiency of the pump.

According to the data of experimental studies, the loss of working fluid in the conjugation "body–spool" of the dispenser is about 90% of the total loss of working fluid in the metering pump and can reach the value 18 l min⁻¹. Loss of working fluid in the couplment of the flow amplifier components, preliminary and shut-off valves, power cylinders change during operation in a small range (0.05–0.06 l min⁻¹) and during maintenance can be reduced to almost nominal values by performing adjusting and cleaning operations, as well as by replacing the seal.

Tests were carried out on the working fluid, which is provided by the manufacturer for a particular combine harvester. The load regimes and the temperature of the working fluid were created within the limits prescribed by the normative documentation for hydroelectric generators and combine harvesters. During the experimental studies, the evaluation of the initial diagnostic parameters (nominal, permissible, limiting) were determined. To determine the effect of changes in structural parameters on the main performance indicators of the operability of steering control of combine harvesters, which are regulated by the relevant standards, the experimental studies were carried out. Complete sets of hydraulic units of the power steering of the combine harvesters with different degree of wear of the surfaces of the parts were installed on the experimental installation, on which such parameters were created and controlled:

- frequency of the drive shaft of the gear pump; feeding of the supply pump and the metering pump;
- pressure and temperature of the working fluid;
- steering wheel speed;
- the duration of the complete displacement of the pistons of the hydraulic cylinders, which corresponds to the complete rotation of the steerable wheels from one extreme position to the other;
- speed of the steering wheel slip;
- speed of displacement of pistons of hydraulic cylinders;
- load on the rods of hydraulic cylinders;
- loss of working fluid in hydraulic units and their interfacing.

Based on the results of the study, a list and normative values of diagnostic parameters (nominal, permissible, limiting) were determined. The nominal values of the diagnostic parameters correspond to the nominal values of the technical condition parameters of the new hydraulic units in accordance with the technical requirements of the manufacturer. Limit values of diagnostic parameters meet the
The technical condition of hydraulic units, in which further operation of combine harvesters is impossible based on the requirements of traffic safety and cost-effectiveness.

The permissible values of the diagnostic parameters were determined according to the existing methods [7] proceeding from the fact that they meet the technical condition of the hydraulic units in which this unit has the possibility to operate during the determined period of time without fail until the next diagnosis:

\[ P_A = P_N - \frac{P_L - P_N}{1 + T_2/T_1}, \]

where \( P_A \) – allowable value of the deviation of the diagnostic parameter; \( P_N \) – the maximum (nominal) value of the diagnostic parameter for the new unit; \( P_L \) – limit value of the diagnostic parameter; \( T_2 \) – normative value of the before-repair life of the unit; \( T_1 \) – the normative value of the frequency of diagnosing; \( \alpha \) – indicator of the unit wearing dynamics.

To measure justified diagnostic parameters, the sets of means for their use have been developed [9].

Troubleshooting is carried out according to the developed algorithms. A set of mutually agreed rules, methods and means of express, operational and periodic diagnosis of hydraulic drives of combine harvesters, the effectiveness of which was confirmed by laboratory and production tests.

3. Conclusions

1. The application of the developed system of technical diagnostics of hydraulic drives of the combine harvesters steering control ensures that the readiness of the hydraulic turbo units is adjusted to 0.85-0.90, and increases the use of their resource by 20-25%.

2. The duration of express diagnosis of the hydraulic power steering has the average value of about 5 minutes, and a full diagnosis using external technical diagnostics is about 30 minutes.

3. The credibility of the technical diagnosis of the hydraulic steering gear for a given depth of fault location is in the range of 90-95%.

4. References

BEARING CONSTRUCTION OF PASSENGER’S SEAT, AND THE ACCT/AFFECT OF THE SAFE AREA DURING THE BUS’S ACCIDENT

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Abstract: This paper investigations detail analysis of the influence the type of construction and the way of fixing seat bearers on basic bus construction and its superstructure. Before performing experimental investigations it was modelling of tension-deformation condition of across frame made by using Finite Element Methods. During experimental investigations on basis of this analysis it was founded three measuring points where deformations were measuring. According results from experimental investigations it was third type of seat bearers allowing raise of safety area of bus passenger’s.

Keywords: SEAT BEARERS, ACROSS FRAME, DEFORMATION, PASSENGER’S SAFETY AREA

1. Introduction

Static investigations of bus across frame are for definition of side frame of bus superstructure made, for less weight construction which will be ECE standards satisfied. These investigations are for aspect of passengers safety area satisfied in condition of bus turning over.

For investigations of the influence of seat bearers on static bearing of superstructure side frame, were three side frames from the same material made, quality x5CrNi1810, with real frame bus dimensions. The time of experiments the seat bearers were put on the basis of bus construction and the frame of the bus. Three types of constructive bearer’s seat were used. By static experiments of frames were F-I diagrams obtained (Deformation the frame depending from the Force which it’s loading). By continuously measuring the deformations of measuring frame points (places) were curve deformation obtained which are passenger’s safety area defined.

Experimental investigations were by normal force which is acting in the upper area of the frame done, where is this force action during the bus’s accident (overturning) expected. Steel cord appointing direction of the force action, is around 15° for horizon plane (Fig. 1).

With variable force F assigning, by hand lever using, in the upper part of the frame, with variable force increasing from 200 [N] it was deformation of the frame in three points measuring, on “a”, “b” and “c” point. For every additional increasing force, it was frame unloading, for opportunity to measure irreversible deformations in these three points. Point “a” is upper horizontal plane gotten off basis bus construction, point “b” is close up seat bearers and point “c” is placed on upper angle of side frame, where are the most values of deformations expected.

Analysis of tension-deformation condition of side frames is by computer calculations made on loading conditions which are experimentally realized. Method of Finite Elements3, 4, 5 and programmer packet NISSA which are method finite elements based are for these calculation used. The way of finding these measurements places are mathematical modeling done based on frame mathematical modeling. Mathematical model is 408 elements connected in 412 nodes connected. Finite elements grid of bearers construction was of side frame number 4 calculated, from the first side frame of windbrake1 (Fig. 2).

![Fig. 1 View of section frame with seat bearers and deformation measuring points.](image1)

![Fig. 2 Finite elements grid of bearer’s construction of side frame.](image2)

2. Results from experimental investigations

First type of seat bearers were on basis construction fixed, on horizontal plane by two screws (quality 10.9), with vertical frame same by two screws with the same quality. Table 1 shows results from investigations of side frame by first type of the seat bearers.

<table>
<thead>
<tr>
<th>Load [N]</th>
<th>Deformation [mm]</th>
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<tbody>
<tr>
<td>200</td>
<td>a</td>
</tr>
<tr>
<td>400</td>
<td>a</td>
</tr>
<tr>
<td>600</td>
<td>a</td>
</tr>
</tbody>
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Depending of Force from deformations, F [N] is y axis performing, a [mm], b[mm] and c [mm] are deformation of side frame at point measuring x axis performing (Fig. 2).

![Fig. 2 Depending between loadings (forces) and deformations at measuring points of side frame with first type of seat bearers.](image3)
### Table 1: Results from experimental investigations of side frame with first type of seat bearers.

<table>
<thead>
<tr>
<th>F[N]</th>
<th>a [mm]</th>
<th>b [mm]</th>
<th>c [mm]</th>
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<tr>
<td>600</td>
<td>0</td>
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<td>450</td>
</tr>
<tr>
<td>5200</td>
<td>0</td>
<td>14</td>
<td>470</td>
</tr>
<tr>
<td>5400</td>
<td>0</td>
<td>15,5</td>
<td>520</td>
</tr>
</tbody>
</table>

Second type of seat bearers were by angle supercharged made on the upper part of bear, it was difference of way of fixing made on basis construction, it was metal sheet fixed (with dimensions 40x340x3 [mm]) between basis construction and seat bearers, for decreasing area pressure on the place of contact, concerning to be obtained point of vantage tension condition.

The way of fixing was the same as previous experimentally investigations.

Results are from experimental investigations of side frame with second type of seat bearers shown on Table 2.

Results from the Table 2 are graphically shown (Fig.3), concerning depending the Force from deformations, F [N] is y axis performing, and a [mm], b[mm] and c [mm] are deformation of side frame at point measuring Fig.1 performing, points measuring x axis performing.

Third type of seat bearers was the same fixing on the basis of constructive like second type, but on vertical plane of the frame it was added “Z” profile, which have been welded on upper side of the frame, but on the basis it was fixed by screws on construction of the frame.

Results from experimental investigations of side frame with third type of seat bearers shown on Table 3.

Results from the Table 3 are graphically shown (Fig.4), concerning depending the Force from deformations, F [N] is y axis performing, and a [mm], b[mm] and c [mm] are deformation of side frame at point measuring Fig.1 performing, points measuring x axis performing.

### Table 2: Results from experimental investigations of side frame with second type of seat bearers.

<table>
<thead>
<tr>
<th>F[N]</th>
<th>a [mm]</th>
<th>b [mm]</th>
<th>c [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>0</td>
<td>0,1</td>
<td>8</td>
</tr>
<tr>
<td>800</td>
<td>0</td>
<td>0,5</td>
<td>16</td>
</tr>
<tr>
<td>1000</td>
<td>0</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>1200</td>
<td>0</td>
<td>1,5</td>
<td>30</td>
</tr>
<tr>
<td>1400</td>
<td>0</td>
<td>1,5</td>
<td>35</td>
</tr>
<tr>
<td>1600</td>
<td>0</td>
<td>1,5</td>
<td>40</td>
</tr>
<tr>
<td>1800</td>
<td>0</td>
<td>2</td>
<td>45</td>
</tr>
<tr>
<td>2000</td>
<td>0</td>
<td>2,5</td>
<td>50</td>
</tr>
<tr>
<td>2200</td>
<td>0</td>
<td>3</td>
<td>57</td>
</tr>
<tr>
<td>2400</td>
<td>0</td>
<td>3</td>
<td>63</td>
</tr>
<tr>
<td>2600</td>
<td>0</td>
<td>3</td>
<td>70</td>
</tr>
<tr>
<td>2800</td>
<td>0</td>
<td>3</td>
<td>79</td>
</tr>
<tr>
<td>3000</td>
<td>0</td>
<td>3,5</td>
<td>88</td>
</tr>
<tr>
<td>3200</td>
<td>0</td>
<td>4</td>
<td>97</td>
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<td>3400</td>
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<td>4</td>
<td>113</td>
</tr>
<tr>
<td>3600</td>
<td>0</td>
<td>4</td>
<td>120</td>
</tr>
<tr>
<td>3800</td>
<td>0</td>
<td>4,5</td>
<td>56</td>
</tr>
<tr>
<td>4000</td>
<td>0</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>4200</td>
<td>0</td>
<td>6</td>
<td>182</td>
</tr>
<tr>
<td>4400</td>
<td>0</td>
<td>6</td>
<td>225</td>
</tr>
<tr>
<td>4600</td>
<td>0</td>
<td>6</td>
<td>252</td>
</tr>
<tr>
<td>4800</td>
<td>0</td>
<td>6</td>
<td>350</td>
</tr>
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<td>5000</td>
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<tr>
<td>5400</td>
<td>0</td>
<td>8</td>
<td>530</td>
</tr>
</tbody>
</table>

### Table 3: Results from experimental investigations of side frame with third type of seat bearers.
From analysis the results from experimental investigations of side frame with first seat bearers, we can find that first durable deformations are evident on point “b” by force of 3400 [N] made notification, and by increasing the value of force until 4300 [N] these deformations are value of 11 [mm] had.

For third type of seat bearers, according to the results which are on Table 3 given, durable deformations on point “b” are by value of 3800 [N] force evidenced, and they are by loading of 4300 [N] on down part of the frame.

Point “c” deformations for first type of seat bearers is from 2600 [N] beginning, and with value of 4300 [N] force they are have had 270 [mm] deformations.

Point “c” deformations for second type of seat bearers is from 2600 [N] beginning, and with value of 4300 [N] force they are have had 252 [mm] deformations.

Point “c” deformations for third type of seat bearers is from 3000 [N] beginning, and with value of 4300 [N] force they are have had 210 [mm] deformations.

The force value bigger than 4300 [N], for all three types of seat bearers, frame deformations on point “c” are increasing and by smaller values of the force F [N], what means that strain of the material is decreasing until margin of extension.

3. Conclusion

Passive safety buses, buses like transport devices for passengers, according to the EU regulations, should be on high level, distinctly for the buses construction. According ECE regulations of European Committee, R65\(^2\), are obligatory a lot of experimental investigations made on direction of holding passenger’s safety area in case of traffic accidents. Most important element which has had an influence on the passenger’s safety area, and passenger’s safety, is construction, concerning construction of sets bear. These types of seat bearers have had most important influence of displacing the deformation, by height of side frame from bus superstructure.

Energy absorption of construction, which is corresponding breakdown and depending from mechanism of breakdown, constructive connections of nodes, and it’s proportional of diagram Force – movement (deformation). The value of energy absorption is from bear construction during the buses overturning depending from constructive solutions and whole static system.

Static system of side frame was by minor strain and strength characteristic changing of fixture seat bearers constructed and projected, like bearers elements of basis constructive.

From the results of experimental investigations of the side frame we can conclude that deformations on “b” point, for first two types of seat bearers, were by force value of 3400 [N] beginning, but on third type of seat bearers this force is bigger for 400 [N] value and the values of deformations are smaller four times than previously two types. According deformation analysis on point “c”, for first two types of seat bearers by maximum force of 4300 [N] loading, deformations on point “c” have had: 270 [mm] and 252 [mm] respectively value, but for third type of seat bearers these deformation has had 210 [mm] value.

Third type of seat bearers are, from constructive aspect according research in this paper, allowing raise of 60 [mm] on upper zone from side frame passengers safety area and around 8 [mm] on down part of the frame.

4. References


Table 3: Results from experimental investigations of side frame with third type of seat bearers.

<table>
<thead>
<tr>
<th>F [N]</th>
<th>a [mm]</th>
<th>b [mm]</th>
<th>c [mm]</th>
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<tbody>
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<td>600</td>
<td>0</td>
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<td>0</td>
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THE IMPORTANCE OF SOCIAL RESPONSIBILITY IN THE PREFERENCE OF PORT OPERATIONS BY INTERNATIONAL COMMERCE COMPANIES - A STUDY IN KOCAELİ AREA / TURKEY

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Abstract: Port operators are logistics companies. When we look at port management in Turkey today; competition among these operators seems to be intensifying. Therefore, this competition is pushing the port operators for differentiate their services. In this context, it can be said that one of the strategies that will differentiate port operators is the sense of social responsibility. The aim of this research is to determine how effective the port management's social responsibility understanding is among the factors that international commerce companies operating in Kocaeli / Turkey prefer to operate a port. For this purpose, a questionnaire was applied to 32 international commerce companies operating in the Kocaeli Region and according to the survey results, it was seen that social responsibility concept took the fourth place after the shortest time of cargo handling, the lowest cost of cargo handling and the undamaged and without any losses of cargo handling. According to this result, it is suggested that port operators should emphasize social responsibility concept more than other factors and emphasize social responsibility more in promotion activities.

Keyword: INTERNATIONAL COMMERCE COMPANIES, PORT OPERATORS, SOCIAL RESPONSIBILITY

1. Introduction

Port operators are among the quintessential building blocks of logistics and supply chain. Among the most critical port cities of Turkey, Kocaeli is the city renowned for its industry and logistics operations. Located at the intersection of highways connection the two continents Asia and Europe, Kocaeli is geographically situated in the eastern part of Marmara Region and Marmara Sea. In that regard, while international commerce companies and the significance of social responsibility in their selection process. The findings would also indicate the requirements that a company must follow to meet the financial and legal terms, to practice a business strategy and policy meeting business ethics, expectations of internal and external people and other institutions, and to fulfill the needs and contentment of involved parties (Yüksel et al., 2005). Social responsibility as a term means; “to the end of assisting in sustainable development and improvement, the promises that companies make to soar the life quality of an entire society” (Kärnä et al., 2003). Social responsibility “safeguards brand image, boosts competitive advantage, enables brand recognition and increases the likelihood to be favored by potential customers” (Argüden, 2002, Çerik and Özarslan, 2008). Social responsibility is important not only for manufacturing companies of consumer products. It is equally significant for companies operational in industrial sector; hence protecting the society, plants and animals, the sea, environment and natural habitat should be among the leading responsibilities of all business companies.

3. Objective and Benefits of This Study

It is thus the objective of this study to identify the factors that international commerce companies operating in Turkey-Kocaeli Region consider while selecting a port operator and the significance level of social responsibility in their final choice. It is estimated that the findings of this study will provide information to port operators about service-purchase priorities of international commerce companies and the significance of social responsibility in their selection process. The findings would also shed light to developing policies and strategies in line with the obtained results and this study would thus raise public awareness toward this issue.

4. Method

The reason behind selecting Kocaeli Region as the case study region is Kocaeli's role as the most vibrant port and industrial city of Turkey. Due to the time and cost limitations of the study and
intensive workload, non-randomized sampling method was applied and respondents were selected via convenience sampling method. 32 international commerce companies in total were given the survey and this study was conducted as a pilot study.

Data collection tool of the study was face-to-face survey method. The survey included questions directed to measure the significance level of social responsibility, in comparison to several other factors, behind the choices of international commerce companies selecting a port operator. Survey questions were ranged in a scale as 1: Not important at all, 5: Extremely important. The scale employed by Tandoğan(2009) was the reference of this application. Data collection process was conducted between the dates 23 September–30 November 2016.

Survey included questions directed to measure the significance level of social responsibility , in comparison to several other factors, behind the choices of international commerce companies selecting a port operator. Survey questions were asked to select the factors in Table 1 according to significance level that they look for in purchasing service from any given port operator (1: Not important at all, 5: Extremely important) and below- listed answers were collected;

Table 1: International Commerce Companies’ Reasons in Selecting a Port Operator and Significance Level of Social Responsibility

<table>
<thead>
<tr>
<th>Factors</th>
<th>N</th>
<th>Mean</th>
<th>Standart Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cargo handling in a shortest time</td>
<td>32</td>
<td>4,7187</td>
<td>.63421</td>
</tr>
<tr>
<td>Image</td>
<td>32</td>
<td>3,7813</td>
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<tr>
<td>Social responsibility</td>
<td>32</td>
<td>4,3125</td>
<td>.78030</td>
</tr>
<tr>
<td>Promotion activities</td>
<td>32</td>
<td>4,1875</td>
<td>.82060</td>
</tr>
<tr>
<td>Cargo handling with lowest cost</td>
<td>32</td>
<td>4,6563</td>
<td>.74528</td>
</tr>
<tr>
<td>Cargo handling without any losses and with no damage</td>
<td>32</td>
<td>4,5625</td>
<td>.71561</td>
</tr>
<tr>
<td>Cronbach's Alpha:</td>
<td>0,7543</td>
<td></td>
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</tr>
</tbody>
</table>

Table 1 exhibits that; respondent international commerce companies operating in Kocaeli Region paid the highest level of importance to the feature of handling of load/discharge in the shortest time by a port operator. The second factor was handling of the load/discharge with lowest cost. The third factor was handling of the load/discharge without any losses, and with no damage. Social responsibility factor ranked as the fourth factor.

6.Conclusion

Kocaeli Region is among the lead cities of Turkey in terms of its port operations as well as international commerce activities. Recent boost in the export and import potential of Kocaeli Region, in effect, increased the competition among port operators. As a consequence, the directors of port operator companies have been led to implement new policies and strategies. One strategy is detecting what factors international commerce companies favor in their port operator choices and to identify the level of significance paid to social responsibility factor as a differentiation strategy. Likewise, in this pilot study too, the survey questions were directed to 32 international commerce companies operating in Kocaeli Region to measure the level of significance paid to social responsibility factor in selecting a port operator. This survey manifested that respondent international commerce companies operating in Kocaeli Region paid the highest level of importance to handling the load/discharge in the shortest time by a port operator. In maritime transport, time is the utmost factor. The sooner a load/discharge is handled the quicker it is feasible for the buyer to start manufacturing process and exhibits its product in the market earlier than its competitors. This is an advantage for the ship owner too. The sooner handling means that the ship owner can ship another load to transport.

Second factor was selected as the handling of the load/discharge with the lowest cost. This finding evidences that international commerce companies pay heed to port costs and emerging prices. The third factor was handling of the load/discharge without any losses, or with no damage. Accordingly, survey respondents favored to receive their loads/discharges as recorded in shipping document. Social responsibility factor was ranked as the fourth item in selection process. Considering the increased level of harmful factors to the nature, environment and sea in modern age it is deemed significant to rank social responsibility factor among the upper ranks and even at the top rank to consider. To achieve that mission, port operators have been assigned with critical duties. Accordingly port operators are expected to organize trainings and seminars to promote the protection of sea and environment; sponsor relevant activities; train the local citizens and by raising the collective awareness to help the international commerce companies to choose social responsibility as one of the top-priority factors while selecting a port operator.

References


İzmit Körfezi Liman Bölgesi Raporu, Haziran 2011, p.43


All data collected during the study process was assessed via SPSS 15.0 package program.

5.Findings

5.1 International Commerce Companies’ Reasons in Selecting a Port Operator and Significance Level of Social Responsibility

32 international commerce companies answering the survey questions were asked to select the factors in Table 1 according to significance level that they look for in purchasing service from any given port operator (1: Not important at all, 5: Extremely important) and below- listed answers were collected;
MARKETING AND PRODUCT DEVELOPMENT IN THE AUTOMOTIVE INDUSTRY GLOBALLY

MARKETING И ПРОДУКТОВО РАЗВИТИЕ В АВТОМОБИЛНАТА ИНДУСТРИЯ ПО СВЕТА

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Abstract: Many social, economical and technological trends begin to work together in order to transform the mobility and to create new urban models for the next decades. The trends coming from the technology development will revolutionize the way the automotive industry responds to the changing consumer behavior. Building new partnerships will lead to transformational change. The connectivity and the automation will fundamentally change the automotive industry. The expected operational ecosystems include e-hailing mobile applications for shared electric vehicle, infotainment services and personalization inside the autonomous vehicles, connectivity to the infrastructure and provision of various services due to the Internet of Things, which will grant safe, sustainable and reliable transit.

Keywords: MARKETING, PRODUCT DEVELOPMENT, AUTOMOTIVE INDUSTRY, MARKETING INNOVATIONS, MARKETING STRATEGY

Introduction
At the present moment the human mankind is challenged to develop the global transformation of the human-machine connection. The focus goes mainly to the safety and social changes. The automatization naturally will change the labour market and will increase the unemployment. From other hand, it will help reducing those 94% of the accidents caused by human factor (KPMG, 2013), and will provide opportunity for the disabled or older people to move freely. It will also provide opportunities to the families with low incomes for savings, instead of buying and servicing cars, which they anyway use rarely. Depending on the location, landscape, climate conditions, the cities will be developed in more advanced way with the respect of the choices which people make as an investment in this technology.

It is a personal choice for this technology. People will be able to choose not to drive if they will, or to have the safest option for travelling, if they prefer driving. The autonomous vehicles and the smart transport systems will be able to provide information how people use the infrastructure. Still there is a nostalgia for the travelling – people love to jump in their cars and to travel faster and longer when they want. (Parment A., 2014). However, the present trend tend to be different. The roads are crowded and congested, the travelling time is becoming longer. People try to options to cut time and distance when they travel, and stress and fatigue respectfully. Now the current generation travel longer as time compared to the previous generations. (Warren T., 2016). The development of the technology and Internet of things (IoT) changed significantly the consumer behavior and the product development in many industries, incl automotive. The consumers live in a connected world and expect their important devices to perform in the web and in a network. The IoT is developing rapidly and the vehicles will be part of this connected ecosystem, thus creating ongoing relationships between companies and consumers. (Mohammed J., 2015; Stevenson J., 2017)

The trends
The automotive industry is in a process of the technical revolution. Shared vehicles, electrical vehicles, autonomous vehicles, telematics, personalization, augmented reality, driver assists, infotainment. The automotive companies should develop a strategy before starting to transform. Four main directions for strategies in the digital world are offered (Stevenson J., 2017):
- Talking to broader digital landscape – the technology and the digital wave impact all industries and the automotive companies should follow best digital practices in all industries, learning and adapting.
- Recognizing customer expectations – this means strategy for the entire consumer journey and experience; as becoming more connected, the consumers require more personalization, services and opportunities for purchase via smart device/web.
- Laying groundwork for future agility – the companies not only should predict the future, but to predict how it will happen in practice; this is the way companies to become innovators.
- Expecting digital disruption – at all levels of the value added chain; using the generated data to facilitate the decision making; having a flexible plan to expect changes.

The trends are naming the new cars as “connected and smart”. There are several critical dimensions, which the automotive industry should consider and to be able to mange – macroeconomic forces, new personal mobility and stricted regulations. (Hirsh E. et al. 2016, PwC)

The long life cycles and the serious investments make the planning in the automotive industry a complex factor. Over the last decade all automotive companies were after the sales volumes, in order to improve the profiles during and after the crisis, aiming at larger economies of scale if and where possible. It will be very challenging for the companies to satisfy all specific local requirements. Among them are the quotas, taxes, preferences for types of engines, climate, design, cultural factors etc. This requires solid presence with factories, or near by factories, and strong dealer network.

The connected and the smart vehicles are only the beginning in the future development of the automotive industry. Their impact is very strong on the way the companies reorganize their businesses. These vehicles shape a future which was unbelievable a decade ago. At the present moment, two separate industries consolidate in order to create and develop these new vehicles – the automotive and the technology. The industries bring in different cultures, different product development models and business operations. The participation of high-tech companies brings the necessary knowledge to develop technology which includes the critical components for the connected, autonomous and communicational capabilities of the vehicles. From other hand the automotive business is something which is done best by the automotive companies. This synergy has the potential to create the future cars.

Despite of the fact that the autonomous and electric vehicles are the future, it is expected that their sales will be difficult. (Hirsh E. et al. 2016, PwC). The conventional engines will be dominating in the next couple of decades until the volumes of the traditional and the smart vehicles on the road become even (Litman T., Victoria Transport Policy Institute, 2017). In this situation the newer vehicles will differ mainly by their innovative technology and features such as driver assists and global web connectivity.

Despite of the fact that the automotive industry should focus on new mobility features in the vehicles, the stricter regulations on the
CO2 emissions are on their way and the automotive companies are dependent on this too. To meet the new standards, significant changes in the engines are necessary. The in short term. Having in mind the life cycles of the models, it would mean that still today we should see maximizing the fuel efficiency and minimizing the CO2 emissions, as well as further use of the alternative resources and renewable energy.

The tendencies which rise by the technologies will revolutionize the way industry responds to the changing consumer behavior, new partnerships will be created and will bring transformational change. (Gao et al. 2016)

Today the economies are changing rapidly, prompted by the emerging markets, the accelerated rise of the new technologies, sustainability policies and the changing consumer preferences for the ownership. The digitalization, the rise of the autonomy and the new business models have revolutionized the other industries and their impact is imminent for the automotive industry. These forces lead to four technology-driven trends in the automotive industry (Gao P et al., 2016), defined as disruptive: diverse mobility, autonomous driving, electrification and connectivity. These four trend will enforce and cherish each other, and the automotive industry should be prepared for the new disruptive technology and should reshape its value proposition. Based on these trends, the authors present eight perspectives on the automotive industry in 2030:

- The profits in the automotive sector will increase and will diversify based on the mobile-on-demand-based services and the data-based services. The connectivity and the autonomy will allow the vehicles to transform into a platform for the driver and the occupants, and to use their travel time to consume new media formats and services or to enjoy other forms of entertainment in their free time. The raising speed of the innovations, especially in the software industry, will introduce upgrade opportunities in the vehicles, similar to smart devices.

- Despite the shift towards shared mobility, the new cars sales will continue to grow but with lower rate, at around 2% per year. This drop will be led by macroeconomical factors, as well as the new mobility services, car sharing and e-hailing.

- The consumer behavior for the mobility is changing which will result in 1 out of 10 cars sold in 2030 to be a shared vehicle, and the rise of the fit-for-purpose mobility solutions. The consumer preferences, stricter regulations and the technology disruption, bring fundamental change in the individual mobility behavior. Multiple modes of transportation to complete their journeys are used by the modern consumers. Nowadays the consumers don’t go after goods and services - these are delivered to them. Dense urban environments proactively discourage private-car use. The traditional new cars sales model is expected to be complemented by diverse on demand mobility solutions. The consumers will choose the best solutions according to their need. It is expected over 30% of the mileage of new sold cars to be from shared mobility by 2030, and 1 out of 3 cars to be used for shared rides in 2050.

- The city type will replace the countryside or regions, as most relevant dimension for segmentation. This will define the mobility behavior, as well as the speed and range of the automotive revolution. The new solutions market potential will be based on the segmentation of the cities according to their density, economic development and opportunities. Consumers’ preferences, the regulations and the policies, and the cost of the new business models will differ based on these criteria.

- Once technological and regulatory issues have been resolved, up to 15 percent of new cars sold in 2030 could be fully autonomous. The fully autonomous vehicles will hit the market not earlier than 2021-2022. Until then the main role for preparing the regulators, companies and customers will have the advanced driver assists, which could take over for a while and under certain conditions.

- The electric vehicles are becoming more competitive and they are gaining speed, however their adoption will vary at local level. Stricter regulations on the CO2 emissions, lower costs for batteries, developed and available charging infrastructure and the increasing adoption by the consumers will create conditions for serious penetration of all types of electric vehicles. Various forecasts predict different share of new electric car sales by 2030, which vary between under 10% up to 50%. Most of the sales are expected in the cities with very dense population, having strict CO2 emissions regulations and offering strong incentives in the purchase of such vehicles - subsidy by the state, low or no taxes, reduced price of the electricity. The opposite is expected in the countryside, with less developed charging infrastructure, longer travel distances and dependency of the range. By constant improvements of the technology and the batteries’ prices, the differences will be overcome and the electric vehicles of any type will gain bigger share, on the expense of the conventional vehicles.

- Within a more complex and diversified mobility and industry landscape, the companies will be forced to competet simultaneously on multiple fronts and cooperate with competitors. The paradigm shift in mobility as a service, and the newcomers on the market, will force the traditional automotive players to compete with everthing which provides solid user experience in travel as well as alternative ways to spend their money instead. The mobility services suppliers (Uber), high-tech giants (Apple, Google), and especially the manufacturers (Tesla) seriously change the competitive landscape. The traditional automotive manufacturers which are put under constant pressure to reduce cost, improve fuel efficiency, reduce CO2 emissions and keeping financial stability, will be in the middle of diverse situations in the evolving automotive and technological environment, which will lead to consolidations and various forms of partnerships and alliances. The software competences are becoming one of the key factors for differentiation in the industry. The software is critical for the assists, the safety, the infotainment, connectivity and IoT. The cars are integrating in the world of connectivity and the manufacturers have no other choice but to be part of the new transport ecosystems, which appear as a result of trends in the changing consumer behavior and technological development.

- New market entrants are going to target initially not only specific econically attractive segments and activities along the value chain before exploring further fields. Besides the most popular players, many new entrants outside the industry are also expected, bringing new influences and trends – start-ups and tech companies with capital. The big Chinese automotive manufacturers could also play serious role in changing the landscape and new technologies’ penetration at global level.

**Fig4**: New vehicles market in 2030, Source McKinsey&Company
The autonomous technology

The potential benefits, which the advocates of the autonomous technology predict, are significant convenience, safety, congestion reduction, fuel economy, pollution reduction. Human mistake lays in 93% of the accidents on the road, and the autonomous vehicles will reduce these accidents by 90% (KPMG 2012; Fagnant u Kockelman 2013), incl. system mistakes, (“death by computer”), cyberterrorism (Bilger 2013), will offset the risk by the people behavior on the road (especially when they feel safer) and the side effects such as increased traffic by faster or cheaper mode of transportration. (Eeenenberger W., 2009; Fung B., 2013; Kockelman, et al. 2016; Lin 2013; Ohnsman 2014). If people are feeling safer, the occupants could use the seatbelts less, the others on the road could become less careful, the vehicles could operate faster and closer one to another, and human-drivers will be part of the autonomous vehicles groups on the road, which will provide new risks and requirements. Millard-Ball (2016) supposes that the pedestrians will be less careful and less responsible because of the autonomous vehicles. Detailed analysis by Sivak and Schoettle (2015) concludes that the autonomous vehicles could be less safe compared to an average driver, and they even could increase the number of crashes when there are both autonomous vehicles and human-driven vehicles on the road. The estimated cost of vehicle emissions, congestion and parking, energy economy and CO2 emissions reductions, are still not clear mainly because of their contradictory nature and effects. The opportunity for working and leisure in the cars will make some users to choose bigger cars, which to serve as offices and bedrooms, and to travel longer distances on yearly basis. The autonomous taxis and self-parking cars will possibly have more empty travels Despite of the benefits coming form the increased travels and mileage, the autonomous vehicles could increase the external influences such as cost for and by congestion, parking, liability and third-parties risk, carbon emissions and energy. Some stargeis such as plateauing could be limited to some highways and roads only, and the vehicles with human-driver could increase the congestions on the regular roads. The autonomous vehicles could reduce the public transport use, but new ways to travel could appear, which require bigger range and total mileage. The autonomous vehicles could be programed to optimize the comfort of the occupants. Le Vine, Zolfaghari and Polak (2015) made a research on the matter, as the occupants are more sensitive on acceleration than the drivers, and since they are going to use their time in the car as they will, it is possible for the sake of comfort they to program the vehicle to accelerate and brake more smoothly, in comparison to the conventional cars. However, this could result in reduction of the road capacity.

The increased cost for the production of autonomous vehicles are still not clear too. Sensor, computers, processors, controls and software are required. Their cost are in thousand USD, but naturally their prices will drop when they enter into mass production. (Silberg G., KPMG 2012).

It is stated that the autonomous technology and possibilities will result in more shared vehicles – sharing personally-owned vehicles and shared taxis. (Fagnant and Kockelman 2013; Schonberger and Gutmann 2013). Sivak and Schoettle (2015) estimate that if one household’s vehicles serve to many users, it would reduce the ownership with 43% and to increase the total mileage with up to 75%. Despite all, it is difficult to predict the exact effects. There are many reasons people to prefer owning a vehicle. Status, convenience, luggage, mileage, and a personal driver. Yes, the autonomous vehicles could reduce the cost for the personally owned vehicles. However, the effects could also be insignificant. Especially for the taxis the maintenance and keeping them clean, the personal comfort and peace, will be important. An important matter is vandalism and the costs occurring with it.

Vehicle-to-vehicle (V2V) communications and connectivity to the infrastructure (Ninah et al. 2015) could be on the market in couple of years, making the autonomous vehicles smarter and safer. These new rule for connectivite between the vehicles will additional provide new trends in the autonomy, as well as they will energize the automotive and the tech industries for new customer-oriented solutions and personalizations. This will impact not only the cars, but also buses, trucks, trains, and public transport. It is expected the autonomous technology to reduce operational cost with up to (Naughton K, Bergen M., 2017).

Despite of the big progress in the automotive industry, significant improvements are required to reach Level 4 and 5 of autonomy. (Simonite 2016). In the present moment most of the new cars are Level 1, Tesla’s models could be considered Level 2 due to certain features. Couple more years are needed for testing and development before the authorities and the potential consumers to be sure that Level 4 or 5 to operate in all conditions. (Bilger B., 2013; Schoettle and Sivak 2015).

An analysis on the future fleet on the road predicts, that to have predominant fleet of autonomous vehicles in 2035, most of the new car sales after 2025 have to be autonomous, as well as the new cars sales levels to triple, so a renewal of the fleet to happen in just a decade instead of three decades. This will require most of the drivers with low and middle income who choose used cars or cheap new model, to spend a lot more money to buy new vehicle with autonomous features. In addition, a lot of other conventional vehicle have to be scrapped because of the lack of such features. (Litmann T., Victoria Transport Policy Institute, 2017).

The autonomous vehicles could raise the prices of the cars with thousands, and will require additional investment by the users for subscription fees for special navigation, maps, online services etc. Despite that the autonomous technology will offer great benefits for some users, it is not clear what part of the drivers will accept the value of these benefits in additional costs. There is ageneral support of the concept, but there are also significant preoccupations about privacy, personal data and safety, as well as very low readiness to pay additional amount for the autonomous features in the vehicles. (Schoettle and Sivak 2014). In the beginning, the autonomous vehicles will present small part in the the total sales, with a market share which is growing in the following decades, when their performance is improved, prices fall and the benefits are more visible for the mass consumer. Within time, naturally the autonomous vehicles will increase their market share in the overall fleet, until becoming mainstream their mass penetration after 2050. (Litmann T., Victoria Transport Policy Institute, 2017).

Product offerings

The autonomous vehicles begin to make a move from the labs to the showrooms. Tesla, BMW, Daimler, Ford and Volvo announced that they will have fully autonomous models on the road by 2021-2022. Google’s Alphabet presented its project called Waymo, and along with Chrysler launched the autonomous Pacifica minivan, which to hit the road in 2017. Besides, the company is in negotiations with Honda in order to integrate the technology in their models too. (Naughton K, Bergen M., 2017).

Google’s autonomous project gathered huge attention, as during the last seven years, more than 2 million kilometres were logged in testing. Similar to Android OS, Waymo could also develop a software for autonomous vehicles, to license it for the automotive manufacturers and to earn from the services and data. After quiting its Titan Project and car development, Apple is also taking similar approach.

At the present day (spring 2017), people can have a glimpse on the autonomous driving on the backseat on a Uber taxi (Volvo or Ford) in couple of US states, or eventually to have a look at Chevrolet Bolt’s test rides. GM is also testing the vehicle in carssharing Lyft’s fleet. The main point is that the customer should get used to the technology and potentially buy such vehicle one day. The company is working on more autonomous system called Super Cruise via Cruise start-up, which will allow literally hands-free driving on the highway. The decision for initial integration of
technology in the shared vehicles does make sense, as the LIDAR sensors for monitor the environment are still expensive, and economy of scale is required. Still, the experts in the automotive industry don’t take on the wheel. It is expected the technology to be available for the end users very soon, which puts serious pressure on the rest of the big players. Instead of working step by step, the company launches the technology and the rest should catch up. VW Group presented in April 2017 its concept models form main brands in the group, which integrate driverless features. Mercedes is working on its systems, sensors and maps for couple of years, and announced that by 2020 will launch autonomous taxis on the road. BMW is also a key player. Regarding the electric vehicles, the manufacturers are also under serious pressure to electrify their offerings, in order to meet the more and more stricter regulations on CO2, especially in Europe and China. The main issues is the availability of battery cells in the next decade, in order to respond to the great demand by the companies. The most active companies are VW Group, Daimler, BMW, General Motors and Ford Motor. VW Group is leading for now. The company expects to sell between 2 and 3 million fully electrical vehicles per year up to 2025 r. (Gibbs N., 2017). Tesla has a plan to sell 1 million such vehicles per year globally. Only in Europe. Nissan forecasts 20% of its sales to be electric vehicles. Ford expects 15% to 20% of of the Chinese market to consist of electric vehicles. If as destination point is considered 2025, Mercedes forecasts that 15 to 25% of company’s sales globally will be of cars with batteries. BMW has the same forecasts, but it includes also the plug-in hybrid models in this number. Ford intends 25% of its global sales to be full or partial electric vehicles. (autonews.com)

In 2016 GM, Renault and their main battery partner LG Chem, removed one of the main obstacles for the successful sales of electric vehicles – the range. GM announced that Chevrolet Bolt/Opel Ampera could go for 500 km with a single charge, and Renault announced the second generation Zoe to have a range of over 400 km. The next big leap regarding the range is expected around 2019. (Gibbs N., 2017)

**Conclusion**

The introduction of the autonomous vehicles could be slower and more complicated compared to most of the forecasts. Technical challenges could be more complicated to solve too, so the autonomous vehicles to be available on the road not before 2030-2040 (Litman T., Victoria Transport Policy Institute, 2017). They could have higher production cost and prices, and their benefits to be less than forecasted, and the negative effects – more. The technical issues, the issues with privacy, data protection and personal preferences could decrease the consumer adoption, and the fleets to continue to consist mainly human drivers, despite of the changing consumer behavior on the mobility and the positive expectations. The faster adoption will require faster production, integration and renewal of the overall fleet, in comparison with previous innovations and their mass production. It is a field which requires continuous research and analysis.

Despite of the above, the industry is at the threshold of launching. It is not a matter of proving it, but a matter of selling the technology to the manufacturers, taxi companies, ride and share companies and end-users. The success in 2030 will require the automotive companies to be in constant expectations of new market trends, to research alternatives to the traditional business models, and to develop new business models and successful strategies serving their businesses and especially the consumers in the digital world. The industry is transforming from competition between direct competitors into new competitive relationships, but also in partnerships and opened ecosystems. To succeed, the automotive manufacturers and providers should form new alliances or to be part of the new ecosystems. With the increasing role of the software in forming the innovations and value of the product, the companies should act in a way that their competencies and processes respond to the new challenges and the consumer definition of innovations, software based value, cybersecurity, personal data protection and constant product updates. The automotive manufacturers should additionally differentiate their products and services, and to offer new ways of providing value and full customer experience with the products.

**References**

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Abstract: Each society makes everyday trials for improved management with communal waste. Each innovation that offers enlarged quality represents possibility for future improved strategy. Imperative of every man today is healthy living environment and maximally healthy way of living. Therefore in this paper one quite different concept will be represented – solution of the problems that the communal waste could create. If it is known that this phenomenon is inevitability and there is no possibility that no men could be exempted from the need to create a communal waste then this be solved upgraded and improved. The best and most suitable is every solution to be supported with a model. Here as a model is the desired quality of the service with completely justified scientific communal waste then this be solved upgraded and improved. The best and most suitable is every solution to be supported with a model. Here as a model is the desired quality of the service with completely justified scientific maintainability would be the presented logistic model - LMMCW about management with the communal waste and the possibility for qualitative and maintainable development with distinguished contributions for the people.

Keywords: LOGISTIC MODEL - LMMCW, BENEFIT, CONCEPT – SOLUTION, INFLUENCE, COMMUNAL WASTE

1. Introduction

Innovative solutions of the management with the communal waste MCW, are more and more present in the contemporary analyses. Consideration of new logistic model for management with the communal waste (LMMCW) and new logistic strategy about management with the communal waste (LSMCW) are possible only with the scientific rules product of the logistics concretely for these problems of the traffic transportation communal logistics.

The purpose of this paper is with scientific methodology to put the main parameters and indicators of LMMCW and LSMCW considered for Republic of Macedonia (RM) as a concrete example. Having in mind this the theoretical purpose is the possibility which is offered by the scientific methods and the possibility to allow application of measures and solutions from the domain of management with the communal waste (MCW). Concretely this has to allow successful identification, solution and implementation of the benefits for each resident, expression of quality which the new LMMCW and LSMCW possess. With this the social benefit of the development of new LMMCW represents a top quality and desired level of service in this domain.

2. Purpose and hypothetical frame of this paper

The purpose of this paper is the positive influence of the model strategically to feel every man. 

The main hypothesis is the creation and development of new LMMCW. Separate hypotheses are:

- The considered – logistical aspects, concepts, tasks, functions, levels and approaches really to portray the PARAMETERS of LMMCW (phase 1 of LMMCW).
- The trustworthy data about the populated places, the population, the communal waste (CW), the area, the density, the households and the apartments represented to give contribution as INDICATORS, (phase 2 of LMMCW represented officially through the State institution for statistics of Republic of Macedonia (SISRM).
- The proposed policies to be applicable in the future decisions expressed as output logistical elements and that is through development of real six SCENARIOS with by five ALTERNATIVES for each scenario and with by ten POSSIBILITIES as OPTION for each alternative represented as (phase 3 of LMMCW).
6. Identification and performance of the logistical model for management with the communal waste

The performance of the model most often is in phases and that is:
- Phase 1: Defining of the problem and the necessity (defined in this paper),
- Phase 2: where and how the logistical model shall have certain effect (RM as a state),
- Phase 3: which will be the connections and relations that will be base or foundation of the model (the entire road and organizational infrastructure for MCW in RM – as an input through defining the parameters and indicators of LMMCW),
- Phase 4: how the functionality of the model will be (selection of scenarios, alternatives and possibilities as options as output elements),
- Phase 5: how certain benefits of the model will be realized (concrete estimation and influence expressed with clear and precise explanation), and at last,
- Phase 6: how the model will be controlled (transition from alternative into alternative or higher scenario with clear and precise economical, technical technological or ecologically useful action).

The performance of LMMCW is defined through the following scales of influence of the model are defined a sequence of scales of influence. Concretely for LMMCW is modified one scale of values which are in function of performance of the concrete LMMCW. These tables of performance of the concrete LMMCW are given in the following table number 1, respectively interpreted.

<table>
<thead>
<tr>
<th>Coeff.</th>
<th>Influence</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,1</td>
<td>Very little</td>
<td></td>
</tr>
<tr>
<td>0,2</td>
<td>Little</td>
<td></td>
</tr>
<tr>
<td>0,3</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>0,4</td>
<td>Medium high</td>
<td></td>
</tr>
<tr>
<td>0,5</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>0,6</td>
<td>Very high</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 Logistical aspects, concepts, tasks, functions and levels and approaches as indicators part of LMMCW

7. Possibility for strategic view of the logistical model for management with communal waste

The possibilities that are offered by LMMCW are six unique scenarios: Scenario 1 – Scenario with very small influence, Scenario 2 – Scenario with small influence, Scenario 3 – Scenario with medium influenceScenario 4 – Scenario with medium big influence, Scenario 5 – Scenario with big influence and Scenario 6 – Scenario with very big influence

These possibilities modeled and programmed are represented in the following title of this paper where six windows are represented, that are compound part of the new LMMCW.

8. Program view of the logistical model for management with communal waste

The program view of LMMCW modeled and formed with the previous scientific methodology is represented at the following figure number 1. At figure number the basic first window of LMMCW is represented. The textual further explanation is valid, which is the following: LMMCW as a model modeled and formed upon previous scientific methodology is functional with that at the start it must clearly be defined the state for which the research is performed, the number of regions in that state defined with concrete name, the number of municipalities defined with concrete name and at last defined the character of the municipalities (urban or rural). In the phase one of LMMCW the adequately represented data of table 1 defined with parameters as influences of the logistical aspects, concepts, tasks, functions and levels, and also approaches for each municipality (as real and also desired) – expressed as logistical estimations. In the phase 2 (represented influences in the table 2) are represented the indicators as real data for each municipality as an influence for the inhabited places, the population, the communal waste, the area, the density, the households and the apartments – expressed as logistical influences. And at last phase 3 selection of real and desired scenario represented in table 5 as one segment of the six possible scenarios which LMMCW offers as options. The model offers possibility for selection of state, region and community, calculation of the logistical estimation, logistical influence and offers selection of concrete scenario. That is given in the following figure 1 where it is emphasized the selection of state, region and community and also the calculations of the logistical estimation and influence and also the selection of the alternative in other words the real scenario.

Fig. 1 Program view for REAL CALCULATIONS
9. Scientific contribution of this paper

After finishing this paper the following results are offered: (Proof about the validity of the logistics at MCW. Scientifically analyzed logistical parameters expressed through adequate logistical estimation. The planned division of the regions in RM should be scientifically and legally defined. Scientifically analyzed logistical indicators expressed through adequate logistical influence.

The methodologies are scientifically represented (with their latest phases) for creation, forming, modeling and programming of new LMMCW and new LSMCW with application of the methods at multi criteria analysis, influences and decisions for obtaining optimality at this field with survey of RM. At the end it has proof for the applicability of LMMCW through application, valorization, validation and feasibility of technological, effective and productive) viewing the matters.

At last this paper should have to offer the following theoretical and practical scientific contributions in applicative sense, and that is:

Theoretically: development of theoretic frame (new LMMCW and LSMCW) at level of regions in RM, based on the behavior of the users, and the technical possibilities that are available in RM in accordance with the valid Laws.

Methodologically: This paper is justified because for the first time aspects and policies for creation new LMMCW and LSMCW in RM were outlined.

Practically: through considering of more aspects, a possibility was created for analysis and prediction of the behavior of the individuals in new LMMCW and LSMCW and establishment of the most effective (cost effective) way of offering of better logistic services in the process of MCW in RM.

Benefit of this paper

Encircled in this way this paper deserves scientific view which fulfills the requirements of such one research. The benefit of this work should have the whole science which comprises the technological disciplines with a special accent on the traffic transportation engineering. The basis for scientific contribution is the logistics, transportation logistics and the communal logistics as disciplines which are unbreakable part of the traffic transportation engineering and planning.

References

EXCHANGE SYSTEMS

1. Introduction

The globalization of maritime transport requires establishment of legal regulations at international (International Maritime Organization) and at regional (European Union) levels. European Union (EU) policy issues and regulations are seldom related to one member state only. The common framework approach to regulations related to electronic data exchange systems of EU ports and of the economic operators in maritime transport is a prerequisite for efficient coordination and implementation of strategic policies and measures. Main policy objectives for promoting transparent and efficient solutions based on innovative information technologies in maritime transportation within the EU include:

- improving the safety and security of maritime transport services and environmental protection (integrated surveillance, monitoring and control systems incorporating adequate intelligence means for proactive, remedial and cross-border operations);

- increasing the competitiveness of the EU maritime transport and logistics industry (improved utilization of advanced information and communication technologies leading to higher quality of shipping services and facilitating reduction of operational costs and increased competitiveness of the sector);

- reinforcing the human factor (there is a serious shortage of qualified people in seafaring and maritime professions within EU due to the lack of flexible continuing professional education at sea and ashore whereas ICT solutions can support competence development through long-distance learning).

The development of the MSW and of the port communication systems has led to the introduction of the concept of Port Community Systems (PCS) serving as integration points for all stakeholders of the community being interconnected via Maritime Single Windows (MSW). The ideal operation of a Port Community System involves no need for bi-directional communication lines between the various port-related actors as they all have access to the information they need through the central communication system [11].

2. Theoretical background and legal framework

The European Union White Paper for the future of transport sets the guidelines for a Single European Transport Area in which all barriers between modes and between borders are to be eliminated. In particular, it calls for a Blue Belt in the seas around Europe which would simplify the formalities for ships travelling between EU ports [5].

EU Maritime Single Windows have been associated primarily with two interrelated policies [3]:

- Directive 2002/59/EC for vessel traffic monitoring (the "VTMIS Directive") aimed to improve safety and environmental protection in European seas;

- Directive 2010/65/EU for ships arriving in and/or departing from ports of the Member States (Reporting Formalities Directive), describing the actions that Member States should implement to make efficient use of electronic data transmission and information exchange systems.

Further to above, the legal basis for the adoption of EU Directive 2002/6/EC is the International Maritime Organization (IMO) Convention on Facilitation of International Maritime Traffic (FAL Convention) that entered into force in 1967. The purpose of the convention is to enhance the efficiency of maritime transport by digitalization, formalities simplification, setting forth documentary requirements and procedures associated with vessels’ movements in international voyages. However, every port communication system reflects the port specific requirements therefore vessels’ reports and cargo documentation are often specific to the port [11]. Reporting requirements and hence the use of the single window will depend on where a ship or the cargo is on its voyage [6]. The timeline in the transportation process by sea is presented in Figure 1.

![Figure 1. Timeline in a transport process [6]](image)

EU Directive 2002/59/EC (SafeSeaNet) sets forth the guidelines that the ship operator, agent or master have to notify the competent authority, at certain time prior to entry into a port of a member state and provide strictly specific data related to the cargo or the vessel. Member states are obliged to monitor the status of all ships operating in their mandatory reporting systems and vessel traffic services as pursuant to the requirements of the IMO FAL Convention [11]. SafeSeaNet (SSN) is a specialized network facilitating the data exchange in an electronic format between the maritime administrations of the member states [11]. The system has been designed basis the EU legislation, regulations related to port reception facilities (waste disposal) and Port State Control (Paris Memorandum of Understanding) having significant level of reliability and security. All EU member states have developed systems to accept electronic reports via a Maritime Single Window as of June 1, 2015 for reporting formalities applicable to maritime
transport for arriving and departing ships within EU ports. Thus integration of information flows is achieved providing the business stakeholders, local customs and government administrations with relevant import and export data. Furthermore, the EU Directive 2002/59/EC requires that each country organizes coordinated methods for request of reporting procedures.

SafeSeaNet was established as a centralized European platform for maritime data exchange, linking together maritime authorities from across Europe. Evolution of SafeSeaNet during the last decade includes a number of developments that had an impact on Maritime Single Window solutions. Some of them are: integrated distribution of LRIT/AIS information via SSN, integration of SSN and CleanSeaNet functionality to facilitate pollution incidents analysis and identification of potential polluters, visualization of ship inspection information on the SSN GIS interface, SSN access mechanism improvement, etc. [3].

[12] defines the Single Window concept as “a facility that allows parties involved in trade and transport to lodge standardized information and documents via a single entry point to fulfill all import, export and transit-related regulatory requirements. If information is electronic, then individual data elements should only be submitted once.”

The European Port Community System Association (EPCSA) represents the interests of the Port Community Systems Operators in Europe and promotes the role of PCSs in the MSW. EPCSA’S policy is aimed at encouraging the development of Port Community Systems as an efficient way of simplifying port procedures and means by which the requirements of Directive 2010/65/EC can be implemented. Some of the vital issues in the role of PCSs in MSW systems include: transition paths to unifying messages submitted by carriers and cargo agents to PCSs; potential of harmonization between PCS messages with the requirements of the ship formalities directive as agreed by all Member States.

PCS in general is a local initiative that is realized in an IT environment being specific to a port while the MSW is a country-level national system [9]. The MSWs are controlled by the government as pursuant to Directive 2010/65/EU. As the latter is not directly providing guidelines for the PCS therefore they are to be developed in addition to the MSWs initiatives in the ports. The PCSs can be either privately or publicly controlled and developed. Port community systems can integrate functionalities that are required by the parties benefiting from the PCS. In practice, PCS serve as electronic gateways for the MSW. The main differences between PCS and NSW are [9]:

- MSWs are country-specific, while PCSs are port-specific;
- Data submitted to MSW cannot be reused whereas PCS data can be used further or for other purposes;
- MSWs are government-controlled while PCS can be either government or public driven

The specific ports Single Window systems has a Business-to-Government (B2G) character as it provides local level information about the vessel to the authorities on a port level, while a Port Community System has a Business-to-Business (B2B) character acting as a tool to exchange commercial and logistics information among the members of a port’s community [10].

### 3. Functionalities, benefits and integration of PCSs in the European Union

According to EPCSA’s White Paper [4] the PCS supports electronic transmission of: vessel notification towards Harbor Master/Port Authority and Customs; cargo declaration, manifest filling/summary declaration towards Customs; ship’s stores declaration; crew’s effects declaration; dangerous goods declaration towards the Harbor Master/Port Authority, waste disposal and port dues declarations. The economic operators can further use the information already stored in the PCSs for business-to-business processes (outturn reports, vessel information, etc.). The definition of a Port Community System is: a neutral and open electronic platform enabling intelligent and secure exchange of information between public and private stakeholders in order to improve the competitive position of the sea and air ports’ communities [4]. The PCS optimizes, manages and automates port and logistics processes through a single submission of data and connecting transport and logistics chains. According to [7] a PCS Operator is an organization that is either public, private or public/private that operates and maintains a Port Community System and where the Port Community System represents the core of that organization’s business.

As per [8], research on the functions of PCSs have been carried out outlining the following functional areas: shipping lines, freight forwarders, terminal operators, port operators, customs, land carriers, container freight stations. The main functionalities for port operators are: ship arrival/departure confirmation, harbor dues, vessel inspection request, immigration clearance, reception of dangerous goods declaration, vessel arrival notification, notification waste disposal, statistics of supply chain performance, berth allocation management. Based on research of various authors [2] have summarized the benefits of the PCS (Table 1).

<table>
<thead>
<tr>
<th>Digital economies benefits</th>
<th>Economic benefits</th>
<th>Community attendance benefits</th>
<th>Quantification Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce cost of information access</td>
<td>Reduce cost of communication</td>
<td>Increased competitiveness at stakeholder level</td>
<td>Value of time and labor saved</td>
</tr>
<tr>
<td>Extra revenue (government authority or administrator)</td>
<td>Correct taxation (port authority services)</td>
<td>Increased access to information</td>
<td>Cost of previous forms of communication</td>
</tr>
<tr>
<td>Prevention of illegal transactions</td>
<td>Prevention of illegal transactions</td>
<td>Added value services</td>
<td>Value of revenue</td>
</tr>
<tr>
<td>Time and labor consumed to correct errors</td>
<td>Time and labor consumed to sort and verify data</td>
<td>Revenue in added value services through PCS</td>
<td></td>
</tr>
<tr>
<td>Measurement of the increased labor productivity</td>
<td>Efficiency use of resources</td>
<td>Compliance with community standards and regulations</td>
<td>Better use of equipment capacities</td>
</tr>
<tr>
<td>Increased accessibility to community</td>
<td>Increased access to information</td>
<td>Compliance with community standards and regulations</td>
<td>Less investment needed for business growth</td>
</tr>
<tr>
<td>Savings in costs of information</td>
<td>Revenue in added value services through PCS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Current integration pilots in EU ports are concentrated on close integration efforts between several PCSs for achievement of a specific purpose via common user interface and single access for all participating PCSs. Another potentially feasible functionality of integrated PCSs within the EU is the multiple use of data provided by ships from previous port(s) which ensures for saving of time. Yet another developed area is the realization of the global data exchange where PCSs exchange data with extra-community PCSs. The latter is a prerequisite for integration with customs data exchange systems. Based on the present status of the PCSs integration level within the EU the following challenges can be outlined: heterogeneity of PCSs due to national/local regulations, technological diversity of existing PCSs, refraining from sharing confidential business information, need for benefits sharing between main beneficiaries of information and parties investing in PCSs integration.

Table 2 illustrates the features and building blocks that were incorporated into the MSW pilot projects of the EU countries of the Mediterranean and the Black Sea regions.
The “Bilateral message exchange” design represents the most feasible integration option which realization requires only a limited amount of data from another PCS. The data exchange is performed via transfer of messages or specific data. In cases where there are more than two PCSs to be integrated, the “Multilateral message exchange” design presents the case whereas two ports completely integrate their original PCSs into one IT system providing the same interface for both ports. There might be a practical limit on functionalities of one system that takes into account all diverse regional, local and municipal specifics and regulations. With the “Central PCS or multilateral system integration” design complete PCS integration between a larger number of systems is achieved by provision of a common interface for all participants but maintaining the port-specific PCS for locally-specific functionalities.

Figure 2 [9] presents the four main PCS integration designs. The “Bilateral message exchange” design represents the most feasible integration option which realization requires only a limited amount of data from another PCS. The data exchange is performed via transfer of messages or specific data. In cases where there are more than two PCSs to be integrated, the “Multilateral message exchange” design is applied and it provides for a central connectivity platform functioning at national or European levels. Front office cooperation in Bremerhaven and Hamburg is an example of the latter design. Barcelona and Marseille integration case is based on bilateral or consortium data sharing of specific messages between the PCSs and the development of shared services. The “Full bilateral system integration” design presents the case whereas two ports completely integrate their original PCSs into one IT system providing the same interface for both ports. There might be a practical limit on functionalities of one system that takes into account all diverse regional, local and municipal specifics and regulations. With the “Central PCS or multilateral system integration” design complete PCS integration between a larger number of systems is achieved by provision of a common interface for all participants but maintaining the port-specific PCS for locally-specific functionalities.

Figure 2: The four main PCS integrating designs [9]

4. PCS in Bulgarian Black Sea ports

Based on the EU “Operational Program on Transport 2007-2013” and as pursuant to EU Directive 2010/65/EU, a new organizational and technological structure has been established in Bulgaria: National Centre for Electronic Exchange of Documents in Maritime Transport (NCEEDMT) that is functioning as a MSW. The operational functionalities of NCEEDMT allow for single electronic input of data whereas competent authorities receive the required information automatically which considerably reduces the time for documentary exchange. NCEEDMT has two structural entities: Bourgas Information Center and Varna Information Centre that coordinate the activities in the port terminals in Bourgas and Varna respectively.

As of December 2015, based on [1] the Bulgarian Port Infrastructure Company introduced a pilot project “Mover” as an extension of the already developed MSW. The objectives of the pilot project include: improvement of the technology of movement of vessels in the ports, improvement of the safety and quality, facilitation of the business. The pilot project (Figure 3) involves the following stakeholders: VTMS authorities, pilot stations, port terminals, tug companies, state authorities (customs, immigration, economic operators).

Common interface is used for access to data and traffic planning is made by the VTMS control bodies whereas automatic messages are sent to the users for each re-planning. The model consists of a database, a business layer, validation module, service layer. Data elements cover several classes: initial data, secondary data and reference data. The expected results are related to achieving more efficient traffic planning, facilitation of the planning process, reduction of ships’ stay in ports, financial benefits for the business. The pilot project is an useful technological tool for validating the flow of data between parties and improvement of the functional capabilities of the MSW in general being a technical add-on to the existing MSW.

5. Conclusion

Despite recent trends for digitalization in maritime transport most of the services are still realized via paper-based solutions. The EU legal framework and the achievements of national authorities for development of the MSWs have traced the path for the introduction of PCS. Although the benefits of PCS are clear to all stakeholders the provision of standardized exchange of information is a technological challenge. The design, realization and usage of a PCS is a multi-stage process incorporating diverse layers and modules enabling transactions of business entities, port operators, customs, government agencies, etc. The development of the PCSs in Bulgarian Black Sea ports is inevitably on the right track on the basis of the already fully functioning MSW and the applicable national legal framework.

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Abstract: Distribution of volumes and their change in the diesel engine cylinder is an essential parameter of each numerical model. Quasi-dimensional numerical model divide space inside the engine cylinder into two main areas: fuel spray packages and a large surrounding area without combustion, which is used for air distribution into the fuel spray packages. This paper analyzes the four-stroke diesel engine for the light truck drive in several operating modes. Numerical model is validated by using laboratory measurements. In a selected engine operating mode are presented the results of a numerical model for the observed volumes inside the engine cylinder. The observed volume change provides insight into the details of the air-fuel mixing process and fuel evaporation. Described changes are the basis for the calculation of heat-release and pressure changes in the cylinder. The developed numerical model provides insight into the details of the process inside the engine cylinder which cannot be measured with standard measuring equipment.

Keywords: FUEL SPRAY, ZONE WITHOUT COMBUSTION, LIQUID FUEL, THERMODYNAMIC VOLUME

1. Introduction

Quasi-dimensional (QD) numerical models for internal combustion engine (ICE) simulations were developed in order to achieve a compromise solution between Zero-dimensional (0D) and Computational fluid dynamics (CFD) numerical models. While 0D models use a homogeneous mixture of gases in the cylinder [1], CFD models provide the most detailed simulations, but with long calculation time [2].

Calculation start for a QD numerical model begins at the start of fuel injection. Each fuel spray must be divided into spray packages and new spray packages are created as injection continues, until its end, Fig.1. Every spray package is monitored through 3 indexes: index along the symmetry axis of the nozzle (i), index vertical to the symmetry axis of the nozzle (j) and index (k) for each fuel spray if the injector has several nozzles. Around the fuel sprays is a zone without combustion (zone of fresh air) - (ZWC) [3].

The QD model main assumption is that between spray packages is not allowed any exchange of mass or energy. The only necessary condition is fulfilled.

2. Numerical model

Numerical model equations were designed for a direct calculation of pressure and temperature changes in the cylinder, without the need for numerical iterations. The complete numerical model development, along with its main equations is presented in [5]. It can be used for simulation of a range of direct injection diesel engines, not only a high speed, but also for ship two-stroke slow speed diesel engines [6].

Equations are calculated for the thermodynamic (TD) volume of each package (only the volume of gases and vapors in the package).

The package thermodynamic volume is the geometric package volume without the volume of liquid fuel. In the zone without combustion (ZWC) is not present any amount of liquid fuel, so its geometric volume is always equal to its thermodynamic volume.

The properties of liquid fuel in the fuel spray package are monitored by separate, independently developed mathematical models. Liquid fuel energy conservation equation is used for monitoring the temperature of liquid fuel, basic parameter for the fuel evaporation simulation. In QD numerical model fuel vapor is considered as an ideal gas in the gaseous mixture with other species.

Combustion chamber geometric volume and its change define kinematics of crankshaft mechanism. Geometric volume is reduced to the volume of injected liquid fuel and the resulting volume was used in the equations related to the thermodynamic processes.

The total geometric volume of any fuel spray package will be \( V_{g,k,i,j} \) while the geometric volume of ZWC will be \( V_{ZWC} \). The liquid fuel volume inside each fuel spray package \( V_{l,k,i,j} \) will be:

\[
V_{l,k,i,j} = m_{l,k,i,j} \rho_{l,k,i,j}
\]

where \( m_l \) and \( \rho_l \) are the mass and density of liquid fuel.

The thermodynamical volume of the same fuel spray package \( V_{td,k,i,j} \) is:

\[
V_{td,k,i,j} = V_{g,k,i,j} - V_{l,k,i,j}
\]

The sum of the geometric volumes is equal to the total volume of the combustion chamber \( V_g(\varphi) \):

\[
V_g(\varphi) = V_{ZWC} + \sum_{k} \sum_{j} V_{g,k,i,j}
\]

where \( \varphi \) is crank angle.

Total thermodynamical volume for the entire combustion area \( V_{td}(\varphi) \) is the actual geometric volume reduced by the total current volume of liquid fuel:

\[
V_{td}(\varphi) = V_g(\varphi) - \sum_{k} \sum_{j} m_{l,k,i,j} \rho_{l,k,i,j}
\]

The rate of change in cylinder thermodynamic volume is defined by the kinematics of crankshaft mechanism and with a speed of change in liquid fuel total volume. Liquid fuel total volume is changed during injection, evaporation and re-condensation. In this QD model, the effect of the change in the liquid fuel volume caused by thermal volume dilation is neglected.
\[
\frac{dV_{\text{acp}}(\phi)}{d\phi} - \frac{dV_{\text{proc}}(\phi)}{d\phi} \sum_{k} \sum_{j} \frac{1}{\rho_{\text{acp},k,j}} \left( \frac{dm_{\text{acp},k,j}}{d\phi} - \frac{dm_{\text{proc,acp},k,j}}{d\phi} \right) = \left( \frac{dm_{\text{lfi},k,j}}{d\phi} - \frac{dm_{\text{vap},k,j}}{d\phi} + \frac{dm_{\text{rc},k,j}}{d\phi} \right) \tag{5}
\]

where index “\(lfi\)” denotes injected liquid fuel, index “\(vap\)” denotes fuel vapor and index “\(rc\)” denotes liquid fuel re-condensation.

In the last part of the equation (5) must be taken into account signs in parentheses that are related to liquid fuel. Liquid fuel mass inflow in the above equation has positive sign (fuel injection and re-condensation) since they increase the volume of liquid fuel, while evaporation reduces the volume of liquid fuel, and has a negative sign. The signs that apply to liquid fuel are opposite when considering the volume of gaseous section.

The rate of change in total thermodynamic volume for the entire engine cylinder is defined by:

\[
\frac{dV_{W}(\phi)}{d\phi} = \frac{dV_{\text{acp}}(\phi)}{d\phi} + \sum_{k} \sum_{j} \frac{dV_{\text{acp,proc},k,j}(\phi)}{d\phi} \tag{6}
\]

The rate of change in thermodynamic volume in the zone without combustion (ZWC) is:

\[
\frac{dV_{\text{ZWC}}(\phi)}{d\phi} = \frac{dV_{\text{proc,ZWC}}(\phi)}{d\phi} + \sum_{k} \sum_{j} \frac{1}{\rho_{\text{acp}}} \left( \frac{dm_{\text{acp},k,j}}{d\phi} \right) \tag{7}
\]

where index “\(\text{acp}\)” denotes the mixture of clean air and combustion products which remain in the cylinder from the previous combustion process.

The rate of change in thermodynamic volume in the spray package:

\[
\frac{dV_{\text{acp,proc,ki,j}}(\phi)}{d\phi} = \frac{dV_{\text{proc,ki,j}}(\phi)}{d\phi} + \sum_{k} \sum_{j} \frac{dm_{\text{acp,ki,j}}}{d\phi} \frac{1}{\rho_{\text{acp},k,j}} \tag{8}
\]

In equations (7) and (8) index “\(\text{proc}\)” refers to a process volume change due to the cylinder process thermodynamics. It is calculated as the difference between the current and previous volume, divided by the angular integration step.

3. Engine specifications and measurement results

Investigated diesel engine was a high speed direct injection turbocharged engine MAN-D-0826-LOH15, Table 1. The measurements were performed in the Laboratory for Internal Combustion Engines and Electromobility, Faculty of Mechanical Engineering, University of Ljubljana, Slovenia.

**Table 1. Engine specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement</td>
<td>6.87 l</td>
</tr>
<tr>
<td>Number of cylinders</td>
<td>6</td>
</tr>
<tr>
<td>Peak power</td>
<td>160 kW</td>
</tr>
<tr>
<td>Cylinder bore</td>
<td>108 mm</td>
</tr>
<tr>
<td>Stroke</td>
<td>125 mm</td>
</tr>
<tr>
<td>Crank radius</td>
<td>62.5 mm</td>
</tr>
<tr>
<td>Compression ratio</td>
<td>18</td>
</tr>
<tr>
<td>Nozzle diameter</td>
<td>0.23 mm</td>
</tr>
<tr>
<td>Number of nozzle holes</td>
<td>7</td>
</tr>
<tr>
<td>Combustion chamber</td>
<td>Bowl in piston</td>
</tr>
</tbody>
</table>

During the measurement period, the engine was connected to an eddy current brake Zöllner B-350AC. For the brake control is used a control system KS ADAC/Tornado, which producer is Kristl, Seibt & Co.

Laboratory measuring sensor AVL GH12D was used for the cylinder pressure measuring. This sensor was placed in an extra hole in the cylinder head.

For the analysis of change in volumes in the QD numerical model, several measurement sets were made. The selected set of measurements is presented in Table 2.

**Table 2. The measurement results (MAN-D-0826-LOH15)**

<table>
<thead>
<tr>
<th>O.P.*</th>
<th>Fuel consumption (kg/h)</th>
<th>Air consumption (kg/s)</th>
<th>Rotational speed (min⁻¹)</th>
<th>Power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.198</td>
<td>0.100764</td>
<td>1498</td>
<td>43.78</td>
</tr>
<tr>
<td>2</td>
<td>18.040</td>
<td>0.126717</td>
<td>1502</td>
<td>89.32</td>
</tr>
<tr>
<td>3</td>
<td>14.773</td>
<td>0.191578</td>
<td>2401</td>
<td>56.27</td>
</tr>
<tr>
<td>4</td>
<td>28.841</td>
<td>0.260685</td>
<td>2399</td>
<td>126.05</td>
</tr>
</tbody>
</table>

*Operating Point

Simulations with developed numerical model were done at each presented operating point. Except a detailed calculation of in-cylinder volumes change, the model calculates a large number of different engine parameters, for each spray package and also for the zone without combustion. In this paper is presented numerical model results for operating point 2.

4. Numerical model results and discussion

Fig.2 shows the change in thermodynamic volume of the entire observed engine cylinder. Cylinder thermodynamic volume decreases in the phase of compression (until 360 °CA) and increases during the phase of cylinder expansion.

**Fig.2. Change in thermodynamic volume for the entire engine cylinder**

Fig.3 presents thermodynamic volume rate of change for the entire engine cylinder and for the ZWC. In order to explain the volume rate of change for ZWC, in Fig.4 is presented a change in the overall ZWC volume.

At the beginning of the operating substance entrance from the ZWC in spray packages, the volume of the zone without combustion decreases, proportional to the volume of operating substance which enters in all spray packages of all fuel sprays. ZWC discharge becomes more intense than the spray packages advance through the cylinder while at the same time the expansion in the cylinder increases the volume of the zone without combustion. The result is that the cylinder expansion has a greater effect on the volume of a ZWC than cumulative discharge of operating substance in the spray packages, thus volume rate of change for ZWC becomes positive and the total volume of the zone without combustion increases in this area.

While expansion in the cylinder continues, operating substance volume discharge from ZWC into the spray packages becomes more intense than the ZWC volume increase caused by a cylinder expansion, so the volume rate of change in the ZWC becomes negative, and the volume of the zone without combustion decreases. The ZWC total volume reduction in this area is also caused because
of spray packages volume increase what will further reduce the volume of the zone without combustion.

Just before 470 °CA is achieved the minimum operating substance mass in the ZWC and the ZWC volume, which corresponds to the minimum mass, remains constant until the exhaust valves opening. Increase in volume caused by cylinder expansion from that moment on causes increase in a volume of each spray package and has no influence on the volume of ZWC.

In developed quasi-dimensional numerical model has been introduced such numerical limit in order to prevent the occurrence that in the spray packages enter the nonexistent mass of operating substance from the ZWC.

At the moment of the exhaust valves opening, all the zones inside cylinder (all spray packages and ZWC) are mixed and so mixed exits from the cylinder to the engine exhaust.

Fig.3. Thermodynamic volume rate of change in the cylinder and in the ZWC

Fig.4. Volume change in the ZWC

Although in the ZWC fuel evaporation and combustion does not occur, characteristics and properties of the operating substance in this zone significantly influence the processes in spray packages, during an exchange of operating substance from ZWC to spray packages. Any error in the operating substance properties calculation for the ZWC can significantly disrupt the processes of fuel evaporation, fuel vapor mixing with the air and the combustion, so the results obtained by the simulation would not be correct.

Inside the QD numerical model is developed sub-model for calculating operating substance’s thermodynamic properties in every observed calculation step. The results of this sub-model are compared with results presented in [7] and deviations in the results have not been observed.

Thermodynamic properties sub-model enable insight into the change of important operating substance characteristics, not only in the ZWC, but also in every fuel spray package. The next four figures present some results of this sub-model for the zone without combustion.

The density of the gaseous operating substance in the zone without combustion, Fig.5., increases during the phases of compression and at the start of combustion, followed by decrease due to cylinder expansion and discharge of the operating substance into the spray packages.

The adiabatic exponent in the zone without combustion, Fig.6., decreases during compression and at the beginning of combustion after which increases during the expansion. Just before the moment of exhaust valves opening, adiabatic exponent of operating substance in the ZWC becomes almost equal to the adiabatic exponent of air.

Fig.5. Change in gas density in the zone without combustion

Fig.6. Change in adiabatic exponent in the zone without combustion

Not only the equilibrium molar concentration of O₂, but also all the other equilibrium molar concentrations in the ZWC show the same trend-they increase during the fuel evaporation and at the beginning of combustion they started to decrease and decreases until the opening of the exhaust valves, Fig.7.

Fig.7. The equilibrium molar concentration of O₂ in the zone without combustion

Fig.8. shows kinetic molar concentration of NO in the zone without combustion. Kinetic molar concentration of nitric oxide in the ZWC is very important for the calculation of the total emission of nitrogen oxides, from the entire investigated diesel engine.

Kinetic molar concentration of nitric oxide in the ZWC grows slowly, until the moment just before the opening of the exhaust valves. At that moment NO kinetic molar concentration suddenly increases and finally partially reduces from its maximum value at the moment of exhaust valves opening.

Among other volumes, it is yet interesting to show the change in total volume of liquid fuel in the cylinder (sum for all spray packages), as presented in Fig.9.

The total volume of liquid fuel in the cylinder initially increases during fuel injection. When fuel evaporation starts, the volume of liquid fuel starts to decrease. The liquid fuel volume decrease is
more significant as evaporation becomes more intense. At the moment when fuel evaporation finished, the volume of the liquid fuel becomes equal to zero.

5. Conclusion

Volumes change and distribution in the diesel engine cylinder is a very important element of each numerical model, as is the case of presented QD numerical model. Change in volumes inside the cylinder gives insight into details of in-cylinder process, what is essential to provide accurate and precise numerical simulation results. Volumes inside the cylinder, according to QD model specifications, are divided in two main parts: fuel spray packages and zone without combustion.

As the zone without combustion contains mostly air, it would be wrong to assume that it’s operating substance thermodynamic characteristics and volume change does not have a major impact on several important processes, as air-fuel mixing process and fuel evaporation.

In this paper is presented not only cylinder and ZWC thermodynamic volume change, it is also presented some important operating substance thermodynamic characteristics change inside ZWC, calculated with separately developed numerical sub-model. Knowledge of operating substance thermodynamic property changes in the ZWC is important not only for mentioned processes, but also for the accurate calculation of emissions (primarily NOx and Soot) from one cylinder and from the entire engine.

Liquid fuel does not participate in the thermodynamic volume of the cylinder, so its properties were calculated with separate developed mathematical models. One of the results for the liquid fuel numerical model is also presented in this paper.

The developed numerical model provides insight into the details of the process inside the engine cylinder which usually cannot be monitored with standard measuring equipment.

6. Literature


Environmental pollution should be understood as a permanent process caused mostly by anthropogenic factors, that is man. The products of combustion from internal combustion engines are toxic and harmful effects on humans and the environment. This is one reason for research of biogas as an alternative fuel and its benefits for smaller amounts of harmful products in its combustion. For this purpose is reconstructed diesel engine that runs with a mixed fuel diesel- biogas where diesel fuel used for combustion and biogas propulsion engine combustion. Thus it is given the overall internal construction of this type of engine. There is calculated speed characteristics of the diesel engine and the reconstructed motor biogas. Thus these diagrammatic comparisons will indicate the nature of the changes in both engines.

Keywords: BIOGAS, INTERNAL COMBUSTION ENGINE, RECONSTRUCTED DIESEL ENGINE, SPEED CHARACTERISTICS;

1. Introduction

Pollution is a qualitative and quantitative change of physical-chemical and biological characteristics of the main components of the environment that is geospatial. It is the result of rapid development, which is a consequence of technical - technological revolution in our century, but based on the opportunities to meet the growing energy demand. At one point due to mismatch of needs and opportunities the world has experienced an energy crisis. The consequence of this has increased interest of better and more rational use of existing and search for new energy sources.

Environmental pollution should be understood as a permanent process caused mostly by anthropogenic factor ie man, who with his greed seeks natural resources to make the most of their own interests. The more people wanted to change the environment, the more burdened globe with different degradation problems that require urgent resolution.

Until the beginning of the rapid development of industrialization, urbanization and motorization, which in different countries occurred at different times, it was believed that the sources of the essential components of the environment, air and water are limitless. Clean air and water were in abundance, and pollution occurred as a product of human activity were easily assimilated and removed because of great power of selfcleaning of the media.

But directly with growth of all kinds of activities, begin to appear the first warning signs that the forthcoming crisis of survival, not only for the surrounding ecosystems, but also human, if not urgently start control the sources of pollution. This would mean that environmental degradation gradually penetrated deep into all aspects of the environment in which a person lives, so it is difficult to determine its dimensions and consequences it causes. Source of pollution or environmental pollutant is any object that somehow emitted (discharged) harmful substances in the environment.

The products of internal combustion engines (fixed or embedded in various vehicles) are toxic and harmful effects on humans and the environment. This is one reason for exploring the various types of alternative fuels. On these fuels are made investigations from various aspects, but one of the most important is the smaller amount of harmful products of internal combustion engines over conventional fuels. This enables better quality of air safety and health of people, energy conservation and economic development.

2. Reconstruction of diesel engine

For diesel engines that run on a mixed fuel diesel- biogas, diesel fuel used for combustion of biogas which is fed into the intake manifold of the diesel engine through a special diffuser in which the gas and air are mixed to form a homogeneous mixture. At the end of the compression tact it is injected a small amount of diesel fuel used for combustion of the mixture.

The regulation of engine power depends on the regulation of the fuel mixture and method of regulation. Method of regulating the fuel mixture is: qualitative, quantitative and combined.

In qualitative way of regulation changing the composition of the combustion mixture is performed by the feed regulation valve in the gas, but at low loads the mixture is homogeneous and it can lead to absence of ignition. In quantitative regulation, the change of power is done by changing the quantity of a mixture at a constant composition.

At combined regulation of power in the field of high loads is used qualitative, but in areas of low loads is using quantitative way of regulation. This mode of regulation further complicates the construction and regulation of gas-diesel system.

At starting, engine running on diesel fuel. Once you reach the temperature 60 °C to 70 °C with a special switch includes an electronic control unit which activates a solenoid valve connected to the pneumatic installation of the vehicle and activates the pneumatic working cylinder which is coupled with the lever pump for high pressure and limited the number of revolutions engine on 800rpm (by limiting the amount of fuel supplied). With an increase in the load (increase in engine speed) and limited notch rack pump for high pressure through the accelerator pedal is operated dispenser biogas and proportional to the load increases the amount of biogas from the gas reducer through limiter maximum speed and the diffuser (mixer) which is fitted between the air filter and the engine suction manifold. Upon reaching the maximum engine speed set by the Electric Control Unit impulse given by electric generator which excludes electro magnetic valves for high and low pressure, and with this is interrupted the addition of biogas. Also impulses from electric generator perform opening electro magnetic valves for high and low pressure biogas when to restrain diesel fuel by stopping the notch rack pump high pressure, and further power control is performed by dosing of biogas.

The consumption of gaseous fuel is inspect from the control unit which is placed in a prominent position on the dashboard of the vehicle. When the pressure in steel bottles (tank biogas) will fall to 0.5 MPa pilot light turns on red light that signals that you need to load the biogas.
characteristics are determined one or several power ratings, which conditions. In this, depending on the engine type and its guaranteed by the factory - manufacturer for specific operating engine with fully open drajsler regulator or fully bringing the fuel. Maximum power - it is an effective power that can develop in necessary for operation of the engine, but not actuated it. losses for bringing into operation of the auxiliary mechanisms that engine to a working machine. Useful power efficient - the (defined) and may have several types: Effective power - power of the engine and under the standard conditions. They are used to draw the performance of (atmospheric) conditions are taken those in which the values of (atmospheric) conditions of work engine. For standard external operation mode influenced by pressure, temperature and humidity of the environment that surrounds it. They are known as external indicators, it called constant mode of engine operation. But when indicators (parameters) will change over time, the regime is called continuous or indicator changes around an average value of the parts of the engine depending on the conditions of leaks workflow. So each speed mode, the effective power (torque) of the engine changes from zero (ie idle motion) to a maximum value that the engine can develops. Change of power at a given speed is achieved through appropriate control devices – for example drajsler regulator in Spark Ignition engines and mechanism for fuel injector to diesel engines or engines with injection benzin. Both end positions for device management determines the interval of the possible modes of operating engines.

Mode engine (operating mode) includes the operating conditions of the engine, characterized by the totality of the values of the main indicators of its works. Some of the indicators or factors may be viewed as basic, and other factors are constant or not taken into consideration. Then emphasizes that the basic indicator is given the term "speed mode engine", "mode of engine load" etc. When the mode of operation of the engine is characterized by continuous or indicator changes around an average value of indicators, it called constant mode of engine operation. But when indicators (parameters) will change over time, the regime is called irregular.

3. Operating modes and features engine

The totality of the main indicators of the engine - the rotational speed of crankshaft axis, load (power or torque), thermal condition and others, characterize the regime of its work. Depending on the purpose of the engine, ie the machine, which it propelled, power (torque) and rotational speed of crankshaft axis must be changed in a wide range without impair its reliability. The lattest is connected with the thermal and mechanical load on the engine: the effective power (torque) of the engine changes from zero (ie idle motion) to a maximum value that the engine can develops. Change of power at a given speed is achieved through appropriate control devices – for example drajsler regulator in Spark Ignition engines and mechanism for fuel injector to diesel engines or engines with injection benzin. Both end positions for device management determines the interval of the possible modes of operating engines.

Engine power depending on the conditions under which recording (defined) and may have several types: Effective power - power that engine to a working machine. Useful power efficient - the difference between the effective power of the engine and power losses for bringing into operation of the auxiliary mechanisms necessary for operation of the engine, but not actuated it. Maximum power - it is an effective power that can develop in engine with fully open drajsler regulator or fully bringing the fuel. Nominal power - it is the effective power of the engine, which is guaranteed by the factory - manufacturer for specific operating conditions. In this, depending on the engine type and its characteristics are determined one or several power ratings, which are the standards and have different names. Exploitation power - effective power that the engine can develop in conditions of exploitation indefinitely. Economic power - extended effective power, in which the engine has the lowest specific fuel consumption. Minimum power - the smallest effective engine power with which it can work indefinitely.

Rotation Speed of crankshaft in the engine, which in some modes of operation of the engine, can have several types. Nominal Rotation Speed - speed of rotation of the crankshaft of the engine, which the plant manufacturer recommends using at nominal and exploitation power. Maximum turning at idle - maximum speed of rotation at idle, set out in the technical conditions of the engine. Minimum speed of rotation at idle - the minimum speed of rotation at idle, set out in the technical conditions of the engine which provides reliable continuous work of the engine idle for no less than 10 minutes.

Minimum working speed of rotation - the minimum speed of rotation at fully open drajsler regulator or completely bringing fuel, in which the engine is running steadily for a long time.

Rotation speed corresponding to the maximum torque - the rotational speed of the crankshaft at which the engine develops maximum torque. Maximum operating speed of rotation - the highest speed of rotation of the crankshaft in a completely open drajsler regulator or completely bringing fuel (diesel engines), provided the technical conditions of the engine. Usually the speed matches with nominal.

4. Calculation of internal combustion engine speed features and their diagrammatic display

The design of internal combustion engines particular interest is the absolute value and the expected nature of the changes to its basic parameters: power, torque, mean effective pressure, fuel consumption ratio, hour fuel consumption, coefficient of excess air, charge ratio, etc. Certain idea about that can get by setting external speed characteristic.

4.1. For Diesel engine

1. The range of change in the rotational speed of crankshaft of the engine:

\[ \eta_{\text{min}} = 350 \div 700 \, \text{min}^{-1} ; \quad \eta_{\text{min}} = n_{\text{N}} ; \]
\[ \eta_{\text{min}} = 400 \, \text{min}^{-1} ; \quad \eta_{\text{max}} = n_{\text{N}} = 1500 \, \text{min}^{-1} ; \]

2. Draw the power curve

\[ P_{\text{ex}} = P_e \cdot \frac{n_x}{n_N} \left[ 0,87 - 1,13 \left( \frac{n_x}{n_N} - \left( \frac{n_x}{n_N} \right)^2 \right) \right] \, \text{kW} \]
\[ P_e = 16,5 \, \text{kW} ; \quad n_N = 1500 \, \text{min}^{-1} ; \]

3. Draw the curve of torque

\[ M_{\text{ex}} = \frac{3 \cdot 10^4 \cdot P_{\text{ex}}}{n \cdot n_x} = 9554 \frac{P_{\text{ex}}}{n_x} \, \text{Nm} \]

4. Draw the curve mean effective pressure
\[ p_{ex} = \frac{P_{ex} \cdot 30 \cdot \tau}{V_p \cdot n_x} \text{ MPa} \]

\[ V_p = 1.82 \text{ dm}^3 \text{ (technical information) - working volume of the engine;} \]

5. Draw the curve of specific fuel consumption

\[ g_{ex} = g_{ex} \left[ 1,55 - 1,55 \frac{n_x}{n_N} + \left( \frac{n_x}{n_N} \right)^2 \right] \text{ m}^3/\text{kWh} \]

\[ g_{ex} = g_{ex} \left[ 2,1 - \frac{n_x}{n_N} + 0,8 \left( \frac{n_x}{n_N} \right)^2 \right] \text{ m}^3/\text{kWh} \]

6. Draw the curve hour fuel consumption

\[ G_{h} = g_{ex} \cdot P_{ex} \cdot 10^{-3} \text{ kg/h} \]

7. Draw the curve of the coefficient of excess air

\[ \alpha = (0.7 \pm 0.8) \cdot \alpha_N - (0.0001 \pm 0.0004) \cdot n_x \]

\[ \alpha_N = 1,2 + 2,2 \]

Selected value for \( \alpha_N = 1,7 \)

The final formula is: \( \alpha = 0,75 \cdot \alpha_N - 0,0001 \cdot n_x \)

8. Draw the curve charge ratio

\[ \eta_{ex} = \frac{p_{ex} \cdot \alpha \cdot \alpha_N \cdot g_{ex}}{3600 \cdot \rho_B} \]

For naturally filling \( \alpha < 1 \)

4.2. For Gas engine

1. The range of change in the rotational speed of crankshaft of the engine:

\[ n_{min} = 400 \text{ to } 600 \text{ min}^{-1}; \quad n_{max} = (1,1 \pm 1,2) \cdot n_N; \]

\[ n_N = 1500 \text{ min}^{-1}; \quad n_{max} = 1,1 \cdot 1500 = 1650 \text{ min}^{-1}; \]

2. Draw the power curve

\[ P_{ex} = P_{ex} \cdot \frac{n_x}{n_N} \left[ 0,87 \cdot 1,13 \frac{n_x}{n_N} - \left( \frac{n_x}{n_N} \right)^2 \right] \text{ kW} \]

3. Draw the curve of torque

\[ M_{ex} = 3 \cdot 10^4 \cdot P_{ex} \cdot n \cdot n_x = 9554 \frac{P_{ex}}{n_x} \text{ Nm} \]

4. Draw the curve mean effective pressure

\[ p_{ex} = \frac{P_{ex} \cdot 30 \cdot \tau}{V_p \cdot n_x} \text{ MPa} \]

5. Draw the curve of specific fuel consumption

\[ g_{ex} = g_{ex} \left[ 1,55 - 1,55 \frac{n_x}{n_N} + \left( \frac{n_x}{n_N} \right)^2 \right] \text{ m}^3/\text{kWh} \]

\[ g_{ex} = g_{ex} \left[ 2,1 - \frac{n_x}{n_N} + 0,8 \left( \frac{n_x}{n_N} \right)^2 \right] \text{ m}^3/\text{kWh} \]

6. Draw the curve hour fuel consumption

\[ G_{h} = g_{ex} \cdot P_{ex} \cdot 10^{-3} \text{ kg/h} \]

7. Draw the curve of the coefficient of excess air

\[ \alpha = (0.7 \pm 0.8) + 0,0006 \cdot n_x \text{ for } n_x = n_{min} \text{ to } 0,8 \cdot n_N; \]

\[ \alpha_N = 1,2 + 2,2 \]

Selected value for \( \alpha_N = 1,7 \)

8. Draw the curve charge ratio

\[ \eta_{ex} = \frac{p_{ex} \cdot \alpha \cdot \alpha_N \cdot g_{ex}}{3600 \cdot \rho_B} \]

Table 1: Calculation data for DIESEL engine.

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<th>n (min(^{-1}))</th>
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<th>M</th>
<th>p</th>
<th>g</th>
<th>G</th>
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Fig. 2 Total speed characteristics of diesel engine depending on rotation speed

Table 2 Calculation data for GAS engine (test engine)

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Fig. 3 Total speed characteristics of gas engine depending on rotation speed (test engine)

5. Conclusion

There are analyzed the parameters derived from speed characteristics of the internal combustion engine i.e. effective power Pe, torque Me, average effective pressure pe, specific fuel consumption ge, hour fuel consumption Gr, coefficient of excess air α, charging ratio M. Analytical method used to draw features based on mathematical, theoretical and partly empirical relationship between the basic parameters of the working cycle and the factors affecting them. So, it got the correct course of movement speed characteristics (graphically expressed depending on each indicator of the rotation speed) that were compared with curves on a test engine and thus can determine all modes of engine operation. Thus it became evident that the curves of the gas engine have the correct course of motion curves and thus proved that the reconstruction of diesel engine was completely relevant.

6. References

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INFLUENCE OF ETHANOL TO THE FUEL MIXTURE ON CHARACTERISTICS OF THE PETROL ENGINE

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Faculty of Engineering and Technology – Dnipropetrovsk State Agrarian and Economical University, Ukraine
e-mail: derkach_dsau@i.ua, addsau@gmail.com

Abstract: The ecological effect was studied when using ethanol-containing fuel mixtures in gasoline engines. It has been established that with increasing the mass fraction of ethanol in the fuel mixture, the amount of carbon monoxide and oxygen emissions decreases in the exhaust gases, and the amount of carbon dioxide increases.

KEYWORDS: ETHANOL, FUEL MIXTURE, PETROL ENGINE.

I. Problem Statement
Ukraine – is the largest European and world supplier food and coarse grains. An actual problem of harvesting agricultural crops was resolved and it’s significantly reduced of yield losses past 5 years. Growing early grain crops occupy a special place in the sphere of crop production, yearly square of growing one is about 16 million ha. Around 6 million ha of them occupy winter wheat. Based on USA Agricultural Ministry data, in 2016 Ukraine placed the second place for yields of winter wheat in the World [1]. Nowadays even in the risk zone of farming, in condition of natural moisture deficit the yield of winter wheat at the level 7 t/ha, and maize – from 8 to 10 t/ha is normal. Food problem is solved within the country and today there are all premises for development of manufacturing fuel on petroleum origins. Among these fuels the bioethanol is particularly effective [2].

Today bioethanol relate to non-traditional kind of engine oil, but the first tests of its application refered to the end of XIX century, when there was no food operation of petroleum. But at the beginning of XX century it was crowed out by more cheaper mineral fuel (mostly, through improving cracking mechanism of petroleum). That at time turning to bioethanol caused by the range (number) of reasons: high and unstable prices for petroleum; not acceptable ecological condition; desire to the number of countries, including Ukraine, is to get independence of energy products’ another countries etc. Despite the quite good an ethanol dimension, European countries to subsidize farmers ... ";

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The aim of the present work is to study the impact of bioethanol on some characteristics of modern engines.

Political aspects:
- These aspects are closely intertwined with economic and environmental aspects: with economic, it is primarily the support of farmers and the creation of a favorable investment policy, with environmental, it is linked to the fact that environmental safety becomes part of national security. Therefore, it is not surprising that a number of legislative acts stimulating the production and use of biofuel have been adopted in the numerous leading countries in the world (USA, Germany, France, Sweden, etc.).
- The Ministry of Agricultural Industry of Ukraine in 2007 was initiated the tax incentives for producers of biofuel. At the end of 2006, the Cabinet of Ministers of Ukraine approved a program for the development of biofuel production for 2007-2010; According to this program, by 2010, 100% of vehicles with internal combustion engines should be converted to bioethanol (not performed). Ukraine planned to build up to 2010 at least 20 biodiesel plants. The draft law "About the development of production and consumption of biological fuels" (No. 3158 of June 8, 2007) provides for all producers of gasoline the norms of compulsory consumption of bioethanol: in 2008 - at least 2%; In 2009 - 3%; In 2010 - 5%; In 2011 - 10%. Biofuel should be manufactured in accordance with the procedure established by law and complied with state standards. Biofuel can be used directly as fuel in its pure form, as a component for the production of other fuels or for mixing with traditional fuels. The state standard for biofuel was also developed: for biodiesel ДСТУ 6081: 2009, and for bioethanol - ДСТУ 7166: 2010.

Unfortunately, in the following years no development of biofuel production occurred. The reasons of this in the article, which will be not considered by us, because they are more political than economic. However, today in Ukraine there are extremely favorable conditions for the production of this type of fuel.

Formulation the objective of the study. The aim of present work is study an impact bioethanol on some characteristics of modern engine.

Research procedure. To determine the main characteristics of the engine during work with various mixtures of gasoline and bioethanol, known methods were used, the diagnostic complex "Спрут-Диагностик" gas analyzer Infrakar M1.01, the stand for cleaning and adjusting the injectors of the gasoline engine Спрут-Форсаж-Турбо (Picture 1).

The investigations were subject to:
- fuel mixtures of gasoline AE95 and bioethanol E5, E10, E15 and E20;
- engine «Volkswagen» monoinjection type, with the number of revolutions of the crankshaft 1000 ± 15 rpm;
- the composition of the exhaust gases was determined by the gas analyzer Infrakar M1.01;
- the temperature of the exhaust gases was recorded in the exhaust manifold using a thermocouple;
- the temperature of the coolant and its rate of change was measured by the "Спрут-Диагностик" temperature sensor.

2. Tests result

It is found that the density of ethanol, which was used in the tests was equal to 0.77, and pure gasoline - 0.73 g/cm³. Therefore, with an increase in the mass fraction of ethanol in the fuel mixture by 20% (E20), its density increased by 4% (Picture 2). As seen from the graph, the fuel injection amount is inversely proportional to the density. Thus, under identical conditions of the fuel (supply pressure was 0.5 MPa) to increase the fuel density difference between the amount of fuel A95 and E20, was 6%.

On the Picture 3 the main characteristics of engine and fuel mixture are showed (ρ - density of fuel mixture; Te - temperature of exhausted gases; Vd - speed of engine heating rate till work mode; Pм - vacuum pressure in an exhaust manifold) dependence on the content of exhaust gases: carbon dioxide СО₂ and gas CO. As can be seen, with increase percentage content of bioethanol the engine warm-up speed Vd to work mode and temperature Te of exhausted gases declined slightly; that’s why we may talk about reducing the heat load on engine. Reducing of vacuum pressure Pм in the intake pipe with growing share of bioethanol may be connected with width reduction of oil film on the surface of cylinders, that in general reducing the width in the piston group; this may be due to density reduction in the fuel mixture (density of ethanol less then density of fuel).

![Picture 1](image.png)

Picture 1. Stand «Спрут-Форсаж-Турбо»:
1 – control panel; 2 – injector; 3 – glass for the fuel collection.

![Picture 2](image.png)

Picture 2. Dependence density fuel-mixed ρ and the amount of fuel Q injected from its composition.

![Picture 3](image.png)

Picture 3. The main characteristics of engine from fuel mixture.
Analyzing the main environmental indicators of exhaust gases at a crankshaft rotation speed of \( n = 1000 \text{ min}^{-1} \), it was found that with an increase in the mass fraction of ethanol from 0 to 20%, carbon monoxide emissions decreased from 3.46 to 1.21% or 2.85 times (Picture 4). The amount of carbon dioxide increased by 15% respectively. This indicates that with the increase in the amount of ethanol in the fuel mixture, more complete combustion occurs.

As can be seen from the graph, the amount of oxygen \( O_2 \) decreases, which, when ethanol is burned, takes a more active part in the afterburning of the ethanol-containing mixture. When all types of mixtures are burned, the excess air factor \( \lambda \) increases simbatically the proportion of ethanol.

With regard to the composition of exhaust gases, with a rotational speed of the engine crankshaft of 2000 rpm, the results indicate that the dependencies have a slightly modified appearance (Picture 5). So, the maximum of \( CO_2 \) in the exhaust gases falls on the mixture of E15 and further there is an insignificant decrease in this index. Compared to pure gasoline, with this mixture, the amount of \( CO_2 \) increased by 19%. However, even with the combustion of the E20 mixture, the amount of \( CO_2 \) decreased by 4%. In reverse proportion to the amount of \( CO_2 \) in the exhaust gases is the amount of oxygen \( O_2 \), the volume fraction of which decreases (with an increase in the proportion of ethanol), and in gases of the mixture E20 - slightly increased. Obviously, the excess \( O_2 \) does not enter the combustion reaction and is released separately. The amount of carbon monoxide \( CO \) is steadily decreasing and in gases of the mixture E20 it is 2.3 times less than in the exhaust gases of pure gasoline A 95.

The smallest value of the coefficient \( \lambda \) is also observed at the burning of mixture E 15. As can be seen from the dependence (Picture 5), a rapid increase in the amount of carbon dioxide occurs with an increase in the mass fraction of ethanol and a maximum which is in the E 15 mixture.

It should be noted that the engine performance was stable during working on all fuel mixtures.

4. Conclusion
1. Stable engine work on the fuel mixture E5 is possible without adaption of the fuel system, at the reduction of heat load to the engine; the dilution in the intake pipe is within the permissible range.
2. Engine work on the fuel mixture E15 has following features: educing the heat load to the engine by 12 %, reducing the vacuum pressure in the intake pipe by 18%, which can lead to malfunctioning of engine at the long term operation.
3. Ecological aspects: ecological effect was insignificant when the engine being worked on a mixture E5, but at the working on a mixture E15, the decrease in carbon dioxide \( CO_2 \) by 12.5% was observed.

5. References
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Abstract: There are in the article systematically finding out scientific-methodological and organizational-economical foundations of the development of biofuel market, forming of energy crops market, which used as plant origin bioraw material and economical estimation of their usage in the area of agro-industrial complex. World trends of development of biofuel from plant origin bioraw material were generalized, theoretical-methodological bases of forming biofuel market and its social-economic meaning in development of agro-industrial complex and economy integrally, other problems of organization of producing of bioenergy crops and competitiveness of biofuel market were examined. Prospects of development of biofuel were economically substantiated. The main problems, which restricting biofuel market are the absence of the accurate strategy of development.

KEYWORDS: ROOT CROP, BEET TOPS, ROOT CROP HEAD, CLEANER, WORKING MEMBER, SENSING MEMBER, NORMAL REACTION, DEFOLIATOR

1. Introduction

Optimistic forecasts concerning the inexhaustibility of traditional natural resources of energy carriers (coal, oil, gas, peat, etc.) are a thing of the past. There are calculations according to which the explored oil reserves will be exhausted by 2018, the production will be reduced by 30-40%, and the demand for energy consumption in the world will increase by 20%. And this trend will increase from year to year, as the extraction of fossil energy sources is reduced and in the near future the reserves of these energy carriers, according to international experts, will be exhausted. And these are global destructive phenomena in the biosphere, the rapid growth of the cost of natural energy sources, the accumulation of excessive amounts of organic waste from industrial, agricultural and domestic sources, which is a real threat to the existence of civilization, unless, of course, their new sources are found in time. Pessimists believe that this will happen for 20-25 years, optimists point to a period of 50-70 years. But both agree in one: the development of mankind is possible only if new types of energy-saving biotechnologies and raw materials, in particular renewable energy sources (RES), are attracted, which, as is known, can be used in more than ten areas of the economy.

Actually, today there is no need to agitate for the production of RES and biofuels. Europe has already understood this and started to grow biomass from specialized crops and solve the problem of renewable energy, when biofuel was worth ten times more expensive from traditional sources. After 10 years, the price almost equalized. And it's useless to think that the price of oil will fall [2].

The recoupment of capital expenditures for the construction of refineries and the purchase of appropriate means for processing bio-raw materials for fuel directly depends on the constant receipt of biocement. Bio-raw materials in the form of energy crops (oil and sugar, sugar-containing), as shown by literature sources and domestic experience, are a reliable source for solving the problem of the development of biofuel market in the countries of the world. For example, over the past few years, more than 100 ethanol plants have been built in the United States. Grain, especially corn, goes to ethanol production. The plant worth $ 150 million pays off for the year; 60% of these enterprises belong to farmers. There is no question to give subsidies from the budget, subsidies. The US produces much more grain than it consumes. The "extra" grain there always tried to attach to the foreign market. Now, a decrease in exports is forecasted here, as it began to be used more in the production of ethanol. Therefore, now the corn market in the world has so rapidly increased. It is much more profitable to direct it to biofuels than to export. Profit American farmers are offering their customers a renewable, environmentally friendly alternative fuels.

The same picture with the use of reed in Brazil. The global sugar market is also heating up in other countries of the world.

For Ukraine, which every year consumed about 200 mil ton e.f. fuel-energetic resources (FER) and refer to the scarce energy countries, because it meet their electricity demand about 53% and imported about 75% of necessary volume of natural gas and 85% of crude oil and oil products, price of which constantly is growing up, the problem of new sources of energy is very urgent. Exactly development of biofuel market and new types of energy saving biotechnologies and raw material, namely, renewing sources of energy (RSE) as is generally known can be used more than in ten areas of economy, open for Ukraine, which have powerful potential of renewing sources of energy almost of all types (solar energy, wind energy, biomass, biofuel, geothermal energy, micro water power), the unique chance is the way to the energy and ecology-food safety.

There are calculations according to which the exploitation of renewable energy sources promises a great potential according to the world trend of reducing consumption of fuel energy and taking into account the Kyoto Protocol, which Ukraine signed together with other states. According to expert estimates, the annual total potential of the biomass of agro-industrial production of Ukraine available for energy production is about 49 million tons of fuel equivalent, technically achievable– 36 million tons of fuel equivalent, and economically expedient– 27 million tons of fuel equivalent. Ukraine can provide food products using only up to 70% of land suitable for agricultural production. So, has reserves of increasing volumes of marketable crop production through innovative technologies, which makes it possible to export a significant part of it and convert it into biofuel.

Ukraine possesses a powerful potential for renewable energy sources of almost all types (solar energy, wind energy, biomass, biofuel, geothermal energy, microhydroenergy). The use of this resource promises a great potential according to the world trend of using renewable energy and taking into account the Kyoto Protocol, which Ukraine signed together with other states. According to expert estimates, the annual total potential of the biomass of agro-industrial production of Ukraine available for energy production is about 49 million tons of fuel equivalent, technically achievable– 36 million tons of fuel equivalent, and economically expedient– 27 million tons of fuel equivalent. Ukraine can provide food products using only up to 70% of land suitable for agricultural production. So, has reserves of increasing volumes of marketable crop production through innovative technologies, which makes it possible to export a significant part of it and convert it into biofuel. For potential investors, the development of the biofuel market in Ukraine provides for the acquisition of positive changes in terms of efficiency in business activities and, at the same time, economic and social expediency for the national economy as a whole. This factor, combined with favorable soil and climatic conditions for growing crops with a high level of biomass energy accumulation during vegetation and available labor, makes Ukraine extremely attractive for the development of the biofuel market. For the opportunity to develop bioethanol production in Ukraine, business companies from several countries are already competing, which makes it possible to...
receive not only food but also renewable energy through agriculture.

The production and use of biofuels in agriculture in Ukraine, the development of its market is an objective prerequisite for creating additional jobs, increasing employment of the rural population, increasing the efficiency of production and the welfare of the peasants. After all, most processing enterprises are located in rural areas, and for some localities they are the main payers of taxes to local budgets. On their basis social and household infrastructure of rural settlements is built, and the irregular work of processing factories painfully hits precisely the most vulnerable layers of the population—leads, in particular, to problems with providing children's gardens, schools, and houses with heat and electricity.

To significantly increase biofuel in Ukraine's energy balance, it is necessary to create alternative energy facilities for the most promising technological areas and form an efficient market. But the use of new energy sources (hydrogen, direct conversion of solar energy to electric, thermonuclear fusion) is rather problematic, especially for large-scale use. The development of this direction inhibits the lack of an effective biofuel market. Meanwhile, it is bioenergetics that can develop at the fastest rates. Among renewable energy sources, energy carriers of biological origin or biofuels are becoming more widely developed: biodiesel, bioethanol, biogas.

There are several reasons for the economic and social need to increase the volume of fuel and energy resources and the development of the biofuel market in Ukraine, starting from considerations of energy security, diversification of national production, support for innovation and ending with the economic and social efficiency of the biofuel market development on the basis of high motivation for growth in the agricultural sector, positive social shift in relation to rural employment and environmental security.

3. Results and discussion

Practical experience in the formation of the biofuel market in European countries shows that biomass: carbonaceous (vegetation, wood chips, seaweed, grain, paper, packaging) or sugar-bearing (sugar beet, sugar cane, reeds, sorghum) is of the greatest importance among renewable energy resources that since ancient times it has been used by mankind and is still a source of energy on most of the planet. Energy-attractive plants of the European soil-climatic zone include the following: 1) one-year-olds with a high content of sugars and starch (sugar beet, cereals, corn, potatoes) for the industrial production of bioethanol; 2) oil crops (rape, sunflower, soybean, oil flax), from which oil and biodiesel are produced; 3) perennial herbaceous plants (miscanthus large or reed, interspecific hybrid of sorrel – rumex, millet, Jerusalem artichoke, mallow pennilvan, peasant gopher, sakhalin mountaineer, etc.). Biotechnologies are also being developed that are based on the achievements of gene energy and genetic engineering, which makes it possible to revise the stereotypes of bioethanol production based on energy crops, expand the variety of sugar and starch-containing crops and reduce the cost of biofuel production.

The sown areas of energy crops have sharply expanded in recent years and in Ukraine—in the limits of more than 2 million hectares, the technologies of growing, harvesting and previous preparation of raw materials are improved, deepening research on improving the genetic potential of energy countries, efficiency and energy intensity of growing alternative crops suitable for processing on biofuels, scientific recommendations on the growing of bio raw materials are developed, which it is expedient to use when determining the forecast yield (and this, as well as observance of the scientifically grounded system of farming in the regions of Ukraine, optimal structures of sowing areas, crop rotation systems and the technology of their growing, is an indispensable condition for the formation of an effective biofuel market).

Our studies show that one of the most potential and unused sources of renewable energy for Ukraine is the production of rare biofuels from biomass (crops, wood cultures, herbaceous plants). For this purpose, it is most promising and economically justified to grow such types of energy crops as corn, triticale, wheat, various kinds of sorghum and millet, sugar beet and their processing products (mela), sunflower, rape, potatoes, agricultural and forestry waste, miscanthus, poplar, energy willow, stems and sunflower husks, etc. With bio-raw materials, liquid, gaseous and solid fuels are obtained. Depending on the use, liquid biofuel is divided into: a) for carburetor engines with external formation of a fuel-air mixture, b) for diesel engines with internal formation of a fuel-air mixture, c) liquid biofuel for boilers instead of black oil. For the production of bioethanol – cereals, primarily corn kernels, sugar beets and potatoes; Biodiesel fuel – seeds of oleaginous crops, in particular castor oil, sunflower, soybean.

Considerable prospects in Ukraine have some non-traditional cultures capable of accumulating large biomass, in particular because photosynthesis occurs in them for a long period, from early spring to late autumn, as well as fast-growing tree species and new varieties of poplar, willow and other tree species cultures. Potatoes have a record for accumulating energy per hectare of area in our conditions, but the problem of its storage for a long time before processing has not been solved.

An important culture, in terms of bioenergetics, is sugar beet. The latest scientific research and feasibility analysis confirm: in the list of alternative crops, sugar beet, which can be processed directly in sugar plants in a concentrated 25% syrup with further processing at distilleries, is the most attractive. For the production of 1 ton of 25% syrup, it is necessary to process 2 tons of sugar beet roots. In production conditions, you can get 166.5 liters of bioethanol. The technology of its cultivation, transportation and storage is well developed, but a number of problems with obtaining biofuel from this raw material, in particular a significant reduction in energy costs, are not solvable.

Ukraine has favorable conditions for growing rapeseed. Provided that 10% of agricultural land is taken as a crop and yield of 25 centners per hectare, the country can annually grow up to 8.5 million tons of seeds, processing of which provides an output of about 3 million tons of biofuel per year. Unfortunately, with respect to rapeseed, as a raw material for obtaining biodiesel fuel, there have not been thorough studies on the economic efficiency of its cultivation in different regions of Ukraine in comparison with other cultures. Are not developed in the regions and priority technologies for obtaining biofuel crops.

Perspective bioenergetic crops are chicory and Jerusalem artichoke – plants, which, under appropriate climatic conditions, do not require very high quality soils.

Another high-performance sugar-bearing culture, which deserves additional research, is sugar sorghum. This drought-resistant plant up to 4 m in height contains up to 20% sugar in its leaves and stems. Given the great selection potential, unpretentious growing conditions, one can consider this crop as a perspective raw material. An important economic effect is that when processing sugar sorghum for ethanol there is no need to convert starch into a sacchariferous mass, both from raw grain and corn.

An important criterion for the industrial production of biofuels is the possibility of ensuring the processing of raw materials throughout the year, because transportation costs for the delivery of
raw materials to the plant and its storage prior to incorporation into the technological process are significant costs of the whole technology cycle.

Actual tasks for development of bio-raw materials market in Ukraine are: development and using modern technologies for growing energy crops, which are planned for industrial processing for biofuels, increasing production crops, ensuring crop protection, technical modernization of agro-enterprises, reaching optimal power, developing and implementing regulatory frameworks, alignmented with EU legislation [6].

Ukraine has collected a sufficient information and legal database for scientific and theoretical support of the main areas of renewal of the fuel and energy complex through the planned use of biofuels, in particular rare. To do this, it is necessary to establish a serial production of technological equipment at the existing machine-building and mechanical plants. At the same time, it is necessary to conduct economic studies and calculations on the further development of agricultural areas, which will transform some of the production potential into the development of agricultural crops for processing them for biofuel. The possibilities and expediency of using for the biofuel residues of such crops as wheat, barley, corn, taking into account the need to preserve the organic matter of the soil, etc., have not been determined. In the conditions of our state, because of the growing shortage of organic matter in soils, it is not yet practical to use agricultural waste as raw material for fuel, and therefore it is better to leave straw, corn stalks and soybeans on the field (except for sunflower leaves). But in some cases, if there is a surplus of waste, it can also be processed into chemical products and biofuels. And in any case, we must strive for the result of changes and transformations to become an increase in the economic efficiency of management and not create barriers to the country’s food security.

Undoubtedly, by organizing the work on the formation of the biofuel market in Ukraine, the state should, as it is done in the leading countries, introduce temporary, by the way, significant, tax and other incentives for biofuel producers. An extremely important factor in increasing the efficiency of biofuel production is the selection of plants to increase the availability (by the content of useful substances) for the production of bioethanol and biodiesel fuel. In solving this problem, modern methods of biotechnology will play a leading role. It is not just about increasing the productivity and plant resistance to abiotic and biotic stresses, but also about changing the biochemical features of grain or other products (the content of pentosans, the change in the ratio of amylase and amylopectin, etc.). It should be emphasized that the participation of fundamental science in the development of bioenergy will largely be determined by its stock in the direction of both the creation of new genotypes of cultivated plants, more adapted to use their products and biomass for the production of biofuels, and in the search for new, non-traditional crops with an increased conversion factor of photosynthesis energy in the desired biomass at relatively low costs of fossil energy for their production, transportation and storage. In solving these problems, genomics, in particular genetic engineering, botany, biochemistry, plant physiology, will play a significant, and perhaps decisive role. It is also encouraging that the Verkhovna Rada, the President and the Government have demonstrated support for the development of renewable energy sources and adopted a number of normative acts, the adoption of which will stimulate the production of alternative fuels [3].

In order to overcome obstacles to the development of the biofuel market in Ukraine on the basis of ethanol, biodiesel and to ensure sufficient export volumes of this fuel, it is advisable:

- develop a strategy – an action plan for at least 10 years for the sustainable development of biofuel. The plan should be consistent, systemic and clearly delineate the effective use of budgetary funds within the proposed ways of reforming in this area. To create a biofuel market and attract serious investors to Ukraine, a clear policy course is needed, supported by a functioning legislative and regulatory framework;

- to introduce a set of measures for the development of intensive technologies for the cultivation of high-energy plants (grains, oilseeds, sugar and starch-containing) and the necessary volumes of biomass for other crops for the production of biofuels and other energy carriers, which in turn can be used in cogeneration plants to provide the process with electricity and achieving non-waste production;

- implement arrangements for the entry of Ukraine into the market consumption of environmentally-friendly renewable fuel energy, including ethanol fuel, biodiesel, etc. components;

- to adopt legislative and legal acts on the mandatory use in Ukraine of motor fuels with antiknock detergent oxigenic components;

- to ensure non-admission of mutual substitution, for the purpose of financial abuse in the sale of biofuels;

- to create energy-autonomous enterprises on radioactively contaminated lands of Ukraine in order to obtain rapeseed raw materials for biodiesel production and decontamination of these lands and their return to full-fledged activity [7, 8].

The issue of development and production of alternative energy sources in Ukraine is at the stage of development when financial support is needed and a deep understanding in state structures and scientific circles about the need for wider promotion of production and use of biofuels and changing stereotypes of bureaucrats' thinking [2].

Energy independence is an extremely important strategic goal, because Ukraine has already felt that this means being in energy dependence. We need very different approaches to solving renewable energy. Analysis of the modern market of technological equipment and technologies proves that, technically, there are no important obstacles to the industrial production of biofuels. According to our research, the economic effect of production will increase under the conditions of the optimal choice of technology for growing and processing, the justified location of the necessary equipment in
The strengthening of the diversification of agribusiness with a view to reducing market risks remains topical. In this respect, it should be remembered that Ukraine should not repeat the mistakes of the global division of labor and globalization that led to the specialization of a number of countries in the production of raw materials or a limited set of export commodities for world markets [4, 5].

4. Conclusions

Considering the above, it is possible to draw conclusions regarding the possibility of forming a biofuel market in Ukraine to the level, as defined by the Kyoto Agreement and Directive 2003/30/EC, without causing problems to provide the population with food in accordance with existing needs, norms, prospects. Bioenergy is a powerful stimulus for the development of the agricultural sector. It intensifies the flow of investment in agriculture, helps improve technology and infrastructure, increase food production and reduce its cost.

Of particular importance is the development of the concept of the organization of enterprises with processing of biomass with full provision of their local raw materials base. The use of non-traditional crops is a significant potential of the domestic economy and a guaranteed future reserve, which opens significant prospects for the development of society, the economy and overcoming environmental problems. Perspective development of RES in the country, according to the principles of the Green Book, should be based on economic competition with other sources of energy, while simultaneously implementing state support measures for advanced RES technologies that reflect public interest in improving energy security, environmental cleanliness and countering global climate change.

The development of the biofuel market in Ukraine should be consistent and justified, taking into account the possible impact on the national economy and the natural environment and rely on international experience and take into account the need to maintain a balance between food, feed and energy use of agricultural products. The state can not stand aside as regards the creation of bioenergy technologies for the production of biofuels, and in terms of developing the market and promoting the protection of this product and its international competitiveness.

The main problems that restrain the biofuel market are: the lack of a clear development strategy, which would take into account all the factors influencing the provision of energy and food security, ensuring an increasing demand for motor fuel and preserving the fertility of agricultural land; lack of a balanced system of legal, regulatory and other market instruments that would permit effective economic activities in the production and consumption of biofuels; Insufficient development of the storage and sale infrastructure for liquid biofuels; lack of effective control over the quality of biofuel at all stages of its production and sale; unfavorable conditions for attracting investments, including foreign ones; Low level of implementation of decisions and normative and legislative acts at all levels of government. With the aim of introducing and stimulating the development of alternative energy and the wider use of new fuels, the necessary state program for the scientific development of biofuel production from alternative sources of raw materials, preferential support of credit resources and a consistent investment policy of the state regarding the creation of financial funds to promote scientific research in the field of alternative sacchariferous crops. In programs on energy, ecology, land use, water supply and agricultural development, measures should be prescribed for preferential taxation of new types of fuel, reduction of customs payments for imports for foreign equipment that is used in alternative energy.

5. References


