Abstract: The paper presents the development of a simulation model of a car for the research of its controllability under the influence of a sudden gust of crosswind, viewed as a mechanical system with three stages of freedom. The parameters of the mechanical system, consisting of an ideal solid body are determined. A model of three differential equations is obtained, which describes the translational movement along the horizontal transversal axis, and the rotary motions respectively around the vertical and the horizontal longitudinal axes. The acceleration functions are obtained, the linear transversal velocity, the two angular velocities and the rotation angle are determined. The simulation model is created by MATLAB and its toolbox SIMULINK. Some results are given and analyzed for six locations of the mass centre, which show the influence of the mass centre location upon the car controllability.

Keywords: CAR, VEHICLE, CONTROLLABILITY, MATHEMATICAL MODELING AND COMPUTER SIMULATION

1. Introduction

Until the advent of computers, analysis can be divided into two areas - theoretically and experimentally. The numerical modelling is a separate direction, apart from the first two, though it has its aspects that rather complement them or even replace them. Numerical modelling does not have the roughness of the strict mathematical analysis, although it is based on the fundamental mathematical analysis in the construction of equations for numerical solution. This makes it closer to the experimental analysis, retaining many of its disadvantages. To research the controllability of a car through simulation models, the analyser at startup of the computer, can monitor the processes the same way as with the experimental models. During the simulation, "experiments" are performed with a specific configuration of the machine with determining of the effects by changing various parameters on its work, and the advantage in relation to the experiments is that the system configuration is changing without additional manufacturing or processing. With the simulation models it is not necessary to watch for the installation and connection of measuring instruments, since there is constant access to all places in the machine.

On the other hand, the model will always be an approximation of reality, and can not completely replace physical experiments and theoretical analysis. Therefore, the simulation results [6, 7] require confirmation of practical results, to which are dedicated a number of issues about controllability of cars [1, 2, 3, 4, 5].

The main objective of this work is to investigate the influence of the mass centre location in a vertical longitudinal plane on the parameters of controllability of a car with impact of a sudden gust of crosswind, examined with the established simulation model as a mechanical system with three degrees of freedom [7].

2. Formulation of the problem

When building a mechano-mathematical model to analyze controllability of a car, as in most cases, the following assumptions are taken [2, 7]: the movement is through a horizontal surface with a specified speed, the steering wheels are set for a rectilinear motion, the vertical displacements and rotations of the chassis in relation to the transversal axis are absent; the redistribution of the normal load on the wheels is ignored, the resulting motion consists of rotation around the vertical axis, lateral movement and heel of the masses located above the springs.

For small deviations of the car from its rectilinear motion it is assumed that the external forces are proportional to the linear and angular displacements and their derivatives.

Instead of the heel axis, joining the centres of the front and rear suspension heel, another axis is selected that is parallel to the supporting surface and lying in the longitudinal vertical plane of symmetry. The new axis passes through the intersection of the vertical line that runs through the mass centre, with the axis of the heel [2]. The intersection O is considered to be the beginning of the coordinate system and the basic kinematic, geometric and mass parameters of the mechanical system; these are shown in Fig. 1.

![Fig. 1. Coordinate system of a car with three degrees of freedom: I and II - front and rear heel centers; m - mass of the car; m_s - suspended masses; m_u - unsprung masses](image1)

![Fig. 2. Forces and moments acting on the car with three degrees of freedom: I - axis of the heel](image2)
With the thus chosen coordinate of origin, just below the mass centre of the car, the latter is exemplified by two concentrated masses ms and mu, arranged so that the sum of their moments in relation to the mass centre of the car is equal to zero. The system in hand has only three degrees of freedom and for independent coordinates are taken the transverse velocity $V_c$, [m/s], the angular velocity along the vertical axis $r$, [rad/s] and the heeling angle $\phi$, [rad].

The forces and moments acting on the car, viewed as a mechanical system with three degrees of freedom, and their indications are shown in Fig. 2.

Lateral force $Y$, [N] and moments $N$ and $L$ in [Nm], respectively, around the vertical and longitudinal axes caused by the action of crosswind on the car are presented in Fig. 3.

![Fig. 3. Forces and moments generated by the action of crosswind on the car](image)

To determine the aerodynamic forces and moments, the results of the coordinate system used for measurements in wind tunnels are brought forth to the adopted coordinate system. The lateral force and moments around the vertical and longitudinal axes caused by the action of the crosswind on the car are presented in Fig. 3.

The coefficients of the moments around the vertical axis, respectively of the lateral force on the front wheels of the heel $C_{f,\phi}$, - the coefficient of lateral force on the front wheels of the heel $C_{f,\phi}$, - the coefficient of the lateral drag of the front and rear wheels $C_{f,\phi}$; $C_{f,\phi}$ - the coefficients of the lateral drag of the front and rear wheels [N/rad]; $a, b$ - the distances from the mass centre to the axis of the front and rear axe [m]; $\alpha_f, \alpha_r$ - the coefficients of the front suspension heel along the chassis and the rear wheels steering due to the heel.

The coefficients of the moments around the vertical axis, representing their partial derivatives in relation to the established coordinates are calculated by the formulas

\[
Y = \frac{1}{2} \rho U^2 AC_Y, \\
N = \frac{1}{2} \rho U^2 A(C_p l - x_n C_T), \\
L = \frac{1}{2} \rho U^2 A(C_p l - z_n C_T),
\]

where $\rho$ is the air density, [kg/m^3]; $U$ - the velocity of the coordinate origin in the direction of the axis Ox, [m/s]; $V_w$ - the lateral speed of the air flow, [m/s]; $C_T, C_Y$ - the aerodynamic coefficients, respectively of the lateral force, the steering moment and the moment of heel; $l, t$ - distances between axles and wheels of the car, [m]; $x_n, z_n$ - the distances in the longitudinal and vertical directions of the adopted the coordinates of the origin and the point $O'$ (Figure 3), which is the origin of the coordinate system for the measurements in wind tunnel [m].

### 3. Differential equations

Based on the adopted above assumptions and symbols, the differential equations system can be written in the following form

\[
\begin{align*}
m(\ddot{V} + rU) + m_h \ddot{\phi} &= Y + Y_f + Y_r + \dot{Y}_f + \dot{Y}_r \\
I_\phi \ddot{\phi} - I_{\phi} \dot{r} &= N + N_f + N_r + \dot{N}_f + \dot{N}_r
\end{align*}
\]

where the right sides of the equations are the active forces and moments represented as linearly dependent on the coordinates and their derivatives, except those obtained by the action of crosswind shear $Y$, [N], the moment about the vertical axis $N$, [Nm] and time around the longitudinal axis $L$, [Nm].

From the differential equation system (4), after the transformation are obtained functions of the three accelerations

\[
\begin{align*}
\dot{V} &= \frac{1}{m}(Y + Y_f + Y_r + Y - m_h \ddot{\phi}) - rU \\
\dot{r} &= \frac{1}{I_r}(N + N_f + N_r + N - I_r \ddot{\phi}) \\
\ddot{\phi} &= \frac{1}{I_\phi}(L + L_f + L_r + L - m_h \ddot{V} + rU)
\end{align*}
\]

The coefficients of shear forces, representing their private derivatives in relation to the generalized coordinates are calculated by the formulas

\[
\begin{align*}
Y_f &= \frac{1}{U}(C_f + C_r), \\
Y_r &= \frac{1}{U}(aC_f - bC_r), \\
Y_f &= \frac{\partial Y_f}{\partial \phi_f} - C_r \epsilon_r,
\end{align*}
\]

where $U$ is the velocity of the mass centre along the axis Ox, [m/s]; $C_f, C_r$ - the coefficients of the lateral drag of the front and rear wheels [N/rad]; $a, b$ - the distances from the mass centre to the axis of the front and rear axe [m]; $\alpha_f, \alpha_r$ - the coefficients of the front suspension heel along the chassis and the rear wheels steering due to the heel.

The coefficients of the moments around the vertical axis, representing their partial derivatives in relation to the established coordinates are

\[
\begin{align*}
N_f &= \frac{1}{U}\left[aC_f - bC_r + \frac{\partial(\overline{AT})}{\partial \alpha_f} + \frac{\partial(\overline{AT})}{\partial \alpha_r}\right], \\
N_r &= \frac{1}{U}\left[a^2C_f - b^2C_r + \frac{\partial(\overline{AT})}{\partial \alpha_f} + \frac{b^2(\overline{AT})}{\partial \alpha_r}\right],
\end{align*}
\]
where \( \frac{\partial (AT)}{\partial \alpha_f} \) and \( \frac{\partial (AT)}{\partial \alpha_r} \) are the coefficients of stabilization moments, respectively of the front and rear wheels of the corners of their lateral drag [Nm/rad];

The coefficients of the moments around the longitudinal axis, representing partial derivatives in relation to the angular velocity and the angle of heel are

\[
L_f = \frac{\partial L}{\partial \varphi_f} + \frac{\partial L}{\partial \varphi_r}, \quad (12)
\]

\[
L_r = \frac{\partial L}{\partial \varphi_f} + \frac{\partial L}{\partial \varphi_r} + m_gh, \quad (13)
\]

where \( \frac{\partial L}{\partial \varphi_f} \) and \( \frac{\partial L}{\partial \varphi_r} \) are coefficients of damping moments respectively of the front and rear suspension [Nms/rad];

\( \frac{\partial L}{\partial \varphi_f}, \frac{\partial L}{\partial \varphi_r} \) - the coefficients of the moments resulting in deformation of the elastic elements, respectively on the front and rear suspension [Nm/rad].

4. Computer modeling

The integration of the system of the three functions of acceleration is performed with Simulink in MATLAB, by taking full advantage of formalization [6, 7].

For better efficiency the work is carried out by three windows:

1) MATLAB Editor/Debugger, where the values of the parameters are assigned and the preliminary estimates of the parameters and the coefficients involved in the functions of acceleration are calculated;

2) Simulink, where in parametric form the simulation model is built, presented in Fig. 4;

3) MATLAB Workspace, where the text file from MATLAB Editor/Debugger is launched and the results from the simulation are visualized, by using the options on the "plot".

The model provides visualization only of the state variables but practically it is possible for each point of the diagram.

5. Simulation results and analysis

With the thus created simulation model numerical experiments are performed for the six positions of the center of gravity of the car: at two heights and at three locations in the longitudinal direction, presented in Table 1:

<table>
<thead>
<tr>
<th>Location</th>
<th>h, [m]</th>
<th>a, [m]</th>
<th>b, [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.3</td>
<td>0.8</td>
<td>1.3</td>
</tr>
<tr>
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<td>0.3</td>
<td>1.05</td>
<td>1.05</td>
</tr>
<tr>
<td>3</td>
<td>0.3</td>
<td>1.3</td>
<td>0.8</td>
</tr>
<tr>
<td>4</td>
<td>0.5</td>
<td>0.8</td>
<td>1.3</td>
</tr>
<tr>
<td>5</td>
<td>0.5</td>
<td>1.05</td>
<td>1.05</td>
</tr>
<tr>
<td>6</td>
<td>0.5</td>
<td>1.3</td>
<td>0.8</td>
</tr>
</tbody>
</table>

The results of the numerical experiments for the transverse velocity \( V \), the angular velocity \( r \) and the angular velocity \( \phi / dt \), and the heeling angle \( \phi \), are presented graphically in Fig. 5, ..., 12.

From the graphically presented results for transverse velocity in Fig. 5 and 6 the following conclusions are drawn:

1) When the mass centre of the car is positioned behind the middle of the clearance (locations 3 and 6), a large negative value of the transverse speed is received, which increases in value by increasing of \( h \) (location 6), the transition process is with the longest duration and with aperiodic character.

2) When the mass centre of the car is positioned in the middle of the distance between the axes, a less negative set value of the transverse speed is obtained, and the transition process is of short duration, and with periodic characteristic (locations 2 and 5).

3) When the mass centre of the car is positioned in front midway between the axes, a small but established positive value of the transverse velocity is obtained, and the transition process is with the shortest duration and with periodic character (locations 1 and 4).
From the graphically presented results for the angular velocity around the vertical axis of the car in Fig. 7 and 8 following conclusions can be drawn:

1) With the mass centre of the car positioned behind midway between the axles (positions 3 and 6), the most positive set value of angular velocity around the vertical axis of the vehicle is obtained, which increases with increasing h (location 6), and the transition process is with the longest duration and with aperiodic character.

2) With the mass centre of the car positioned in the middle of the distance between the axles of a vehicle, a small positive set value of angular velocity around the vertical axis of the vehicle is obtained, and the transition process is with a shorter duration and with periodic character (locations 2 and 5).

3) With the mass centre of the car positioned in front midway between the axles of the car, the smallest positive set value of angular velocity about the vertical axis of the vehicle is obtained, the transition process is with the smallest duration and with periodic character (locations 1 and 4).

From the graphically presented results for heeling angle in Fig. 9 and 10, and from the phase portrait of the movement of the heel - Fig. 11 and 12, the following conclusions can be drawn:

1) With mass centre of the car positioned behind midway between the axles of the car (positions 3 and 6), the highest negative set value of the heeling angle is received that increases in value with increasing h (location 6), the transition process is with the longest duration.

2) When the mass centre of the vehicle is positioned in the middle of the distance between the axles of a vehicle, a small positive set value of angular velocity around the vertical axis of the vehicle is obtained, the transition process is with a shorter duration and with periodic character (locations 2 and 5).

3) With mass centre of the car positioned in front midway between the axles of the car, the most positive set value of the heeling angle is received, the transition process is with the smallest length and with periodic character (locations 1 and 4).

4) The increasing of h leads to decrease in value of the maximum angular velocity of the heel, and increase of the
minimum angular velocity of the heel, and also leads to increase of the transition process duration.

6. Conclusion

With the here presented research with the established simulation model in MATLAB with Simulink environment of the parameters that characterize the controllability of a car, seen as a mechanical system with three degrees of freedom, under the impact of a sudden gust of crosswind the following conclusions can be drawn:

1) With pulse effect of a sudden gust of crosswind the parameters of controllability of the car significantly depend on the location of its mass centre in the longitudinal direction as well as in the vertical direction.

2) The simulation model for research of the controllability of car under the influence of a sudden gust of crosswind can be used both in designing new cars and in parameter analysis of controllability of the existing two-axle vehicles.

3) The simulation model for research of the controllability of car under the influence of a sudden gust of crosswind can be used for the training of students.

References


RESERCHES REGARDING THE IMPROOEMNT AND THE MODERNIZATION OF THE PUBLIC PASSENGERS TRANSPORT IN THE PERIPHERAL AREA OF PITESTI

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Abstract: The transport is an essential element in the essential activities of our society. Therefore, it must be tackled with policy at all levels, from the overall (i.e. United Nations) to the City Councils. A major importance is solving the dilemma between the policies oriented to increase, which tends to generate more transport and the environmental policies, which require the reduction of emissions. These can be difficult to fulfill if technological development to reduce emissions are outweighed by the increase of transport.

Public transport wants to improve continually his performance by meeting the citizen’s need and expectations, through high quality of public transport by implementing, maintaining and improving an Integrated Management System: Quality, Environment, Health and Safety, Social Responsibility, information security etc.

Based on the analysis realized with the local authorities (in order to identify the transport request), on the field visits (in order to evaluate the condition of the roads) and on the discussions with SC Publitrans 2000 S.A (in order to evaluate their technical possibilities and to identify the economical implications) we have made proposals that will be the preliminary conditions for the development of the metropolitan transport system:

- The local public transport system (inside the metropolitan area) will have an unique character, including the payment system: the passenger will be able to use one or more than one route using a single ticket, even if the price will be different base on then zone in which the travel is realized and it will be limited in time;

- The main routes will follow the access points in Pitesti, linking Pitesti with the towns in the peripheral area/metropolitan area and their length will be maximum 16 km (the maximum accepted value-for the most charged route Pitesti-Mioveni which is a „heavy public transport axe”);

- The minimum accepted frequency on the main routes will be 4 trips/hour, that is a following limit of 15 minutes (it is a „psychological limit” the traveller must accept for the transhipment from a district route to a local one and inverted);

- At the end outside the area/metropolitan area of the main routes will be arranges buss stations where the exchange of travellers between the two transport systems local and district will be accomplished;

- The district routes will not interfere with the local metropolitan transport network, the district routes being limited to the buss stations specially arranged outside the metropolitan area;

- The buss stations inside Pitesti will be used only in the purpose of the public inter-district transport and for the local public transport.

Keywords: TRANSPORT, NETWORKS, SYSTEM, METHODS, PASSENGER

1. Introduction

Socio-economic development and industrial development of Pitesti has lent to the formation of a peripheral/ metropolitan zone in which Pitesti and the cities Mioveni and Stefañesti have become poles for the passenger transport.

Therefore, they have initiated the procedures in order to create a inter-communitarian association that should intercede for the development of a unique public passengers transport system consisting two components: a modern transport network with trolleybus, that should link the three cities in the area and a transport network with urban busses, that should take into account also the adjacent communes in the peripheral area.

Development of the transport system, with unique and permanent character, is based on studies realized by the University of Pitesti for the Local Council of Pitesti and the District Council of Arges, study in which the evaluation of the passenger’s fluxes has been / was the experimental part on which the projection of the transport network has been based on.

On this purpose we have proposed the improvement and modernization of the passenger transport network in the Arges District by extending the public transport network in the nearby zone of Pitesti and the resizing the district transport system, the closeness of these two components being assured trough the judicial proposal of laying out some buss stations for the passengers transport.

Together with the extension of the road network for the transport in the peripheral area by buss, given that the increasing demand for the “heavy passenger transport axe” Mioveni – Pitesti – Stefañesti, it is proposed that these three cities should be / to be connected by a faster transport network.

In this way we can assure the compression of the district network’s length and the growth of the economical efficiency for both components of the transport system –in the district and in the peripheral area.

Current situation regarding public passenger transport realized by regular services within this area is:

• In Pitesti it works a unitary system of local public transport system realized by S.C. Publitrans 2000. S.A. associated with S.C. Girexim Universal SA Piteşti, with a fleet of 110 busses of medium capacity/ vehicle park containing 110 medium capacity busses (fig. 1.1), we can see that some of the transporting lines have line endings also in the neighbouring localities (Arpechim-in Bradu, Service in Stefanesti and Bascov in Bascov township), which is explained by the fact that they preserved some features of the old system of local urban transport and pre-urban / town and pre-town public system, which gives a unitary character to the urban and the peri-urban area of Pitesti.

• The passengers transport between Pitesti and the other cities is assured by district transport lines, but also by local transport lines at the townsships level: some neighbouring communes (Bradu, Băbana and Bascov) have promoted their own local transport system. This fact does not correspond at all with the unitary transport system; known to be fundamental for the modernization of the public transport and for the growth increase its performances.

Thus, we can observe that, in moment in the peripheral area previously defined there is, beside the local routes, a number of 85 routes (80 district routes) and 5 local routes of nearby towns (one in Bradu, two in Babana and two in Bascov).
The public transport network of Pitesti is presented in the chart 1.

Fig. 1 The local public transport network in Pitesti.

2. The steps to follow for the development of public passenger transport network

In order to develop a public transport system, based on the contract [15] we have analysed the transport requirements at the peri-urban level and the technical possibilities of a gradually extension of the existing public transport network at the level of the entire area.

Based on the analysis realized with the local authorities (in order to identify the transport request), on the field visits (in order to evaluate the condition of the roads) and on the discussions with SC Publitrans. 2000 S.A. (in order to evaluate their technical possibilities and to identify the economical implications) we have made proposals that will be the preliminary conditions for the development of the metropolitan transport system:

1 – The local public transport system (inside the metropolitan area) will have an unitary character, including the payment system: the passenger will be able to travel on one or more than one route using a single ticket, even if the price will be different based on the zone in which the travel is realized and it will be limited in time;

2 – The main routes will follow the access points in Pitesti, linking Pitesti with the towns in the peripheral area/metropolitan area and their length will be maximum 16 km (the maximum accepted value for the most charged route Pitesti-Mioveni which is a ,,heavy public transport axe”);

3 – The minimum accepted frequency on the main routes will be 4 trips/hour, that is a following limit of 15 minutes (it is a “psychological limit” the traveller must accept for the transhipment from a district route to a local one and inverted);

4 – At the end outside the … area/metropolitan area of the main routes will be arranges bus stations where the exchange of travellers between the two transport systems local and district will be accomplished;

5 – The district routes will not interfere with the local metropolitan transport network, the district routes being limited to the bus stations specially arranged outside the metropolitan area;

6 – The bus stations inside Pitesti will be used only in the purpose of the public inter-district transport and for the local public transport;

Moreover, given that the studies realized regarding the transport demand [15,16] have shown that on the route Pitesti-Mioveni the travellers’ flux is permanent and it has elevated values (almost 2000 travellers/day –fig. 2), it has been decided that is necessary on this route to create the conditions of a faster transport line, and the analysis have brought to the necessity of the heavy transport flux from the Pitesti Mioveni route.

Fig. 2 The volume of passengers for the route Pitesti – Mioveni.

So, we have reached the proposal of building a new driveway between Pitesti and Mioveni and a bypass for Pitesti (see fig. 3), the new driveway will become a part of the national road DN 73 Pitesti Brasov, that will take overt the heavy traffic between Pitesti and Mioveni, and the present national road between Pitesti and Mioveni will be declassed at the district level and it will be into the District Council administration.

In this way, on the route Pitesti Mioveni will exist only light traffic a modern and capable of performances fast transport line will be possible to be set-up.

Fig. 3 The road arrangement in order to relocate the heavy traffic from the route Pitesti-Mioveni-Maracineni and the location for the 8 bus stations.

According to this imposed conditions, following a program through which have been taken into account the towns together with which Pitesti forms an inter-communitarian association, have been identified the transport request in the area and the access ways in the metropolitan area.
So, we have reached the conclusion that they can be taken into consideration 8 access ways in the suburbs and we have decided that on every one of them, outside the metropolitan area will be arranged a transhipment bus station for the two public transport systems- metropolitan and district (see fig. 3).

In Tab. 1 it is presented the correspondence between the 85 routes outside the metropolitan area and the 8 proposed routes, those last ones having the end in one of the 8 buss stations. In the last column is specified the length with which the district routes will be lessened once the limitation ant the transhipment buss station will be settled.

**Table 1**: Data regarding the correspondence between the routes at the level of the transhipment bus stations.

<table>
<thead>
<tr>
<th>Type and no. rout e</th>
<th>Buss station/ town</th>
<th>Interme diary town</th>
<th>Buss station / town</th>
<th>Length of the rout e L4 km</th>
<th>Propos ed periph eral route</th>
<th>Shrink ing amoun t, S, [km]</th>
</tr>
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<tbody>
<tr>
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<td>Piteşti Nord</td>
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<td>Piteşti Sud - Mioven i</td>
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<td>Căteanele</td>
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<td>Mozačeni Vale</td>
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<td>Pitești Nord</td>
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<td>Pitești Sud</td>
<td>Costești</td>
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<td>Costești</td>
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<td>Pitești Sud</td>
<td>Costești</td>
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<td>148</td>
<td>Pitești Sud</td>
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<th>Buss station/ town</th>
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<th>Buss station/ town</th>
<th>Leng th of the rout e [km]</th>
<th>Shrink ing amoun t, $ S_0 [km]</th>
<th>Propon ed periph eral route</th>
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<td>Pitești Sud</td>
<td>Costești</td>
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<td>Pitești Sud</td>
<td>Costești</td>
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<td>151</td>
<td>Pitești Sud</td>
<td>Costești</td>
<td>Richițe le</td>
<td>8</td>
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<td>152</td>
<td>Pitești Nord</td>
<td>Trivale</td>
<td>Golea ca</td>
<td>8</td>
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<td></td>
</tr>
<tr>
<td>153</td>
<td>Pitești Sud</td>
<td>Trivale</td>
<td>Costești</td>
<td>8</td>
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</tbody>
</table>

Regarding the promotion program for those routes peripheral/metropolitan (that will became main routes of the public transport network) we should think about a gradual development of an unique local public transport system at the entire defined peripheral are (it will start with new routes or with the extension of the existing routes inside Pitești, then they will be included the local routes of the peripheral townships as the contract for the local operators will expire and it will be finalized this year when the contract for the district routes will expire and the network will be extended on the entire area);

Also, we must define an urban area at the level of Pitești and a peripheral area at the level of the other towns so that the taxing could be realized differentially: urban are, urban area-peripheral area, and peripheral area;

All the 8 routes will become main routes (the passengers fluxes will be brought together in the buss stations and they will be very large all day long), and regarding the three transport poles (Pitești, Mioveni and Ștefănești), on the routes Pitesti-Mioveni and Pitești-Ștefănești those fluxes will reach very large amounts, fact that will sustain the opportunity to develop a fast transport line Pitești-Mioveni-Ștefănești.

Taking into account the geographic and socio-economical conditions in the area, we can sustain the promotion of a modern
transport means: the tire trolley, which cumulates the advantages of the buss and the trolley and eliminates all their disadvantages.

Based on the realized studies, we have established the program of the peripheral transport network extension at the entire metropolitan area (tab. 2) taken into account the legal restrictions, because most of these routes are now being used based on legal contracts: as local routes, in the peripheral towns or as district routes.

Table 2: Program of the metropolitan/peripheral public transport extensions.

<table>
<thead>
<tr>
<th>Route</th>
<th>No. Of correspondent district routes (N)</th>
<th>Date of the integration into the metropolitan transport network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitești Sud - Mioveni</td>
<td>19</td>
<td>01.07.2011 (when the contract for the present district transport line Pitești – Mioveni will expire)</td>
</tr>
<tr>
<td>Pitești Nord - Bascov</td>
<td>10</td>
<td>01.05.2010 (when the contract for the present local transport line Bascov, Bascov – Dobrogostea and Bascov – Prislop will expire)</td>
</tr>
<tr>
<td>Pitești Nord - Smeura</td>
<td>9</td>
<td>01.07.2011 (when the contract for the present district transport line Pitești – Smeura will expire)</td>
</tr>
<tr>
<td>Pitești Sud - Ștefănești</td>
<td>16</td>
<td>01.07.2011 (when the contract for the present district transport line Pitești – Ștefănești will expire)</td>
</tr>
<tr>
<td>Pitești Sud - Zama Rece</td>
<td>7</td>
<td>01.07.2011 (when the contract for the present district transport line Pitești – Zama Rece will expire)</td>
</tr>
<tr>
<td>Pitești Sud - Bradu</td>
<td>8</td>
<td>01.01.2009 (when the contract for the present local transport line Bradu, Pitești – Bradu will expire)</td>
</tr>
<tr>
<td>Pitești Sud - Albota</td>
<td>12</td>
<td>01.07.2011 (when the contract for the present district transport line Pitești – Albota will expire)</td>
</tr>
<tr>
<td>Pitești Nord - Trivale</td>
<td>4</td>
<td>Any insertion (there are already local routes with the ending in Trivale)</td>
</tr>
</tbody>
</table>

3. Conclusions-Appraisations regarding the opportunity of developing a fast transport line between Pitești – Mioveni and Ștefănești

This thee town (Pitești, Mioveni and Ștefănești) are part of the peripheral area and they have become, grace to their socio-economical development, into public transport poles. We can say that a “heavy axe” has been created between Pitești and the nearby towns Mioveni and Ștefănești.

So, only by evaluation of the passengers fluxes on the old transport means on the route Pitești – Mioveni (the minibuses-considered to be unattractive because of the diminished level of comfort and security) - v. fig. 2 and 3, we have reached the conclusion that the daily volume of passengers is about 1800 passengers/day in the working days and half of it in holidays. As following, we can appreciate that the daily passenger’s volume, in the conditions of a modern public transport system between the three poles (Pitești, Mioveni and Ștefănești) will have greater values, fact that sustains the opportunity of developing a fast transport line between Pitești – Mioveni – Ștefănești.

Taking into account the geographic and socio-economical conditions in the area, we can sustain the promotion of a modern transport mean: the tire trolley, which cumulates the advantages of the buss and the trolley and eliminates all their disadvantages.

Obviously in order to accomplish this purpose it is necessary the inter-communitarian association we mentioned before (between Pitești, the township Maracineni and the towns Mioveni and Ștefănești), in order to develop this public transport system that will allow the construction of the necessary infrastructure.

Hereinafter there are presented a series of considerations regarding this type of public transport, known as Translohr, designation that can be found in the name of the European constructor who has promoted this type of transport in the last few years.

Translohr is a new generation of urban trolleys with a reduced weight. A real mean to conquer the urban space and to profoundly change the city and his utilization way, this trolley offers a unique facility thanks to his manoeuvrability and his weight adjusted to the human needs.

Fig. 4 Translohr – the modern trolley.

This trolley presents all the characteristics of the modern trolley: permanent guidance, great transport capacity, double directionality (double driving cab), modulation, full descended floor (25cm), full internal communication, all this overtaking, thanks to the tire scrolling, the well known inconveniences of the trail scrolling: the heavy floor, the noise in bends, high installation costs and long implementation terms.

Translohr bring together the technical performances (reversible frames, the turning ray reduced to 10.5m, mechanical guidance system installed on a central rail, secured breaking system, simplified depot equipments) and discretion (silent and slender).

The modulation of Translohr components allows the utilization of many types of dimensions 18, 25, 32, 39 or 46 m according to the number of modules that are utilized.

Fig. 5 Modulation of Translohr components.

The tire trolley assures a very small turning ray (10.5 m at the rail, no Mather the frame’s type) fact that allows an easy implementation for the strait streets-that need small turns).

Equipped with a double cab at each one of the endings, the trolley’s frames have double direction. This fact allows the exploitation without a turning zone at the end of town route end using depots with a single exit.

The ascending capacity is 13% thanks to the proper engine and to the superior adherence realized by the tires that assures with no problem the organization of the transport line on the superior terraces of the Arges inside Pitești.

The trolley’s guidance is assured by two inclined at 45°bearings that penetrate a central rail.
The low flat floor of Translohr allows the access at the level of the footpath (for a difference of 23 cm between the road and the footpath).

Translohr transport systems have been developed in six cities in the world:

- In France: Clermont-Ferrand (since November 2006) and Paris (Saint Denis-Sarcelles since 2011)
- In Italy: Padova (since March 2007), Aquila and Mestre-Venice (since 2010);
- In China: Tianjin-Teda (since the 10th of May 2007) and Shanghai Pudong;

In order to organize a unique transport system at the level of the peripheral area it is necessary the functioning of the inter-communitarian association, who will propose a developing program for the local public passengers transport by regular services.

The benefits of such a transport system for the entire community are real, the system being developed based on the present and future necessities for transport - fact that will assure it a permanent character.

Given the dinamique of the transport demand and the fast urban development, this transport system becomes must be implemented as flexible as possible. This characteristic will be assured by the transport by busses - the second component of the local public transport system.

In order to organize a unique transport system at the level of the peripheral area it is necessary the functioning of the inter-communitarian association, who will propose a developing program for the local public passengers transport by regular services.

Given the dynamic of the transport demand and the fast urban development, this transport system becomes must be implemented as flexible as possible. This characteristic will be assured by two ways:

- Through a flexible transport program and a flexible transport capacity for both of the components (transport by bus and by trolley);
- Through a flexible buses public transport network;

The benefits of such a transport system for the entire community are real, the system being developed based on the present and future necessities for transport - fact that will assure it a permanent character.

The transport is an essential element in the most activities of our society. Therefore, it must be tackled with policy at all levels, from the overall (i.e. United Nations) to the City Councils. A major importance is solving the dilemma between the policies oriented to increase, which tends to generate more transport and the environmental policies, which require the reduction of emissions. These can be difficult to fulfill if technological development to reduce emissions are outweighed by the increase of transport.

Public transport wants to improve continually his performance by meeting the citizen’s need and expectations, through high quality of public transport by implementing, maintaining and improving an integrated management system: quality, environment, health and safety, social responsibility, information security etc.

References:

15. ** Study and optimization solutions for passenger transport in the metropolitan area and the route Pitesti - Mioveni", Contract no. 14329/27.11.2009, Beneficiary: Arges County, Contract Director: Nicholas V
ALTERNATIVE TYPES FUELS - MADE FROM AGRICULTURAL BIOMASS
(BIOGAS)

Vangelića Jovanovska¹, autor
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Abstract: Biogas is a typical “product” of urban discharges, which has a great negative environmental impact. To avoid this negative effect, it can be burnt at very high temperatures, producing smoke emissions composed of CO₂. A useful alternative is to use biogas as fuel to feed co-generation plants, producing electricity. At the moment biogas is used as fuel, introducing it directly in the combustion chamber. Nevertheless the heterogeneity of the gas stresses the engine, reducing its life. The new technology should treat the biogas before putting it into the engine, reducing its heterogeneity and stabilising it in that range of characteristics which are acceptable for the engine. Such a technology has the advantage to preserve the environment from the emission of biogas, guaranteeing, at the same time, a higher safety of discharges. In fact, biogas produced by urban discharges could create big gas pockets with a high pressure, that could cause explosions. Using biogas as fuel for internal combustion engines will make discharges safer than before and at the same time it will be a useful alternative source of power. While biogas has multiple benefits at the individual family level, it also has several qualitative and quantitative benefits at the societal level.

KEY WORDS: BIOGAS, AGRICULTURE BIOMASS, FUELS, METHANE,

Introduction

Biogas is generated when bacteria degrade biological material in the absence of oxygen, in a process known as anaerobic digestion. Since biogas is a mixture of methane (also known as marsh gas or natural gas) and carbon dioxide it is a renewable fuel produced from waste treatment. Anaerobic digestion is basically a simple process carried out in a number of steps that can use almost any organic material as a substrate - it occurs in digestive systems, marshes, rubbish dumps, septic tanks and the Arctic Tundra. Humans tend to make the process as complicated as possible by trying to improve on nature in complex machines but a simple approach is still possible, as I hope you see in the links below.

If you are new to biogas/biofuel and anaerobic digestion for waste treatment or fuel production these pages are intended to assist you. If you only need some simple information the first couple of links will be most useful, while the later pages are to help those considering starting a digester project.

Methane, which is makes up from 0% to 80% of biogas, forms explosive mixtures in air, the lower explosive limit being 5% methane and the upper limit 15% methane. Biogas mixtures containing more than 50% methane are combustible, while lower percentages may support, or fuel, combustion. With this in mind no naked flames should be used in the vicinity of a digester and electrical equipment must be of suitable quality, normally “explosion proof”. Other sources of sparks are any iron or steel tools or other items, power tools (particularly comutors and brushes), normal electrical switches, mobile phones and static electricity. If conducting a flammability test take a small sample well away from the main digester, or incorporate a flame trap in the supply line, which must be of suitable length (minimum 20 m).

Biogas consists mainly of CH₄ and CO₂, with low levels of H₂S and other gases. Each of these components has its own problems, as well as displacing oxygen.

CH₄ - lighter than air (will collect in roof spaces etc), explosive (see above).
CO₂ - heavier than air (will collect in sumps etc), slightly elevated levels affect respiration rate, higher levels displace oxygen as well.
H₂S - (rotten egg gas) destroys olfactory (smelling) tissues and lungs, becomes odorless as the level increases to dangerous and fatal.

Adequate ventilation, suitable precautions and adequate protective equipment will minimize the dangers associated with biogas, making it a good servant rather than a bad master.

Benefits of biogas

Biogas technology makes optimal utilization of the valuable natural resource of dung; it provides nearly three times more useful energy that dung directly burnt, and also produces nutrient-rich manure.

As a cooking fuel, it is cheap and extremely convenient. Based on the effective heat produced, a 2cu m biogas plant could replace, in a month, fuel equivalent of 26 kg if LPG (nearly two standard cylinders), or 37 liters of kerosene, or 88kg of charcoal, or 210 kg of fuel wood, or 740 kg of animal dung. In terms of cost, biogas is cheaper, on a life cycle basis, than conventional biomass fuels (dung, fuel wood, crop wastes, etc.) as well as LPG, and is only fractionally more expensive than kerosene; the commercial fuels like kerosene and LPG, however, have severe supply constraints in the rural areas.

Potential of biogas

In India, the dissemination of large-scale biogas plants has began in the mid-seventies and the process has become consolidated with the advent of the National Project on Biogas Development (NPBD) in 1981, which has been continuing since. Against the estimated potential of 12 millions biogas plants, 2.9 millions family type and 2700 community, institutional and night soil-based plants have been set up till December 1999. This is estimated to have helped in a saving of 3 million tons of fuel wood per year and manure containing nitrogen equivalent to 0.7 million tons of urea.

However, in terms of total dung that is available in the country, the potential is much more. The bovine population in India is 260 millions. Adult bovine produces an average of 10kg of dung per day. Since grazing is a common practice in India, all the dung produced cannot be collected. If it is assumed that 75% of the dung is collected, nearly 2 millions tons of dung would be available everyday. At 25 kg per one cubic meter, this dung can feed as many as 40 millions biogas plants of 2 cubic meter capacity, which can be considered the ultimate potential for biogas technology.

But even this high potential of biogas is based on animal dung only. However, all organic matter can technically be used to generate methane; if the scientific experiments that are going on in the country under the patronage of MNES to develop alternative feed stocks (such as water hyacinth, kitchen waste, and poultry waste) come to fruition, potential for biogas generation could be virtually unlimited. It can be mentioned in this context that human waste is an excellent source of biogas which would enhance the potential; substantially. With such high potential, which can be routed to hitherto unemphasized applications of shaft power and electricity generation, biogas can make a significant contribution to the development of small industries and agriculture, and thus to the overall advancement of the rural areas.

Materials and methods of biogas production

Two kinds of materials are used to produce biogas in this Base: Dung (pig waste) and distiller's grains.
In a small pig farm, the quantity of dung collection is 4 kg/d per head. There are 90 heads of pigs in the Base, so the quantity of dung each day equals to 360 kg/d. The total solids (TS) are 18%. If the fermentation materials entering the digester are calculated by 8% of TS concentration, the quantity of input mixed materials of digester is 810 kg. In the different fermentation process and digester construction, the outputs of biogas are different. If using a small hydraulic biogas digester, 13 m³/d of biogas can be produced; If the mesophyllic fermentation is practiced, the biogas yield will increase greatly. The distiller's grains are stillage of ethanol production excluding from the workshop with high temperature of 80°C. The distiller's grains can be used not only for the raw materials alone of biogas fermentation but also for a mixed material with dung so that the higher temperature of the distiller's grains is beneficial for increasing the temperature of fermentation slurry. Because the ethanol production from sweet sorghum may be only carried out during the harvest season, the distiller's grains as raw materials of biogas fermentation will not be supplied continuously. Therefore, the pig waste will be the main raw materials of biogas fermentation throughout the year.

**Digester**

There are three kinds of digesters: hydraulic, half-plastics, and anaerobic filter with sludge bed which were respectively built under the ground of pig houses, beside the pig house, and on the slope to the east side of pigsty, each of them has 10 m³ volume and 2.6 m diameters. On the basis of 80% of volume to input materials, each digester can be inputted 8000 kg slurry to produce the biogas which will be used directly for the biogas stove and lamp in the pig houses. Combined with other digesters, the biogas produced can be provided to the generator as a power fuel. Because the hydraulic biogas digester was built under the ground of pig houses, and the pig house was covered by the plastic film, the digester can avoid the severe cold during the cold seasons and in winter safely. The biogas residue is a kind of high quality organic manure.

**A. Hydraulic biogas digester**

Two round hydraulic digesters were built under the ground to the eastern side of pigsty, each of them has 10 m³ volume and 2.6 m diameters. On the basis of 80% of volume to input materials, each digester can be inputted 8000 kg slurry to produce the biogas which will be used directly for the biogas stove and lamp in the pig houses. Combined with other digesters, the biogas produced can be provided to the generator as a power fuel. Because the hydraulic biogas digester was built under the ground of pig houses, and the pig house was covered by the plastic film, the digester can avoid the severe cold during the cold seasons and in winter safely. The biogas residue is a kind of high quality organic manure.

**B. Plastic covered digester**

The plastic covered digester is a rectangle half-underground pool with 6 m long, 2.6 m wide, and 3 m deep, the pool is covered and sealed by the black red-mud plastics. After the digester is filled with the materials in batch (according to 60% of volume), the digester start-up and produce the biogas which is led out through the duct on the plastic cover and delivered to the biogas tank. In order to increase the outlet pressure of biodigester, a certain load can be added to the plastic cover to adjust the pressure. Because of the bigger area of plastic cover, when the solar radiation is intense, it can have the slurry gain more heat energy, which enables to have an active biogas production process and a high production rate. However this kind of digester does not work during the severe cold seasons. In this case the digester is only as a dung tank. The biogas residues of the digesters after fermentation need to be pumped out.

**C. Sludge bed + Anaerobic digester (UASB + AF)**

This digester will be built on the slope in front of the pigsty. It consists of biogas engineering system with slurry collector, pretreater of raw materials, slurry measuring meter, biogas tank, biogas hydroextractor, desulphurizing and post-treatment equipment.

a. Slurry collector: The solid dung is collected into the slurry collector, the water after washing the cement floor and the waste water of ethanol workshop through the heat exchanger flow into the slurry collector to wait for using.

b. Pretreatment equipment: The slurry after getting rid of big solid, with the aid of the natural slope, flow onto the pretreater through the filter. The concentration of the slurry must be above 7% TS, and PH value should meet the needs of biogas fermentation.

c. Measurer: The fermentation materials were introduced to the digester according digester requirements. At the same time, the temperature of the slurry should reach the requirements for mesophyllic fermentation.

d. Digester: The digester is cylinder, folding style, made of reinforced concrete with 25 m diameters, 7 m high and 36 m³ volume. This is because the Base is located at high ground, the digester is not suitable at a place too high, and should avoid wind and preserve heat energy. The digester is consists of two cylinders, the one outside is anaerobic sludge bed digester and the one inside is anaerobic filter. The digester is located at half underground and a greenhouse is arranged on it to enhance the temperature of digester. The slurry is processed by mesophyllic fermentation (35°C). The slurry in the filter was pumped into digester after getting heat energy from the cooling water of the cogenerator and the waste water of ethanol workshop to ferment. This kind of UASB + AF digester has two advantages, namely promoting the biogas production rate and decreasing the hydraulic retention time to make the digester function steady. The materials inletted a day is 1600 kg, and the hydraulic retention time is 21 days.

e. Biogas storage vessel: The storage vessel adopts the pillow type, with a attached weight plate, increasing the pressure to 350 mm of water column to meet the requests of biogas generator.

f. Hydroextracted and desulphurizing equipment: In order to prevent the generator from the erosion of biogas, the centrifugal hydroextractor and the ferrous oxide should be used to get rid of H₂S in the biogas.

g. Post-treatment equipment: The exhausted materials are separated into solid and liquid. The liquid flows into the fish pool and solid residue is used as manure.

The start-up of USAB process: After the sludge granules are cultivated, it can improve the subsidence ability of sludge, avoid the sludge up float, and make digester work at a high volumetric COD loading to ensure the system to have a steady ability. The granule sludge can stay in the digester for a long time and hence long average cell retention time, so it may accumulate a lot of methanogens to make sludge have higher activity. The biofilm of the granule can protect methanogens against unfavorable impacts, such as, shock loadings and low pH in the short term, etc. The granule forming of the sludge is the key to UASB digestive process. To keep a long steady ability of the sludge is very important to the normal function. As the seed sludge is selected, the thicker types of digested sewage sludge can be considered as proper seed materials for UASB digester. If no this condition, the small amount of crushed granule sludge should be added to the seed materials to promote the bacteria growing and divisive. This attached loading is particularly important to stimulate the sludge curdy. Experimental results obtained indicate that 12-15 kg Vss/m³ suffices are adopted when a thick digester sewage sludge is applied for mesophyllic digester start-up, whereas 6 kg Vss/m³ is recommended in the case the seed sludge is relatively thin (<40 kg TS/m³).

The factors which affect cultivating granular sludge are mainly the kinds of substrate, control and operation conditions, nutrients and environmental conditions.

* Slurry concentration and nutritious substance: In the mesophyllic fermentation using pig dung, it is suitable to use 5% TS of slurry in the beginning. And 7% TS should be added after start-up. The method of backflow sludge is recommended when the concentration of inlet water is high.
Trace elements have significant effect on the growth of bacteria in an anaerobic fermentation system. The researches show that the supplementary enzyme $F_{420}$ of the methanogen contains nickel. The addition of trace elements, such as Ni, Co, Mo, and ZnSO$_4$, into digesters results in positive effects. All these elements should be considered during the cultivation of granule.

* Operation and control conditions: The experiments show the main control conditions influencing the process of forming sludge granule is the sludge loading. The granule will be cultivated when the pig dung is $5\%$ TS, and after functioning for a period of time, $7\%$ TS should be added.

* Environmental conditions: All the conditions which are suitable to bacteria growing will promote cultivation of sludge granule. The suitable temperature suggested for the cultivation of granule sludge is ranged within $35^\circ\text{C}$ to $38^\circ\text{C}$.

Biogas as a substitute for diesel fuel

- Introduction
Because of the current energy shortage, there has been much interest in developing new fuels as alternatives to petroleum fuels. Biogas appears to be a feasible fuel for internal combustion engines because it can be derived from agricultural surpluses and residues which provide the raw material for biogas production. By feeding the byproduct of the biogas production process, a farmer may even incorporate the production of his own fuel as an integral part of the food production system. Because a majority of Chinese farmers are equipped with diesel-powered farm machinery and this trend is growing rapidly, it is important to have a clear understanding of the effects of the use of biogas in diesel engines.

- Objectives
The objective of the research was to demonstrate the feasibility of using biogas as an alternative fuel for diesel engines, and to determine any associated problem. More specific objectives were to modify diesel engines of types commonly used on farms so that they would operate as efficient as possible on biogas alone, or a mixture of biogas and diesel fuel, and to study the performance of the modified engines.

- Performance of biogas alone in L195 diesel engine

  a. Equipment
A L195 diesel engine which was coupled to a water-brake dynamometer was converted to biogas alone. Engine specifications are given in Table 6.1. Biogas from digester of brewer's grain liquid was chosen as a fuel. The composition of the biogas was 63 percent methane, 31 percent carbon dioxide and traces of CO, H$_2$ and H$_2$S. The lower heating value of the biogas was 3000 kcal/m$^3$. And the average pressure for biogas inside the storage tank was 600 mm of water column.

<table>
<thead>
<tr>
<th>Table 1. Specifications of L195 engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cylinders</td>
</tr>
<tr>
<td>Displacement (cm$^3$)</td>
</tr>
<tr>
<td>Compression ratio</td>
</tr>
<tr>
<td>Combustion chamber</td>
</tr>
<tr>
<td>Governed speed (RPM)</td>
</tr>
<tr>
<td>12 hr. power (hp)</td>
</tr>
<tr>
<td>Specific fuel consumption (g/ hp) hr</td>
</tr>
</tbody>
</table>

A gas carburetor, especially designed for biogas, was used to mix the gas and the air. It contains a control valve and a T-tube with a venturi throat. Fig. 6.4 shows its schematic diagram. The amount of biogas was controlled by the throttle valve of the carburetor to improve the properties of biogas and air mixture. In this way, the biogas was first mixed with air from air filter inside venturi throat of the gas carburetor. And then, the mixture of biogas and air was introduced to the combustion chamber of the engine.

b. Modifying combustion chamber
Because the L195 engine has a indirect injection combustion chamber, an intensive eddy of air will be produced during operation of the engine. This makes it difficult to start the engine, and to maintain a stable inflammation. Therefore, the area of combustion chamber section was increased in order to eliminate the above problems. After modification of the combustion chamber, the compression ratio also had a slight decrease.

c. Installing a spark ignition system
The original fuel injection system was eliminated. A spark plug was installed in the position of the original diesel injector orifice. The spark plug should be considerably chosen so that its electrodes could be located at a proper position of the combustion chamber.

d. Appending a biogas control apparatus
A conical valve was used in order to control the amount of biogas admitted to the gas carburetor. In addition, a linkage which connects the conical throttle of the gas carburetor and governor of the engine was mounted on the engine. Moreover, a main valve was used for controlling the flow of biogas. A gas flow meter was used for measuring the flow rate of biogas. And a U-shape manometer was used for measuring the pressure of biogas, and a pressure regulator for maintaining pressure of biogas was installed on the engine.

C. Testing procedure
Variables measured were: torque, speed, flow rate of biogas, and exhaust temperature. The torque output and engine speed were measured using a water-brake dynamometer (Model SCJ-1). The temperature of the exhaust gases was determined by thermocouple connected to a potentiometer. The flow rate of biogas was measured by the gas flow meter (Model LZB-25). The compression ratio was changed through increasing or reducing the numbers of cylinder head gaskets. The tests were carried out at different compression ratio conditions, such as 13.4:1, 16.5:1 and 17.4:1. A proper spark timing was determined under each compression ratio after comparison. A piezoelectric pressure transducer was installed in the cylinder head to measure the pressure in the combustion chamber when the compression ratios were 13.4:1 and 16.5:1. From the pressure curves, it can be seen that no denotation and misfire occurred. When load performance of the engine, using biogas alone, was tested, the amount of biogas supply was controlled manually.

D. Results

  a. Load Performance of the engine
The load performances of the engine at three compression ratios were tested. The results are shown in Fig.6.6. Specifically, when the engine using biogas alone operated at 2000 RPM with 39.2° rank angle of spark timing and compression ratio being 17.4:1, its load performance data are shown in next table.
From the Table it can be seen that the maximum power of the engine operating on biogas alone was about the 90 percent that of the engine's original power. The temperature of the exhaust gases were ranged within 550 °C to 610°C, which was slightly higher than the usual temperature level. The heat consumption rate was 3000 kcal/hp/hr.

C. Stability of engine performance at low speed

The engine using biogas alone showed a stable operation at a low speed. No vibration occurred. And the engine running with biogas alone performed well at low speed (around 400-500 RPM).

D. Start performance

The engine using biogas alone could be started well as other gasoline engines do. No other fuels were needed to start the engine.

Discussion:

The compression ratio has a great effect on thermal efficiency and combustion performance of the engine. High compression ratio means a high thermal efficiency. However, too big in a increase of the compression ratio may cause detonation of the engine. It was unknown what the maximum compression ratio was. However, according to experiments, when the compression ratio reached 17.4:1, no severe combustion and detonations were observed. From the Table it can be seen that the maximum biogas consumption was not very high within a very wide load range when the combustion ratio was 17.4. And the power was also not lower than that of engine's original power. This suggests that biogas has a higher anti-detonation value. Therefore, to increase compression ration is an effective way for improving the performance of the engine operating on biogas alone.

- Dual-fueling a 2100 diesel engine with biogas

A. Equipment and procedure

The engine used in this study was a case model 2100 2-cylinder, direct injection diesel engine which was connected to a 12 kw generator. The engine was rated to 22 hp at 1500 RPM. The compression ratio was 16:1, because the engine could not reach its maximum loads under the regulated electric load, a baseline study was run in which all of the fuel energy was supplied by diesel oil before it was converted to diesel/biogas blended fuel. The load performance of the engine using diesel oil alone is shown in Table 6.3. Latter, the original diesel supply system was maintained in order to supply diesel oil as a pilot fuel. A gas carburetor was used to mix the gas and air. The converted engine was loaded in a similar manner while diesel/biogas blended fuel was used. Thus, the performance of the engine using blended fuel could be compared to that of engine operating on diesel only.

Table 3. Load performance of 2100 diesel engine running on diesel oil alone at 1510 RPM

<table>
<thead>
<tr>
<th>Power (hp)</th>
<th>Fuel consumption (kg/hr) G_T</th>
<th>Specific fuel consumption (g/hp/ hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.01</td>
<td>-</td>
</tr>
<tr>
<td>5.66</td>
<td>1.82</td>
<td>321</td>
</tr>
<tr>
<td>12.24</td>
<td>2.79</td>
<td>228</td>
</tr>
<tr>
<td>16.46</td>
<td>3.43</td>
<td>206</td>
</tr>
<tr>
<td>18.36</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>19.72</td>
<td>3.93</td>
<td>199</td>
</tr>
</tbody>
</table>

During experiments, both the compression ratio (16:1) and the original injection timing were maintained. The flow rate of biogas was also measured by the gas flow meter (Model LZB-25). An automatic fuel weighing system (Model TCY-69) was used to measure diesel consumption. In order to avoid instability of working load, several lamps were used as loads of the dynamo. Each time when the load was added, the amount of biogas and diesel oil were adjusted manually and automatically, respectively. The percentage of biogas should be increased as much as possible as long as normal combustion was achieved, and the speed and voltage were stable.

Results and discussions

The 2100 diesel engine using biogas/diesel blended fuel could perform very well at its original power levels. Table 6.4 shows the performance data of the engine with duel fuel at 1510 RPM. From the Table it can be seen that percentage of the pilot diesel fuel was ranged within 10.4% to 17.7% when the load of the engine varied from zero to one hundred. And the percentage of pilot diesel fuel was 15% at medium and full loads. In addition, the relative saving rate of diesel fuel was slightly higher than that which is wanted. Because the high relative saving rate of diesel fuel means the small amount of pilot fuel, leading to instability of combustion. Hence, it is suggested that the pilot diesel fuel should not be less than 15%-20%, and the relative saving rate of diesel fuel should be controlled within 75%-80%. From the tests, it is known that the biogas consumption was 0.6 m³ (at standard atmospheric conditions) when 1 kw / hr electricity was generated. After experiments, the engine unit was put into real production. It operated more than 132 hours, generating more than 1000 kw / hr electricity. The data from production practice were about the same as that from the tests.
### Table

<table>
<thead>
<tr>
<th>Power (hp)</th>
<th>Fuel consumption (kcal/hp hr)</th>
<th>Specific fuel consumption (g/hp / hr)</th>
<th>Heat consumption (%)</th>
<th>Pilot fuel (kg/hr)</th>
<th>R (%)</th>
<th>Biogas (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.41</td>
<td>4.18</td>
<td>-</td>
<td>10.4</td>
<td>59.4</td>
<td>-</td>
</tr>
<tr>
<td>5.66</td>
<td>0.70</td>
<td>4.08</td>
<td>124.0</td>
<td>17.7</td>
<td>61.5</td>
<td>1265</td>
</tr>
<tr>
<td>12.24</td>
<td>0.49</td>
<td>6.58</td>
<td>40.0</td>
<td>12.4</td>
<td>82.5</td>
<td>408</td>
</tr>
<tr>
<td>16.46</td>
<td>0.48</td>
<td>7.63</td>
<td>29.2</td>
<td>12.1</td>
<td>86.0</td>
<td>299</td>
</tr>
<tr>
<td>18.36</td>
<td>0.49</td>
<td>8.15</td>
<td>26.7</td>
<td>12.4</td>
<td>-</td>
<td>272</td>
</tr>
<tr>
<td>19.72</td>
<td>0.53</td>
<td>8.15</td>
<td>26.9</td>
<td>13.4</td>
<td>86.5</td>
<td>274</td>
</tr>
</tbody>
</table>

Note: $G_T$ - See Table

$R = \frac{(G - G_T)}{G_T} \times 100\%$, at the same performance conditions

R - Relative saving rate of diesel fuel

The volume of biogas was measured at standard atmospheric conditions

### Conclusions

The modifications of a conventional diesel engine to operate on the dual-fuel system using carbureted biogas and injected diesel fuel as proposed in this paper is practicable. When there is no biogas available, the engine can be switched over to diesel oil alone easily.

The engines running on biogas alone or diesel/biogas dual-fuel can perform well at a very wide load range.

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WEB: www.alternativefuels.com

CRITERIA FOR OPENING OF TECHNICAL INSPECTION STATIONS
- STUDY OF REPUBLIC OF MACEDONIA

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Abstract: Each procedure should have to be in certain frame. That frame always has to be based on certain support. The support and the maintainability of this real research is in exact determination of the criteria for opening of vehicles technical inspection station. High imperative that is product of this paper is the connection of the legal and the technical criteria. Nowadays when each material is strictly regulated with in advance defined procedures, rules and regulations it freely could be stated that in spite of the clearness of the procedures each beginning is difficult. But the logistics in here is to give one different contribution of this field. Therefore in this paper all approaches, concepts and aspects that logistic offers will be offered about real benefit for opening of vehicles technical inspection station. This research is concerned for Republic of Macedonia where the state laws are valid, but anyway the directives of the European Union will be the frame from which we will not go out. That is from the simple reason that Republic of Macedonia is candidate for membership in this Union.

Keywords CRITERIA, STATION FOR TECHNICAL INSPECTION STI, LOGISTICS, VEHICLES

1. Introduction

The functioning of the society and humanity, mobility of the cities, modern living conditions, should undoubtedly be followed by effective, efficient stations for technical inspection. One such system with measures, actions, legal regulation, and rules that refer to the technical inspections will be represented in this paper. The review that represents basis of this paper refers on real data about Republic of Macedonia. Therefore the procedures about defining the criteria necessary for the functioning of the stations for technical inspection will be reviewed systematically and the offered solutions that will come out of it with all benefits will be able to be recognized through the possibility of the users (owners of the motor vehicles) to provide sufficient, requested and also higher level of services.

The organization of the process about defining the criteria about the stations for the technical inspection should be priority for each state. Imperative of each state is well planned procedure and scheme according which these criteria should be applied, that are enough complex and have great influence upon the quality of the performing of this activity. From the existing technical inspection stations in Republic of Macedonia is required forming of optimally organized system in accordance with the needs of the motor vehicle’s owners.

In further the system supported by relevant criteria could result in successful long term, and first of all effective policy and strategy about qualitative and precise defining of the conditions for opening of technical inspection station. While the applied measures and solutions for Republic of Macedonia would be field of realization of the concretely quoted criteria, with stressing out the legal regulations and rules that govern in Republic of Macedonia.

The influential indicators that would be represented in this paper with its positive sides will additionally influence in obtaining of uniqueness and introduction of one qualitative approach when it is a word about technical inspection stations also in Republic of Macedonia. At the same time the quoted criteria would be the institutional frame for implementation of each improved novelty in this field.

2. Personnel, Spatial and technical conditions that must be fulfilled by legal entity authorized for technical inspection stations

In accordance with the Law stipulation from the Law about vehicles, technical inspection of motor and attached vehicles could be performed by legal entity that will be authorized by the internal affairs minister. In order to get the authorization the legal entity should fulfill the conditions that refer to:

- adequate vocational personnel,
- necessary equipment and devices,
- space, and
- insurance of professional responsibility.

The personnel, spatial and technical conditions that must be fulfilled by the legal entity authorized for technical inspection of motor and attached vehicles, the same are regulated with sub law act – Book of Regulations about technical inspection of vehicles.

2.1. – Personnel conditions

According to the Book of Regulations about technical inspection of vehicles, the organization for performing of works about:

- observation and standardization of the criteria for performing of technical inspection,
- giving of expert help and instructing the skilled personnel that perform the technical inspection, and
- performing of expert supervision of technical inspection at the authorized legal entity,

is performed by a manager with completed high education with adequate profession, (Mechanical faculty – direction road transportation, Electro technical faculty, Transportation faculty – direction road transportation) and with working experience of at least three years in the field of motor vehicles.

Technical inspection of vehicles at the authorized legal entity is performed by at least two expert persons for performing of technical inspection who have:

- completed secondary vocational education of traffic, mechanical and electro technical direction.
- completed specialized education for profession controller for performing of technical inspection of motor vehicles.
- license issued by the Internal Affairs Ministry
- driving license for driving a vehicle of at least “B” category, and
- working experience of at least three years from the field of motor vehicles.

2.2. – Spatial conditions

The spatial conditions are defining the conditions that must meet the building that is used by the legal entity for performing of technical inspection of vehicles.

The same must be built of hard construction, and the technological line should be adequate for maximum allowed dimensions of vehicles of the categories for which the legal entity is authorized to perform the technical inspection of vehicles.

In the building of the station for technical inspection of vehicles should have to be found room for:

- administrative works
- technical inspection of vehicles
- registration of vehicles and work with parties.

2.3. – Technical conditions and equipment for performing of technical inspection

The technical conditions and the equipment for performing of technical inspection of vehicles are defining:

- the devices and the equipment that must be possessed by the station for technical inspections,
- the informative equipment connected in unique system that will allow application of unique program solution for automatic processing of data about the technically inspected vehicles and safe transfer of the same to the automatic recordings of the registered vehicles that is kept by the Internal Affairs Ministry.

The authorized legal entity for performing of technical inspection of vehicles, should possess the following devices and equipment: device with rollers, device for measurement of the idle stroke of the steering wheel (angle meter), device for control of the direction and the intensity of the lights (Regloscope), Dynamometer for measurement of the force of the pressure on the pedals of the operating brake, Compressor, Meter (nonius) for measurement of the depth of the design of the pneumatics, Device for measurement of the noise that emit the vehicles (Fonometer), Device for spectral measurement of colors – Spectrophotometer and a catalogue for determining the nuance of the color of the vehicle, Meter or Metering tape, Device for measurement of emitting of smoke, Device for measurement of volume percentage of carbon monoxide, Stop watch or adequate chronometer, Indicator for check up of the evaporation point of the braking fluid, Device for control of the attachments on the electrical installation, Device for control of the highest speed of the mopeds, Device for intake of the exhaust gasses, Device for checking of the impermeability of the gas installations – gas detector, Device for checking of the correctness of the elements of the system for elastic support and the system for guidance of the wheels of the vehicle, Device for control of the geometry of the steering mechanism – directing, Measuring device for checking of the dimensions, axes span and wheels span; Device for measuring the darkness of the glasses, catalogue with homologation markings of the wheel; Device for measurement of the deceleration of the vehicles at the streets; Two wedge-shaped pads for the vehicle wheels; Device for testing of the braking system at moped and motorcycle; Informative system that will allow application of the simple program solution for automatic processing of data about the technical inspections of the vehicles; CCD camera with software for recognition of letters and numbers of registration plates, connected with the informative system; Basic auto mechanical tools: Skilled literature and catalogues; Rules about standards for the vehicles that are subject to technical inspection; manuals for handling and maintenance of the technical equipment; and also other rules that are of importance for performing of the technical inspection; Canal for checking of the undercarriage of the vehicle with minimal length of eight meters, width of 0.8 to 1.0 meter and depth of 1.4 to 1.8 meters with (Canal lifting device (hydraulic or pneumatic) for lifting of at least one axle of the vehicle with capacity of at least 3.5 in other words 12 t for freight vehicles and Hydraulic device for control of the gap in the steering system, guiding and supporting of the vehicle.

Beside the above quoted devices for technical inspection of the vehicles, the authorized legal entity for performing of technical inspection should have also:

1. At least two analogue manometers for measurement of pressure in the pneumatic braking system of the vehicle, with length of at least 12 meters with standard attachments;
2. Adapter with which the manometer could be attached with the standard attachments on the pneumatic braking system of the vehicle, on which is connected the pneumatic braking installation of the attached vehicle.
3. Adapter with the help of which the manometer could be connected on the steering (yellow) and feeding (red) line between the towing and the attached vehicle;
4. Manual valve for regulation of the compressed valve. The authorized legal entity should possess adequate informative equipment connected in unique system that will allow application of unique program solution for automatic processing of data about the technically inspected vehicles and a safe transfer of the same to the automatic recording of the registered vehicles that is kept by the side of the Internal Affairs Ministry. With the unique system it should be allowed:

1. scope of data about the vehicle and the owner and also number of the technical inspection in accordance with the data consisted in the driving license;
2. scope of results of measurements of the measuring devices and input of the irregularities established from the visual inspection of the vehicle through the computer system in the database;
3. preventing of change and correction of the measured values.
4. record for technical changes established at the vehicles;
5. creating of security copies of the data about the vehicle;
6. preventing of any change of the security copies;
7. searching of data according to the registration markings of the vehicle, number of the chassis, date of the performed technical inspection or number of the technical inspection;
8. statistical processing of the data about the performed technical inspections;
9. attachment of the devices for: (measurement of the smoking of the diesel engines, measurement of the exhaust gasses of the petrol engines, measurements of the mass of the vehicle by axles, measurement of the braking force on the periphery of the wheels, measurement of the speed of the motor vehicles with two wheels, measurement of the noise, control of the direction of the lights with built-in indicator about the intensity of the light, control of the direction of the wheels, and input of visually established irregularities);
10. the established and the measured values not to have possibility to be transferred to the data about other vehicle. It should be performed so that the technical inspection of the vehicle is not possible to be closed if all prescribed values that are required for single vehicle are not measured.
11. electronic certificate of the technical correctness of the vehicles that is prepared by the controller;
12. to perform control and estimation of the coordination, in other words non coordination of the vehicles with the prescribed conditions and he must not allow positive certification of the technical correctness of the vehicles, if it is find out that the vehicle is technically incorrect.

With introduction of the Book of Regulations for technical inspection of vehicles, Republic of Macedonia could be said that have succeed to satisfy one good part of the requirements of the Directive that first of all refer to the technical conditions. Left in that way undefined are a lot of very important criteria from which directly depends bringing of objective estimation about the condition of the vehicle at the technical inspection. These criteria refer to:
- maximal number of technical inspections of one station for technical inspection of vehicles in populated place or municipality,
- minimal distance from one to another station for technical inspections in and out of populated place,
- minimal necessary number of employees in the STI,
- scale of norms for evaluation of wages of the employees with possibility for its unification in accordance with the scope of work,
- equalization of the price for the technical inspection.

### 3. Establishing of network and criteria for the necessary number of stations for technical inspections of vehicles

For establishment of network and criteria about the necessary number of stations for technical inspections of vehicles, in other words about establishment of the conditions and the criteria for opening of new station for technical inspections (necessity and economical justification).

With establishment of unique common acts (especially of those with which uniform amounts for the compensation are prescribed, the scale of norms for work and elements for evaluation of the labor), condition for establishment of the economical justification could be created for opening of new station for technical inspection of vehicles, and with its application by the side of the already existing stations for technical inspections material preconditions are provided for normal operation of the stations for technical inspections, and also for equalization of the standards about the height of the wages of the employees in the stations for technical inspection of vehicles, in other words conditions are created for payment of approximately same wage of the employees in dependence of the height of the realized number of technical inspections, disregarding the fact in which station is employed.

#### 3.1. Scale of norms for work

The scale of norms for work and the uniform elements for evaluation of the results of the work in the stations for technical inspections because of different kind of services that are performed in the stations for technical inspections, are reduced to uniform unit measure (PC scale of norm that represents value of spent time about technical inspection of passenger car). The scale of norms are expressed in time units (minutes) and are divided in three basic scale of norms:
- **Theoretical scale of norm**
- **Real scale of norm**
- **Calculative scale of norm**

All three scale of norms could be expressed in quantity, as a quantity of performed job assignments (or job operations) in one time (of hour, day, month or year), or in time, as a time necessary for performing of unit of job assignment (or job operation), during which the quantity of performed assignments behave as a reciprocal values referring the time necessary to perform the unit job assignment (job operation).

#### 3.2 Defining of real number

The real number of vehicles that could be technically inspected in one STI with two controllers in one shift (in accordance with the legal regulations) and the theoretical time necessary for one technical inspection, in accordance with the condition for the real scale of norm, that data refer to Republic of Macedonia (data taken from research by the authors).

- \[ 17.16 \times 0.85 = 20, 18 \text{ min.}, \text{ or } 2.97 \text{ vehicles per hour} \ (60 : 20,18), \text{ or} \]
- \[ 7.5 \times 2.97 = 22.75 \text{ vehicles per day} \ (where 7.5 are working hours of the employee during the day – half an hour goes for rest and lunch), \text{ in other words:} \]
- \[ 22.75 \times 240 = 5346 \text{ vehicles per year}. \]

#### 3.3 Calculative – Estimative number

The calculative – Estimative number of vehicles according to which each STI should establish the uniform compensations, to plan the work and the revenue, and to perform evaluation of the results of the work, in other words which should economically justify the work of the STI in accordance with the theoretical time and the condition for the calculative scale of norm in (data taken from research by the authors).

- \[ 17.16 \times 0.65 = 26.4 \text{ min.} \text{ or} \]
- \[ 2.27 \text{ vehicles per hour}, \text{ or} \]
- \[ 7.5 \times 2.27 = 17 \text{ vehicles per day}, \text{ in other words} \]
- \[ 17 \times 240 \times 365 = 4806 \text{ vehicles per year}. \]

From the above it could be seen that one STI with introduction of two shifts operation with 4 (four) controllers in shift, it could serve 16,000 vehicles.

In some way these data should be benchmark in establishment of criteria for opening of new station for technical inspection of vehicles that will refer to the minimal number of technical inspections of one station, in other words: (realization of the authors)

1. The capacity of the stations for technical inspections on one technological line should be established on 16,000 PC units (passenger cars) annually. PC unit represents the common part of the regular technical inspection of the passenger car, and new station could be opened:
   - On road distance bigger than 20 km from the closest station for technical inspection of vehicles.
   - On road distance bigger than 10 km to conclusive 20 km from the closest station for technical inspection of vehicles, if the average percentage of usage of the capacity of the existing STI in the place in which the closest STI is found, is bigger than 65% (measured in passenger cars).
   - In place or town in which already exist one or more stations for technical inspection of vehicles, if the average number of technical inspections in the total number of all existing stations for technical inspections in that place or town is bigger than 16,000 PC per year on one technological line.
2. New station for technical inspection of vehicles in accordance with indent 1 and 2 could be opened under condition that in the area in which gravitates the new station for technical inspections has registered at least 4000 vehicles, number that is considered for bottom limit for economical justification for building of new station for technical inspection of vehicles. Under area toward which gravitates the new station for technical inspection of vehicles is considered the area of the municipality that is closer to the new station than to the existing STI.

3. New station for technical inspection could be opened under condition if the existing station or the existing stations for technical inspection in the town or the populated place, in time of six months from the appearance of the need for opening of new station for technical inspection that is find out with analysis by the expert organization, in the scope of the existing building of the station for technical inspection, does not increase the capacity, in other words does not build new technological line. The announcement of the need to increase the capacity in other words the building onto a new technological line of the owner of already existing station for technical inspections submits the existing organization.

**Conclusion with stated directions**

With bringing of the new legal regulations not only it should contribute for increasing of the technical correctness of the vehicles, but also will contribute for protection of the living environment. And beside the intensified criteria for announcement of technically correct vehicle, with introduction of some news referring the authorizations of the STI for performing activities that are not directly connected with the technical inspections, the users of the vehicles get certain benefits referring the satisfaction of the needs connected with certain inspections of the vehicle.

The possibility that the authorized legal entities for performing of technical inspection to perform additional activities that refer on testing of vehicles, to allow the users of vehicles fast and with reduced costs to perform testing of the gas devices for vehicle drive, to perform testing of the transparency of the darkened glasses, to perform identification and certification of the technical data, to get CEM licenses not only in one place but also widely in the Republic.

Of course that some of the criteria that refer to the technical incorrectness for some users of vehicles will have negative effect because the owners of those vehicles in order to be able to further use them in the traffic will be exposed to financial expenses.

Republic of Macedonia beside that in great measure has brought legal and sub legal rules with which almost have coordinated its regulations with those of EU, anyway remains to bring additional regulations with which completely will be coordinated with the criteria of EU.

The necessity for prescription of the mentioned criteria is imposed from the reason that the liberalization of the conditions that have to be met by the legal entity for performing of technical inspection allows condition to be opened great number of new STI of vehicles. To this easing circumstance for opening of new STI it could be added also the expectations for bigger earnings from the side of the newly opened stations for technical inspections, which will be motive and reason for opening of new STI. These reasons impose conditions for fats and uncontrolled flood of stations for technical inspections in Republic of Macedonia during that without recognition the justification for opening or giving license for new STI. This thing will contribute to obtain on quantity of STI but not also to quality of the technical inspections. This state is opposite of the strains and efforts of the society so as to reduce the traffic accidents caused by the factor “vehicle”.

In the absence of the above quoted criteria, in absence of strict mechanisms for control over the work of the stations for technical inspection of vehicles and the intention in shortest time term to return the invested means for building and equipping of the new stations for technical inspection of vehicles, since the appearance of the first newly opened station for technical inspection, disloyal competition will be created.

The disloyal competition will be expressed through: reduction of the price for the service technical inspection, “letting go” of technically incorrect vehicles, manipulation with the payment of the height of certain compensations necessary for the registration of the vehicle, manipulation with presentation of the number of performed technical inspections e.t.c.

Giving of approval for work of a new STI without real analysis about the necessity and the justification for opening of new STI could cause great difficulties in operation not only to the already existing STI, but also to the newly opened STI. This specially could negatively reflect in the municipalities with insufficient number of vehicles for technical inspections, and to STI that are on close distance to already existing one in one settlement. The reason for that will be the reduction of the scope of work at already existing stations for technical inspection of vehicles, and also not having guarantee that those scope of work that the new STI will attain, will be sufficient to fulfill the expectations for great earnings, and also return of the investments.

The book of regulations for technical inspection of vehicles predicts recording of the procedure for technical inspection and also the results taken from the control of the technical correctness of the vehicle. This condition gives hope in future to prevent the disloyal competence and allow legality in working of the STI.

During that in order to issue approval for new STI the real necessity for opening of new STI must be analyzed, based on these criteria. In the everyday strains for reduction of the traffic accidents and reduction of the victims of the traffic accidents, it should be considered first of all on the quality not on the quantity.

These concluding realizations are taken on the base of real scientific researches and statements by the authors.

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