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WPŁYW ORGANIZACJI PRACY SAMOCHODU NA WARUNKI ROZRUCHU SILNIKA SPALINOWEGO

THE INFLUENCE OF THE VEHICLE WORK ORGANIZATION CONDITIONS ON THE ENGINE START-UP PARAMETERS

Podczas etapu planowania przewozu określonego rodzaju ładunku, bierze się pod uwagę: uwarunkowania techniczne posiadanych środków transportu, odległości pomiędzy założonymi punktami dowozu, czas i koszt przewozu, a także czasy załadunku i wyładunku. Inne czynniki, związane z warunkami pracy danego środka transportu oraz jego wpływem na otoczenie, najczęściej nie są brane pod uwagę podczas procesu projektowania tras przejazdu.

Wydaje się, że znajomość wpływu warunków organizacji pracy samochodu oraz rozruchu silnika spalinowego na środowisko naturalne ma także istotne znaczenie przy planowaniu organizacji przewozu. Niniejszy artykuł prezentuje omówienie przeprowadzonych analiz statystycznych wyników eksploatacyjnych badań samochodu dostawczego LUBLIN i jego silnika spalinowego 4CT90. Przeprowadzone analizy miały na celu określenie związków pomiędzy organizacją pracy samochodu a warunkami w jakich następują rozruchy jego silnika spalinowego.

Słowa kluczowe: *organizacja pracy pojazdu, warunki rozruchu silnika*

The technical parameters of the means of transport, the distance between particular points of carriage, the time of loading and unloading the cargo, the time and the cost of the transport are taken into consideration during the planning of the transport specified shipment.

Another factors, which are connected with the influence of the working conditions of the means of transport on the natural environment, are not taken into account during the planning of their routes. Nowadays it seems, during the planning of the organization of the transport service, that the knowledge of the influences of the vehicle and its combustion engine work conditions on the natural environment is significant. This paper presents the results of the statistical analysis of the maintenance research of the LUBLIN delivery truck and its engine 4CT90. The conducted analysis aimed at the estimation of the relations between the vehicle work organization conditions and the parameters of the engine start-up.

Keywords*: vehicle work organization, engine start-up parameters*

1. Introduction

The technical parameters of the means of transport, the distance between particular points of carriage, the time of loading and unloading the cargo, the time and the cost of the transport are taken into consideration during the planning of the transport specified shipment. Another factors, which are connected with the working conditions of the means of transport, are not taken into account during the planning of their routes [4,5,6].

Nowadays the transport systems are mainly based on the use of the vehicles which are driven by the combustion engines. The work of the vehicle assemblies generates the noise and the vibration of the surrounding elements. Additionally, although the development, the combustion engines are characterized by the emission of toxic compounds of exhaust gases [1,7]. For these reasons, it's necessary to take into account the influences of the vehicle and its combustion engine on the natural environment during the planning of the organization of the transport service.

The engine start-up and the work of non-warm engine seem to be the most important functional states. Due to unfavourable physical processes that take place during these states there is an increased emission of toxic compounds of exhaust gas and the wear of selected tribological engine units. We can also observe the high noise level and the overloads in the vehicle electric power system. The extent of such negative processes depends on engine start-up parameters: the temperature and the time of the engine start-up, the value of current consumed by a starter etc [3]. The working conditions of the vehicle, which depend on the organization of its driving, influence on the engine start-up parameters

Thus, the knowledge of the influence of the vehicle work organization conditions on the engine start-up parameters has theoretical and practical meaning. The paper presents the results of the statistical analysis of the maintenance research of the LUBLIN delivery truck and its engine 4CT90. The conducted analysis aimed at the estimation of the relations between the vehicle work organization conditions and the parameters of the engine start-up.

2. Operational research

The operational research was carried out using LUBLIN III delivery truck (maximum authorized total weight < 3,5 t) used by Polish Postal Service in Lublin. This truck has the 4CT90 diesel engine produced by a Diesel Engines Factory „ANDORIA S.A." in Andrychów. The engine was characterized by the following general data: the cubic capacity: 2,417 dm^3, max. power 63,5 kW at 4100 rpm and develops maximum moment 195 Nm at 2500 rpm. The engine was fitted with an in-line fuel injection pump.

The investigated truck was one of the several ones being currently at the disposal of the Lublin Branch of Polish Mail. A special recorder constructed to register the selected parameters of LUBLIN III operation and activity of the 4CT90 engine was mounted [2]. Basing on the results of the researches of selected parameters of the 4CT90 engine start-up and its operation as well as activity of the LUBLIN III vehicle the followed variables were obtained:

1. t_{pause} – the time of the pause in the vehicle operation with the engine switched off before the start-up [min],

2. t_{work} – the time of the engine operation before its next start-up [min],
3. t_{oper} – the time of the vehicle operation before the next engine start-up [min],
4. l_{veh} – the distance covered by the vehicle before the engine start-up [km],
5. l_{pis} – the distance covered by the piston before the engine start-up [km],
6. T_{agent} – engine (cooling agent) temperature at the engine start-up [°C],
7. I_{ave} – the average value of the current consumed by the starter during the engine start-up [A],
8. t_{start} – the work time of the starter during the engine start-up [s].

The first five parameters are connected with the organization of the LUBLIN III delivery truck work conditions. Next three ones concern the parameters of the engine start-up.

3. The analysis of the results of the researches

3.1. The correlation analysis

The obtained results of the maintenance researches were analysed by a computer programme STATISTICA. The correlation analysis was first carried out. The results of the data analysis are presented in the matrix ***r*** of the line correlation coefficients between specified random variables:

$$r = \begin{array}{c|cccccccc|} & t_{pause} & t_{work} & t_{oper} & l_{veh} & l_{pis} & T_{agent} & I_{ave} & t_{start} \\ t_{pause} & 1.00 & 0.01 & -0.02 & -0.03 & 0.02 & -0.55 & -0.42 & 0.61 \\ t_{work} & 0.01 & 1.00 & 1.00 & 0.97 & 0.92 & 0.18 & 0.13 & -0.16 \\ t_{oper} & -0.02 & 1.00 & 1.00 & 0.98 & 0.92 & 0.20 & 0.15 & -0.18 \\ l_{veh} & -0.03 & 0.97 & 0.98 & 1.00 & 0.93 & 0.16 & 0.15 & -0.17 \\ l_{pis} & -0.02 & 0.92 & 0.92 & 0.93 & 1.00 & 0.17 & 0.12 & -0.01 \\ T_{agent} & -0.55 & 0.18 & 0.20 & 0.16 & 0.17 & 1.00 & 0.43 & -0.71 \\ I_{ave} & -0.42 & 0.13 & 0.15 & 0.15 & 0.12 & 0.43 & 1.00 & -0.63 \\ t_{start} & 0.61 & -0.16 & -0.18 & -0.17 & -0.01 & -0.71 & -0.63 & 1.00 \end{array} \quad (1)$$

Basing on the values of the correlation coefficients we can see the correlation between the time of the pause in the vehicle operation with the engine switched off before the start-up and the engine start-up parameters. When this time increases the value of the engine temperature at the engine start-up and the average value of the current consumed by the starter during the engine start-up are reduced. But the work time of the starter (this time can be identified with the time of the engine start-up) increases. Another parameters which describe the vehicle work organization conditions haven't the essential influence on the engine start-up parameters. The values of the correlation coefficients show some relations among the parameters connected with the organization conditions. The values of the distance covered by the vehicle and the distance covered by the vehicle before the engine start-up are directly proportional to the time of the engine operation and the time of the vehicle operation before the next engine start-up.

3.2. The canonical analysis

The carried out analysis between two distinguished set of the parameters was the canonical one. We can state that the group of the parameters which describe the vehicle LUBLIN III work organization conditions explains only 31% of the total variance occurring inside this group. The set of the 4CT90 engine start-up parameters interprets 100% variability appearance inside this set. The group of the parameters connected with the vehicle work organization conditions explains about 35% variability inside the set of engine start-up parameters. The set of the engine start-up parameters determines only 11% of the variance occurring inside the organization parameters group. It certifies that some factors which cause the variability inside the groups of the vehicle work organization and the engine start-up parameters exist. They weren't taken into the analysis.

Basing on the calculations we can separate three canonical roots. The value of the canonical correlation coefficient of the first canonical root equals R_{k1}=0.6838. The value of the statistics χ^2 is equal 3990.7 and the probability level p=0.00. The characteristic value of this canonical root is equal 0.4677. The value of canonical correlation coefficient of the second canonical root is considerably small and equal R_{k2}=0.2349 (χ^2=21.1621 with p= 0.006). The characteristic value of the second canonical root is only 0.0551. The value of the canonical correlation coefficient of the third canonical root is equal only R_{k3}=0.133 (χ^2=5.066 and p= 0.166). This coefficient isn't statistically significant. Basing on these results we can state that only the value of the canonical correlation coefficient of the first canonical root is statistically essential. This coefficient will be presented in details.

The first separated canonical root explains 23% variance of the results in the first group of the parameters describing the vehicle work organization conditions. The same root separates more than 71% variability which occur inside the set of engine start-up parameters. In the first canonical root the set of engine start-up parameters explains only 10% variances in the group of the parameters describing the vehicle work organization conditions. The group of the parameters which describe the vehicle LUBLIN III work organization conditions explains only 33% variability inside the set of engine start-up parameters. The system of the canonical variables for the first canonical element assumes:

$$\begin{cases} U_1 = -0.898 \cdot \dot{t}_{pause} - 1.645 \cdot \dot{t}_{work} + 2.887 \cdot \dot{t}_{oper} - 0.803 \cdot \dot{l}_{veh} - 0.185 \cdot \dot{l}_{pis} \\ V_1 = 0.435 \cdot \dot{T}_{agent} + 0.149 \cdot \dot{I}_{ave} - 0.543 \cdot \dot{t}_{start} \end{cases}$$

where U_i – the canonical variable, which represents the parameters connected with the vehicle work organization conditions, V_i – the canonical variable, which represents the set of the engine start-up parameters, $\dot{X}_i$ – the standardized variable for the following analyzed parameters

Basing on the value of the coefficients at the particular standardized variables we can state that the parameter t_{oper} which describes the time of the vehicle operation before the next engine start-up has the greatest contribution to the U_1 canonical variable. The time of the engine operation and the time of the pause in the vehicle operation with the engine switched off before the start-up are in the next sequence. For the canonical variable V_1 the working time of the starter during the engine start-up has the greatest contribution. The engine temperature at the engine start-up is next.

In the first group of the parameters describing the vehicle work organization conditions the value of the canonical load for the time of the pause in the vehicle operation with the engine switched off is very high and equals –0.929. It shows the strong correlation between this parameter and the canonical variable U_1. The canonical loads for the next organization parameters don't exceed the value 0.3. In the set of engine start-up parameters the value of the canonical load for the working time of the starter during the engine start-up is equal –0.945. For the engine start-up temperature the value of the canonical load is high and equals 0.883. For the average value of the current consumed by the starter the value of the canonical load falls down and equals only 0.678.

Basing on the value of the canonical loads we can state that the time of the pause in the vehicle operation with the engine switched off has the most connection with the canonical variable which represents the parameters describing the LUBLIN vehicle work organization conditions. The canonical variable describing the 4CT90 engine start-up has the most connection with the working time of the starter and the engine start-up temperature.

3.3. The neural networks analysis

The next analysis, connected with searching of relationships between the set of engine start-up parameters and the group of the parameters describing the vehicle work organization conditions, was a neural networks analysis. Basing on the results of this analysis we can state that the MLP 5:5-11-3:3 neural network gives the best solution to the regression problems. This multilayer perception (characterized by the 5 neurons in input layer, 11 neurons in hidden layer and 3 neurons in output layer) is presented on Figure 1.

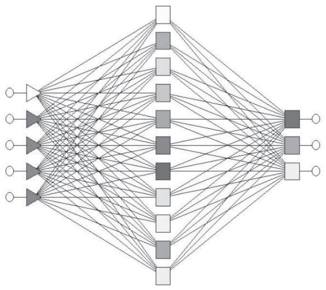

Fig. 1. The MLP 5:5-11-3:3 neural networks which give the best solution to the problem of the influence of the vehicle LUBLIN III work organization conditions on 4CT90 engine start-up parameters

The neural network MLP 5:5-11-3:3 takes into account all parameters connected with the vehicle work organization conditions. The time of the pause in the vehicle operation with the engine switched off has the top rank in this network. In the next order of the rank is: the distance covered by the vehicle, the time of the vehicle operation, the time of the engine operation. The distance covered by the piston has minimum rank. Unfortunately this neural network was characterized by the values of the errors for the following data sets: validation (error equal too 0.1301), training (error equal too 0.1353) and testing (error equal too 0.1538). The values of these errors exceed 95% level of confidence. It shows that this neural network does not give the satisfactory solution to the regression problem between the parameters describing the vehicle work organization conditions and the engine start-up parameters. It's caused by the dimensionality, interdependency and redundancy of the variables in the group of the parameters describing the vehicle work organization conditions.

4. Conclusions

Basing on the results of the statistical analysis of the operation research of the LUBIN III delivery truck and 4CT90 diesel engine we can state that the most important parameter (which is connected with the organization of the truck work conditions) influencing on the engine start-up condition is the time of the pause in the vehicle operation with the engine switched off. When this time increases the value of the engine temperature at the engine start-up is reduced and the work time of the starter during the engine start-up increases.

The results of the analysis show that the another analyzed parameters, connected with the organization of the LUBLIN III delivery truck work conditions (the time of the engine operation and the time of the vehicle operation before the next engine start-up, the distance covered by the vehicle and the distance covered by the piston before the engine start-up), have not crucial influence on the engine start-up parameters.

During the planning of the transport system we must aim at the minimizing of the time of loading and unloading the cargo in the particular points of carriage.

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