RESEARCH ON IMPROVING THE MAINTENANCE ACTIVITIES FOR MILITARY VEHICLES

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Abstract: *The current maintenance system, preventively planned and applied to the military equipment according to the necessities, involves the rigorous execution of maintenance operations, which results in high costs and volume of work. These causes generally determine the formality of planned repairs and maintenance, with detrimental effects for the availability of vehicles. Moreover, the constructive-functional level of the current technical systems leads to the reorientation of adopting maintenance strategies that correspond to the availability level of the constructive kits to computerized diagnosis operations, such as the maintenance based on operational reliability. For some types of vehicles, the periodical technical inspection, besides allowing for regular traffic on public roads, can offer significant data for the managerial and technical implementation of the maintenance based on operational reliability within the military units. The paper aims at offering viable and efficient solutions for executing maintenance activities and for making vehicles available by turning to good account the data resulting from the technical diagnosis process, correlated with an optimal management of maintenance.*

Keywords: making a diagnosis, reliability, maintenance, maintenance methods, maintenance strategies.

1. Introduction

The principal *objective* of the maintenance strategy based on operational reliability is the maintenance of vehicles in functional order in the interval between two scheduled repairs, by executing preventive maintenance activities (maintenance and repairs).

A maintenance system generally includes:

- preventive maintenance actions consisting in carrying out maintenance;
- corrective maintenance actions consisting in carrying out repairs.

The practice of using vehicles demonstrates the fact that certain types of technical inspection and maintenance require the execution of repairs before the respective kit or piece is accidentally broken, situation in which the overall operation (goal, identification of defect, execution) is called "preventive repair".

Such an example is the periodical technical inspection which is performed at an interval of six months, one year or two years, depending on the destination group and the type of vehicle. Exceeding the admissible limits of the wear out, angles, etc. of the functional measured parameters determines the halt in employing the respective vehicle, which no longer guarantees safety in use according to the established norms although it still has a functional capacity.

Another example of technical intervention for which the execution of preventive repairs is required is represented by the technical checking and maintenance, both those performed periodically (before starting the ride/mission, getting back) and those that have a high degree of complexity which are performed according to a schedule

(maintenance no.1, maintenance no.2, casual maintenance).For instance, during a simple visual operation of checking the sealing of a cooling installation, carried out in order to eliminate possible leaks of anti-freeze liquid, there can be seen weak or out-of-order collars, hose-pipes that are worn out due to the long period of exploitation, broken radiators, corroded expansion recipient, so on, which necessitates their replacement through preventive repair operations.

Fig. 1. The scheme of the cooling installation

In figure no. 1, a scheme of the cooling installation of a vehicle engine is presented for orientation [1], indicating some of the sensitive things which require preventive repair operations.

Figure no. 2 presents a piece of equipment used to measure the compression of the fluid inside the cylinders of a vehicle engine [2].

Fig. 2. Compressometer

This equipment determines the value of the pressure at the end of the compression course, which can be compared to the nominal values and to the bottom limit indicated in the technical instructions.

The working operation is specified in the technological charts for the execution of the types of maintenance that have a high degree of complexity.

Rezultatele măsurătorilor oferă date de ansamblu cu privire la gradul de etanșare al camerei de ardere, fiind cuprinse în categoria de operațiuni de diagnosticare generală.

The results of these measurements offer general data with regard to how tight the sealing of the burning chamber is, being included in the category of general diagnosis operations. The values of pressure registered as being under the admissible bottom level require the dismantling of the engine and the continuation of diagnosis operations on the pieces/elements for the accurate determination of the place necessitating preventive repair interventions. There can be innumerable examples.

The parameters of general diagnosis offer only global information related to the overall technical order of the vehicle or of some of the component parts, the diagnosis established in the course of such testing being either "corresponding or not corresponding" for being used.

In conclusion, the *general diagnosis* provided assesses the functionality of the vehicle according to the requirements related to the economical use of fuel and lubricant, the safety of traffic and the ecological norms of complex pollution (chemical, optical and acoustic).

In this presented context, the maintenance strategy based on operational reliability becomes all the more important because it takes place in both stages of providing the diagnosis: *general* and *on the elements*.

2.The characteristics of the maintenance strategy based on operational reliability

The objective of this strategy is to identify at an early stage *the critical points* in the functioning of the component sets and parts of the vehicles so that [3, 4], by an efficient

orientation of human, material and technical resources, a decision can be made as to establishing the *moment* when the technical intervention will take place.

Establishing the intervention moment depends on the values of the element diagnosis parameters, this category of parameters offering narrower information, capable to restrict the area of investigation and specifying the exact place of the fault.

The parameters used in giving the diagnosis on elements are the parameters specific to the phenomena accompanying the fundamental working processes, for example pressures, vibrations, noises, chemical modifications, etc.

In case the equipment necessary for giving the diagnosis on elements is missing, the specialized literature [3] offers efficient *methods* of maintenance management, which enable the identification of critical points in the functioning of the component parts, the establishing of the moment of technical intervention, as well as the elaboration of measures to be taken in order to reduce the criticality of the faults, such as:

- the analysis of the way in which the defect has taken place, of the effect and of the criticality (AMDEC);
- the origin of the fault;
- the PARETO method, etc.

In the second phase of the implementation of the strategy, there are established the conditions in which certain component parts and kits, although functional, indicate an impending failure.

Therefore, at this stage, the aim of the maintenance based on operational reliability is that of classifying the defects that might appear into *functional defects* and *potential defects*.

Thus, the potential failure represents an identifiable physical condition indicating an imminent functional failure.

The principle of this strategy based on operational reliability is the determination of the symptoms that allow for evaluating the deterioration limit, so that the whole set can be used to the maximum without the appearance of the functional failure.

In conclusion, the strategy of the maintenance based on operational reliability resort only to those efficient, applicable models of preventive maintenance which help to prevent the ways in which the critical components break down [4, 5].

In the case of vehicles, the following *critical points* can be defined in the functioning of the component parts and pieces that ensure the availability of the whole vehicle:

- the engine;
- the transmission;
- the propelling system;
- the braking installation;
- the steering mechanism.

This categorization can obviously be completed, but the analysis is restricted to the mentioned component parts for the sake of highlighting only those systems ensuring the basic functions of the vehicle, respectively *propulsion* and *traffic safety*.

In order to point out to the utility of the methods of maintenance management that rely on the principles of the maintenance strategy based on operational reliability, a case study is further realised to render a *model* of practical application of these maintenance methods, which will allow for the increase of the operational reliability of the component parts being exploited/used.

3. A case study regarding the application of the methods of maintenance management based on operational reliability

The target of the study was the range of vehicles belonging to the Roman-DAC model, manufactured and supplied to the military structures in the 1980-1998 period.

The data in the study were collected from a station of technical inspections authorized by the Romanian Transportation Register and pertaining to a centre of maintenance. These were obtained during the technical check-ups performed within the periodical technical inspection.

The truck models for which the maintenance needs data were collected for the two component systems that provide the safety of traffic on public roads, the braking installation and the steering mechanism

respectively, are equipped with a traction in the formula of 4x4 and 6x6 wheels, an engine having a horse power between 135 and 256 and a transportation capacity between 3 and

19 tonnes. The peculiarity of the study consists in the fact that it refers to a lot of vehicles manufactured and supplied to the military units over a long period of time.

Fig. 3. The distribution of the number of trucks tested according to the year of manufacturing

According to the chart in figure no. 3, most of the tested trucks belong to the ones manufactured in 1993, 16 in number, and the least number of tested trucks is 1, manufactured in 1990.

In the chart of figure no. 4, the distribution of the number of trucks is presented for the years in which the inspection took place, the greatest number belonging to the years 2011 and 2012.

Fig. 4. The distribution of the number of trucks tested according to the year of periodic technical inspections

This nonuniform distribution of the tested vehicle according to the years of manufacture and the years of inspections can not point to the frequency of defects and their causes, in which case the traditional methods of maintenance management are resort.

At an early stage, the PARETO method will be used in order to identify percentage of the defects of the two studied systems, braking and direction respectively, by consulting the history of the data collected during the periodical technical inspections.

Fig. 5. The distribution of the number of defects according to their type in the braking installation

The basic principle of the PARETO method consists in the fact that 80% of the defects are the result of the 20% of causes. Thus, figure no. 6 presents the hierarchy or the classification of the types of defects. The chart in figure 6 highlights the defects having a negative quantitative impact on the time of unavailability, the PARETO method ascertaining that the first two defects

(imbalance in braking forces on deck and inefficient service brake) correspond to a considerable percentage of the unavailability total.

These two defects could be grouped into a first set of failures having a repetitive character and a great percentage in the total time of unavailability.

Fig. 6. Classification of the types of defects according to their number in the braking installation

In a classification of type ABC failures, a second group of defects could be those appearing randomly, having a medium percentage in influencing unavailability (*inefficient parking brake, air losses beyond the admissible limit and the compressor overflowing oil in the braking installation*).

The third group of defects are the ones appearing randomly and having a low influence on unavailability (*the vehicle brakes without being given the command, losses of oil in the compressor, too low pressure in the reservoirs/tanks, suspicious thumps in the compressor and no functioning of the ramp brake*).

In practice, the elimination of the causes determining the appearance of the defects belonging to the first group will be achieved through maintenance activities. The elimination of the causes of defects belonging to the third group will be paid attention to. The causes of the faults pertaining to the third group will be focused on in the analysis of the malfunctioning of the installation although the frequency of these defects is very low and the gravity of the effects is reduced.

With regard to the analysis of the secondly studied system, the steering mechanism respectively, from the point of view of identifying the causes determining the appearance of major defects and their hierarchy by means of the Pareto method, figure no. 7 presents the major defects of the steering mechanism, as they are dealt with in the instructions for use and the specialized handbooks, based on the study carried out on the considered lot of technically inspected vehicles.

In particular, the defects that occur during exploitation are the ones that draw the attention due to the unexpected maintenance activities executed within unscheduled repairs, for which the technical conditions of repair and control were not provided for the performed repairs (*the vehicle does not maintain direction in movement and the premature wear out of tyres on the front axle*).

According to the hierarchy criterion of defects, previously analysed in the braking installation of type "ABC" (figure no. 8), for the steering mechanism the influence of such

a first group of defects that affect to a certain extent the unavailability time of the vehicle is more reduced as compared to the braking installation because of the secondary effects of this system on the safety of the road traffic. A second group of defects could be the ones which determine a clumsy turning of the vehicle.

Like in the first case, attention will be given to eliminating the causes of the defects of both groups, the causes of the defects of the third group (*the steering mechanism vibrates and the steering mechanism gets stuck*) will be carefully handled in the analysis made to the breaking down of the mechanism, since the frequency of emergence of these defects does not play an important role, as well as their third effects on traffic, on the driver's and the passengers' comfort and on the

maintenance costs in restoring the functionality of the vehicle.

In conclusion, the present paper is confined to analysing by means of the Pareto method the causes of the main defects that may occur in the functioning of the components of vehicles. This analysis may represent a modality of improving maintenance activities for vehicles.

This study can be further continued by using a more complex method, "The analysis of the way in which the break down occurs, of its effect and its critical point" respectively, through which the gravity of failure appearance for each component part is paid attention to, as well as the preventive maintenance activities are established.

Fig. 7. The distribution of the number of defects according to their type in the steering mechanism

Fig. 8. Classification of the types of defects according to their number in the steering mechanism

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