Increase of cars reliability at the expense of their warranty service abroad process improvement

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Abstract* – *The article is devoted to the development of theoretical and practical methods of solving problems associated with the development of the system of the corporate service of trucks and increase efficiency of its functioning. It is shown the influence of the climatic conditions of the region operating on the indicators of operational reliability. The proposed method will allow to organize the accumulation of statistical data on the most frequent reasons of premature refusals emergence in certain service conditions; accumulation of analytical data from the dealer centers allowing the producer purposefully to improve a design of the car, increasing its reliability and safety.

Keywords – operational reliability, forecasting of refusals, климатические условия, warranty, warranty packages, breakdown statistics

I. Introduction

In conditions of automobilization growth and accelerating competition, reliability of motor vehicles becomes one of primary factors of competitiveness, therefore the problem of its non-failure operation is solved at all stages of their life cycle – from designing up to recycling. Motor vehicle manufacturers bear the responsibility for its technical condition at all operation phases, however warranty period is the most responsible as any deviations from warranty package can negatively affect reputation of a producer and lower confidence to a brand among customers and owners. Duly, fast and qualitative service is most demanded for cargo motor vehicle owners as at commercial operation of the truck each extra hour of idle time waiting for service is measured by the missed benefit. It forces manufacturers to search for new company service management forms and to optimize business processes.

II. Supply of spare parts and service quality

Position stability of automobile producer company in the foreign markets depends on strategy quality on company service (CS) management, which is substantially defined by planning and forecasting result accuracy applied by its development. CS development success abroad is guaranteed by systemic approach to creation of a dealer service network (DSN) and to processes management at its functioning that is provided with quality of the initial information including on the vehicle operation region, and also by reliability of tools for its analysis and forecasts for the subsequent period.

One of the important factors essentially influencing the quality of car service is providing company service centers with spare parts.

The problem of spare parts delivery planning in DSN is solved in most cases at intuitive level. Such approach leads to losses in case of absence of the necessary positions in a warehouse, and at storage of unclaimed spare parts.

For planning efficiency increase of structure and spare parts delivery time it is necessary to consider, that various car units, components and systems have a different resource and possess a different degree of reliability which depends on a set of the factors having stochastic character.

Operating a vehicle, it is necessary to remember, that any, even the most perfect motor vehicle, cannot carry out its functions for a long time without qualitative and duly maintenance service and observance of operation conditions. Duly parts replacement which have expired service life, allows not only to increase safety of the vehicle operation, but also to avoid failure of parts mating to them.

Breakdown information analysis of automobiles shows, that each model in the certain operation conditions at the fixed operating time has some number of parts, which breaks more often than others, named "limiting" reliability, or "critical" on reliability. Thus, in Kramarenko G.V. [2] opinion, on 15-18 thousand parts which the vehicle consists of, 3-4 thousand have service life less, than the service life of vehicle itself, but only 400 parts are critical on reliability.

III.Methods of planning of the supply of spare parts

The most effective method of vehicle operational reliability increase is the prevention of breakdowns based on a technical condition forecasting at a certain operating time, and also planning of service time according to results of the analysis. Forecasting of the possible breakdown moment, i.e. probable defining that controllable parameter goes out acceptance limits in a definite time, allows to plan deliveries of spare parts under the nomenclature and quantity for duly replacement of unreliable elements in view of operation conditions, climatic conditions in specific region, season, type, model and a vehicle configuration [1].

Breakdown of car unit, component or system arises during the moment of time $T_{break.}$, which with the certain probability can be predicted. According to technical products operating experience, change of breakdown rate $\lambda(t)$ of majority of objects is described by U-shape curve and is divided into three operational stages [1]: during running-in period the raised breakdown rate is observed which is connected with detail running-in and is caused, as a rule, by industrial defects. During regular operation breakdowns have casual character and appear suddenly, first of all, because of non-observance of operation conditions, changes of loading, influence of adverse external factors, etc. (fig.2). The third period is characterized by increase of breakdown rate that is caused by ageing and other reasons connected with long operation.

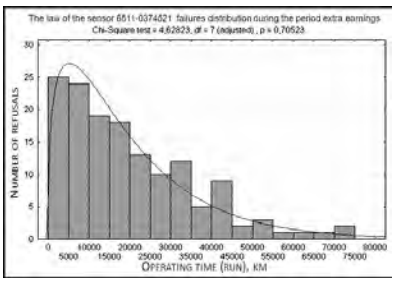

Fig. 1. Breakdown distribution
of the gauge 6511-0374521 during running-in period
(latent defects of the manufacturer)

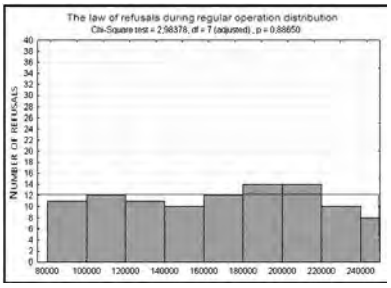

Fig. 2. Breakdown distribution
of the gauge 6511-0374521 during regular operation
(external influences)

It is impossible to deal with breakdowns during running-in period, but it is possible to reveal the parts on the basis of the references statistics analysis in a car center which are mostly subjected to early breakdowns. Qualitative and quantitative structure calculation mechanism of spare parts warranty packages (SPWP) have been developed for breakdown-free service at a running-in period formed for the next party of sold automobiles and sent in the operation region together with it.

During regular operation breakdowns appreciably depend on operation conditions, have stochastic character and that is why the forecast for spare parts demand is carried out on the basis of the dependences established by the DCC references analysis.

As the warranty period is the most important for maintenance of client's loyalty, first of all, a question on maintenance of qualitative service is solved during this period. Appointing the warranty period, the producer company includes not only running-in period, but also a part of regular operation period. However, as a curve breakdown rate nature testifies, dependences of breakdown quantity on an operating time on these sites are described by two essentially different laws. Therefore spare parts supply process should include two functionally various mechanisms.

Spare parts warranty packages (SPWP) qualitative and quantitative structure design procedure is necessary for a running-in period. SPWP are formed for the next party of sold automobiles and sent to operation region together with it. Possible references planning method is necessary for a regular operation period owing to breakdown of this or that part in view of the statistical information analysis data under references to DSC during previous period. Such planning method serves a basis for a delivery date structure and calculation formation in control centre of a dealer service network (DSN). Consignment structure in both cases is formed in view of the information on breakdowns during the warranty operation period [2].

IV. Methods of accounting and analysis of information on breakdowns

It is the most reasonable to use opportunities of information systems and technologies for statistical data accumulation on breakdowns. These are control systems of databases for the account of breakdowns, allowing to reveal all kinds of breakdowns on a breakage mode and a unit in which it has appeared, and also on conditions in which the vehicle was operated; programs of the statistical analysis for processing the statistical information and other specialized IT development for the automobile service, enabling to lower risk of early breakdowns. Studying character effects can be based on the information on the breakdowns arising while in service, fixed in the form of claims of the consumer, after their careful processing and the analysis. The account of the information, its formalization and classification on malfunctions and the breakdowns, realized in the form of defects codifier, and also its analysis in view of various factors, allow to reveal the reasons of early breakdowns emergence and to take measures on their prevention. The system of gathering, formalization and the analysis of damage statements is necessary for this purpose which will allow the service centers experts to enter, and to employees of the producer company to look through and analyze claims.

When turning to the service center, data is registered by means of information system about its reasons which serve as the initial information for the subsequent analysis. For making a sample on one of factors, value of all others remains fixed. Distribution law parameters of a mean time between breakdowns random variable are defined for the generated data file by means of Statistica program [3]. The schedule of distribution law is constructed according to the histogram of empirical data then its conformity is defined to selective data at the fixed significance value.

Results of the analysis serve for development and updating intended both for the service centers, and for automobile owners special instructions which observance will allow to provide trouble-free operation of the vehicle. In conditions of service network expansion alongside with operational parameters of motor vehicles the analysis of the following commodity market parameters is necessary:

- Region potential;
- A policy and the national legislation;
- Competitive advantage of a producer company in the analyzed market;
- Characteristics of the system providing an opportunity of adequate and duly reacting to situations, developing in the considered market.
- Characteristics of all subsystems activity synchronization system of firm-producer on efficiency securing of export functions execution.

The big number of the parameters describing conditions of operation causes a search of the means providing efficiency and accuracy of the analysis carrying out. It is possible to achieve these requirements by means of the

data operative analysis technology i.e. online analytical processing (OLAP). A basis of the given technology is a multivariate data cube – an OLAP cube.

V. Study of the influence of climatic conditions on the statistics of breakdowns

While revealing reserves of automotive enterprise service centers processes efficiency increase it is necessary to consider, that various car units, components and systems have a different resource in different conditions and possess a different degree of reliability which, in turn, depends on set of factors having a stochastic character. In particular it is typical at expansion of commodity markets and development of DSN abroad. At breakdowns forecasting and car service planning the account of such factor, as climatic conditions as it renders essential influence on a parameter of reliability is necessary.

Research of climatic conditions factor influence was done on the basis of statistical data sample on the breakdowns, accumulated by CJSC Foreign Trade Company of KAMAZ. At drawing up a breakdown distribution country by country the parameter of breakdown rate (i.e. breakdown quantity of one car) was considered, as the probability of their occurrence increases at growth of a motor vehicle fleet size. Fig. 3 presents the diagram and function of breakdown distribution country by country. Thus factor of correlation $R^2 = 0,63$, that does not satisfy demanded accuracy for the purposes of forecasting and planning.

To exclude influence of the climatic factor on the forecast accuracy, three groups of the countries has been allocated with similar climatic conditions on the basis of climate classification by Keppen V.P. [4].

Schedules of breakdown rate distribution and functions of breakdown distribution were made separately for each country group (Fig. 4-6). According to the given data, the coefficient of distribution law correlation for each of climatic country group is much more, than by their generalized consideration.

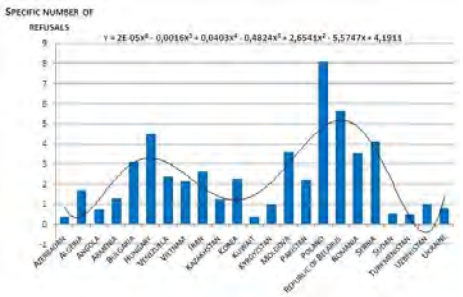

Fig.3. Breakdown rate distribution country by country

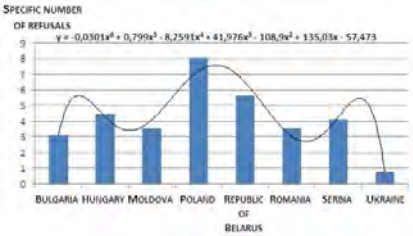

Fig.4. Breakdown rate distribution country by country of group 1

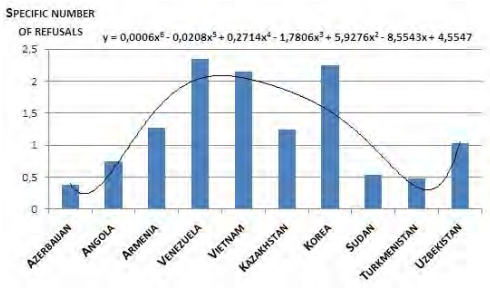

Fig.5. Breakdown rate distribution country by country of group 2

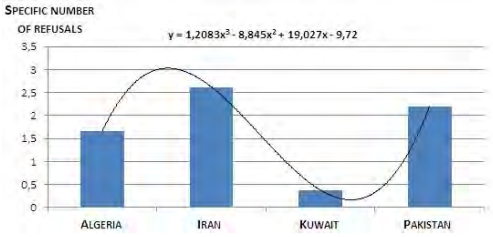

Fig.6. Breakdown rate distribution country by country of group 3

Results of performed researches testifies to necessity of taking into account the climatic conditions factor at breakdowns forecasting and car service planning.

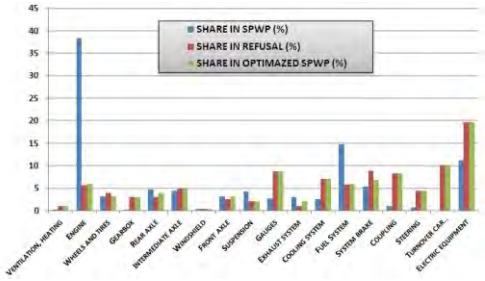

Fig.7. SPWP structure comparison to the information on breakdowns

VI. Methods of spare parts providing warranty and post-warranty periods

As DSN provision abroad with necessary spare parts during the warranty period is one of prominent aspects of producer company warranty observance, the essential attention is paid to formation method development of their deliveries. Methods are formed on the basis of the breakdown statistics analysis during the warranty period. However, in our opinion, the insufficient attention is given to region climatic features.

SPWP qualitative and quantitative structure conformity analysis for Cuba was made to confirm this thesis which has a climate of savannas and belongs to the second climatic group allocated according to climate classification of Keppen V.P. [3].

Available information on breakdowns has been grouped in units. The grouping of the spare parts which are a part SPWP has been done in the same way which was delivered in Cuba. Received data were compared, that has allowed revealing deviations of SPWP structure from the number of breakdowns.

Such discrepancies lead to warehouses overstocking and service centers assets freezing because of a significant share of non demanded spare parts and, at the same time, conduct to decrease in quality of service owing to increase in a waiting time due to absence of the necessary spare part. At commercial operation of automobile the increase of repair time leads to loss of confident of the client to a brand.

For conformity of SPWP structure its optimization has been made to the number of breakdowns. Results of redistribution are shown on fig.7 where the structure of the warranty packages is compared made by an available method and in view of Cuban climatic conditions.

Apparently from the diagram, optimized SPWP corresponds more precisely to breakdown distribution on the car units in the given climatic group. Therefore it is possible to assert, that the application of SPWP drawing up method with a view of climatic conditions influence will allow harmonizing its structure to breakdown distribution on the car units.

VII. OLAP technology application for the analysis of data on operational reliability

In the conditions of a service network expansion along with operational indicators of automotive technology is necessary the analysis of a sales market indicators such as:

- capacity of the region;
- policy and national legislation;
- competitive advantage of firm producer in the analyzed market;
- characteristics of the system providing possibility of adequate and timely reflection of situations, developing in the considered market.

A large number of operation parameters characterizing service conditions, causes of search of the means providing efficiency and accuracy of carrying out the analysis. Today to achieve implementation of these requirements it is possible to achieve by means of data operational analysis technology (OLAP). The basis of this technology is made by a multidimensional data cube.

Important feature of an OLAP-cube for us is that at such technology it is possible to set on each measurement the hierarchy defining a way of elements grouping or classification, belonging to this measurement. The OLAP-technology includes some important concepts.

Measurement is a set of one or several types objects organized in the form of hierarchical structure and providing information context of a numerical indicator. In the presented work as the main measurements will be:

- Characteristic of the motor transport unit (Model);
- The characteristic of the service center serving the motor transport (The service center);
- Characteristic of service conditions and branch of use (User);
- Characteristic of operation region (Region).

Members of measurements visualize as points or the sites postponed on axes of an OLAP-cube. For example, for measurement "Region" members will be:

- Category of the region on climatic conditions and a land relief;
- Existence of a network of service;
- Population level. (Fig. 8)

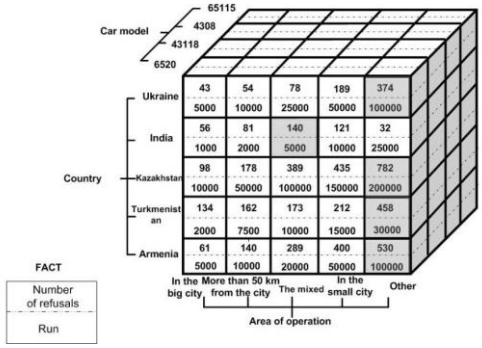

Fig. 8. Three-dimensional OLAP-cube with simple measurements

Conclusion

Annual economic benefit for DSC due to reduction of unclaimed assets enclosed in spare parts warranty packages makes 37400 rubles. Economic benefit for the automobile owner, expressed by decrease in the size of the missed benefit due to repair idle time reduction makes 6992 rubles.

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