ANALYSIS OF THE RELIABILITY OF LIGHT LORRY CHASSIS DURING OPERATION

АНАЛИЗ НА ЕКСПЛОАТАЦИОННАТА НАДЕЖДНОСТ НА ХОДОВАТА ЧАСТ НА ЛЕКОТОВАРНИ АВТОМОБИЛИ

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***Abstract**: The article presents results from the research of the reliability of Citroen Jumper and Fiat Ducato chassis using the Pareto method. Their most common failures and repairs are identified and presented in diagrams.*

Keywords: reliability, failures, repairs, chassis of light lorry, Pareto chart

1. Introduction

The systems providing reliability comprise the entire lifecycle of the machines, from the design and the construction to the operation. The methods ensuring reliability are specific to each stage of the lifecycle. For example, achieving the organization's reliability goals requires strategic vision, proper planning, sufficient organizational resource allocation and the integration of reliability practices into development projects. Reliability design describes the entire set of tools that support product and process design to ensure that the expected reliability is fully met throughout the life of the product with low overall life-cycle costs. The main factors influencing the reliability of machines, especially the means of transport are the conditions and modes of operation, as well as organization and management processes of maintenance and repair.

The successful solution of tasks related to improving the reliability can be achieved by taking management decisions based on information obtained from statistical data of the occurred failures, the expenditure for repairs and the automobiles downtime.

The common failures of a certain structure, the likely causes of the failure occurrence and the ways to minimize them can be determined successfully using the Pareto chart.

2. Results and discussion

Pareto diagram represents a particular form of vertical bar graph that highlight the most important among a set of factors. In quality control it gives the most common reason for faults and failures and helps to reduce or completely eliminate them. The construction of this chart is based on processing of statistical information or other form of data collection. Pareto chart focus on actually the most important factors of the study (the highest bars in the graph) and less to those which are insignificant. Pareto charts for analysis of the reliability (Fig. 1) are built on the following algorithm:

1. Classification of failures chosen in accordance to the studied object.

2. Defining the form for registration of the failures.

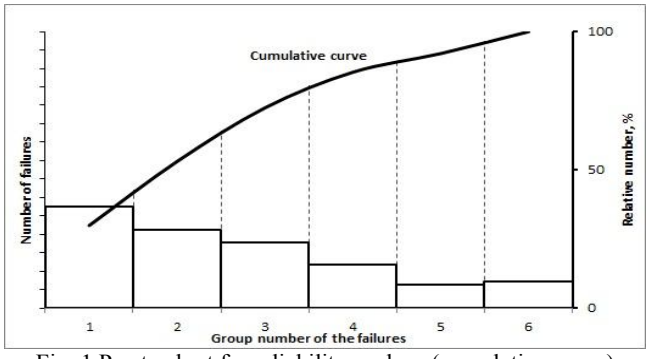

Fig. 1 Pareto chart for reliability analyze (cumulative curve)

3.Developing methodology for processing statistical information.

4. Processed data are arranged in descending order.

5. Plot a horizontal and two vertical axes. On the horizontal axis are plotted the considered factors. On the left vertical are plotted the measured values of the analyzed parameters, and on the right - relative values of this parameter as a percentage of total value.

6. Plot a bar chart for different types of failures.

7. Draw a Pareto curve. On the Intervals corresponding to each vertical of the horizontal axis are plotted the accumulated sums (measured in units or in percentages) which are joined by straight lines.

Pareto principle was used as a scientific tool for reliability analysis. Based on this principle, an analysis of the cost of repairing various types of failures is made. C_{sp} indicator is used to determine the average specific costs (materials and labor) for distance covered per unit of time (1).

$$C_{sp.} = \sum_{j}^{N} \frac{C_{ij}}{L_j} \qquad (1)$$

Where C_{ij} is the cost of removing the i^{th} type of failure of the j^{th} vehicle;

L – the mileage of j^{th} vehicle covered during the study

The study was conducted based on statistical data obtained from expenditures report made for the repairs or prevention of the failures of individual elements of the chassis for 28 cars Citroen Jumper and 29 cars Fiat Ducato. The total distance covered $\sum L_j$ is 829470km (Citroen Jumper) and 5134432km (Fiat Ducato), and the average distance is 286024km and 177049km respectively. For the chassis of Citroen 373 failures were registered and divided in 16 classes (groups), and for Fiat Ducato - 390 failures, divided in 9 classes (groups).

For each group of failures (repairs) for the specific model, C_{sp} costs and their relative share in percentage $C_{\%}$ was determined using formula (1) (Table 1 and Table 2).

Tabl. 2 Specific costs for eliminating the failures of Citroen Jumper

№	Type of failure (repair)	C_{sp} lv/1000 km	C, %
1	Front strut bearing replacement	0,91	25,3
2	Front hub bearing replacement	0,81	22,5
3	Front wishbone bushes replacement	0,8	22,2
4	Ball joint replacement	0,77	21,4
5	Rear hub bearing replacement	0,099	2,7
6	Power steering rack replacement	0,061	1,7
7	Bar link replacement	0,06	1,7
8	Welding on the base of the front shock absorber	0,05	1,3
9	Inner steering connecting rod replacement	0,04	1,1

Tabl. 2 Specific costs for eliminating the failures of Fiat Ducato

№	Type of failure (repair)	C_{sp} lv/1000 km	C, %
1	Front hub bearing replacement	1,84	33,6
2	Front strut bearing replacement	1,31	24
3	Front wishbone bushes replacement	0,96	17,5
4	Ball joint replacement	0,87	15,9
5	Bar link replacement	0,23	4,2
6	Power steering rack replacement	0,12	2,2
7	Welding on the base of the front shock absorber	0,06	1,1
8	Inner steering connecting rod replacement	0,05	0,9
9	Rear hub bearing replacement	0,02	0,3

To analyze the reliability of the chassis for the investigated vehicles based on data from Table 1 and Table 2, bar and Pareto charts were built.

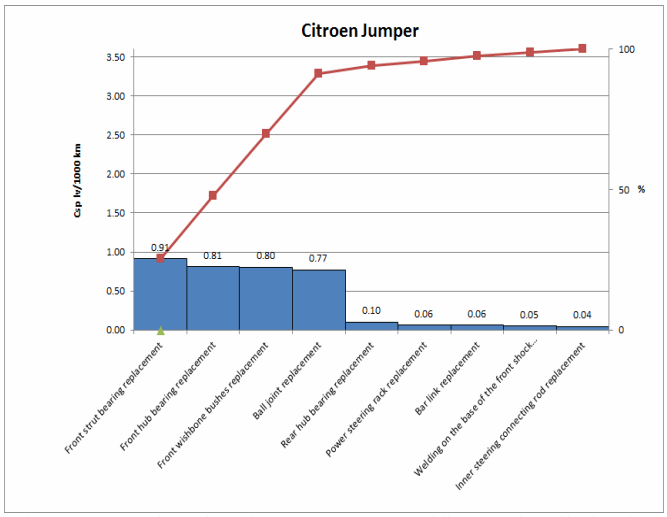

Fig. 2. Pareto chart for Citroen Jumper specific cost for eliminating the failures

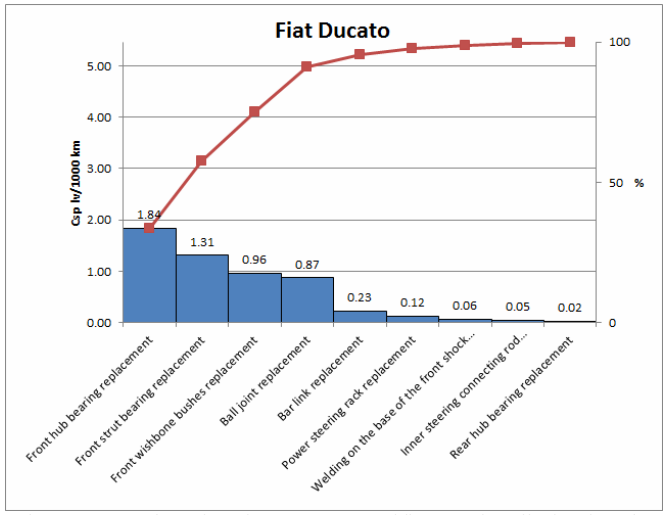

Fig. 3 Pareto chart for Fiat Ducato specific cost for eliminating the failures

In order to choose standard for classification of the typical failures for the mentioned vehicles it is required the cumulative growth curve for specific costs $C_{\%}$ to be greater than the calculated average for this model. The average value of the specific costs to repair the chassis' elements for Citroen Jumper is:

$$C_{\%} = \frac{100}{9} = 11{,}1\%$$

The average value of the specific costs to repair the chassis' elements for Fiat Ducato is:

$$C_{\%} = \frac{100}{9} = 11{,}1\%$$

From the Pareto chart (Fig. 2 and Fig. 3) can be determined that Citroen Jumper and Fiat Ducato include the following four typical failures (repairs):

- front strut bearing replacement;
- front hub bearing replacement;
- front wishbone bushes replacement;
- ball joint replacement.

3. Conclusion

More detailed analyze shows that the frequent changes of elements of the chassis and suspension (bearing, hub bearing, front wishbone bushes, ball joint**)** is due to the poor country road conditions and the replacement of the original spare parts with alternative, which have less reliability and higher probability for failures.

The comparison of specific costs for eliminating of failures of both vehicles shows that Citroen Jumper has significantly lower cost for maintenance than those for Fiat Ducato. The reason is the poor road conditions in urban compared to rural areas. The distance Citroen Jumper covered is up to 200,000 km of rural areas while Fiat Ducato travelled only in urban regions. This show how significant is the influence of the road conditions and modes of operation on the cost of maintaining the chassis.

The results of the study allow detecting the most unreliable components of the chassis and suspension. This can help the management staff responsible for maintenance and repairs to take appropriate decisions to improve reliability and increase the efficiency of operation of these vehicles.

4. References

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