Research of New Cars Quality

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Abstract. The article deals with the study results of the quality of new cars in the production control process in the delivery condition to the consumer. The research was conducted on the basis of resource tests and using information-statistical analysis. The quality assessment of new cars and their role in customer satisfaction is given.

1. Introduction
Currently, ensuring the quality of the car and its operational efficiency most significantly depends on the relevant indicators of the electrical complex. Moreover, this issue is important given the prospects for the development of new types of vehicles, such as electric vehicles and cars with a combined power plant.

Quality is known to lay in the design and is ensured in production. The processes of measuring the quality of new cars have to be implemented at different stages of the life cycle. This should be covered by design tools and the production system and, of course, by car operation. [1, 2]

The goal of the research is to actualize the problem of ensuring the quality of automotive equipment based on a comprehensive study of the data array reflecting defects of new cars that are identified at the stage of production output quality control. Besides, the information-statistical analysis of the data array on car system failures during the warranty period of operation is carried out in the article, highlighting the most important systems in terms of operational quality. As a result of the study, an analysis and comparison of production control data and warranty operation data was conducted to assess the equivalence of the weight of the detected defects of new cars at the stages of the life cycle. [3]

2. Key research findings
As a research base, data selection is defined as the results of industrial output quality control, as well as data from the warranty operation of one of the most popular passenger car models made in our country. The study period covered the entire 2017 and 6 months of 2018. In addition, the data of an independent expert laboratory were used in the research process, which conducted the study of car shipping of the considered brand as an analog of production control and during operation, as an analog of the warranty period. In conclusion, summarized data on the results of the resource tests of cars of the investigated brand are presented. [4, 5]

As a research tool, a modified Pareto diagram is used, which reflects the accumulated level of defects according to statistical data for specific vehicle systems. The expert method based on information - statistical analysis of new car quality problems is also used. [6]
Let us consider the study results of the quality of cars according to the data from the output quality control department of the product and from the enterprises of a branded car service to the parent company. They reflect the level of defects in new vehicles before a sale and during warranty service (Figures 1 - 4). According to the workshop, the largest number of cars’ defects of the considered brand for a year and a half of analyzing (from January 2017 to June 2018) is manifested on the systems "Car Interior" (about 34%) and "Car Body" (about 26%). These systems make up the bulk of the cost of fixing defects. The electrical equipment system takes third place both in defects (23.8%) and in costs (20.2%) and, therefore, is the most defective one of the functional systems. [7-10]

It should be noted that not all cars with one defect are fixed during the inspection in the workshop. Because of this, the actual values of defectiveness and advertise ability of the electrical equipment system may be higher.

According to the warranty operation (the results of the elimination for the same year and a half), the majority of vehicle defects are manifested in the electrical equipment system of 17.5%. The electrical equipment system takes the second place and makes up 17.8% of the total costs of the guarantee in terms of warranty costs (the first place is occupied by the engine system, which accounts for 17.9% of the costs).[11-15]

Thus, the analysis of defects and their causes revealed in the output inspection workshop, as well as during the period of warranty operation, allows to single out the most significant problems of car quality using informatization: body assembly defects, defects in the internal combustion engine, problems with the quality of electrical equipment. It is these problematic aspects of the quality of automotive equipment that currently determine the list of the most pressing problems. Their solution can significantly reduce the cost of eliminating defects both within production and in warranty, as well as the quality of products. [16-21]

Figure 1. Costs broken down by systems in the output control workshop.
3. Results
Let us turn to the analysis of the results of independent tests of automotive vehicles obtained in an international certified laboratory. In summary, separate problems during control tests of the study six brands of cars and their visualization are presented in Table 1. Tests were conducted in several areas of expert assessment based on information - statistical analysis of quality: quality of car shipping; quality according to the results of testing the components and assemblies of cars for durability; risk assessment of vehicle operating safety.

There is an analysis of the quality of car shipping in columns 1, 2, Table 1. The evaluation resulted in the following problems were identified: the requirements for fastening the fuel supply hose (problem 1, Table 1) to the internal combustion engine (ICE) were not met; for this reason, a fuel leak occurred; mismatch of the braking characteristics of the rear wheel lock during sudden braking; broken wire connector to the headlamp lighting system; indicators on the dashboard do not work. There are the
problems that can reduce consumer satisfaction in the delivery condition: noise and vibration of the internal combustion engine; gear shifting is difficult (problem 2, Table 1); poor quality fastening of upholstery panels; difficulty opening / closing the tailgate (problem 3, Table 1). Considering and summarizing these problems, the main reason for the non-compliance with the quality requirements for car shipping can be revealed. This is the same reason shown earlier, when analyzing the quality of production results, and associated with low quality of car assembly.

Quality according to the results of testing units and assemblies for durability is in columns 3, 4, Table 1. The following problems were identified in cars quality during road tests on public roads within 5000 km: transmission failure in the car: the driver could not engage the second and third gear of the gearbox (gearbox) after stopping; loss of the initial tightening torque of the front left drive shaft nut (problem 1, Table 1); failure of the fuel pump connector (problem 2, Table 1); the front left cap of the wheel disc is disconnected (problem 3, Table 1); failure of the front left power window; high engine oil consumption; incorrect connection of the engine temperature sensor; leaking rear windshields.

Risk assessment of vehicle operation safety is in columns 5, 6 Table 1. The following problems were identified during the tests: harmful contact of the throttle valve control cable with the engine fan cover (problem 1, Table 1); harmful contact of the brake tube with the fuel hose (problem 2, Table 1); harmful contacts of cooling hoses with several connections (problem 3, Table 1); harmful contact of the spark plug wiring with the engine cover bracket (problem 4, Table 1).

Table 1. Results of testing new Russian-made cars.

| Problems | Visualization | Problems | Visualization | Problems | Visualization |
|----------|---------------|----------|---------------|----------|---------------|
| 1.       |               | 3.       |               | 5.       |               |
| 2.       |               | 4.       |               | 6.       |               |
| 3.       |               | 1.       |               | 2.       |               |
| 4.       |               | 3.       |               |          |               |
| 5.       |               |          |               |          |               |
Summarizing the results of the resource tests of six cars, special attention should be paid to quality problems, the reasons for which are the quality of cars assembly. Most of the identified problems related to issues of executive quality formed at the assembly lines of automobile manufacturers. In conclusion, we turn to the results of operational tests of 10 cars of this brand on a range of up to 240 thousand kilometers on public roads. The ranking of the data obtained during the operational tests of automotive equipment for the main classification reasons for failures showed that:

- about 40% of the identified problems were related to the assembly quality of units and cars;
- about 30% of the problems were connected with the insufficient structural quality of brackets, tubes, hoses and other elements, various automobile systems;
- up to 20% of problems were related to failures of elements of the electrical system;
- about 10% of problems were due to the presence of harmful contacts of various elements and systems of cars.

Thus, the results of operational tests and other studies discussed above reveal the most significant problems of vehicle quality. They are the insufficient quality of assembly operations on conveyors, the presence of quality problems of individual units and assemblies (ICE, gearbox), as well as quality problems of elements vehicle electrical systems. Moreover, the importance of automobile electrical equipment in terms of quality and operational efficiency would steadily increase. Data on the level of defectiveness and the costs of their elimination clearly show that the electrical system confidently occupies one of the two leading places of anti-rating. At the same time, the results of expert assessments based on information - statistical analysis and resource tests of automobiles clearly show the importance of ensuring the quality of production and assembly of electrical components.

Let us go to the issue of assessing the quality of new cars on the part of the consumer environment. The analysis of the correlation between individual estimates that determine the unit elements of ensuring the quality of new cars in the delivery condition allows us to draw some conclusions regarding the initial, after-production quality of new cars. According to the obtained data, the consumer is more susceptible to changes in satisfaction: the correlation coefficient is 0.65 in case of a change in the quality of the finished product (car). The consumer is suggested to be most sensitive to the primary quality of new cars, and if it is high, then satisfaction is relevant. Ensuring the quality of service (correlation coefficient 0.61) and the cost of ownership (0.6) are also important. A sensitive relationship is observed between satisfaction with service and cost of ownership (0.56); between satisfaction with service and car quality (0.51).

In other words, it turned out that it is important for the consumer: the primary high quality of the purchased car, the acceptable perceived value of quality (cost of ownership), and quality of service. Moreover, all this should be already provided at the start, that is, when the car is bought. The consumer is not very sensitive to the fact that the possible quality problems that arise during the operation will be resolved quickly, whether at the design or production level or in the service. This does not increase loyalty and satisfaction.

**Conclusion**

The comprehensive study showed that in the current production conditions, the level of defectiveness, as well as the predicted level of relevant indicators for the component base of the electrical equipment system, could not be estimated. Unfortunately, it is necessary to use primarily data from the period of operation to assess the quality of electrical equipment.

At the same time, based on a cross-analysis of data on defects detected in the processes of output quality control, warranty operation, expert assessment based on information - statistical analysis and life tests, a complete picture is formed. It allows highlighting the electrical system as a key one in terms of ensuring the quality of new cars. In this regard, there is a need for the development of analytical and hardware methods and tools for assessing and predicting the quality of electrical equipment of cars at the production stage. This requires the development of appropriate diagnostic production systems that solve the problems of both assessing and predicting the operational efficiency of new cars, at least within the warranty period.
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