Actualization of the ensuring the repeatability quality problem of a car generator set in conditions of large-volume production

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Abstract The causes of technological errors are quite numerous and varied, and they can be classified according to various criteria, for example, by the type of technological operations (errors in the machining operation of parts, winding and laying the windings into stator's slots, etc.). The program performs an automated calculation of the characteristics of the generator when the input dimensional parameters of the core change within the limits of the tolerance field for each of them set by the technical specifications (TS). The algorithm of the program is based on the method of calculating a three-phase synchronous generator with a cranked rotor. To assess this effect, a system of interconnected computer programs and mathematical models has been built, with which it is possible to determine the weight of the influence of technological deviations in the manufacture of the generator on its performance and the characteristics of the electrical system as a whole. Reducing the variation of the generator reliability indicators can be achieved by phased assessment and timely adjustment of the quality level of design, production and ensuring their connection with the quality management system.

Keywords: quality, car's generator, no-load characteristic (NCL), current-speed characteristic (CSC), rotor

1. Introduction

Competition compels manufacturers of any goods, including automotive vehicles, to reduce more and more the development and organization of new products. Nowadays, computer-aided design (CAD) systems have become the generally accepted means of such acceleration. However, CAD, unfortunately, have one very significant drawback: with their help, it is difficult to take into account the influence of inaccuracy in the manufacture of parts due to the technological features of production. The causes of technological errors are quite numerous and varied, and they can be classified according to various criteria, for example, by the type of technological operations (errors in the machining operation of parts, winding and laying the windings into stator's slots, etc.). Technological errors of the parts (components) determine the variation of the output characteristics of the considered electrical products relative to the values specified by the technical conditions, and thereby predetermine their reliability and quality. The quality of engineering products is mainly determined by technical parameters. These include a set of characteristics of the product, corresponding to the established or estimated needs of potential
consumers. For a car generator, these are the no-load characteristic (NCL) and current-speed characteristic (CSC).[1-3]

So the question arises: is it possible to check the quality of the design after loaded the development characteristics of the generator in accordance with the technological support of production? This task we have decided through integrated simulation.

2. Research

To this end, has developed a program for calculating NLC and CSC, a block diagram is shown in Figure 1.

The program performs an automated calculation of the characteristics of the generator when the input dimensional parameters of the core change within the limits of the tolerance field for each of them set by the technical specifications (TS) (table 1). The following dimensional parameters are considered: outer diameter of the rotor $D_p$, inner diameter of the stator bore $D_i$, length of the stator bore $l_i$, inner diameter of the pole system $D_m$, gap at the junction $l_{st}$, sleeve diameter $l_{vt}$, sleeve length $D_{vt}$.[4-5]

The algorithm of the program is based on the method of calculating a three-phase synchronous generator with a cranked rotor. The results of calculations of NLC and CSC are presented in tables 2, 3. Table 4 shows the average values of the variations in the boundaries of NLC and CSC expressed as a percentage.
Figure 1    Structure of the program for calculating the technical characteristics of the generator

| Parameter | Size, m | Tolerance zone, m |
|-----------|---------|-------------------|
| Dp        | 0.0887  | -0.0001; 0        |
| Di        | 0.0893  | 0; 0.00012        |
| li        | 0.025   | 0; 0.00084        |
| Dvt       | 0.043   | -0.00025; 0       |
| lst       | 0.00005 | -0.00001; 0.00001|
| Dm        | 0.0689  | 0; 0.00005        |
| lv t      | 0.03    | 0; -0.0021        |

Table 1. Group of input dimensional parameters

| Parameter | Size, m | Tolerance zone, m |
|-----------|---------|-------------------|
| Fe(Dimax), A | 434.7 | 489 | 559 | 655 | 799 | 1033 | 1454 | 2350 | 4809 | 11811 |
| Fe(Dimin), A  | 378.3 | 421 | 473 | 542 | 637 | 778 | 1008 | 1421 | 2295 | 4691 |
| Fe(limax), A  | 355.7 | 399.6 | 456.6 | 533.7 | 645.3 | 821 | 1126 | 1721 | 3156 | 7881 |
| Fe(limin), A  | 368.3 | 415.3 | 476.4 | 560.7 | 685.6 | 885 | 1239 | 1979 | 3873 | 10881 |

Table 2. The dispersion of NLC when changing the unit size parameter within the tolerance zone for TS
prioration of the stability of the electromagnetic characteristics will affect the operation of all elements of electrical equipment.

Table 3. The dispersion of CSC when changing the unit size parameter within the tolerance zone for TS

| Id, A | 1.54 | 6.54 | 11.5 | 16.5 | 21.5 | 26.5 | 31.5 | 36.5 | 41.5 | 46.5 | 51.5 |
|-------|------|------|------|------|------|------|------|------|------|------|------|
| n(Dmax), min^-1 | 1232 | 1315 | 1413 | 1509 | 1591 | 1677 | 1776 | 1936 | 2150 | 2515 | 3251 |
| n(Dmin), min^-1 | 1171 | 1249 | 1338 | 1419 | 1482 | 1549 | 1630 | 1770 | 1955 | 2273 | 2915 |
| n(lmax), min^-1 | 1194 | 1272 | 1361 | 1443 | 1505 | 1571 | 1651 | 1790 | 1975 | 2286 | 2884 |
| n(lmin), min^-1 | 1209 | 1288 | 1380 | 1464 | 1530 | 1599 | 1681 | 1821 | 2005 | 2311 | 2894 |
| n(Dpmax), min^-1 | 1176 | 1252 | 1339 | 1415 | 1470 | 1528 | 1600 | 1728 | 1897 | 2181 | 2719 |
| n(Dpmin), min^-1 | 1226 | 1306 | 1401 | 1490 | 1561 | 1636 | 1723 | 1868 | 2056 | 2367 | 2959 |
| n(Dnmax), min^-1 | 1204 | 1283 | 1374 | 1457 | 1521 | 1589 | 1672 | 1812 | 1998 | 2310 | 2904 |
| n(Dnmin), min^-1 | 1201 | 1280 | 1371 | 1453 | 1517 | 1584 | 1666 | 1806 | 1990 | 2300 | 2885 |
| n(Dvmax), min^-1 | 1196 | 1274 | 1364 | 1446 | 1509 | 1575 | 1655 | 1791 | 1972 | 2272 | 2843 |
| n(Dvmin), min^-1 | 1206 | 1285 | 1377 | 1461 | 1525 | 1594 | 1677 | 1820 | 2009 | 2326 | 2932 |
| n(lvmax), min^-1 | 1203 | 1282 | 1374 | 1458 | 1524 | 1594 | 1679 | 1822 | 2012 | 2332 | 2946 |
| n(lvmin), min^-1 | 1200 | 1278 | 1368 | 1448 | 1509 | 1574 | 1653 | 1789 | 1968 | 2268 | 2827 |
| n(lvmax), min^-1 | 1169 | 1259 | 1469 | 1723 | 2084 | 2663 | 3156 | 3242 | 3537 | 3980 | 4714 |
| n(lvmin), min^-1 | 1169 | 1258 | 1469 | 1721 | 2080 | 2655 | 3144 | 3228 | 3518 | 3954 | 4672 |

Table 4. The central tendency dispersion of the NLC and CSC variations with a change in the unit dimensional parameter within the tolerance field of the TS

| Parameter | Dispersion NLC, % | Dispersion CSC, % |
|-----------|------------------|------------------|
| Dp        | 7.82             | 7.96             |
| Di        | 5.45             | 5.68             |
| li        | 2.46             | 2.54             |
| Dvt       | 1.35             | 1.43             |
| Dm        | 1.14             | 1.2              |
| lv        | 1.1              | 1.15             |
| lst       | 1.08             | 1.12             |

From the analysis of variation of NLC and CSC, it can be seen that with TS of deviations of dimensional parameters according to specifications, the limits of variation of the technical characteristics of the generator vary from 1.02 to 15%. This means that for a real generator set of 37.3701, in nominal mode of operation, the current output can vary from 32.5 to 37.5 A.

If we consider that the generator set is the main source of electricity for the onboard system of motor vehicle, the quality of the technical characteristics will affect the operation of all elements of electrical equipment.

To assess this effect, a system of interconnected computer programs and mathematical models has been built, with which it is possible to determine the weight of the influence of technological deviations in the manufacture of the generator on its performance and the characteristics of the electrical system as a whole. The creation and determination of an indicator characterizing the quality of the technological process will make it possible to optimize the quality management system of production processes at the earliest stages of the life cycle of a generator. At the same time, at the design stage, developers will be able to foresee the most probable types of failures, deterioration of the stability of the electromagnetic characteristics of the designed product and test methods necessary for their identification and elimination. In addition, it is also necessary to foresee what types of violations of manufacturing
technology may affect the quality and cause a marriage; what methods should be applied to eliminate them. Proceeding from this, a design tactic must be built.[6-7]

To establish rational requirements for reliability and its reasonable indicators, the most active participation of consumers of products, designers, and technologists is assumed.

The study of the experience of leading foreign firms and the practice of advanced industries shows that it is advisable to concentrate all efforts on the development of the theory of reliability and its practical application on the problems arising at the stages of designing and manufacturing products. This can be explained by the fact that about 25–30% of failures of electromechanical transducers in operation are due to poor workmanship, 8–10% due to mistakes made during design. Therefore, the inclusion of appropriate measures in process chains can play a crucial role in ensuring product reliability.

3. Conclusion

Thus, the fundamental principle of the theory and practice of reliability function (the reliability function of an object is laid during its development is ensured during manufacture and maintained in operation) can be successfully implemented only by organized joint efforts of all the listed participants.

But the main attention to ensuring the required reliability function should be paid to the product developer, since it is at the development stage, product design the required reliability function is ensured by proper selection of construction materials, components, constructive solution, reasonable process with the inclusion of the necessary controls at each design and production stage.

All measures to ensure the reliability function of each specific product at the stages of design and production should be an integral part of the overall process of creating products. By varying them, you can get a product with any desired level of reliability and quality.

At present, at the early stages of product design, the influence of technological factors of manufacturing on its technical characteristics is not assessed, respectively, a preliminary assessment of the quality and reliability function level laid down in production is not made.

The block diagram of the reliability of electromechanical converters is a chain of series-connected links, each link of which is a constructive node. The failure of any of the links leads to the failure of the entire product. Therefore, the probability of no-failure (PNF) of such a product is defined as the product of the probabilities of failure-free operation of its components.

Statistical data on the operation of electromechanical converters show that their operational reliability has a significant variation. For example, for generators of VAZ cars, it is equal to 0.0864, during the warranty run of cars. Reducing the variation of the generator reliability indicators can be achieved by phased assessment and timely adjustment of the quality level of design, production and ensuring their connection with the quality management system. For this purpose, a complex of interrelated and interdependent models is needed that are capable of reflecting the most significant factors affecting the quality and reliability of the generator set.

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