COMPUTER TESTS OF ALTERNATOR RELIABILITY

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Summary: *The analysis of alternator reliability with the use of alternator mathematical model has been carried out in the paper. On the basis of information from 5 car service stations, a passive statistical experiment has been done in order to determine alternator reliability functions.*
Keywords: *reliability, alternator, computer simulation.*

1. Introduction

The dynamic development of electronics contributed to the increase in the number of car elements and circuits which are powered by the alternator.
For that purpose, alternator power is being increased and new constructional solutions are being introduced. Thus a need for constant reliability test arises. Alternator tests make it possible to determine reliability, which is necessary as a comparative criterion against new constructional solutions. The tests lead to organizing the following problems: failure classification, determining wear-out limiting states during maintenance and actual possibilities of making use of reliability analysis. On the grounds of carried out failure simulation in the phase of production processing and carried out statistical experiment, information bank which is properly worked out, can be the basis for making decisions leading to ensuring the required alternator reliability level. Making use of the obtained information proves that 3 stages can be distinguished in the "life" of the alternator. Making use of reliability tests results is significant in all the phases, particularly while:

- designing alternator construction and designing manufacturing process
- manufacturing the alternator
- maintaining alternators

2. Analysis of alternator reliability level in the phase of designing, manufacturing and maintenance.

In the phase of designing the construction and technological process of the alternator, some initial assumptions arise. They determine its purpose, construction details and operational use. Designing both the construction and technological process are the most significant stages, strongly influencing reliability and ensuring alternator proper level. That stage can be properly carried out if the condition of constructor-production engineer strict co-operation and of constructor's thorough knowledge about production plant technological potential is fullfilled. Apart from constructor-production engineer co-operation, there are some basic requirements concerning proper organization of constructional and technological departments, proper technological equipment in those departments, suitably qualified staff etc. In the field of alternator construction the following methods of increasing reliability are the most crucial:

- increasing reliability and life of its constituent parts
- choosing a proper reliability block diagram
- adding to the alternator elements or units duplicating work (so called redundancy).

In the case of modern alternators, each element usually contributes to their reliability. Alternator reliability equals to the product of its constituent elements reliabilities. Such a dependence makes the use of highly reliable constituent elements necessary and limits the increase in the whole alternator reliability as further increase in its constituents elements reliabilities is e.g. technologically impossible and causes the increase in manufacturing costs.

Some possibilities of increasing alternator reliability can be obtained through preserving its proper reliability block diagrams. Using various reliability block diagrams theoretically leaves a lot of freedom in increasing reliability. However in practice, using those block diagrams or their combinations is restricted by constructional, technological and economic factors. The application of that method is always connected with a serious complication in the construction and is hardly ever economically justified. The solution to the problem connected with ensuring the required reliability level in the phase of alternator manufacturing is the following: "Ensure such production conditions that all constructional and technological requirements and conditions assumed in the design phase can be fullfilled". The quality control system used nowadays contributes to the fact that designing technological process, so called by-pass process, and substitute materials many times does not show the decrease in quality. As a rule, alternator reliability in the maintenance process is decreased. As reliability is a time-dependent characteristic, all defects and troubles of alternators begin during their maintenance and consist in reliability level decrease and usually life shortening. Another significant problem is the fact that plants do not adhere to shop discipline in spite of their technological potential. Then the following troubles occur:

- disregard for proper technological parameters,
- disregard for the proper order of technological operations,
- using imprecise control apparatus,
- improper assembly etc.

The proper assessment of a technological process can be obtained only through carrying out maintenance reliability tests. In that way its influence on alternator quality and parameters can be judged. The way the alternator is used decides if it reaches such a level of reliability which has been assumed in its construction and manufacture. It is obvious that alternators might not gain such a level of reliability if they are used with no regard for previously stated requirements. Alternator reliability level is determined as a result of failures occurring during its operation. The following occurrences influence the level of reliability:

1. Failures being the result of errors in the process of construction design and technology design and in the phase of alternator manufacturing.
2. Failures being the result of disregarding technical specifications assumed for the alternator in the process of its maintenance.
3. Preventive activities in the process of maintenance.

In the process of maintenance, alternator reliability can be influenced by complying with technical specifications and rising the level of maintenance process organization.

3. Simulation of production deviations, constructional materials and electric failures influence on alternator initial parameters.

On the grounds of alternator magnetic circuit analysis, a calculation program making it possible to assess the effect of magnetic materials properties on alternator current-speed characteristic has been worked out, Fig. 1 and Fig. 2.

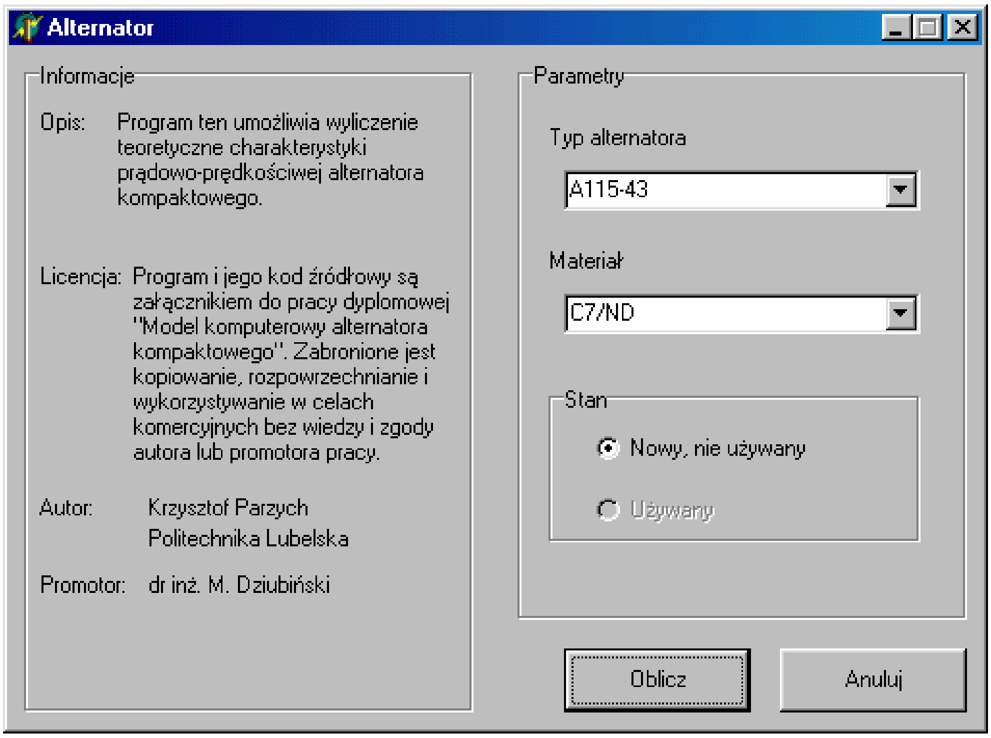

Fig.1. Computer model of the alternator.

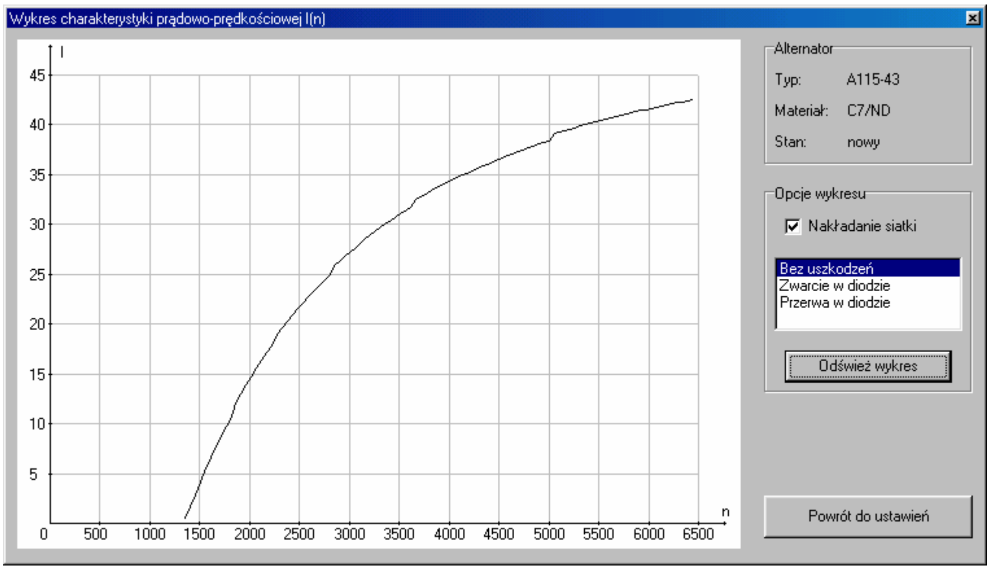

Fig.2. Alternator current-speed characteristic.

In order to assess the effect of rotor geometry on alternator functional parameters, electromagnetic circuit calculation algorithm has been worked out. Variable parameters are the following: fang lenght, by-armature clearance width, the width of clearance between the sleeve and the polar disc. Alternator rotor and the module of program for its dimensions calculation are presented in Fig.3 and Fig.4. Program elements used for simulating the influence of changes in stator magnetic circuit dimensions and calculation program module are presented in Fig.5 and Fig.6.

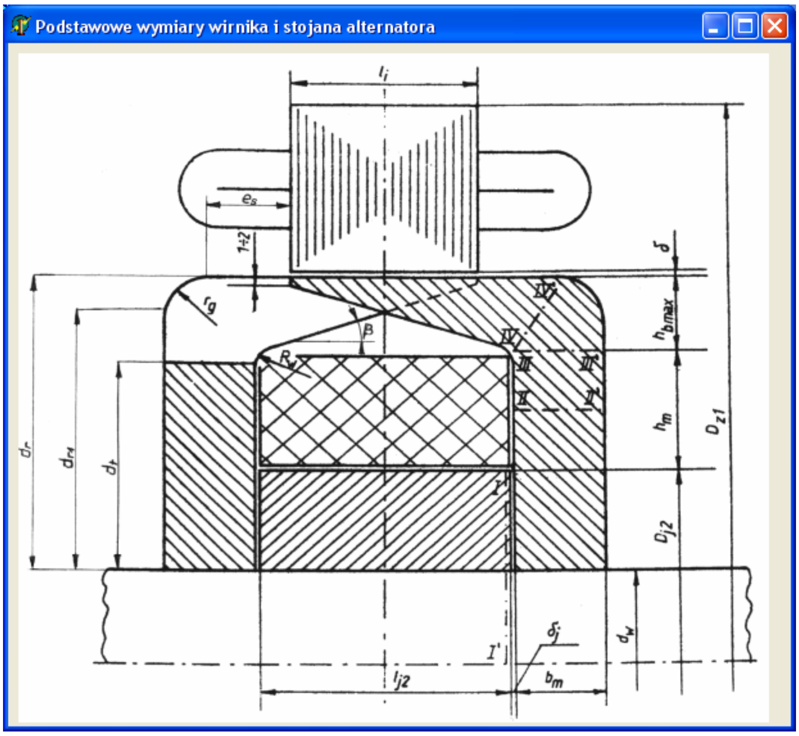

Fig.3 Alternator rotor with basic dimensions.

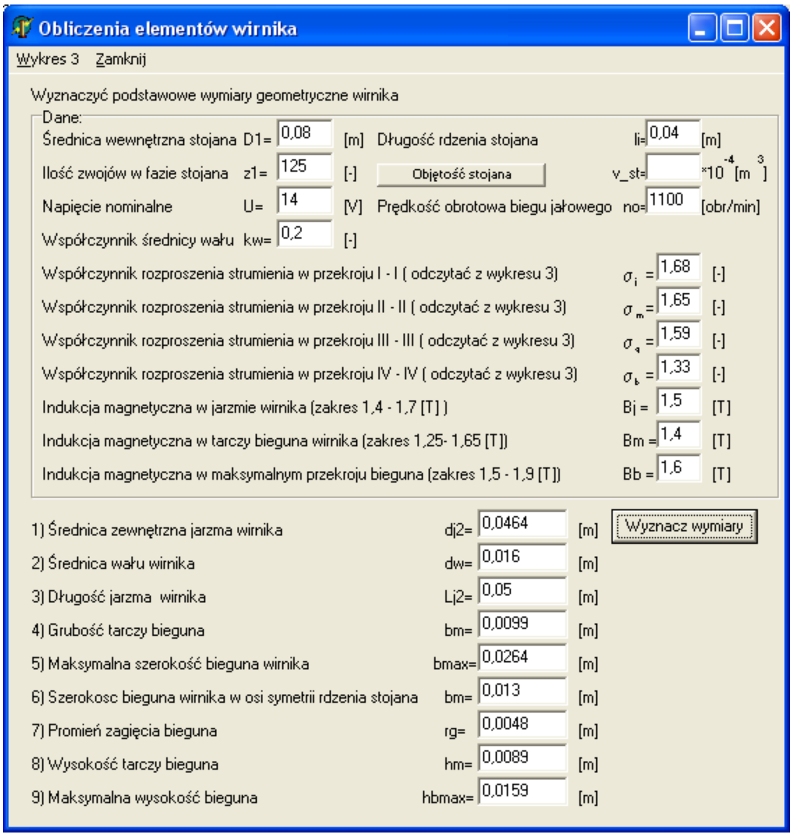

Fig.4 Module of the program for calculating rotor dimensions.

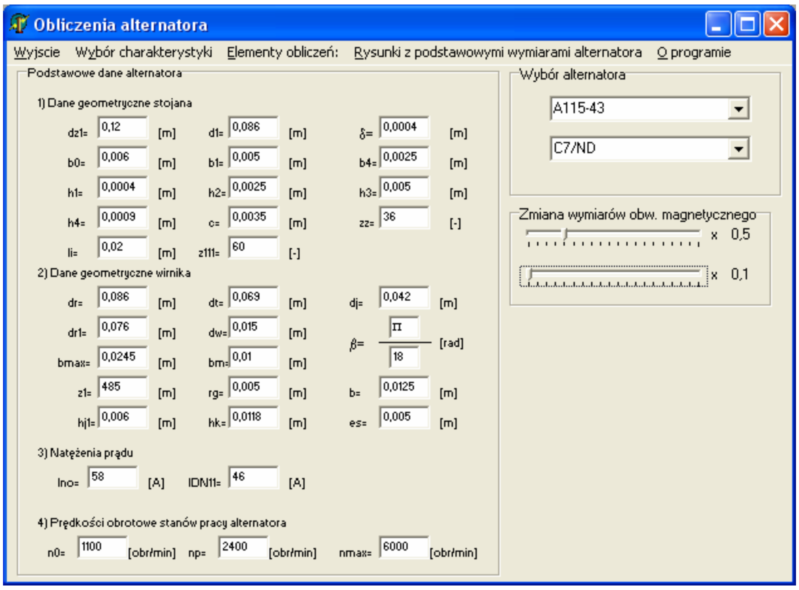

Fig.5 Program elements used for simulating the effect of changes in magnetic circuit dimensions on the course of characteristics.

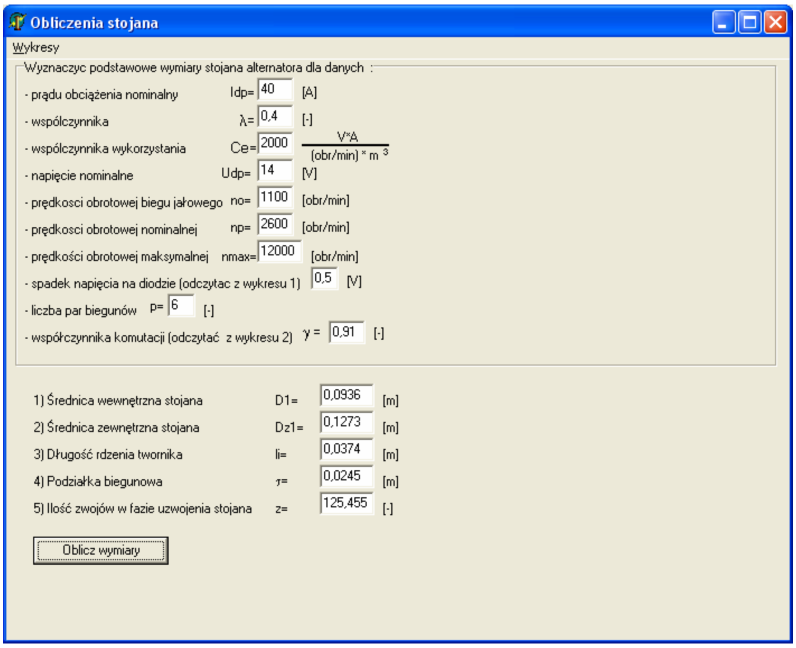

Fig.6 Module of the program for calculating stator magnetic circuit.

The program also makes it possible to simulate chosen failures in stator winding circuit and diode bridge: gaps and shortings in negative diodes, gaps and shortings in positive diodes , gaps and shortings in excitation diodes. Alternator calculating program enables to obtain the flow characteristic on the grounds of rotor and stator geometrical dimensions. Magnetic materials magnetization characteristics strongly influence alternator characteristic. The carried out simulation proved that the change of rotor magnetic material brings a stronger influence on alternator characteristics than the change of stator magnetic material. It results, among other things, from the difference in magnetic circuit sections.

4. Reliability tests of alternators during their maintenance.

The number of failures of alternator and regulator particular elements was determined in the course of studies, Fig.7 and Fig.8.

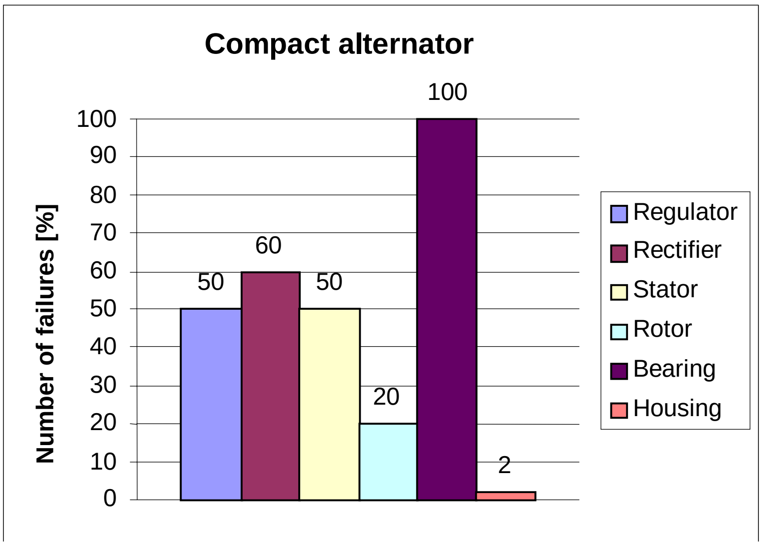

Fig.7. Compact alternator failures

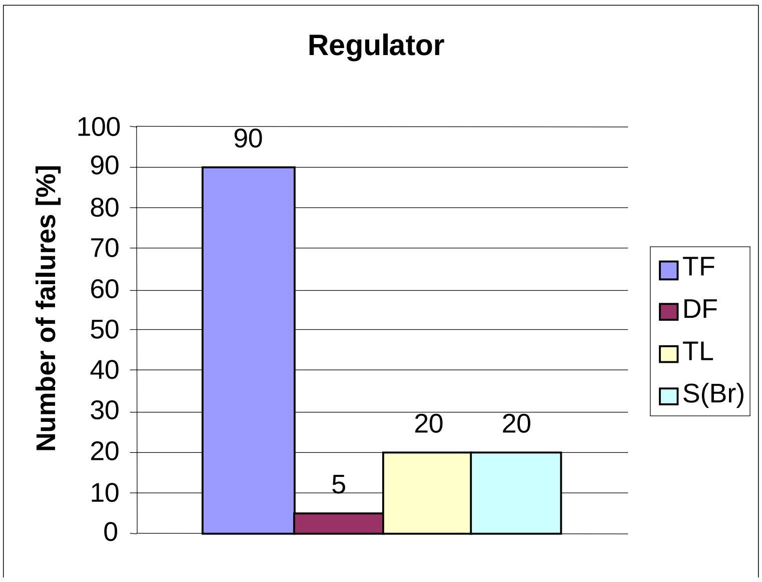

Fig.8. Regulator failures
TF – power transitor, DF - excitation circuit,
TL – signal amplification transistor, S(Br) – measuring unit.

Data for the reliability model determine car mileage up to the moment of failure occurrence. With the aid of the computer program. `Statistica` and with the use of λ-Kołmogorow test of goodness of fit, alternator reliability models have been worked out, Fig.9 and Fig.10.

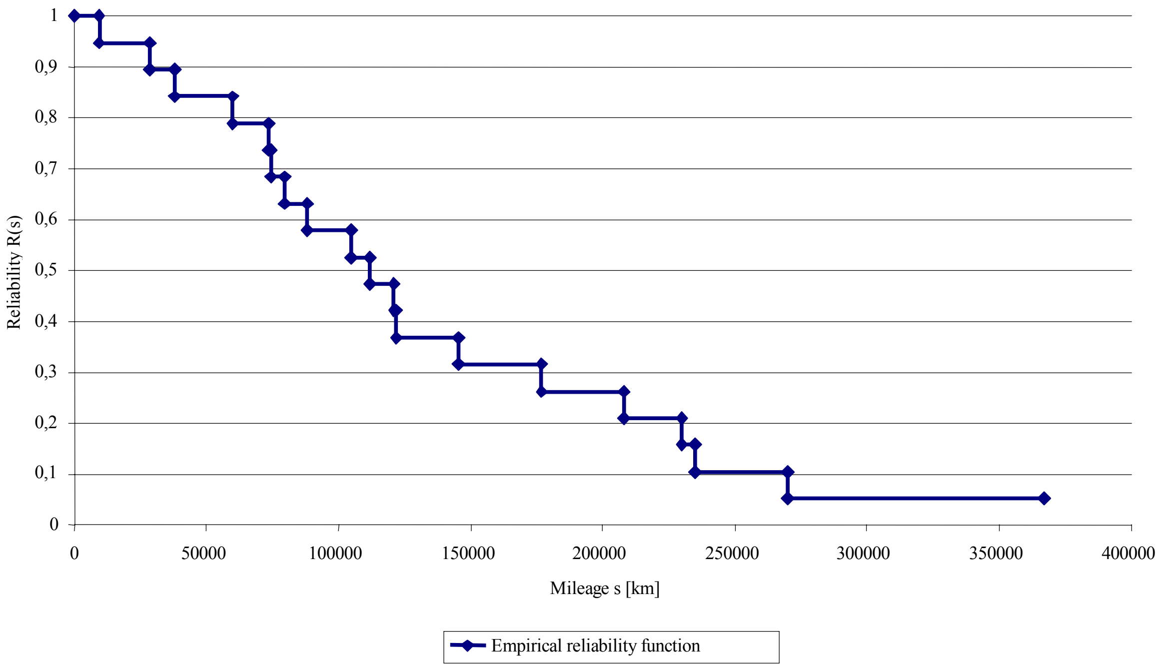

Fig.9. Alternator reliability empirical function.

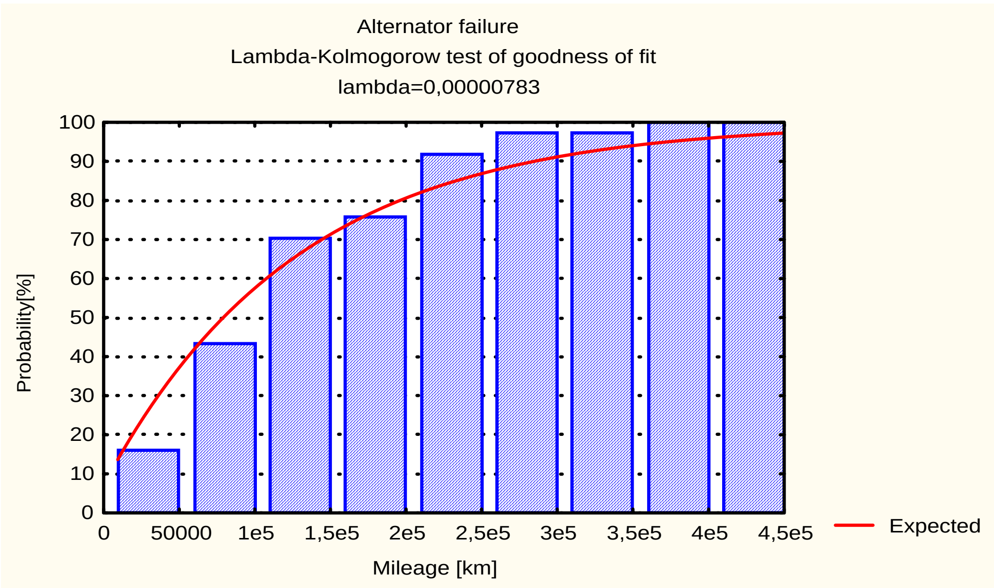

Fig.10. Alternator reliability model.

5. Conclusion

The program worked out for simulating the effect of alternator chosen geometrical parameters resulting from technological process makes it possible to predict alternator current-speed characteristics in the phase of production. The increase in the size of air-gaps in the magnetic circuit causes the increase in magnetic voltage drops and as a result alternator power drop. Gathered information about alternator reliability, its parameters and the use of proper materials make it possible to formulate requirements concerning the construction and assembly technological process.

Recognizing and identifying the causes of alternator elements failures makes it possible to replace it with another one, and also to state new operating conditions. Effective impact on reliability can be realized on the grounds of detailed analysis and synthesis of alternator design, manufacture and maintenance.

6. Literature

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