COMPUTER AND MATHEMATICAL MODELLING OF THE OPERABILITY OF AUTOMOTIVE PARTS USING SOLIDWORKS AND MATHCAD

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It is well known that in engineering practice, CAE systems are an effective tool for performing strength calculations, as they make it possible to evaluate, using numerical methods, how a computer model of a part or assembly will behave under real operating conditions. Therefore, the introduction of modern educational environment methods into the learning process enables a transition from traditional approaches to teaching design toward modelling using CAD systems, followed by the application of integrated CAD/CAE solutions on personal computers, one of which is SOLIDWORKS—a 3D hybrid system for computer-aided design and engineering analysis [1]. An extension of this software, SOLIDWORKS Simulation, uses the geometric model of a part created in SOLIDWORKS to generate a computational (analysis) model [2].

A static analysis of the camshaft of the Cummins ISBe 6.7/QSB 6.7 engine was performed using SOLIDWORKS Simulation. During engine operation, forces from the valve train act on it, including spring forces, gas pressure, and other forces reduced to the tappet. The resultant (equivalent) force acting on the cam amounts to 1407.5 N.

The camshaft is manufactured from steel grade 20. Therefore, steel DIN 1.1151 (C22E) was selected from the SOLIDWORKS material library. It was determined that the maximum von Mises stress in the shaft is 3,762 MPa (Fig. 1), which does not exceed the allowable values. Since the minimum safety factor is ($n = 127.6$), which is significantly higher than the permissible value ($[n] = 3$), the shaft is considered operable. However, it may fail due to wear of the working surfaces. Therefore, the continuation of the study involves determining the wear resistance of the camshaft with mathematical processing of experimental results carried out using the MathCAD system.

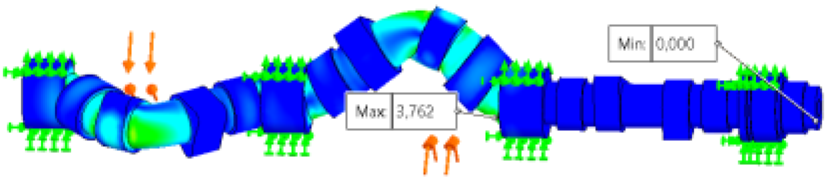

Figure 1 – Diagrams of stresses VON of the camshaft (MPa)

In experimental studies, the system under investigation is often subjected to the influence of a certain excitation factor, and the way the system "responds" to this excitation is observed. Thus, from a mathematical perspective, this involves studying a series of measurements of the variable y at different values of x, as well as analysing the functional relationship y=f(x). In the general case, either the form of the function f(x) is unknown, or its parameters are unknown if the functional form is established based on certain theoretical considerations.

The problem of function approximation can be formulated as follows: instead of the unknown function f(x), it is necessary to select another function φ(x) that best approximates f(x), that is, the deviation of φ(x) from f(x) within a given domain is minimal. In this case, the function φ(x) is called the approximating function.

The processing of experimental results was carried out using MathCAD (the built-in functions intercept, slope, linfit, linterp, pspline, cspline, and interp were used). One of the results of wear resistance data processing is shown in Fig. 2 (using approximation by a power polynomial $y = a + bx + cx^2$).

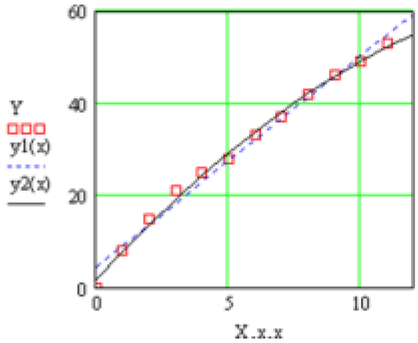

Figure 2 – Approximation by a power polynomial

Thus, the combined use of the CAD/CAE system SOLIDWORKS for computer-aided design and engineering analysis, together with the integrated environment for solving typical classes of mathematical problems and scientific research, MathCAD, makes it possible to comprehensively address the problem of studying strength and wear resistance.

References

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