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DEVELOPMENT OF A MATHEMATICAL MODEL OF THE RADIATOR WORKFLOW UNDER OPERATIONAL POLLUTION CONDITIONS

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Abstract: This article studies the theoretical foundations of the method of diagnosing the radiator with heat load for cooling internal combustion engines (ICE) of motor vehicles. First, the structural structure, operating principles and efficiency levels of existing cooling systems are analyzed. The processes of ensuring the thermal system of the engine are highlighted through physical and mathematical modeling of heat exchange processes in the cooling system. The efficiency of the work and air-based cooling systems are compared, and their advantages and disadvantages are identified. High-efficiency heat exchange equipment is proposed for the implementation of new generation cooling systems. Based on computer modeling and experimental tests, the aim is to ensure energy efficiency and reliability of control power. This study has practical application in automotive, agricultural machinery and other agricultural machinery, and highlights the efficiency of the ICE.

Keywords: cooling, automobile, environment, transport, engine, transport, effect, radiator, water pump, pump, mathematical model, (ICE), modeling, differential.

INTRODUCTION.

Finite element analysis (FEA) was first developed by R. Courant in 1943 and is a method of numerical analysis and minimization of variational calculations to obtain approximate solutions to design systems. FEA consists of a computer model of a material or design that is specified and analyzed for certain results. It is used in the design of new products and in the improvement of existing products. This software is able to verify that the proposed design can be performed according to the design specification before production or manufacture. In the event of a structural failure, the program can be used to help determine design changes to meet the new condition.

Two types of analysis are commonly used in the mechanical engineering manufacturing industry: 2D modeling and 3D modeling. 2D modeling is simpler and allows the analysis to be performed on a relatively simple computer, but it produces less accurate results. However, 3D modeling is not efficient on all but the fastest computers, and produces more accurate results. Within each of these modeling schemes, the programmer can include a number of algorithms (functions) that can make the system behave linearly or nonlinearly. Linear systems are much less complex and usually do not account for plastic deformation. Nonlinear systems account for plastic deformation and are capable of testing most materials to failure. CHET uses a complex system of points called "nodes" that intersect in a type called a "mesh". This mesh is programmed to contain material and structural properties that determine how the structure will respond to specific loading conditions. Nodes are assigned at specific sizes along the material, depending on the expected stress levels in a given area. Parts that are subjected to large amounts of stress have a higher node density than those that are subjected to little or no stress [1].

The main stress points can be: the breaking point of a previously tested material, fillets, corners, complex details and areas of high stress. The mesh works like a spider's web, in that a mesh element is transmitted from each node to each of the neighboring nodes. This network of vectors creates many elements and conveys material properties to the object. Nodes are assigned at a certain density throughout the material, depending on the expected stress levels of a given region. Regions that experience a large amount of stress usually have a higher node density than those that experience little or no stress. This network of vectors creates many elements and conveys material properties to the object [2].

Structural analysis consists of linear and nonlinear models. Linear models use simple parameters and assume that the material is not plastically deformed. Nonlinear models assume that the material has passed its elastic limit. The stresses in the material then change with the amount of deformation.

Vibration analysis is used to test a material against random vibrations, shocks, and impacts. Each of these events can affect the natural frequency of vibration of the material, which in turn can lead to resonance and subsequent failure.

Fatigue analysis helps designers predict the service life of a material or structure by showing the effects of cyclic loading on a sample. Such analysis can show where cracks are most likely to propagate. Fatigue failure can also indicate the material's resistance to damage.

Heat transfer analysis models the conductivity or thermal fluid dynamics of a material or structure. It can be a steady-state or transient transfer. Steady-state transfer refers to the constant thermal properties of a material that cause linear heat dissipation.

Preprocessing: The user creates a model of the part to be analyzed, in which the geometry is divided into a number of discrete subregions or elements connected at discrete points called “nodes”. Some of these nodes have fixed displacements, while others have fixed loads. These models can be very time-consuming to prepare, and the connection codes compete with each other to have the most convenient graphical “postprocessor”. Thus, finite element analysis can be conveniently performed as part of the computer-aided design and engineering process.

The data set prepared by the first postprocessor is used as input to the finite element code itself, which generates and solves a system of linear or nonlinear algebraic equations.

Post-processing: The finite element analysis user examines the set of numbers generated by the code, counting the displacements and stresses at discrete locations in the model. In this way, graphical displays are used to visualize important trends and key points. A simple post-processing display overlays colored contours representing the degree of stress in the model.

ANSYS is a general-purpose finite element analysis (FEA) software package. ANSYS is a numerical method for deconstructing a complex system into very small pieces (of user-specified size) called elements. The software implements the equations that govern the behavior of these elements and solves them all; providing a comprehensive explanation of how the system as a whole behaves. These results can then be presented in tabular or graphical form. This type of analysis is typically used to design and optimize systems that are too complex to analyze in a single step. Systems that fall into this category are too complex due to their geometry, scale, or governing equations [3].

ANSYS provides a cost-effective way to study the performance of a product or process in a virtual environment. This type of development system is called virtual prototyping.

Using virtual prototyping techniques, users can iterate on different scenarios to optimize the product long before production begins. This allows them to reduce the risk of costly, ineffective designs. The versatile nature of ANSYS also allows users to see the entire design and product behavior, electromagnetic, thermal, mechanical, and more.

In current radiator designs, the largest thermal resistance is due to the convective heat transfer (Rco,n,) associated with the air. This accounts for more than 75% of the total thermal resistance. The second largest thermal resistance is due to convection associated with the liquid. These resistances account for more than 97% of the total thermal resistance. Since there is a large thermal resistance associated with the liquid, there is an increase in thermal conductivity. Therefore, there is a need to design a radiator that reduces the percentage of thermal resistance due to air.

The ANSYS Fluent 13.0 computational analysis tool is used to conduct a numerical study of the heat exchanger. The computational domain is first established to validate the current numerical approach. The numerical analysis is then extended by varying selected geometric and flow parameters, such as the height of the radiator fins, air flow velocity, liquid flow velocity, fin and fin thickness, changing one parameter at a time, and comparing the results. Optimal values and recommendations for settings based on the tested variables for the selected compact heat exchanger are obtained [4].

The radiator modeling is described by two methods, one is the finite difference method and the other is the thermal resistance concept. In the performance evaluation, the radiator is installed in a test rig and various parameters, including the mass flow rate of the coolant, the inlet temperatures of the coolant, are selected. One coolant is used as water, and the other is a mixture of water and propylene glycol in a ratio of 40:60. Water is still considered the best coolant, but its limitation is that it contains dissolved salts that are corrosive and impair the flow of coolant.

The test fluid flows through a car radiator consisting of 33 vertical tubes with elliptical cross-sections, and air is forced through the tubes at a constant velocity to create a continuous flow. The test fluid flow rate is varied from Z l/min to 8 l/min to achieve a fully turbulent regime. In addition, the effect of the fluid inlet temperature on the heat transfer coefficient is also analyzed by varying the temperature in the range of 37 - 49°C. The results obtained show that increasing the fluid circulation rate can improve the heat transfer performance.

CONCLUSION

In conclusion, the results of experimental studies are presented. Theoretical studies have been conducted to improve the cooling system. In addition, the conditions for reducing energy consumption in the experimental determination of radiator heat transfer are expressed.

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