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THEORETICAL FOUNDATIONS FOR IMPROVING THE COOLING SYSTEM OF AN INTERNAL COMBUSTION ENGINE

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Annotation: In this article, the theoretical foundations of cooling power supply for internal combustion engines (ICE) from motor vehicles are studied. First of all, the design structure, operating principles, and efficiency levels of existing cooling systems were analyzed. The processes of supplying the engine's thermal system through physical and mathematical modeling of heat exchange processes in the cooling system are highlighted. A comparison of the operational benefits and air-based cooling systems revealed the advantages and disadvantages of the file. High-performance heat exchange equipment has been proposed for the commissioning of a new generation of cooling systems. Based on computer modeling and experimental tests, energy efficiency control is aimed at ensuring power reliability. This study has practical applications in the automotive industry, agricultural machinery, and other agricultural machinery, highlighting the effectiveness of internal combustion engines.
Keywords: cooling, car, environment, transport, engine, transport, effect, radiator, water pump, pump, mathematical model, (ICE), modeling, differential.

Introduction. For different refrigerators (in this case, air and coolant), heat transfer is different and specific. For each of them, physical characteristics are a function of temperature, and some are a function of pressure. The mathematical description of the heat transfer process is as follows:
- heat conduction equations;
- equations of motion;
- equations of complexity;
- heat transfer equations;
- unique equations.

To date, analytical solutions of the system of differential equations of convective heat transfer are obtained only for a limited number of simple problems when introducing certain simplified assumptions. This is explained by the high complexity of the equations, as well as the complexity and versatility of the described processes.
Due to the limited possibilities of the analytical solution of the above differential equations, the experiment is of great importance in the study of heat transfer processes. Experimental study of complex heat engineering processes, depending on many factors, has high costs, duration, and labor intensity.
Re=idem; Pr= For a certain class of experimental problems arising under the conditions of forced movement of heat exchangers, similarity theory is applied. Similar heat exchange processes can fulfill the following conditions: idem.
In this case, the Reynolds number (Re) determines the hydromechanical behavior of the cooling water flows:

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$$Re=\frac{\omega_0 l}{v},' \quad (2.1)$$

$\bar{o}_0$ where is the average velocity of movement of a liquid or gas, usually at the beginning of the system; l-characteristic geometric dimension of the system; v-kinematic viscosity coefficient of cooling water.
The Prandtl number (Pr) is the thermophysical characteristic of the refrigerator. Contains only physical parameters:

$$Pr=\frac{\mu c_p}{\lambda}=\frac{v}{a} (2.2)$$

$y=m/ r a=l/c_p r$ Here: and - the numerical value of the temperature conductivity coefficient given in the tables.
The equality of the numbers Re and the identity of the numbers rg ensures thermal similarity, i.e., the similarity of the fields of temperature pressures and heat flows throughout the entire volume of the systems under consideration[1].
According to similarity theory, such processes must be identical and have a definite number of similarities. In convective heat exchange processes, the determined Nusselt number is Nu, which characterizes the intensity of the convective heat exchange process:

$$Nu=\frac{\alpha l}{\lambda} \quad (2.3)$$

Thus, the state of identification of similarity numbers (Pr, Re = idemidem) is a condition for the variability of the numbers that determine similarity. This ensures the similarity of the processes.
The similarity equation for convective heat transfer processes with forced refrigerant movement, characteristic of the operating process of a cooling radiator, has the following form:

$$Nu=f(Re, Pr)(2.4)$$

However, most experts emphasize that the use of similarity criteria can be achieved only with strict adherence to the rigidity of the physical parameters of the environment and thermal engineering constants. With a significant change in properties, the analysis shows that strict analogy between different processes is completely impossible. These cases do not allow the use of analytical dependencies on the working flow of the radiator when constant and stochastic changes in cooling water flows occur.
The threshold values of the radiator's performance criterion are determined by. The amount of heat released by the engine in the coolant:

$$Q_D=632AN_e \quad (2.5)$$

Here:

$$a=\frac{q_D}{632N_e}=f(N_e, n_D, t_l^{'}, T_w^{''}, G_V) \quad (2.6)$$

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$N_e n_D t_l^{'}, t_W^{''} G_W$Here: a-experimental coefficient; -engine power, W; -crane shaft rotation speed, rpm; -radiator outlet and inlet temperature and air temperature in the liquid, °C; -mass airflow, kg/s.
In real operating conditions, the radiator cannot serve as a convenient criterion due to its complexity, reflecting the heat ratio of one useful cycle of cooling water supply to many factors. The values of this coefficient vary widely. For the maximum load mode, a = 0.8...1.4 (for carburetor engines) and a = 0.45...0.9 (for diesel engines). For radiator-guaranteed drainage, the maximum coefficient values are taken: a = 1.4 (for a carburetor engine) and a = 0.9 (for a diesel engine). Thus, the radiator's heat transfer values are:

$$Q_p^{karb} carb \geq 885 n_{e\,max} \; va \; Q_p^{diz} \geq 569 n_{e\,max} \quad (2.7)$$

At the same time, the critical values of the radiator's thermal conductivity according to the formula can be used only for the operation of the radiator as part of the cooling system. When removing the radiator from the vehicle, the aerodynamic and hydraulic flow regime of the cooler for measuring heat transfer on the stand changes significantly. It is known that the potential characteristics of a radiator in a car depend on many factors.
$\Delta Q_{ppo} = Q\, q_{P0} - \Delta q_{ICE} 0 \leq \tau \leq T$At the design stage, reserves were installed to eliminate the effects of operational pollutants - two heat releases of at least 10% of the maximum calculated heat value emitted. The heat transfer reserve for the new radiator (corresponding inscriptions) is a guarantee of its service life with t in the range 0≤τ≤t:

$$Q_D \leq q_D + Q_{PPR} \leq Q_{P0} (2.16)$$

When outputting a constant value, conversion gives:

$$0 \leq\leq Q_Q p p \tau \leq Q_{pp0} \quad (2.17)$$

Q_{rr0}, the operating conditions of the radiator Q_{rr0} are expressed in relative, dimensionless units:

$$0 \leq q_{r\tau} \leq 1, \quad (2.18)$$

Here q_{RTS}-parameter reflecting changes in the radiator's heat transfer reserve during operation.
The rate of the heat transfer depletion process can be described by the following differential equation:

$$\frac{dq_{p\tau}}{d_\tau} = \frac{d(k_\tau F \Delta t)}{d_\tau}, \quad 0 \leq \tau \leq T \quad (2.19)$$

and

$$k_r = \frac{1}{R_\tau}, \quad (2.20)$$

$r_\tau$here: t-total thermal resistance, operational pollutants (m°C) /W; t-treatment of the boundary

state. Qpt>0 is considered a decreasing function from the experiment.
A solution of a differential equation can yield a very approximate result when applying various iteration methods or mathematical modeling of real operating conditions [4].
When the radiator's performance under operating conditions is steadily disrupted, it is dismantled to restore its functionality by cleaning. In this case, it is possible to clean the outer surface of the radiator and restore the shape of the ribbed plates of the air ducts. As a result, with a constant front radiator area (*F= const*), there is no effect of aerodynamic resistance on the average temperature pressure Δt, the differential equation can be simplified:

$$\frac{dq_{p\tau}}{d_\tau}=\frac{dk_\tau}{d_\tau}=\frac{d(\frac{1}{R_\tau})}{d_\tau} \quad (2.21)$$

Statistical studies have shown that after operation under certain operating conditions of the radiator t, the total thermal resistance will be:

$$R_r=R_{r\,max}\cdot(1-e^{-B\tau}) \quad (2.22)$$

$R_{r\,r\,max}$Here: - maximum total thermal resistance, which tends to approach the pollution curves asymptotically over time (with the maximum possible layer thickness); v - experimentally determined through the values of thermal resistance in the permanent, temporary working segment.
In practice, along with the process of stochastic contamination of cooling surfaces, periodic cleaning is carried out to a degree determined by the methods of their cleaning and the nature of the accumulated contamination. This process is also stochastic, which creates additional difficulties in determining the radiator's heat transfer reserve. Figure 2 uses a graphical interpretation of the radiator's pollution and cleaning process.

CONCLUSION

In conclusion, theoretical research has been conducted on improving the cooling system of internal combustion engines. Information on the operating principle and analytical characteristics of the heat exchange process of the radiator, which is one of the most important parts of the cooling system, is presented. In addition, the amount of heat released by the engine of the coolant in the pradiator was calculated, and recommendations were developed.

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