

3-31-2020

IMPROVING THE PERFORMANCE INDICATORS OF DIESEL ENGINES BY ENHANCING THE COOLING SYSTEM

O.O. Daminov

Tashkent State Technical University, raximresult@gmail.com

O.A. Khushnaev

Tashkent State Technical University

A.I. Yangibaev

Tashkent State Technical University

G.M. Kucharenok

Belarusian National Technical University

Follow this and additional works at: <https://btstu.researchcommons.org/journal>



Part of the [Mechanical Engineering Commons](#)

Recommended Citation

Daminov, O.O.; Khushnaev, O.A.; Yangibaev, A.I.; and Kucharenok, G.M. (2020) "IMPROVING THE PERFORMANCE INDICATORS OF DIESEL ENGINES BY ENHANCING THE COOLING SYSTEM," *Technical science and innovation*: Vol. 2020: Iss. 1, Article 9.

DOI: <https://doi.org/10.51346/tstu-01.20.1-77-0052>

Available at: <https://btstu.researchcommons.org/journal/vol2020/iss1/9>

This Article is brought to you for free and open access by Technical Science and Innovation. It has been accepted for inclusion in Technical science and innovation by an authorized editor of Technical Science and Innovation.

IMPROVING THE PERFORMANCE INDICATORS OF DIESEL ENGINES BY ENHANCING THE COOLING SYSTEM

O.O.Daminov, O.A.Khushnaev, A.I.Yangibaev, G.M.Kucharenok

Abstract. *The article deals with the improvement of the performance of diesel engines by improving the cooling system. It is indicated that there is a number of problems that arise when converting an engine with spark ignition to natural gas. The increase of thermal stress of the engine is illustrated. As a result of researching of features of the parameters and characteristics of a gas-powered automobile engine and optimization of its temperature regime, a very actual scientific and practical task is determined. The engine with the spark ignition installed on the microbus working on the diesel and gas is presented. The results of the spark-ignition engine research on gaseous fuel are presented. The following recommendations are given: to analyze the design features of gas engines; analyze the principles of operation of modern engine cooling systems; to conduct a theoretical study of the engine cooling system of gas buses and minibuses, which would allow to identify the causes leading to an increase in the thermal stress of engine parts when converted to gas fuel, which consists in the specificity and features of the working process; suggest ways to improve the cooling system of gas engines; to develop and propose options for improving the cooling system of gas engines, which will reduce the cooling temperature from 120 to 90 °C.*

Keywords: *cooling systems, performance indicators, spark ignition, gaseous fuel, fuel and economic indicators.*

Taking into account the global trend to acquire the purpose of improving the cooling system of spark-ignition engines of buses and minibuses, powered by natural gas, it is crucial to figure out the following problems: the analysis of structures and processes of cooling systems, identifying the causes leading to increased thermal stress of engine parts when converted to gas fuel, development of measures to enhance the cooling system.

Research of cooling system of automobile and transport engines was carried out by: Gureev A.A., Grigorev M.A., Kavtaradze R.Z., Kostin A.K., Levin M.I., Liventsev F.L., Lukov N.M., Nikolenko A.V., Petrichenko R.M., Petrichenko M.R., Razuvaev A.V. and others. In their researches they concerned the questions of influence of coolant temperature in cooling system on engine heat intensity, its power and efficiency, wear resistance; peculiarities of operation and increase of engine cooling efficiency in high mountain conditions and hot climate conditions. Amid these works, only a very small number is devoted to automotive internal combustion engines (ICE) with spark ignition.

Development of modern engine construction is associated with the acceleration of specific engine power, improvement of fuel and economic indicators and is accompanied by further growth of heat intensity of the main parts that forming the combustion chamber, which is due to changes in heat exchange conditions. Expansion of the cycle temperature limits increases the heat loads on the main parts and reduces the concentration of harmful substances in the exhaust gases.

It is known that the majority of modern engines have a thermal condition close to the optimal one, only at nominal operating modes. However, even in these modes of operation, the temperatures of the parts in the ICE systems do not take optimal values from the point of view of efficiency. This is due to the aspiration to achieve the reserve parts temperature in case of deviation of cooling system parameters. In the case of partial loads, on which automobile engines mainly operate, deviations in the temperatures of parts and ICE systems from the optimal values increase due to imperfect control of the engine temperature regime [1, 2, 15].

One of the directions of reducing the content of harmful substances in exhaust gases and enhancing the fuel and economic indicator of automobile engines is to improve the working process by applying alternative fuels and optimizing the temperature regime of systems and engine parts.

Research of the temperature of coolants of a highly heated part, for instance, a cylinder or cylinder head, coolant, oil, fuel and air, have a significant impact on the technical and economic indicator of engines.

Coolant temperatures T_{co} and oil T_o at the engine exit for diesel and petrol engines are assumed to be within the range of 350 ... 365 and 340 ... 360 K respectively [3, 4].

Taking into account the *methods and methodologies* of the conducted theoretical researches with the use of the mathematical apparatus of the regression analysis realized on the ECM, the maintenance tests have been carried out.

Practical significance and implementation of the research results consist in recommendations to improve the cooling system and to reveal the specific effect of cooling system temperatures on the power and fuel and economic performance of the engine with spark ignition when operating on gas fuel.

Scientific novelty of the research was indicated on the basis of the research and practical analysis of cooling systems of automobile engines with different power systems operating on diesel or gas, scientifically substantiated improvement of the cooling system, which allows reducing the thermal stress of engine parts and improving its performance [6, 7, 11, 14].

The structure and composition of the work include the identified and studied problems related to the operation of gas-powered buses and minibus engines, the results of theoretical and experimental research on the selected subject.

Design features of gas engines

Gas fuel has evolved from an alternative to a separate type of motor fuel. The first deep theoretical and experimental studies of automotive gas equipment date back to the pre-war and post-war period. They were devoted to the analysis of stable operation and regulation of gas pressure, as well as the study of its impact on the operation of the gas engine. As a result, the basis for calculating gas-cylinder equipment (GCE) was laid down.

Analysis of the operation of modern engine cooling systems

The cooling system is designed for forced removal of heat from engine parts flowing with hot gases to ensure their optimal and stable thermal condition [5, 8, 12].

Depending on the way the heat exchange between the engine elements and the environment is organized, there are systems with intermediate coolant (liquid cooling circulating systems) and systems without intermediate coolant (air cooling systems and liquid cooling flow system).

Flow-through liquid cooling system is structurally the easiest to manufacture and operate (Fig. 1).

On the ground transport the circulation two-circuit systems where heat removal is carried out in air, and a cooling liquid is used as the intermediate heat-carrier circulating on the closed contour have received the greatest distribution.

The design of the liquid cooling system is largely determined by the accepted way of organizing the circulation of liquid.

According to the abovementioned feature there are systems: thermosiphon systems, with forced circulation of liquid and mixed cooling systems.

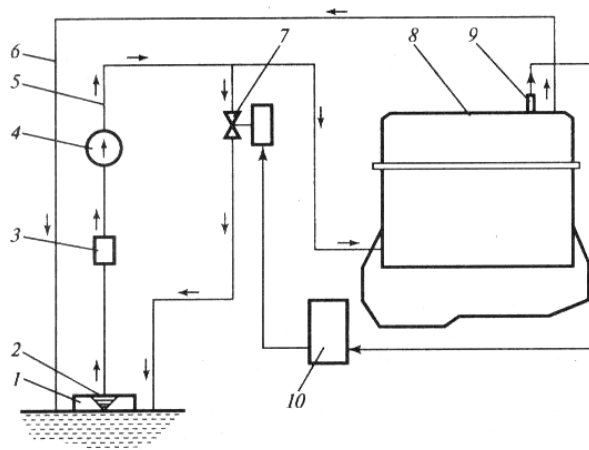


Fig.1. Principle diagram of liquid cooling flow system:

1 - Inlet box; 2 - filter; 5 - check valve; 4 - pump; 5 - mains line supply of water to the engine; 6 - mainline water output engine; 7 - controlled valve; 8 - engine; 9 - temperature gauge; 10 - control unit

In a thermosiphon system (Fig. 2), liquid circulation occurs due to the difference in temperature and density in different areas of the liquid circuit. Such cooling system is the simplest and most inexpensive, but at its acceptable dimensions, thermotechnical is not sufficiently effective. For intensive circulation of liquid in it, a significant temperature difference of Δt_l on the radiator (about 30 °C) is required [13, 15, 16]. Otherwise, low liquid velocities can lead to local overheating and significant temperature gradients in the cooled engine elements.

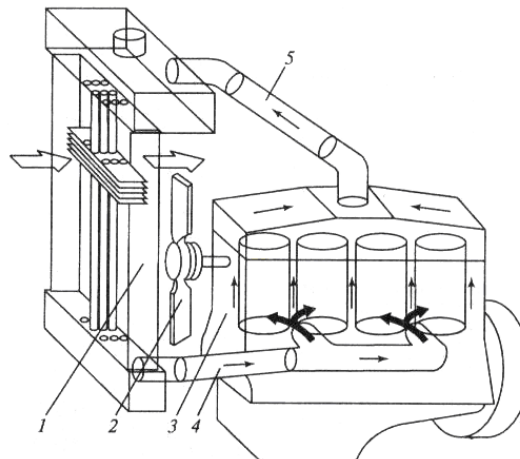


Fig.2. Principle scheme of the thermosiphon cooling system:

1 - Radiator; 2 - fan; 3 - cylinder block; 4 - coolant supply hose from the radiator to the cylinder block; 5 - coolant drain hose from the cylinder block to the radiator

Due to the noted deficiencies in modern transport ICE, thermosiphon cooling systems are not used. The system with forced circulation of the cooling agent is currently one of the main types of cooling systems for auto-tractor engines [4, 9, 18]. Forced circulation of the intermediate coolant along the entire circuit is carried out by the liquid pump 6 (Fig. 3). The cooling agent is supplied through the lower zone of the cylinders.

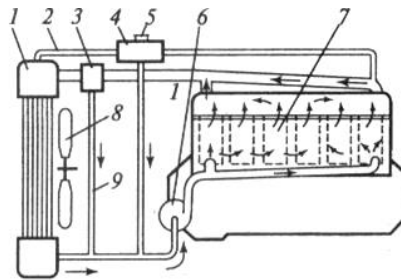


Fig.3. Principle scheme of the circulating liquid cooling system:

1 - Radiator; 2 - steam-air tube; 3 - thermostat; 4 - expansion tank; 5 - expansion tank plug; 6 - liquid pump; 7 - cylinder block jacket; 8 - Fan; 9 - bypass line

Mixed cooling systems (Fig. 4 a, b) the coolant from radiator 1 is supplied to the upper zone of the cylinder cooling jacket (Fig. 4 a) or to the cavity of the block head (Fig. 4 b), or to the cavity of the block head (Fig. 4 b). In the latter case, the engine cylinders are cooled by the thermosiphon effect [17, 19, 20]. When the coolant is supplied to the block head, sometimes (with large linear engine sizes) the distribution pipes 10 are used (Fig. 4 b), which allow intensifying the cooling of the hottest areas of the combustion chambers. Such systems are mainly used on spark-ignition engines.

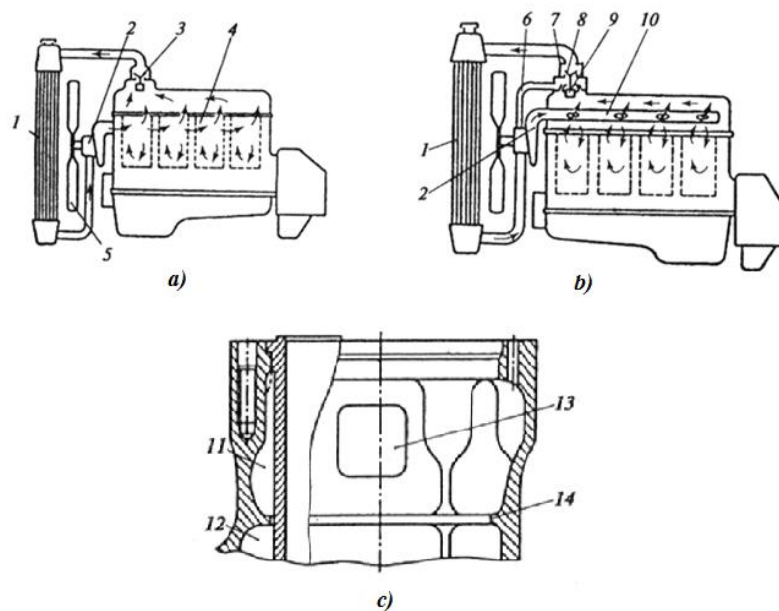


Fig.4. Scheme of mixed liquid cooling systems:

a - with liquid supply to the upper belt of the cylinder cooling jacket; b - with liquid supply to the cavity of the block head; c - two-cavity cooling system; 1 - radiator; 2 - liquid pump; 3 - single-valve thermostat; 4 - engine cooling jacket; 5 - fan; 6 - bypass line; 7 - two-valve thermostat; 8 - main thermostat valve; 9 - optional thermostat valve; 10 - distribution pipe; 11 - upper cylinder cooling cavity; 12 - lower cylinder cooling cavity; 13 - coolant supply length channel; 14 - partition

Therefore, in the process of improving the performance of diesel engines by enhancing the cooling system, the following recommendations can be made:

1. Analyze the design features of gas engines;
2. Analyze the operation principles of modern engine cooling systems;
3. Carry out theoretical research of the cooling system of gas-powered buses and minibus engines, which would allow to reveal the reasons leading to the increase of thermal stress of the

engine parts during conversion to gas fuel, which consists in the specifics and peculiarities of the working process;

4. Suggest ways to improve the gas engine cooling system;

5. Develop and propose variants for improvement of gas engine cooling system, which will reduce the cooling temperature from 120 to 90 °C.

Reference

1. Amir Taghavipour, Mahyar Vajedi, Nasser L Azad. Intelligent Control of Connected Plug-in Hybrid Electric Vehicles. Springer, 2019. P. 198.
2. Péter Gáspár, Balázs Németh. Predictive Cruise Control for Road Vehicles Using Road and Traffic Information. Springer International Publishing, 2019. P. 226.
3. Dvigateli vnutrennego sgoraniya: v 3-x kn.: uchebnik dlya vuzov / pod red. V.N. Lukanina. – M.: Vissh. shk., 2005. - Kn. 1. Teoriya rabochix prosessov / V.N. Lukanin, K.A. Morozov, A.S. Xachiyani A.S. i dr. - 368 s.
4. Dvigateli vnutrennego sgoraniya. V 3 kn. Kn. 2. Dinamika i konstruirovaniye: Uchebnik dlya vuzov / V.N.Lukanin, I.V. Alekseev, M.G.Shatrov i dr.; Pod red. V.N.Lukanina i M.G.Shatrova – 3-e izd., pererab. i ispr. – M.: Visshaya shkola, 2007. –400 s.
5. Daminov O.O. Ichki yonuv dvigatellari nazariyasi. O‘quv qo‘llanma. – T.: “Adabiyot uchquni”, 2018. – 184 bet.
6. Matmurodov F., Sobirov B., Tulanov I., Mirzaabdullayev J., Khakimov J., Daminov O. Mathematical Modeling of the Transfer of Energy Forces from the Engine through Hydro Transmission and Hydro Differential to Executive Bodies. World Journal of Mechanics (Web of Science). USA, Scientific Research Publishing, 2019. P. 105-112.
7. Matmurodov F.M., Daminov O.O., Mirzaabdullayev J.B., Hakimov Zh.O. Mathematical modeling of transfer of the moment from the engine to the executive mechanism. – “East West” Association for Advanced Studies and Higher Education GmbH. European science review (Scientific journal), Austria, Vienna, 2017. № 3–4. (March–April); P. 75-77.
8. Tulaev B.R., Daminov O.O. Ichki yonuv dvigatellarini matematik modellashtirish. ToshDTU xabarlari, 2018. №1, B. 96-101
9. Mikhail G. Shatrov, Valery I. Malchuk, Andrey Y. Dunin, Ivan G. Shishlov, and Vladimir V. Sinyavski. A control method of fuel distribution by combustion chamber zones and its dependence on injection conditions. Thermal science: Year 2018, Vol. 22, Suppl. 5, P. S1425-S1434. (<https://doi.org/10.2298/TSCI18S5425S>)
10. Keum-Shik Hong, Umer Hameed Shah. Dynamics and Control of Industrial Cranes. Springer, 2019. P.177.
11. Tulaev B.R. Matematicheskoe modelirovaniye prosessov teploobmena v DVS/ Monografiya. – Tashkent: Adabiyot uchquni, 2018. S. 176.
12. Tulaev B.R., Khakimov J.O., Mirzaabdullayev J.B. Matematicheskaya model peremesheniya reyki toplivnogo nasosa dvigatelya vnutrennego sgoraniya. // East European Scientific Journal. (Warsaw, Poland), 2018. №2 (30). P. 66-68.
13. Willard W. Pulkrabek. Engineering Fundamentals of the Internal Combustion Engine. Prentice Hall. Upper Saddle River, New Jersey, 2003. P. 345.
14. Śliwiński K., Szramowiat M. Development of cooling systems for internal combustion engines in the light of the requirements of modern drive systems. International Automotive Conference (KONMOT2018). Series: Materials Science and Engineering 421 (2018) 042078 (doi:10.1088/1757-899X/421/4/042078).
15. Balanescu D.T., Homutescu V.M., Lupu A.G. Experimental study on enhanced heat transfer by water spraying in the cooling air flow. The 8th International Conference on Advanced Concepts in Mechanical Engineering. Series: Materials Science and Engineering 444 (2018) 082021 (doi:10.1088/1757-899X/444/8/082021).

16. Eid S. Mohamed, Essam M. Allam: Effect of active cooling control on internal combustion engine exhaust emissions and instantaneous performance enhancement, *British Journal of Applied Science & Technology*, 2015.
17. Xu Wang, Xingyu Liang, Zhiyong Hao, Rui Chen: Comparison of electrical and mechanical water pump performance in internal combustion engine, *International Journal of Vehicle Systems Modelling and Testing (IJVSMT)*, Vol. 10, No. 3, 2015.
18. Tissot J., Boulet P., Labergue A., Castanet G., Trinquet F. and Fournaison L. 2012. Experimental study on air cooling by spray in the upstream flow of a heat exchanger *International Journal of Thermal Sciences* 60 pp 23-31.
19. Xiao L., Wu T., Feng S., Du X. and Yang L. 2017. Experimental study on heat transfer enhancement of wavy finned flat tubes by water spray cooling *International Journal of Heat and Mass Transfer* 110 pp 383-392.
20. Dirbude S., Khalifa N. and Chandra L. 2017. Selective design of an experiment for evaluating airwater hybrid steam condenser for concentrated solar power, in book *Concentrated solar thermal energy technologies: recent trends and applications* (Singapore: Springer Verlag) pp 89-102.