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FREEZING OF CONDENSATE IN THE EXHAUST SYSTEM OF CARS

Kuznetsov N.I., Petukhov M. Yu. (Perm National Research Polytechnic University (PNIPU)), Khaziev A.A., Laushkin A.V. ((The Moscow State Automobile and Road Construction University (MADI))

Abstract: Discussed are the design features of exhaust systems of cars and the factors influencing the formation of condensation in them.

Keywords: exhaust system, design features, the condensate.

Introduction

In the modern metropolis operation of vehicles is characterized by frequent short trips when the engine does not have time to warm up, many hours of movement in traffic jams, long-term operation of the engine at idle, etc.

Under these conditions, the motor and its systems are not warmed up to operating temperature. This occurs most frequently during vehicle operation at low temperatures.

The low temperature of engine parts leads to condensation on the cylinder walls and enters the sump penetration of not only gasoline, which hasn't been evaporated, but also the water formed in large quantities during the combustion of fuel

These operating conditions have a negative impact on car engine: the engine oil accumulates water and unburnt fuel fractions, and in some cases there is oil starvation mode;

Along with this, there are problems in the exhaust system - the silencer is not able to warm up quickly, its walls remain cold and moisture condenses on them. As a result, the system gradually accumulates more water. Thus, at short distances there is an effect of the condensate accumulation in engine oil and exhaust system of the vehicle [1].



Fig. 1. Appearance of the car in the winter

In case of freezing of condensate in the exhaust system there is blocking from the exhaust system of the engine. Start of the motor in this case, becomes impossible. Ability to run only appears during thawing of the exhaust system. Often in such cases, the culprit is considered to be the vehicle manufacturer, as violations of the vehicle operating conditions are not detected.

The authors are informed about cases of judicial proceedings for failure to start the engine during freezing of condensate in the exhaust tract. Some of them ended with the termination of contracts of sale of generally serviceable cars and big fines for a seller. Courts established shortcomings in these cars, which are recognized to be manufacturing defects.

However, the presence of water in the exhaust system is not a sign of malfunction of the car. Moisture condensation in the exhaust system and its accumulation up to block the exhaust during freezing is a direct indication that the operation of the car took place in conditions different from normal.

Motorists are encouraged to make drainage holes in the elements of the exhaust, so that the appear of the water can be removed through them. To prolong the life of the muffler, some manufacturers of exhaust systems, for example, Bosal implement this idea for their products.

Company «ERNST» applies technology CONDENSATE-FREE TECHNOLOGY - removal of condensation inside the muffler vehicle [2]. Cameras and perforated pipe muffler designed so that shortly after launch moisture is entrained by flow of exhaust gases, even if the exhaust system is still cold. Developed parts of the exhaust system configuration help to avoid areas where condensation effect can take place.

Automakers have already faced this problem in Russia, it is recommended for car owners to follow a special operating rules.

The reasons for the pervasion of water into the exhaust system

There are the following ways of getting water into the exhaust system [3,4]:

- Condensation of moisture from the air;
- Water produced by the combustion of motor fuel,
- Water formed as a result of chemical reactions in the catalytic converter;
- Water penetrating into the combustion chamber of the engine cooling system

malfunction.

It is not needed to have deep technical knowledge to understand that if the coolant gets into the combustion chamber - it will not pass unnoticed by the motorist: lack of water will cause the engine to overheat and initialization of a failure of a control lamp on the dashboard of the car, it will increase the engine oil level is formed water-in-oil emulsion in the sump, etc.

The analysis of the causes of water entering the engine during operation of the vehicle and quantitative assessment made on the basis of constructing the equations of chemical reactions of oxidation of hydrocarbons [4] have shown:

- When the motor works water falls into the power vehicle under the conditions of the condensation of moisture from ambient air and to a greater extent by the combustion of motor gasoline;

- Depending on the ambient temperature during combustion of 1 kg of gasoline into the engine air enters from 0.009 to 0.384 kg of water (Table 1);

Table 1

The mass of water flowing into the engine from the ambient air during combustion of 1 kg of gasoline

Ambient temperature, t °C	-20	-10	0	10	20	30
The mass of water entering the engine from the ambient air during the combustion of 1 kg of gasoline, kg	0.009	0.023	0.055	0.111	0.211	0.384

During the combustion of 1 kg of fuel, depending on its composition of hydrocarbon in the engine cylinders, 1.286 ... 1.465 kg of water segregates;

Accumulation of water occurs to a greater extent in the operation of a cold engine, the car travels a short distance and low ambient temperatures.

The moisture condensing from the atmosphere makes a minor contribution (0.6 ... 3.8% - in the temperature range 30 ... -20C) as compared with the water released during the combustion of fuel. Depending on the ambient temperature by the combustion of 1 kg of fuel to the engine falls to 1.3 ... 1.8 kg of water. Of course, much of the water as water vapor into the atmosphere, but at a low temperature until 10-15% of the muffler condenses on the walls and accumulates there.

The authors conducted a series of experiments to study the process of condensation in the exhaust system of motor vehicles and the main factors that determine this phenomenon:

- 1) the degree of capacity utilization of the engine,
- 2) weather conditions (temperature and humidity)
- 3) Production method for implementing and neutralization of exhaust gases of the engine.

On the first factor, the driver can influence in a certain way, by adjusting the intensity of their movement, the second factor - not because it is natural, and the third - relatively manageable.

Design Features of exhaust systems of car

Features of the layout of the exhaust system - the third factor, which determines whether the vehicle is subject to the accumulation of condensation in the exhaust system.

We have investigated the complaints of drivers operating vehicles in a metropolis, which had to start the engine before driving first to melt the frozen condensation in the exhaust system. Were examined 65 vehicles of different classes and with different engine capacity of production in Western Europe, USA and Asia. [5] In the study, the following data were recorded: the layout of the exhaust system, the dimensions of parts of the exhaust system, engine performance, and also features in the design, if any.

In figures 1-4 are photographed exhaust systems of vehicles with certain characteristics.

A vehicle is associated with the risk of condensation and freezing of water in the exhaust system if:

- 1) the location of the exhaust pipes has a lower outlet opening receiving the pipe (Fig. 2);



Fig. 2. The muffler has a lower location of the outlet
(KiaSportage / SL / 2012)

- 2) The muffler has a downward slope toward the front of the vehicle (Fig. 3);
- 3) some elements to the rear feed tube are located below the muffler on the level in the inlet and outlet of the muffler from the front silencer (Fig. 4);
- 4) a large volume of the rear muffler (muffler including if located transversely to the axis of the vehicle) (Fig. 5).



Fig. 3. The muffler has a slope down to the front of the car (AudiQ7 / 4LB / 2012)

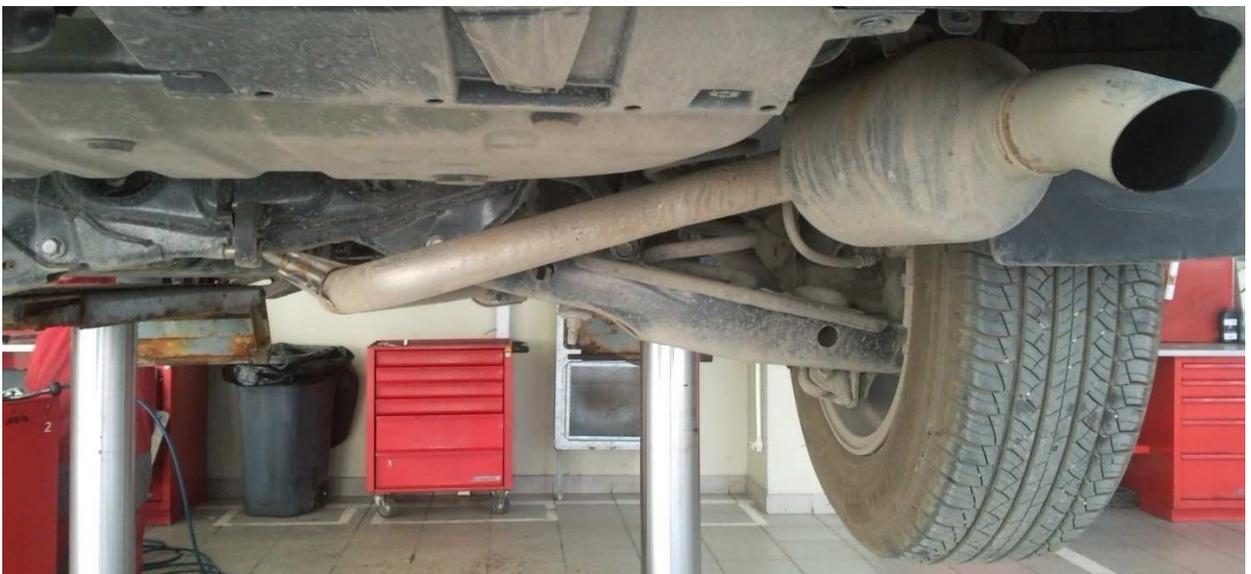


Fig. 4. The some elements of the connecting pipe to the rear muffler are below in terms of the entrance hole in the muffler (ToyotaRav 4 / A40 / 2014)



Fig. 5. Rear muffler large volume (PorscheCayenne / 2014)

The presence of such features in the exhaust system (Fig. 2-4) may result in the fact that the condensate is gradually accumulated in the bottom and narrow part of the exhaust system - the supply pipe to the rear of a vehicle muffler, where it will freeze, thereby not allowing for launch motor.

When operating in the city, a large volume muffler (Fig. 5) is unable to warm up to operating temperature, causing more intense accumulation of condensate.

As a result, studies have identified cars, which due to the nature of the layout of the exhaust system may freeze accumulated condensation in the winter operation:

- MazdaCX-7 (ER 06-12), BMWX5 (E53 99-06), BMWX6 (F16 08-present).
- Volkswagen Tiguan (5N 08-present.), AUDI Q5 (8RB 08-present.), Toyota Rav 4 (A40 12-present).
- Audi Q7 (4LB 05-present.), Porsche Cayenne (955 02-10), Volkswagen Touareg (7L 02-10)

If we use the classification of European Economic Commission for passenger cars, all cars with the problem related to J-segment.

Risk group of vehicles

Experimental studies have helped identify four risk groups of cars the most critical in terms of the formation of condensation in the exhaust system at low ambient temperatures:

- 1) vehicles that are operated in a metropolis,
- 2) cars with a large engine volume (more than 3.0 liters), including high specific power of the engine,
- 3) vehicles that are operated under adverse weather conditions (air temperature slightly below 0 ° C);
- 4) vehicles with design features in an exhaust system (layout, size, branching pipes and bends in the exhaust system)

Recommendations for the operation of vehicles

Ensure complete heating system can issue when traveling long distances, as well as in areas where the engine and its systems are operating at medium and high loads.

Thus, the Volkswagen Group in the owner's manual indicates that the vehicle engine can not warm up at idle, so drive the vehicle should start immediately after its launch, avoiding excessive speed. Only about 4 km the engine reaches operating temperature, and fuel consumption is normalized, and the state of operational rules after driving the car reaches about 20 km. On this basis, should strictly avoid short trips [5].

The manual NISSAN QASHQAI [7] states: "After starting the need to give the engine run at idle for at least 30 seconds. The initial stretch of road drive at a moderate speed, especially in cold weather. "

In the owner's manual Opel Astra is noted that "at very low ambient temperatures do not let the engine run at idle for more than 5 minutes, otherwise it may damage the engine" [8].

Thus, following the recommendations of the manufacturers of vehicles can be avoided or at least significantly reduce the formation and accumulation of condensation in the exhaust system.

The urgency of the problem in Russia

For the driver, the opportunity to sit in the car with the engine warmed up is already a very convenient help. Today, it is easy to implement using the remote engine start car security systems with two-way communication. Running with the command with the remote control or timer automatically tuned to a specific time. This - the basic functions of security emergency vehicle systems. Currently, every tenth car in Russia is equipped with an alarm system with engine startup, and in regions with harsh climates, their share reaches 50%. Therefore, in Russia the problem of the accumulation of condensation in the exhaust system has become quite popular and widely discussed on the Internet.

Conclusion

The reason for the accumulation and freezing of water in the exhaust system of vehicles, is a natural phenomenon of condensation on cold surfaces.

A number of modern car models have features of the exhaust system, which can lead to the accumulation of a considerable amount of condensate. Car manufacturers do not always take into account the use of the vehicle in the major cities in the cold season and this leads in some cases to the inability to start the car engine.

To avoid the negative impacts of this phenomenon are recommended certain rules of operation of the vehicle during the cold season.

It is necessary to organize the data and to develop recommendations for the design of exhaust systems of cars, deprived of the opportunity to accumulate condensation.

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ЗАМЕРЗАНИЕ КОНДЕНСАТА В СИСТЕМЕ ВЫПУСКА АВТОМОБИЛЕЙ

Кузнецов Н. И., Петухов М. Ю. (ПНИПУ), Хазиев А.А., Лаушкин А.В. (МАДИ)

Аннотация. Рассматриваются конструктивные особенности систем выпуска автомобилей и факторы, влияющие на образование конденсата в них.

Ключевые слова: система выпуска, особенности конструкции, конденсат.

1. Кузнецов Никита Игоревич, Пермский национальный исследовательский политехнический университет (ПНИПУ), магистр, 614990, Пермский край, г. Пермь, Комсомольский проспект, д. 29, +7(963)883-80-51, totalgame123@gmail.com.

2. Петухов Михаил Юрьевич, Пермский национальный исследовательский политехнический университет (ПНИПУ), декан автодорожного факультета, кандидат технических наук, 614990, Пермский край, г. Пермь, Комсомольский проспект, д. 29, +7(342)239-14-92, pmu@pstu.ru.

3. Хазиев Анвар Асхатович, МАДИ, доцент кафедры Эксплуатации автомобильного транспорта и автосервиса, кандидат технических наук, доцент, 125319, г.Москва, Ленинградский проспект, д.64, (495) 155-0749, E-mail madi-chim@mail.ru.

4. Лаушкин Андрей Вячеславович, МАДИ, ведущий инженер испытательной лаборатории МАДИ-ХИМ, 125319, г.Москва, Ленинградский проспект, д.64, (499) 155-0749, E-mail: lav82@mail.ru.

Nikita Kuznetsov, Perm National Research Polytechnic University (PNRPU), master degree student, Russian Federation, 614990, Perm krai, Perm, Komsomolsky avenue 29, +7(963)883-80-51, totalgame123@gmail.com.

Mikhail Petukhov, Perm National Research Polytechnic University (PNRPU), dean of Car and Road Building Faculty, Ph.D; Russian Federation, Perm krai, Perm, Komsomolsky avenue 29, phone +7(342)239-14-92, pmu@pstu.ru.

Anvar Khaziev, Moscow State Automobile and Road Technical University, Russian Federation; associate Professor of the Department of operation of automobile transport and auto service, head of test laboratory MADI-CHEM, Ph.D; Russian Federation, 125319, Moscow, Leningradsky avenue 64, phone: (499) 155-0749; madi-chim@mail.ru,

Andrey Laushkin, Moscow State Automobile and Road Technical University, leading engineer of the laboratory of Fuel and oils MADI; Russian Federation, 125319, Moscow, Leningradsky avenue 64, phone: (499) 155-0749; lav82@mail.ru,