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# CAR ZAZ-1102 IMPROVEMENT IN FUEL EFFICIENCY AND ENVIRONMENTAL PERFORMANCE IN WARM-UP PHASE AFTER ENGINE COLD START

*The article considers the question that relates to optimizing fuel consumption and reducing emissions of harmful substances in the exhaust gases of the vehicle in the following modes cold start of the engine with spark ignition and warm-up. To solve this problem device is proposed for increasing the temperature of the intake air at low temperatures, which will improve the mixture formation, gas exchange and better distribution of the fuel-air mixture in the engine cylinders. The use of this device is one of the promising directions of implementation of energy efficient technologies in road transport.*

***Keywords:** engine with spark ignition, cold start engine, heated intake air, improving of gas exchange and mixture formation, increasing the efficiency of internal combustion engines.*

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# ПОЛІПШЕННЯ ПАЛИВНОЇ ЕКОНОМІЧНОСТІ І ЕКОЛОГІЧНИХ ПОКАЗНИКІВ АВТОМОБІЛЯ ЗАЗ-1102 В РЕЖИМІ ПРОГРІВУ ПІСЛЯ ПУСКУ ХОЛОДНОГО ДВИГУНА

*У статті розглянуте питання, яке пов'язане з оптимізацією витрат палива і зменшенням емісії шкідливих речовин у відпрацьованих газах автомобіля в режимах пуску холодного двигуна з іскровим запалюванням та його прогріву.Для вирішення цієї задачі запропоновано використання пристрою для підвищення температури повітря на впуску в умовах низьких температур, що дозволить поліпшити сумішоутворення, газообмін і більш якісний розподіл паливоповітряної суміші по циліндрах двигуна. Використання даного пристрою є одним з перспективних напрямів реалізації енергоефективних технологій на автомобільному транспорті.*

***Ключові слова:** двигун з іскровим запалюванням, пуск холодного двигуна, підігрів повітря на впуску, поліпшення газообміну та сумішоутворення, підвищення енергоефективності ДВЗ.*

**Introduction.** Currently one of the priority development directions of all sectors of the domestic economy is the creation of energy efficient technologies allowing the efficient use of energy resources. This fully applies to the road transport.

Efficient vehicle operation at low ambient air temperatures is associated with different challenges. The most significant ones are the start of the cold engine and subsequent warming up. These modes are preparatory before operating the engine under load and are some of the most unfavourable engine operating conditions in fuel economy and environmental safety.

According to various sources [1 – 4], emissions of carbon monoxide (CO) and hydrocarbons (HC) with exhaust gases in the operation of vehicles with spark ignition engines in low temperatures increase 6 – 10 times, and in the modes of start-up and warm-up engine emits up to 70...80% of total emissions of incomplete combustion of CO and HC products.

Among the main reasons for the difficulties of cold engine starting in low ambient temperature are:

– the deterioration of fuel evaporation conditions, which leads to non-optimal air-fuel mixture;

– high vacuum in the intake manifold, which leads to deterioration processes of gas exchange;

– the increase in the required starting speed of the crankshaft;

– decrease the real capacity of the battery.

At low ambient temperatures, these causes occur simultaneously, exacerbating and complicating the operation of starting and warming up of cold engine. According to [5], the territory of Ukraine it is the temperate climatic zone. In the territory of the state it is formed by temperate continental climate. Of the year (about 4 – 6 months), the cars are operated at temperatures between +5°C and below.

In this regard, decisions of the tasks related to the operation of vehicles in conditions of low ambient temperatures, is relevant.

**Analysis of recent researches and publications.** The influence of seasonal conditions on the fuel efficiency of cars, the concentration of harmful substances in waste gases and the reliability of cars are investigated by many authors. Seasonal conditions are the factors that change periodically throughout the year. It is primarily climatic factors.

Climatic factors in different periods of the year are determined by temperature, humidity, atmospheric pressure, rainfall, force and direction of winds, duration of snow cover etc. Low ambient air temperature has significant influence on the temperature regime of the car units, especially engine and systems, supporting its work and, through their changes on fuel consumption. The most comprehensive analysis of the impact of ambient temperature on fuel consumption and emissions of harmful substances in exhaust gases of cars is given in the works [6 – 10].

It was established in [7, 11] that the fuel consumption by lowering the ambient temperature increases by 10...30%. The increase in fuel consumption is associated with increase in the viscosity of the fuel, deterioration of his ability to atomization and evaporation and, consequently, deterioration of mixture formation and combustion efficiency of fuel-air mixture. The increase in viscosity of gasoline may result in unacceptable depletion of the fuel mixture. Viscosity primarily affects the volumetric amount of fuel passing through the jet per unit time, and therefore on its consumption. Leakage of gasoline through the nozzle when changing temperature from plus 40 to minus 40°C is reduced by 20...30%.

Depending on the time of year and temperature in the region, vehicle operation, the percentage ratio of the concentrations of pollutants from «cold start», «further combined heating» and «hot» car can be in various ratios. Climatic area «moderately warm» in the calculations were obtained by the following relationship: in the warm period 2 – 3 – 95% in the cold period 10 – 15 – 75% [12].

Thus, at low temperatures of exploitation, the deterioration of the thermal state of the motor has significant influence on the increase in fuel consumption and, consequently, increasing the emission of harmful substances in the exhaust gases. In addition, the analysis of the research showed that there is some optimal value of the intake air temperature at which fuel consumption is minimal [13, 14].

Minimum fuel consumption of the internal combustion engine is warmed up. It is observed at the inlet temperature at motor +35...+45°C, its change leads to increase in fuel consumption. For the engine ZMZ-53 the decrease in air temperature in the range from plus 48 to minus 28 according to [14], causes increase in fuel consumption from 2.5 to 16%.

One of the possible ways to improve fuel economy of spark-ignition engines and reducing the emission of harmful substances in the exhaust gas at cold start of the engine and its warming up, is the provision of heated air entering the engine and to stabilize its temperature at +35...+45°C in the future.

**The selection not resolved before the general problem.** To solve the task of reducing fuel consumption and emissions of harmful substances in the exhaust gases in the modes of cold start engine with spark ignition and warm-up, it is necessary to improve the mixture by increasing the temperature of the air entering the engine.

**Statement of the problem.** The purpose of the experimental research is determination of intake air temperature influence on fuel efficiency and emissions of harmful substances in the exhaust gas of the car engine when it is warming up in idle.

The object of experimental research is the car ZAZ-1102, which has carbureted, four-stroke, four-cylinder in-line engine MeMZ-245.

Experimental investigations were carried out in the laboratory of engine testing of National transport University.

To ensure preheating of the intake air equipment with metal-ceramic heating element was used. Tests were conducted on the gasoline A-95 at the same atmospheric conditions. Engine starting and warming was carried out at an ambient temperature of about +3...+4°C at the engine speed of 1400...1500 rpm (optimal steady frequency heating) to the temperature of the engine coolant +85°C.

During testing of the engine the concentration of harmful substances in exhaust gases was evaluated: carbon monoxide CO, carbon dioxide $CO_2$, hydrocarbons HC behind the analyzer of the META, and fuel consumption during warm-up the engine using the fuel flow meter ONO SOKKI DF-311.

In addition, the following controlled parameters of the engine are the following: coolant temperature $t_{coolant}$, the temperature of the air to the carburetor $t_{intake\ air}$, the engine speed n (Fig. 1).

**Main material and results.** According to the conducted researches the following results were achieved:

equipment metal-ceramic heating element provides heating of the air entering the carb around +60...+65°C at an ambient temperature of +3.5°C (Fig. 1).

The temperature of the coolant in the heating air inlet reached +60°C for 360 seconds after starting the engine, without heating for 450 seconds. Time to warm up a cold engine coolant temperature +60°C was reduced to 90 seconds, which is 20%, while the fuel economy was 0,062 kg (about 14%).

Stabilization of the coolant temperature at +85°C was observed when using heated air for 560 seconds, without heating – for 690 seconds after starting the engine. That warm engine (to coolant temperature +85°C) when heating air inlet, is, according to the tests for 130 seconds (about 19%) most of the time warming up the engine with the standard system supply air (Fig.1).

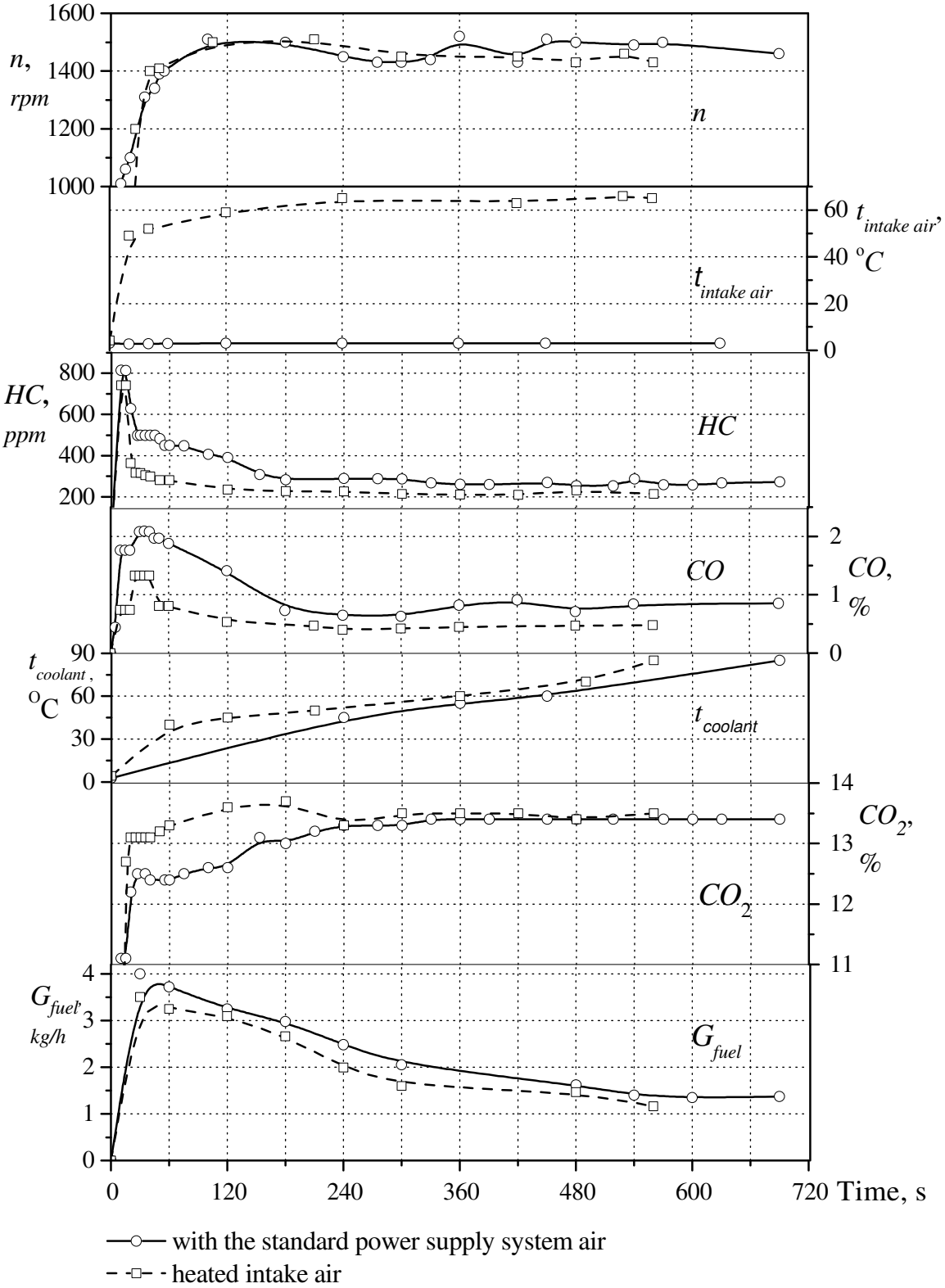


**Figure 1 – The change in the performance of the engine in warm-up mode**

Analysis were derived from experimental studies, dating on fuel consumption, given the time required for warming up the engine coolant temperature +85°C, to determine its quantity. Heated air inlet, fuel consumption is – 0.464 kg with the standard system – 0.582 kg. That is, during the heating of the engine, the results of tests, fuel economy, while heated air inlet is 0.118 kg (20%).

Analysis of the obtained data on engine harmful substances emissions, exhaust gases warming up in idle are showed the following (Fig. 1).

The concentration of carbon monoxide in the exhaust gas without heating the intake air is stabilized at the level of 0,73% for 180 seconds, heating the air at the level of 0,53% for 120 seconds. The concentration of carbon dioxide in the exhaust gases as heated intake air and with a staff almost are equal at the level of 13,4% after starting the engine in 240 seconds (Fig. 1).

The concentration of hydrocarbons in exhaust gases during engine warm-up heated air intake was observed significantly less stabilization occurred after 120 seconds and to the end of the warm-up amounted to about 219 ppm, whereas when working with the standard system stabilization is observed after 180 seconds until the end of the warm-up was about 271 ppm.

Concentrations of toxic substances in exhaust gases of the engine does not fully characterize the harmful effects of the engine environment, as the amount of harmful substances emitted to the atmosphere depends on the amount of combustion products that are formed in the cylinders of the engine and the time of heating.

The calculation of the mass emissions of harmful substances has shown that when using the heated intake air, their number is reduced compared to the regular system (Fig. 2).

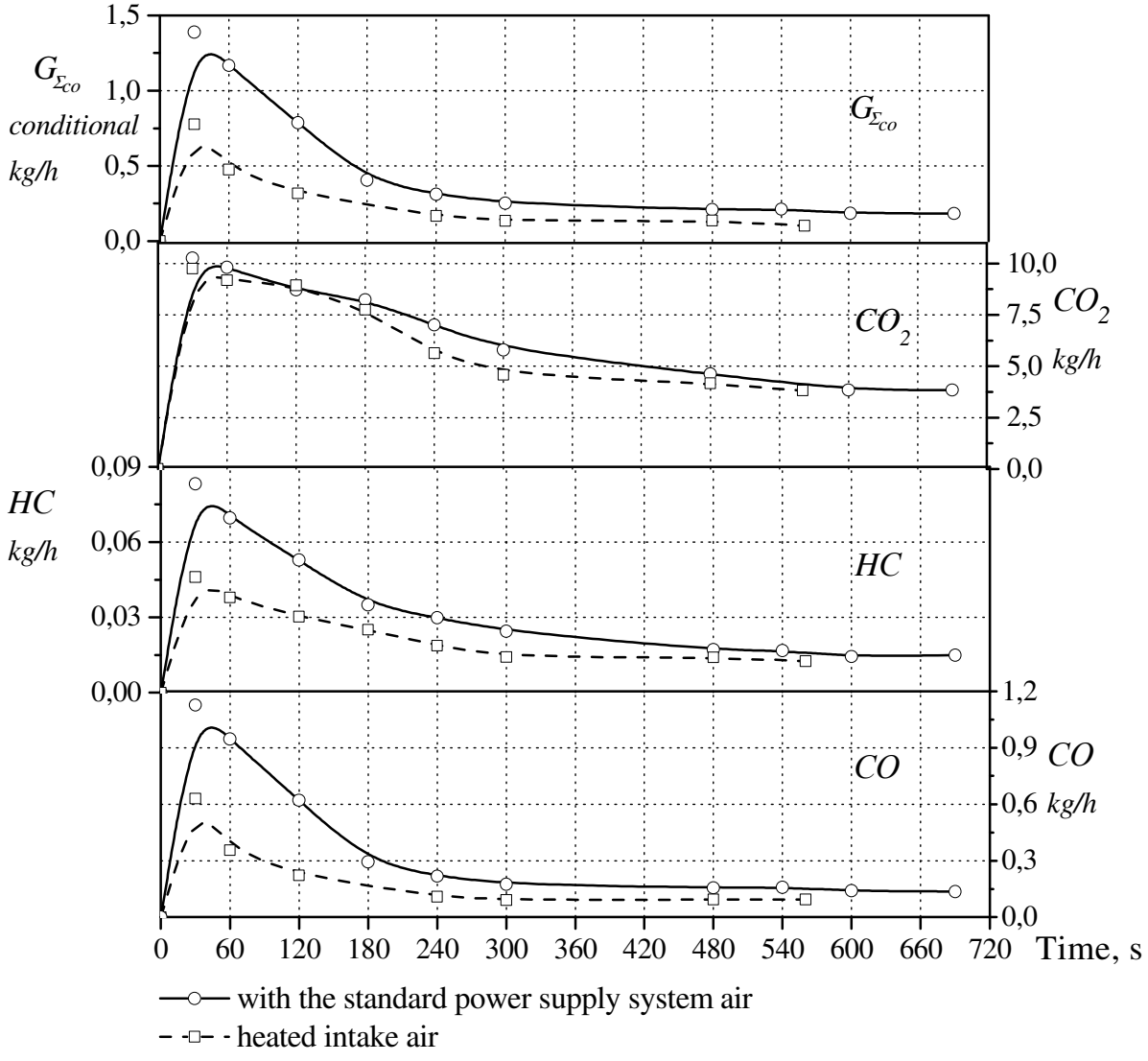


**Figure 2 – The change in the mass emissions and total consolidated harmfulness of exhaust gases in the warm-up phase**

During the test, the engine mass emissions in the exhaust gases averaged, taking into account the time of heating (heated air intake – 560, with the standard system 690 seconds):

– carbon monoxide with heated air – 0,034 kg/h, with the standard system – 0,076 kg/h.

– hydrocarbons, heated air – 0,0039 kg/h, with the standard system – 0,0069 kg/h.

– carbon dioxide heated air 1,047 kg/h, with the standard system – 1.27 kg/h.

The total mass emissions of harmful substances in exhaust gases averaged, taking into account the time of heating (heated air intake – 560, with the standard system 690 seconds) heated air – 0,046 conditional kg/h, with the standard system – 0,11 conditional kg/h.

**Conclusions.** Thus, conducted experimental studies determined the effect of air temperature at the inlet to the fuel economy and emissions of engine gasoline exhaust gases with spark ignition MeMZ-245 with its warming idling, allow the following conclusions:

1. Warm-up time to the engine coolant temperature +60°C decreased by 20%, while the fuel economy with about 14%, coolant temperature to +85°C was reduced by 19%, while the fuel economy was about 20%;

2. Mass emissions of harmful substances in exhaust gases heated air inlet in comparison with the standard system decreased on average:

– carbon monoxide by 55%;

– hydrocarbons by 43%;

– carbon dioxide by 18%;

– total mass emission are reduced to CO by 57%.

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