Influence of air temperature on warming up the engine of automotive vehicles

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Abstract. The air temperature has a significant effect on the warming up of the engine of automotive vehicles. To study this process, comparative experiments on the functioning of tractors in different operating modes were carried out. The value of the coolant temperature was taken as a parameter characterizing engine warm-up. In our studies, the heating of the coolant was considered complete when the temperature at the outlet of the tractor blockhead reached 85 degrees Celsius. The ambient temperature varied from plus 20 to minus 30 degrees. The effect of the load modes of its operation was taken into account on the duration of the tractor engine warming up. The results obtained show that the warm-up of the tractor engine at idle speed has a protracted nature and does not always have a positive result. The process can be intensified by operating the tractor engine under load and using an insulating cover. This reduces the duration of the warm-up process and significantly reduces the unproductive downtime of the tractor.

1. Introduction
To create competitive agricultural production, innovative technical means and technologies are required [1-4]. At the same time, the development of automotive technology is of priority importance [5-9]. Warming up the engine is a problem, especially in difficult climates. Studying the effect of air temperature on this process will expand the area of knowledge in this matter. The new knowledge gained is important for further practical and theoretical development.

2. Materials and methods
Studying the instructions of the manufacturers, research by scientists in this matter. Comparative experiments.

3. Results and discussion
Under operating conditions, according to the manufacturer's instructions, after starting, before loading the engine, it is necessary to bring the temperature of its systems to operating values. Typically, the parameters that characterize engine warm-up are the temperature of the coolant and, in some cases, the crankcase oil. Warming up of the engine is considered complete when the coolant temperature measured at the exit from the cylinder head reaches 75-95° [10-11]. In our studies, the heating of the coolant was considered complete when its temperature at the outlet from the block head reached 85° (the average temperature recommended by the manufacturer).

The graphs of the coolant temperature change under various load conditions and ambient temperatures from plus 20° to minus 30° are presented below.
Warming up of a diesel engine after starting has a different duration, this depends on both the ambient temperature and the load-operating mode of the engine during warming up.

The graphs show that the engine warming up by its operation at idle speed at ambient temperatures of plus 20° and plus 10° without the use of an insulating cover lasts in both cases for 45 minutes and the coolant temperature, having not reached the normal value, stabilizes at 82° and 80° (figures 1 and 2).

Figure 1. Warming up the coolant ($T_o = + 20^\circ$C).

Figure 2. Warming up the coolant ($T_o = + 10^\circ$C).

Warming up the engine at negative ambient temperatures at idle speed even with the use of an insulating cover has an even longer duration; moreover, the coolant temperature does not reach the normal value. Studies show that the temperature in the cooling system reaches only 79° at an ambient
temperature of 0° and only 65° at an ambient temperature of minus 10°, and the coolant obtains the specified temperatures after 50 minutes of warming up (figures 3 and 4).

![Figure 3. Warming up the coolant (T₀ = 0°C).](image)

![Figure 4. Warming up the coolant (T₀ = -10°C).](image)

At an ambient temperature of minus 20° and minus 30°, the coolant temperature does not rise more than 59° and 53° after 55 and 60 minutes of warming up, respectively (figures 5 and 6).

Thus, at negative ambient temperatures, the engine warming up to the normal thermal state of the coolant cannot be carried out by operating it at idle speed. The lower the ambient temperature, the lower the coolant temperature reaches.

It is possible to ensure that the engine warms up to normal temperature, as well as to reduce its duration in conditions of low ambient temperatures, by increasing the hourly fuel consumption of the engine, that is, by warming up the engine by operating it under load.

Warming up the engine to 85° by its operation under a load corresponding to 1/3 of the rated power at an ambient temperature of plus 20° is carried out in 16 minutes (figure 1). At an ambient temperature of +10° - in 20 minutes (figure 2). At a temperature of 0° - in 22 minutes (figure 3) and at
an ambient temperature of minus 10° - in 30 minutes (figure 4). However, at ambient temperatures of minus 20 and minus 30°, the engine warming up by operating with the specified load stops after 50 minutes, and the coolant temperature reaches only 78° and 73°, respectively (figures 5 and 6).

Figure 5. Warming up the coolant (T₀ = - 20°C).

Figure 6. Warming up the coolant (T₀ = - 30°C).

Therefore, at an ambient temperature below minus 20°, it is not possible to warm up the engine to normal temperature by operating it under a load corresponding to 1/3 of the rated power. Under these conditions, engine warm-up is possible only at full and close to full loads. The duration of engine warm-up to 85° by operation under a load corresponding to 2/3 of the rated power at ambient temperatures of minus 10°, 20° and minus 30° is, respectively, 12, 16 and 30 minutes (figures 5 and 6).
Engine operation at rated load provides engine warm-up to 85° in the shortest possible time period:
at ambient temperatures of minus 10°, 20° and 30°, the engine warm-up duration is 6.5, 10 and 15
minutes, respectively.

Considering the graphs of the temperature change of the coolant, it can be seen that the intensity of
its heating gradually decreases, which can be explained by a decrease in the heat flux coming from the
cylinder walls to the cooling water. It is known that the heat flux is proportional to the temperature
difference between the surfaces of the bodies. According to the law of heat transfer [11], the specific
heat flux removed from the heated engine parts into the coolant is:

\[ q = \alpha \Delta t \]  

where \( \alpha \) is the heat transfer coefficient; \( \Delta t \) is the temperature difference between the heated engine
parts and the coolant.

Since in the first minutes of engine operation, the temperature difference between the surface of the
cylinders and the coolant is the greatest, the heat removal into the coolant is more intensive and the
rise of its temperature curves in the first minutes of warm-up is steeper. As it warms up, the
temperature difference between the surface of the liners and the coolant decreases, the heat transfer to
the coolant decreases, which leads to a slowdown in the increase in its temperature. In addition, such a
course of the heating curves over time can be explained by the fact that as the difference between the
temperature of the engine being heated and the temperature of the ambient air increases, heat transfer
from the engine to the ambient air increases.

4. Conclusion
Thus, experiments show that warming up a diesel engine after starting by operating at idle speed is a
long process and is not always possible. The heating process can be accelerated only by operating the
engine under load and with the obligatory use of an insulating cover.

At low ambient temperatures, the operation of the diesel engine after starting under load ensures
not only its warming up to the normal coolant temperature, but also several times reduces the warm-up
time, that is, it reduces the unproductive idle time of the tractor during warming up.

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