Simulation of a three-dimensional model of the intake system of an agricultural tractor engine

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Abstract. The paper defines the nature and parameters of the air flow after passing the throttle valve. This research problem was solved mathematically using a software package for modeling gas-hydraulic processes. The simulation was carried out using the FlowVision software package. For this purpose, using various standard file formats, the geometry was obtained and imported, which is understood as a three-dimensional model of the internal volumes of the engine-intake and exhaust pipelines, the over-piston volume of the cylinder, etc. This allows you to use the SolidWorks computer-aided design system to create a computational domain. For the area of calculation, the volume was adopted, in which the equations of the mathematical model and the volume boundary with the definition of boundary conditions were determined. The resulting geometry is saved in the format supported by FlowVision and used when creating a new calculation variant.

The amount of air entering the internal combustion engine depends on the operating mode of the agricultural tractor. One of the elements that regulate the flow of air in the internal combustion engine is the throttle valve, the opening angle of which determines the amount of air entering the cylinders. However, most of the time, the flap is not fully open, but partially, which leads to a violation of the flow of air flow at the entrance to the intake manifold. This negatively affects the filling of the cylinders with air. In this regard, the most urgent problem of finishing the exhaust system is the organization of the air flow in the intake system at different angles of opening the flap and its location [1-5].

In the course of computer simulation determined the nature and parameters of the air flow when passing them to the intake system of the internal combustion engine, revealed the presence of phase turbulent flow of air directly behind the throttle, has a negative impact on the distribution of the air flow at inlet pipes. A constructive modernization of the intake system is proposed. Using a series of repeated calculations, the optimal geometric parameters of the upgraded intake system were determined. To determine the accuracy and reliability of the data obtained during computer simulation using the program FlowVision, it was necessary to conduct a physical experiment. For this purpose, static aerodynamic purging of the standard and upgraded intake systems of the agricultural tractor engine was carried out [6-13].

Modeling allows you to visualize different parameters. Another parameter that clearly shows the processes occurring in the intake system is the pressure (figure 1).
Figure 1 shows the pressure change as the air flow passes through the intake system. Modeling allows you to get the required visualization layers after the main calculation is completed, based on the calculation stages saved with a certain frequency. In addition, the postprocessor allows you to transfer the obtained numerical values of the parameters of the process under study in the form of an information file to external spreadsheet editors and get the time dependence of such parameters as speed, flow, pressure, etc.

![Figure 1. The distribution of air pressure in the intake system.](image1)

The advantage of the FlowVision program is the ability to quickly obtain data when changing the model under study. To do this, just change the geometry of the model in SolidWorks, upload it to FlowVision and perform a second calculation [14-16].

![Figure 2. Speed field of the new model.](image2)

When analyzing the data obtained as a result of the calculation, it was determined that the throttle valve has the greatest influence on the distribution of the air flow, and the reason for the uneven distribution of the flow through the intake pipes is the zone of turbulent flow located directly behind the throttle valve. As a result, it was proposed to change the geometry of the model and perform a second calculation.
Figure 2 shows the speed distribution of the intake system with the new geometry. As can be seen from the figure, the distribution of speeds in the intake system has become more uniform. The speeds in the intake pipes have leveled off [17-22]. The swirling zone of the flow opposite the inlet pipe of the fourth cylinder and the change in the flow direction to the reverse have disappeared. There was a change in the pressure distribution in the intake system (figure 3).

![Figure 3. Pressure distribution in the intake system with a new geometry.](image)

As can be seen from the figure, the pressure distribution across the receiver and intake pipes has become more uniform. Another advantage of computer modeling is the possibility of not only layer-by-layer visualization of the processes occurring in the model under study, but also the creation of a three-dimensional visualization (figure 4) [23-29]. Thanks to the possibilities of computer modeling, not only the presence of a zone of high turbulence that occurs when the air flow passes the throttle, but also the parameters and nature of this phenomenon are determined [30-36].

![Figure 4. Section of intense turbulent flow.](image)

Figure 4 shows the pressure distribution during the passage of the throttle air flow. The figure shows a zone of the same pressure. As can be seen from the figure, the turbulence zone has an elongated shape along the inlet pipe of variable cross-section. The turbulence zone occurs directly at the throttle edges. During the passage of the flap, there is a breakdown of two flows, which combine and weaken as they move along the channel. In the central part, just behind the throttle, there is a low pressure zone. As can be seen from the figure, the turbulence zone decreases as it moves through the channel and disappears completely when the air flow enters the receiver [37-42].
Modeling allows you to create video files that also very clearly describe the processes that occur in the intake system. Figure 5 shows one of the frames of the created video file. With the help of this video, you can trace the trajectories of the air flow particles as they pass through the intake system. As can be seen from figure 5, when moving through the intake system, the particles of the air flow are compacted when passing the throttle valve. The incoming air flow when flowing around the throttle valve is pushed against the walls of the intake channel and is divided into two streams [43-49].

![Figure 5](image)

**Figure 5.** Movement of air flow particles through the intake system.

Further behind the throttle valve, the flow particles move towards the center of the inlet channel towards each other, where they are mutually mixed. As a result, those particles that passed through the lower flow when entering the receiver during the flow around the throttle valve are on top of the air flow formed behind the throttle valve.

As a result of the application of computer modeling, new data describing the processes occurring in the intake system of the agricultural tractor engine are obtained. The visualization of the processes that occur there is performed.

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