EXPERIMENTAL EQUIPMENT FOR RESEARCHING THE EFFICIENCY OF THE COMPRESSED AIR ENERGY STORAGE SYSTEM

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Abstract

Previously, the author proposed a compressed air energy recovery system that can be used for road transport. To confirm the effectiveness of the proposed system, it became necessary to build experimental equipment. In this work, it is shown that the principal diagram of the compressed air energy storage system has been developed, which, due to the use of a special pneumatic distributor, allows implementing the volumetric control principle with the possibility of computer or controller control. The system creates potential opportunities for functional flexibility and energy efficiency. Experimental equipment was developed as a result of the conducted research. The use of equipment will make it possible to bring the conditions of research into the effectiveness of the compressed air energy storage system as close as possible to real operating conditions.

Keywords: recuperation; compressed air; experimental equipment; energy efficiency; functional flexibility.

INTRODUCTION

Modernity presents a fairly wide range of applications of various types of energy and their combinations for the needs of mankind. One of the types of energy carrier in industry is compressed air, the volume of its use in Ukraine is up to 30%. The use of this type of energy carrier has both advantages and disadvantages. The advantages include: local environmental friendliness, purity of the energy carrier, high speed, the possibility of transmitting signals over long distances, and others. The main drawback is the low energy efficiency of systems that use compressed air as a working medium. [1, 2]

The use of compressed air in mobile machines or vehicles also has advantages and disadvantages. The main drawback is the low energy efficiency of the systems. But for air compression in such machines, it is desirable to reduce the energy use of hydrocarbon-based fuel as much as possible. This causes a rather significant increase in emissions of harmful substances. Therefore, it is quite urgent to use devices and systems that allow to increase the energy efficiency of mechanisms that work on the energy of compressed air. [1, 2, 3]

EXPOSITION

Consider the module for recuperating mechanical energy into compressed air energy for vehicles [1, 2, 3, 4], it turned out that such recuperative braking modules theoretically allow to accumulate energy in the form of pneumatic energy and further use it for the needs of low-pressure pneumatic systems. Also, the use of a more complex compressor, which can work in the mode of a pneumatic engine and low-pressure receivers, will allow to partially reduce the load on the engines when the vehicle moves.

Using generally available data on the technical characteristics of vehicles [3]. After carrying out calculations and modeling of the compressed air energy recovery process, it was established that the accumulated energy during vehicle braking will amount to 33,680 kJ. At the same time, it is possible to reuse 21,000 kJ, which is 8.95% of the energy spent to accelerate the vehicle. Previous studies show that 70-90% of the energy used to accelerate the vehicle during braking, without the use of energy recovery, is converted into heat and dissipated into the environment.

It is proposed to introduce a kinetic energy recovery module into compressed air energy.

A preliminary calculation showed the effectiveness of the proposed system up to 8.5% of the energy spent to move the vehicle [4].

A special 3/2 flow distributor including a pressure valve has been developed for the compressed air energy storage module. This makes it possible to control the pressure in the pneumatic line in front of the pressure valve, which allows the pneumatic air energy module (Fig. 1) to ensure a constant load at the moment of breaking the axles of the drive wheels.

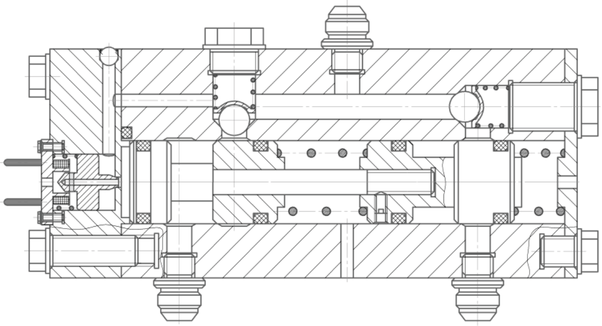

Fig. 1. *Pneumatic distributor with pressure bypass valve*

In the initial position, pneumatic energy is supplied to the pressure valve, which is implemented together with the cylindrical spool. Adjustment of the degree of load is realized by a small distance from the compressor and placing the pressure valve on the spool of the pneumatic distributor. When switching the distributor, the accumulated compressed air from the receiver is fed into the pneumatic network [4, 5, 6, 7].

The use of the proposed pneumatic distributor in the module significantly reduces the number of elements in the module system, its dimensions, and makes the recuperation system cheaper, due to the reduction of auxiliary parts for a sharp increase in the load on the axles of the drive wheels (Fig. 2).

The system works as follows: accumulated pneumatic energy from the compressor enters the receiver through a special distributor with a pressure valve. In turn, it provides the initial effort, that is, the pipeline from the compressor to the entrance to the distributor will always have the initial pressure. This ensures a constant load on the compressor shaft. Depending on the amount of pressure in the main line to the pneumatic distributor, the braking intensity of the drive wheels of the vehicle changes. When using the accumulated pneumatic energy, the distributor is switched and compressed air from the receiver is supplied to the vehicle's on-board network.

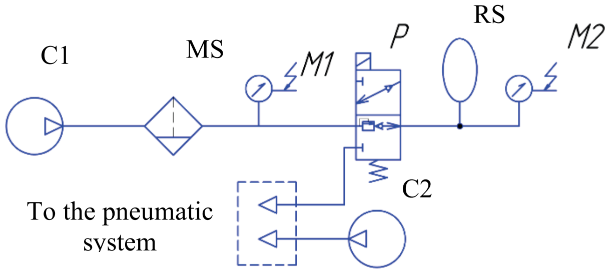

Fig. 2. *Schematic diagram of the compressed air recovery system module*
(C1, C2 - compressor, MS - moisture separator filter, P - special distributor, M1, M2 - pressure gauge, RS - receiver.)

In order to correctly assess the functionality of the proposed system, it was necessary to develop an experimental stand. The experimental stand (Fig. 3) is designed for the practical solution of energy reuse problems in pneumatic systems. The work of the stand is to convert the simulated kinetic energy of movement during the operation of the recuperation system into the energy of compressed air.

The braking process is implemented using the load of the hydraulic motor, which is fixed by an electric clutch with the compressor, by changing the revolutions of the hydraulic motor, we change the operation of the compressor.

The experimental stand is designed with: pneumatic energy storage system compressor C1, mobile machine compressor C2, filter moisture separator MS, pneumatic distributor 2/3 with pressure valve P1, hydraulic distributor 2/4 with proportional control P2, pressure gauge M1 - M5, receiver RS, pump station PS, motor M, pressure valve PV, valve Fa, check valve RV, filter F, tank T.

The hydraulic part ensures the braking process, with the help of a 2/4 hydraulic distributor with proportional control, which supplies liquid to the tank, and the other part through the system further to the pressure valve, with the help of which we change the pressure in the compressed air energy storage system and set the load on the hydraulic motor changing its rotation frequency.

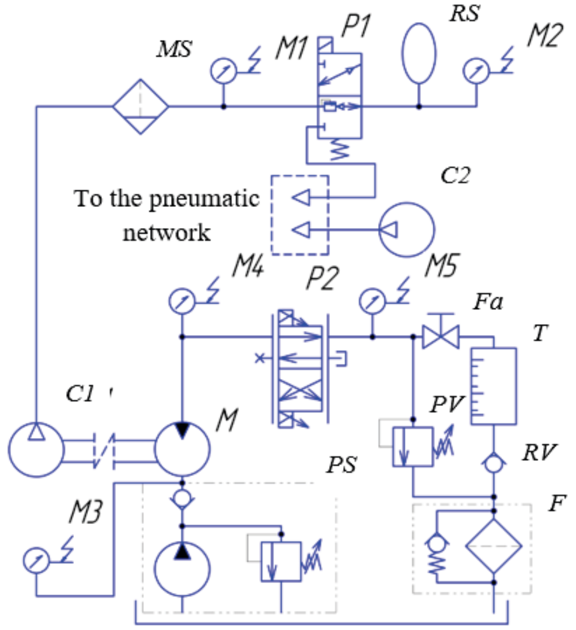

Fig. 3. *A stand for researching the effectiveness of the system for converting kinetic energy into compressed air energy*

(C1 – compressor, C2 – mobile machine compressor, MS – moisture separator filter, P1 – pneumatic distributor 2/3 with pressure valve, P2 – hydraulic distributor 2/4 with proportional control, M1 – M5 – manometer, RS – receiver, PS – pump station, M – motor, PV – pressure valve, Fa – faucet, RV – non-return valve, F – filter, T – tank)

During the development of the stand, the necessary calculations of hydraulic and pneumatic components were carried out. This made it possible to choose pneumatic and hydraulic equipment of the necessary characteristics to ensure the flexibility of the laboratory stand. High flexibility allows conducting field studies in wide ranges of input parameters of the system.

CONCLUSION

The developed experimental stand will allow to evaluate the efficiency of the compressed air energy recovery module.

The proposed method of combining different types of energy carrier allows to evaluate the efficiency of the compressed air energy recovery module in a wide range. This will make it possible to choose rational modes of operation of the recuperation system and, due to the control of the controller, ensure higher efficiency of the system.

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