PUMP PART OF THE HYDROSTATIC SYSTEM FOR KINETIC ENERGY RECOVERY OF VEHICLE

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The paper deals with a part of the hydrostatic system for kinetic energy recovery of vehicles equipped with mechanic-hydraulic drive, namely with the pump part. A description of its use at experimental stand and at experimental vehicle – a pneumatic road roller for finishing the road surface – is introduced. Basic hydraulic and simulation diagrams and examples of simulation results and measuring are shown.

Keywords: *energy recovery, hydrostatic vehicle, drive pump, simulation*

1. Introduction

It is not desirable to waste kinetic energy during mechanical braking of heavy horse commercial vehicles operating in start-stop regime, i.e. with frequent start and stop, but to save this energy and subsequently to use it during the following start [1, 2, 3, 6, 8]. In this paper, attention is paid to the pump part of such a hydrostatic recovery system.

2. The purpose and structure of the pump part of the hydrostatic system for kinetic energy recovery

The purpose of the hydrostatic recovery system is to store kinetic energy of a decelerated vehicle in hydraulic accumulators and to use this energy during the following acceleration of the vehicle. In our case, this vehicle was a pneumatic road roller AMMANN 240 H. A substantial part of the mechanic-hydraulic drive system of the vehicle is **the pump part of the hydrostatic recovery system of kinetic energy** (PPHR). PPHR contains a pump with a drive and control. PPHR is a source of compressed liquid that by means of hydraulic motor drives the vehicle.

3. The PPHR used in the experimental stand

Prior to development an application of the system of hydrostatic recovery of kinetic energy, an experimental stand for testing of recovery principle and optimization of the system was created

Basic parameters of the used pump

The used axial piston pump with proportional flow control (see Fig. 1) was driven by means of an asynchronous electric motor, 22 kW. The electric motor was connected to the

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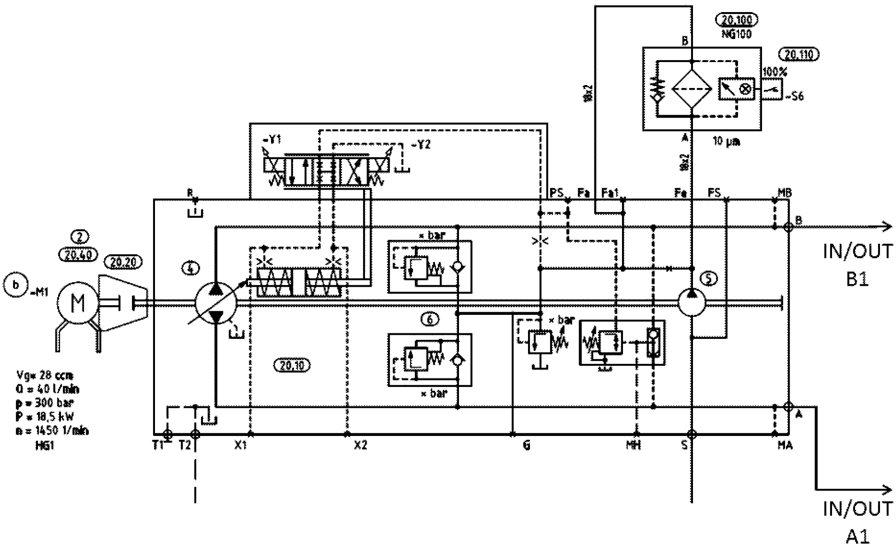

Fig.1a: The hydraulic scheme of the pump block

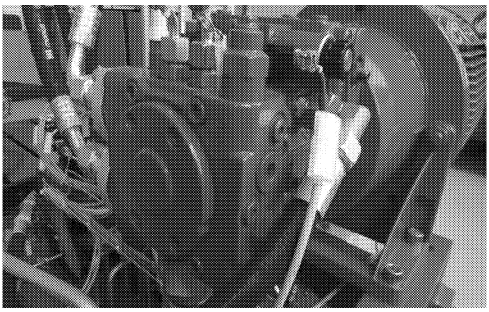

Fig.1b: The pump block on the stand

operating parametr	value	unit
geometric diplacement, V_{g}	28	$\mathrm{cm}^3/\mathrm{rev}$
maximum flow, Q	40	l/min
maximum static pressure, p	30	MPa
nominal power, P	18.5	kW
nominal velocity, n	1450	min^{-1}

Tab.1: The parameters of the pump

pump via an elastic couple. The pump block was connected to the valve block and to the tank.

4. The PPHR model of the stand and its results

A simplified scheme of the stand for hydrostatic recovery of kinetic energy equipped with a controlled pump is introduced in Fig. 2 where PPHR corresponds the left third of the figure. Kinetic energy of vehicle is here represented by energy of the flywheel, the working fluid pulses during recovery between the high pressure accumulator and the low pressure accumulator. A more detailed description can be found e.g. in [6, 7]. According to the above mentioned scheme, a simulation model was prepared [4, 5]; this model also contains a PPHR model.

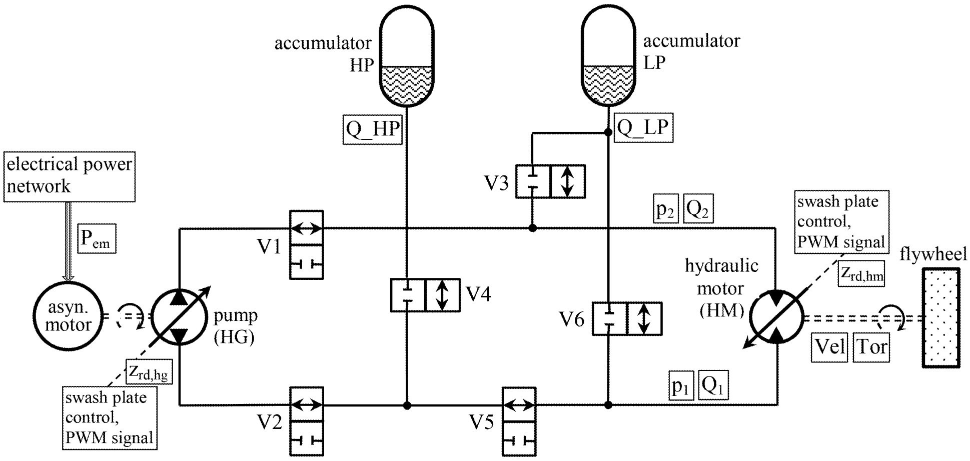

Fig.2: Simplified scheme of the PPHR with a controlled pump

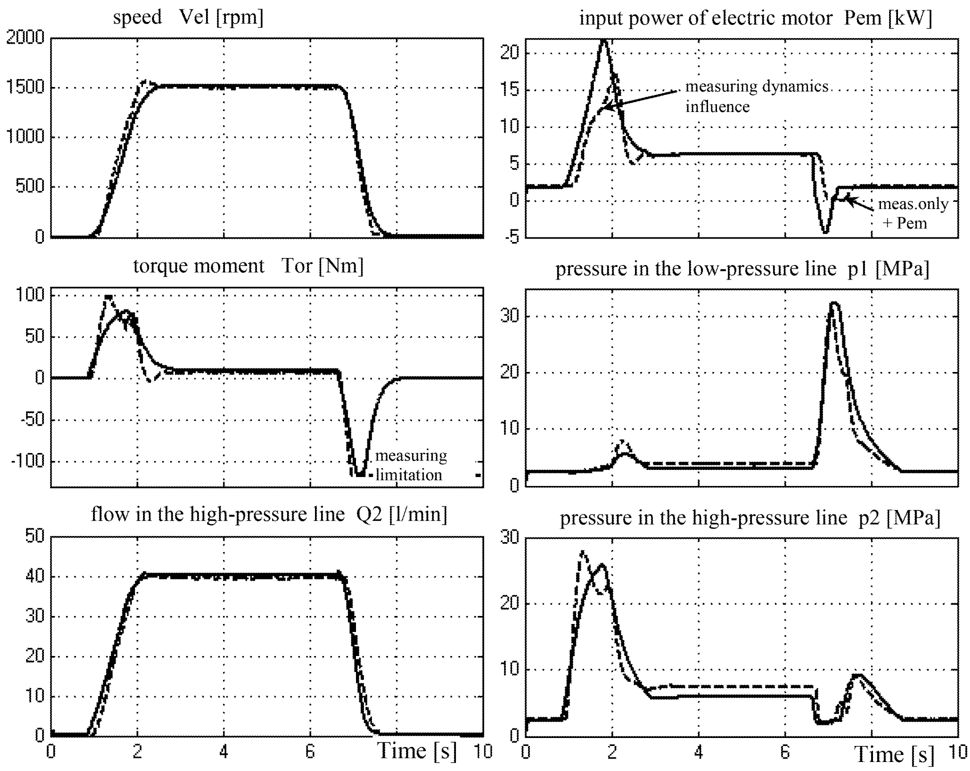

Fig.3: Simulated (full line) and measured quantities (dashed line) during acceleration and stop

Results of measurements and evaluation of results

By means of the experimental stand, a lot of experiments were performed measuring of the most important quantities. A relatively extended simulation model was also created and a number of operation states were simulated. A description of the test is beyond the extent of this paper and therefore an example of coincidence of measured and simulated quantities is at least shown on the case of acceleration and stop of drive.

5. PPHR used in the road roller AMMANN AP 240 H

5.1. Basic parameters of the used pump

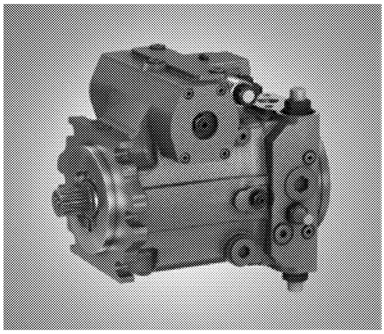

Fig.4: Pump used in the road roller AMMANN AP 240H

operating parametr	value	unit
geometric diplacement, V_g	105	cm^3/rev
maximum flow, Q	231	l/min
maximum static pressure, p	50 (2200 rpm)	MPa
nominal power, P	238	kW
nominal velocity, n	3150	rpm

Tab.2: The parameters of the pump

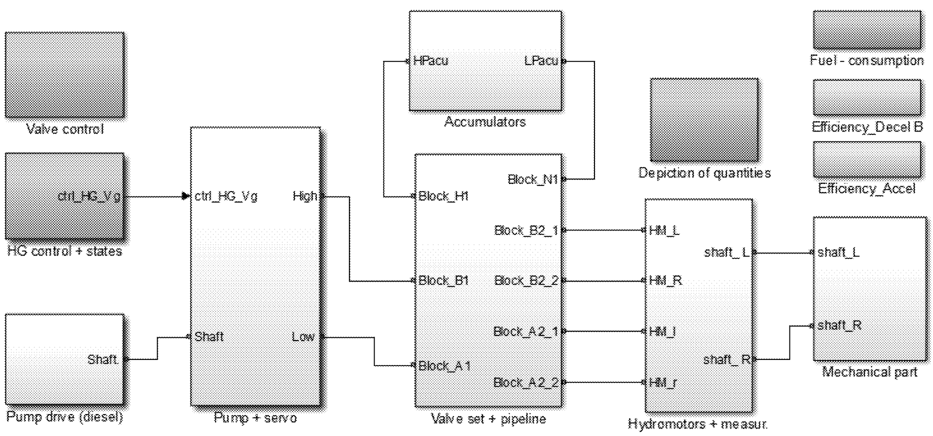

Fig.5: Embodiment of the pump subsystem into the whole model of the roller (3 shadowed blocks on the left hand side)

5.2. The PPHR model of the roller and its results

The PPHR model of the road roller is shown in Fig. 5 in Matlab/Simulink. Each form of shown blocks represents a more complicated structure hidden beneath it.

The pump part is included in the second column on the left hand side. Its input is denoted as Low, the output as High. Control signals (HG control + states) and diesel motor

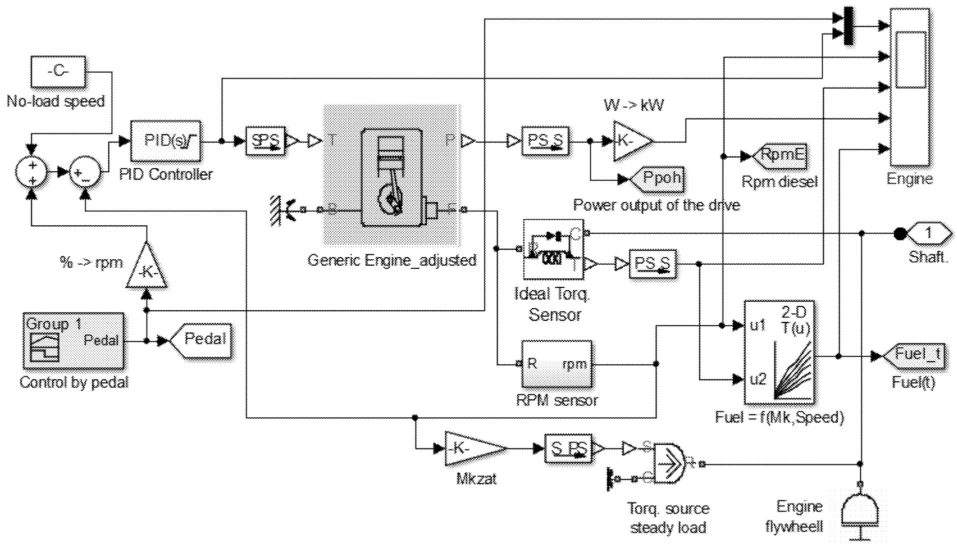

Fig.6: Model of diesel engine drive of the pump, including accessories and fuel consumption measurement

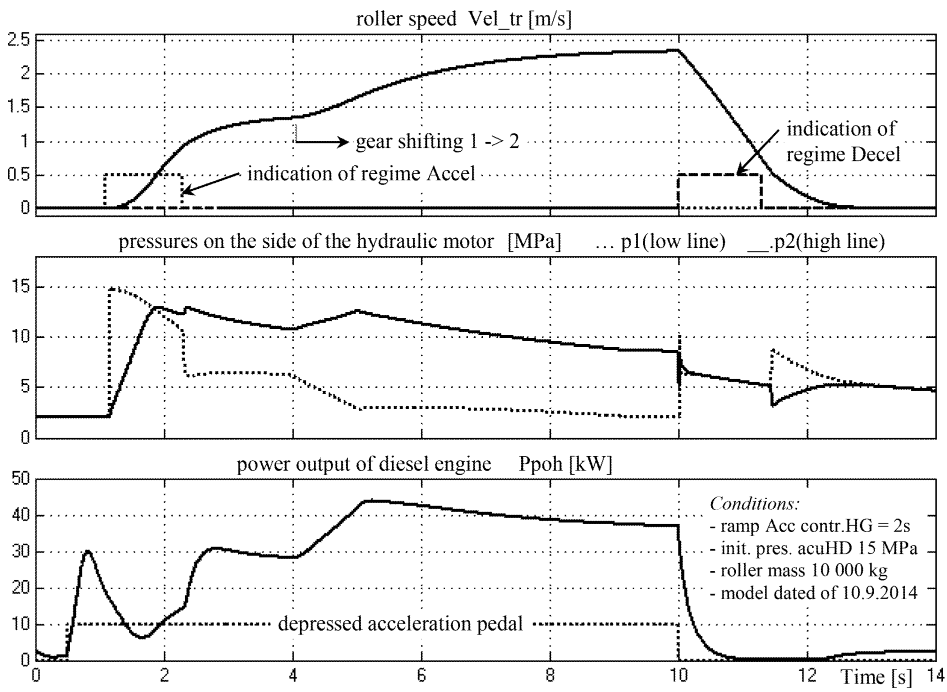

Fig.7: Start and stop of the roller, an example of simulated quantities courses

drive signals enter this block on the left hand side. On its right hand side, the block is connected to the valve block by the low pressure branch and the high pressure branch.

In Fig. 6, which shows the model of the pump drive carried out by diesel engine, the central element is a diesel engine model.

An example of simulation results can be seen in Fig. 7 showing the courses of selected quantities during start and hydrostatic braking. In this example, one can follow e.g. a link between the oil pressure of hydraulic motor and depressing of acceleration pedal.

5.3. Measuring results and evaluation of results

An example of courses of selected measured quantities during the cyclic run of the roller can be seen in Fig. 8. The regime Accel represents a regime of start, the regime Decel represents a regime of hydrostatic braking; index 1 denotes a forward drive, index 2 denotes a backward drive.

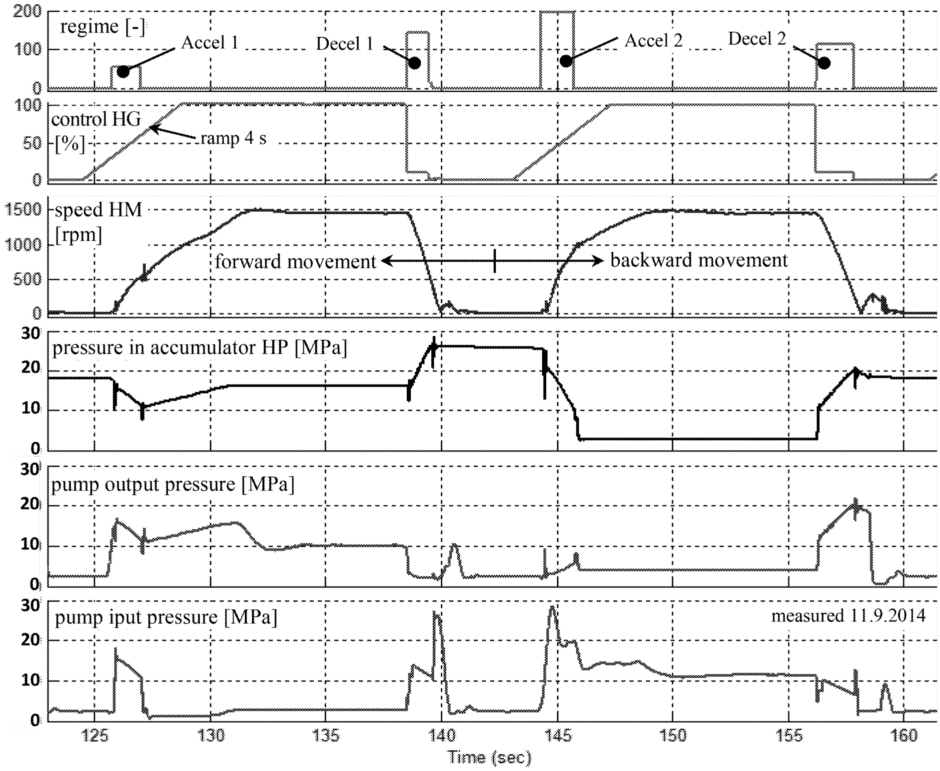

Fig.8: Measuring of cyclic run of the roller with energy recovery (roller mass: 18049 kg)

6. Evaluation of the results

The results of measuring and simulation were sufficiently precise, they are compatible and were used for wholesale design of the pump part of the hydrostatic system for kinetic energy recovery of vehicle.

7. Conclusion

As it is obvious from the course of the solution, the pump part of the hydrostatic recovery system of kinetic energy developed for the experimental stand proved to be suitable as the first stage of the follow-up development and research of pump part of the hydrostatic recovery system of kinetic energy for the road roller. For these cases, a working method turned out to be a combination of computer modeling, simulation and experimental verification of technical quantities of designed pump parts of hydrostatic systems of kinetic energy recovery, both for the stand and the experimental vehicle.

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