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# MODELING OF ROAD ROLLER DRIVE EQUIPPED WITH HYDROSTATIC RECOVERY OF KINETIC ENERGY

Z. Němec*, J. Nevrlý**

**Abstract:** *The present article substantiates and describes the creation of drive model of a road roller equipped with hydraulic recovery of kinetic energy. The article introduces technical parameters of the roller, a scheme of the recovery system, a scheme of the closed hydraulic circuit of the roller, a simulation model of the pump driven by diesel engine, an example of simulation results – time courses of model quantities - and evaluation of model results.*

**Keywords: Modeling, Roller, Drive, Hydrostatic, Recovery.**

## 1. Introduction

The international project "Recovery hydrostatic module for commercial vehicles", EUREKA CZ LF12029, was solved by Brno University of Technology in cooperation with the German company Bosch Rexroth and the Swiss company AMMANN. Mathematical modeling and computer simulation were chosen to deal with the task. For this purpose, the road roller AMMANN AP 240 H (Nevrly, 2015), a product of the Swiss company AMMANN, was selected as an experimental vehicle.

## 2. Basic parameters of road roller AMMANN AP 240 H

The road roller AMMANN AP 240 H (Nemec, 2014), a product of the Swiss company AMMANN, is a pneumatic roller for finishing of road surfaces. A structure of the roller has a basic frame of modular type on which the driver´s cabin is situated, space for a ballast reservoir and an ICE.

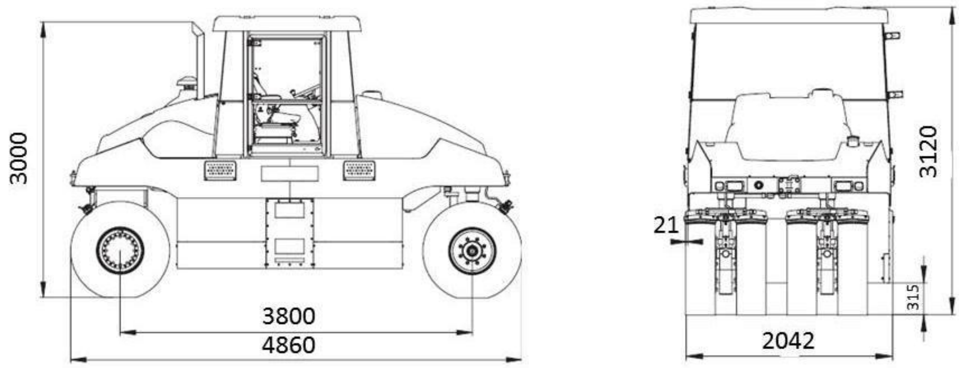


*Fig. 1: Road roller AMMANN AP 240 H, basic dimensions of the roller.*

## 3. Scheme of recovery system, scheme of hydraulic circuit of roller

A high–pressure accumulator (Fig. 2) accumulates the kinetic energy of the road roller during braking and delivers this energy back to the hydraulic motor during acceleration of the roller.

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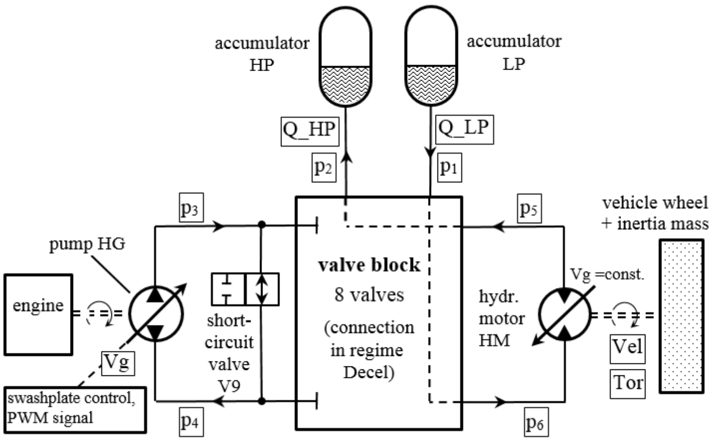


*Fig. 2: The basic scheme of the recovery system.*

The scheme of hydraulic circuit of the roller with the hydrostatic recovery module can be seen in Fig. 3 (regime ACCEL – acceleration). The internal combustion engine (ICE) driving the pump which delivers pressurized oil to the hydraulic circuit can be seen in the figure on the left. This oil then drove two hydraulic motors of the drive (in the figure on the left). The hydrostatic recovery module was connected to the existing hydraulic circuit of the roller as auxiliary equipment. The valve control block can be seen in the figure inside of the dashed rectangle.

Further operation regimes DECEL (braking) and FREE RUN (idle run, see as well in Fig. 5) are described in (Nevrly, 2015).

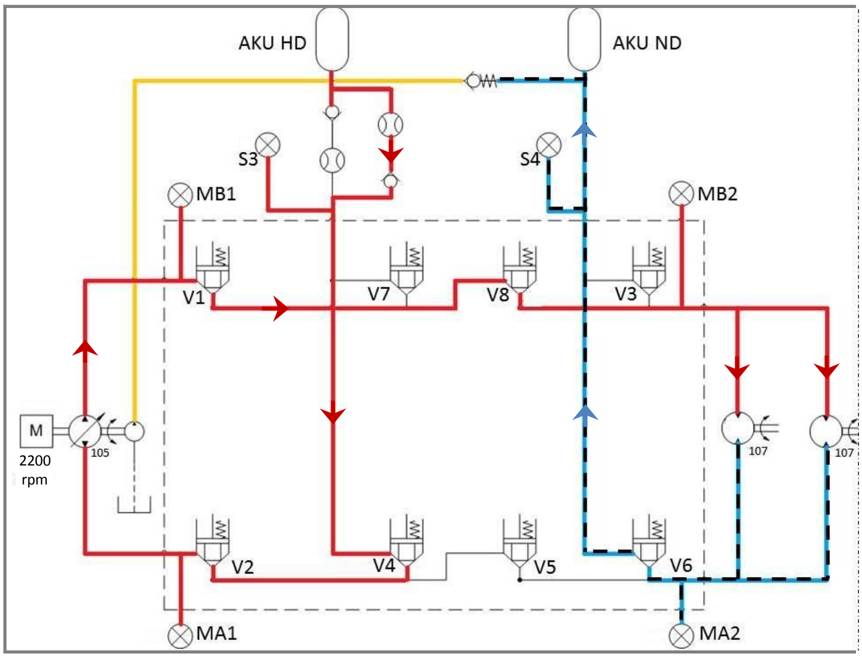


*Fig. 3: The scheme of the circuit of the roller with hydrostatic recovery module (regime ACCEL).*

## 4. Mathematical model of drive

Computer simulation (Nemec, 2016; Filipi, 2010; Stecki, 2002 and Nevrly, 2014) by software Matlab/Simulink was used to model a diesel engine pump drive. The required simulation model of diesel engine drive of the pump can be seen in Fig. 4. This model was created to analyze a fuel consumption in greater detail as well.

The main part of the roller drive model is a model of diesel engine pump drive (Fig. 4). In this case, the central member is a model of diesel engine (Generic Engine modified) which is controlled by a PD controller and connected to a torque sensor.

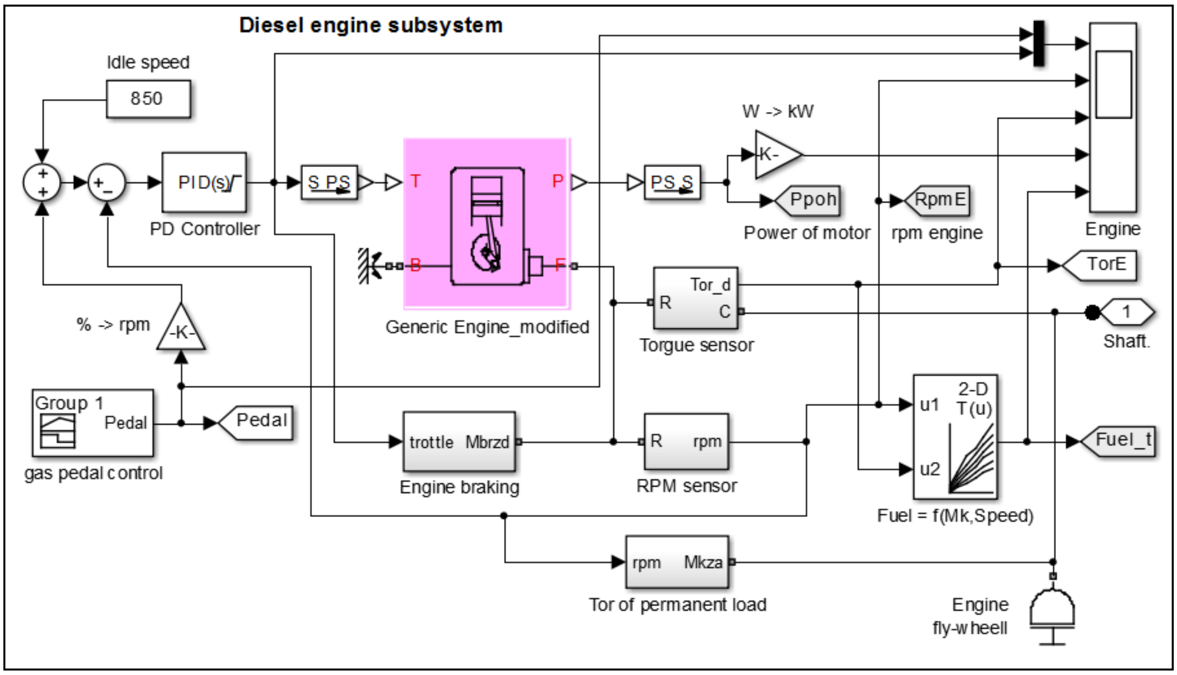


*Fig. 4: Simulation model of diesel engine pump drive.*

## 5. Computer simulation of drive

Fig. 5 illustrates the courses of valve control, pump activation, speed of hydraulic motor, speed of diesel engine, values of pressure (1 bar = 0.1 MPa) in front of hydraulic accumulators of the recovery system (see in Fig. 2).

The left part of the figure shows the acceleration of the road roller which is apparent from speed growth (the third course from above). Valves activation of the regime Accel (use of accumulated energy) can be seen in the first row from above. Growth of diesel speed is apparent in the fourth course from above. This growth is initiated by moving the pedal. Delivery of energy from high pressure accumulator is apparent from the drop of pressure $p_2$.

The right part of the figure also contains speed; a steeper course of diesel engine speed and hydraulic motor speed is connected with active braking due to energy recovery. Growth of pressure $p_2$ illustrates charging of the high-pressure accumulator. The simulated courses are in reasonable agreement with the measured ones.

Measurement of fuel consumption was carried out by means of repeated tests (Nevrly, 2015) during drive on a defined test route, practical tests of the roller equipped with energy recovery were carried out during field tests.

Operating travel speed of the road roller is very low compared with some other commercial vehicles working in start-stop regime, e. g. with garbage vans, city buses, etc. Kinetic energy of vehicle translation movement, as is well known, decreases with the square of the vehicle speed. In spite of this, due to energy recovery, more than 25 % of fuel was saved at vehicle speed of mere 8.6 km/h.

## 6. Conclusion

Modeling of road roller drive equipped with hydrostatic recovery of kinetic energy was an essential part of the model of the entire road roller. This model and its parts served as a tool for design optimization. The result – fuel savings of up to 25 % at vehicle speed of only 8.6 km/h - is considered as unique. It proves that modeling is a way of how to increase effectiveness of hydrostatic recovery of kinetic energy and decrease fuel consumption.

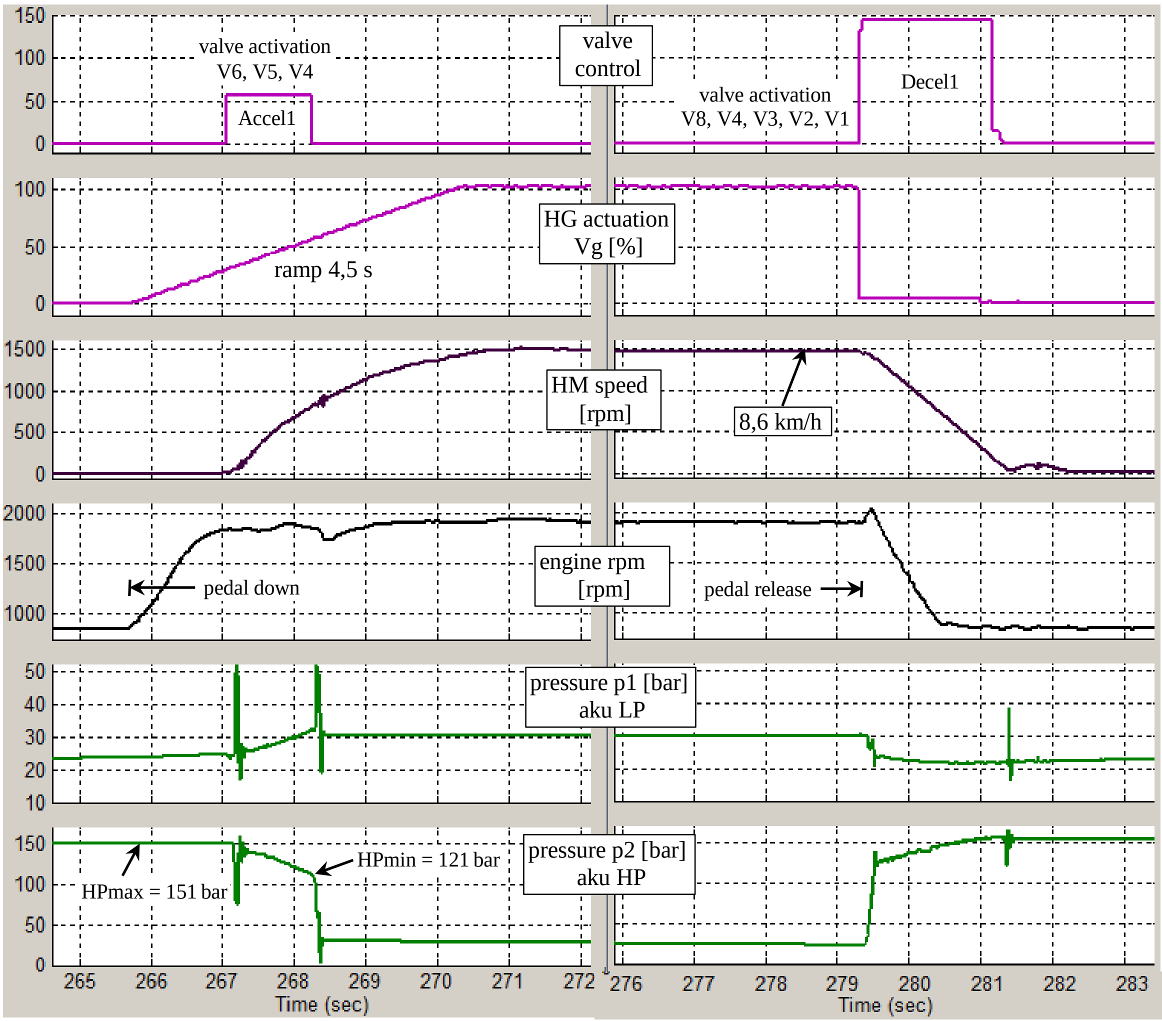


*Fig. 5: Example of start and stop with weight load using energy recovery.*

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