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March 16, 2021

SIMULATION OF THE OPERATING MODES OF THE PROPOSED EQUIPMENT WHEN LOADING THE EXTERNAL CIRCUIT OF THE WORKING HYDRAULICS IN TRACTOR

Juraj Jablonický¹, Peter Kožuch¹, Ľubomír Hujó¹, Romana Janoušková¹, Matej Michalides¹

¹Slovak University of Agriculture in Nitra
Faculty of Engineering
Department of Transport and Handling
Tr. A. Hlinku 2, 949 76 Nitra
Slovak Republic
xkozuchp@uniag.sk

ABSTRACT:

The aim of the presented article is to verify the automatic and manual operating mode of the proposed measuring device for loading the external circuit of the working hydraulics of the tractor in the simulation program FluidSim. Before starting the simulation, it is necessary to select the individual parameters of the tested hydrogenerator UD 20, which is specified by the manufacturer, and to create a simulation model of this device according to the design. The device allows measurements to be made in automated mode by means of an electro-hydraulic proportional valve and in manual mode by means of a throttle valve. In the simulations in both operating modes, the flow rates at increasing speeds and constant pressures from the simulations were compared with the data provided by the hydrogenerator manufacturer. By comparing the data, it is possible to see negligible percentage differences, which are caused by the increasing temperature of the working fluid and the internal resistance of the hydrostatic transducer and filter. From these findings it follows that the proposed electromechanical device meets all the specified requirements and during real operational tests of the tractor hydraulics, its function will be correct.

Keywords: *hydrogenerator, flow characteristic, simulation, tractor, hydraulics*

1. INTRODUCTION

Mechanization in agriculture and related activities are constantly advancing, resulting in improvements and the development of new hydraulic systems or components that are part of the working hydraulics of the tractor, as well as other working machines such as handling and forestry. The development and improvement of hydraulic systems would not be possible without quality research in the field. Current agricultural machinery and equipment is at a high technical level, which means that even measuring and diagnostic technology must meet adequate requirements for the technical level and sophistication of agricultural machinery [1, 2, 3, 4]. In the past, with a lower level of electrification of

hydraulic systems of agricultural technology, simpler and less demanding measuring devices were sufficient to perform either laboratory or operational tests of hydraulic systems. With the growing trend of development of hydraulic systems, it is necessary to improve the measuring technique. Current measuring devices use a high degree of electronization and automation, not only for measuring, but also for recording and evaluating measured values [5]. These devices are subject to ever-increasing requirements, especially in recording data online or in databases for more time-consuming tests of hydraulic systems, repeatability of measurements and elimination of inaccuracies, or errors in the measurement of hydraulic systems [6, 7, 8].

2. SIMULATION MODEL OF MEASURING DEVICE

Before performing simulation processes in manual as well as automated loading mode, it was necessary to enter the characteristics of individual components and hydraulic fluid in accordance with the technical specifications into the simulation program.

The simulation process of loading the external circuit of the tractor's working hydraulics can be performed in two modes in accordance with the design of the electromechanical loading device. Both simulation processes must be able to assess the safety function of the safety valve on the external circuits of the tractor's working hydraulics when it is loaded above the permissible pressure value in our case above 20 MPa. They must also be able to measure the nominal value of the hydrogenerator flow with the required accuracy. In the event of a fault in the safety valve on the external circuit of the tractor's working hydraulics, the device must be secured against damage by its own safety valve, which is set to the maximum permissible pressure value of 20 MPa. The operation of the proposed electro-mechanical device for loading the external circuit of the working hydraulics of the tractor was verified in the simulation program FluidSIM. Based on the design of the loading device, a simulation model of the tested device was compiled. The model shown in Fig. 1 consists of the following parts:

- simulation model of the external circuit of the working hydraulics of the tractor,
- simulation model of the electro-mechanical device for loading the external circuit of the working hydraulics of the tractor,
- electrical control circuit of the electro-hydraulic proportional valve.

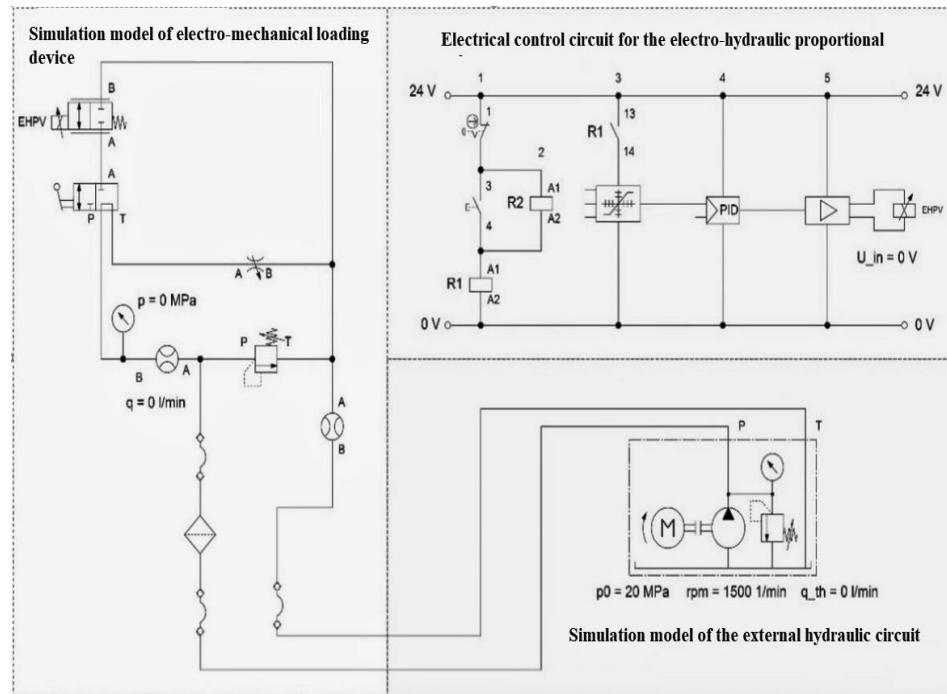


Fig. 1. Model of simulation of loading of external circuit of working hydraulics of tractor

The simulation model of the external circuit of the working hydraulics of the tractor consists of a hydrogenerator connected to the drive, which is secured against overload by a safety valve, which is set to a pressure of 20 MPa. The setting of the maximum working pressure of 20 MPa is based on the real conditions under which the hydraulic system of the tractor works. Several authors [9, 10, 11] deal with the dependences of working pressure and flow of a hydrogenerator during tests of hydraulic transducers in agricultural tractors. The above simulation model consists of all the components shown and described in Fig. 1, but is supplemented by another digital flow meter, which is included in the return line. As stated [10] electro-hydraulic proportional valve is used to create a simulated load is controlled by an electrical circuit, whose software and hardware was solved in cooperation with the Department of Electrical Engineering, Automation and Informatics, Faculty of Technology, Slovak University of Agriculture in Nitra.

2.1. Manual mode simulation

When simulating the manual load mode of the tractor's external working hydraulic circuit, the three-way valve is switched so that hydraulic fluid flows from the tractor's external working hydraulic circuit towards the throttle valve, as shown in Fig. 2. Manual mode also serves to heat the hydraulic fluid to operating temperature. Several authors

[12, 13] deal with the evaluation of hydraulic fluids depending on temperature and pressure. Both authors found that operating parameters, especially temperature and pressure, affect the working fluid and subsequent measurements.

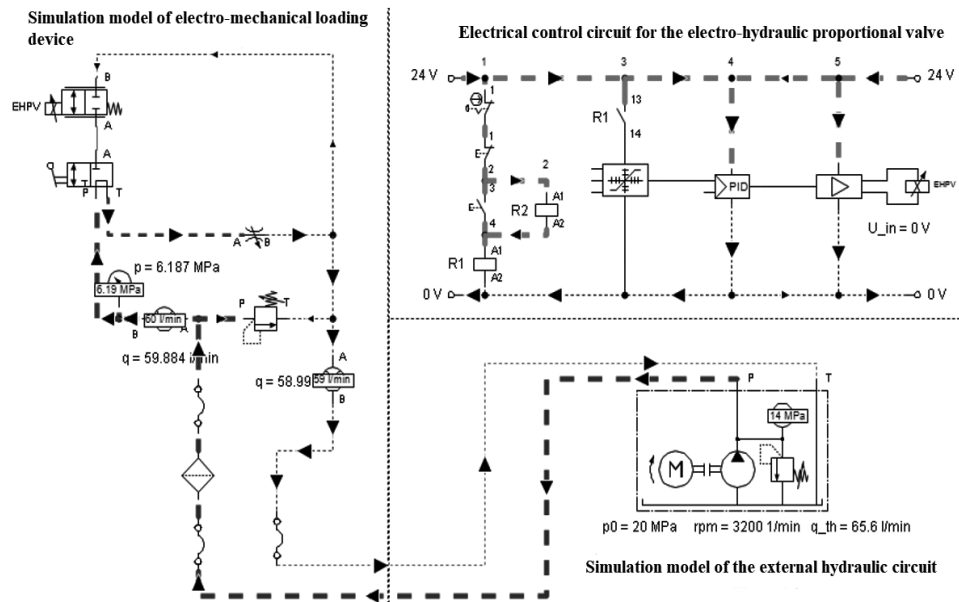


Fig. 2. Simulation of the load of the external circuit of the working hydraulics of the tractor - manual mode

To verify the simulation in manual mode, in Tab. 1 shows the recorded flow values at increasing hydrogenerator speeds, which are compared with the flow values given by the hydrogenerator manufacturer. Flow is important to monitor with regard to the assessment of the technical condition of the monitored hydrogenerator [14]. The flow values were determined at no load and the differences in the simulation values and the manufacturer's values are due to the increasing temperature of the working fluid and the pressure recorded during the simulation and is caused only by the internal resistance of the hydrostatic transducer, filter and piping. The negative difference in the compared flow values is caused by the temperature of the working fluid which affects the viscosity of the working fluid used.

Table 1. Comparison of values from the simulation in manual mode

Speed, nHG, min-1	Hydrogenerator flow, QHGV, dm ³ /rpm	Flow during simulation, QHGS, dm ³ /rpm	Difference, %
500	9.92	10.12	-1.97
750	14.88	15.09	-1.39
1000	19.84	20.02	-0.90
1250	24.80	24.89	-0.36

1500	29.75	29.72	0.10
1750	34.71	34.50	0.84
2000	39.67	39.23	1.10
2250	44.63	43.92	1.60
2500	49.59	48.56	2.08
2750	54.55	53.17	2.53
3000	59.51	57.73	2.99
3200	63.48	61.35	3.36

2.2. Automatic mode simulation

In the simulation in the automated loading mode of the tractor's external working hydraulic circuit, the three-way valve is switched so that hydraulic fluid flows from the tractor's external working hydraulic circuit towards the electro-hydraulic proportional valve as shown in Fig. 3.

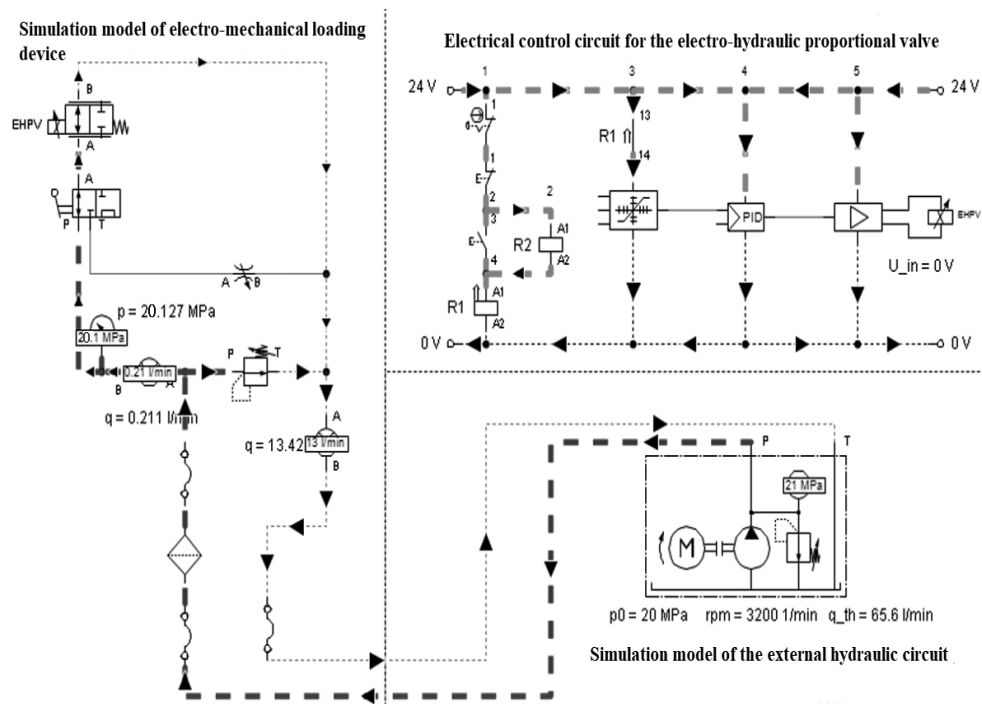


Fig. 3. Simulation of the load of the external circuit of the working hydraulics of the tractor -automatic mode

To verify the simulation in automated mode, in Tab. 2 shows the recorded flow values at increasing hydrogenerator speeds, which are compared with the flow values given by the hydrogenerator manufacturer. The flow values were determined at no load and the

differences in the simulation values and the manufacturer's values are caused by the increasing temperature of the working fluid and the pressure recorded during the simulation and is caused only by the internal resistance of the hydrostatic transducer, filter and piping. The negative difference in the compared flow values is caused by the temperature of the working fluid which affects the viscosity of the used working fluid.

Table 2. Comparison of values from the simulation in automatic mode

Speed, nHG, min-1	Hydrogenerator flow, QHGV, dm ³ /rpm	Flow during simulation, QHGS, dm ³ /rpm	Difference, %
500	9.92	10.13	-2.07
750	14.88	15.12	-1.59
1000	19.84	20.07	-1.15
1250	24.80	24.97	-0.68
1500	29.75	29.80	0.17
1750	34.71	34.64	0.20
2000	39.67	39.41	0.66
2250	44.63	44.15	1.08
2500	49.59	48.58	2.04
2750	54.55	53.41	2.09
3000	59.51	58.14	2.30
3200	63.48	61.81	2.63

Based on the specified requirements, this proposed device can be used in long-term tests focused on the effect of used hydraulic fluids on the wear of elements in the hydraulic system depending on their flow characteristics, as well as to monitor the contamination of applied hydraulic fluids in the hydraulic operating circuit. Several authors [15, 16, 17] state that the pollution of the used liquid has a great influence on the operation of the device. At the same time, according to the author [18] the physico-chemical composition of the used hydraulic fluid also has an effect on the wear of the elements. The main advantage of this technical solution is the possibility of simulating the operating load of hydraulic systems of agricultural, forestry and handling equipment through an electrohydraulic proportional valve and ensuring the repeatability of tests in scientific research.

3. CONCLUSION

The development of hydraulic systems is constantly advancing and hydraulic systems are characterized by a high degree of precision in production. For these reasons, the precise engineering production of individual elements of the hydraulic circuit is important, where it is important to monitor the accuracy of CNC machine tools using new methods and trends [19, 20, 21]. Therefore, it is important to introduce and use more accurate measuring techniques in testing the tractor hydraulics. When comparing the flow values from the FluidSim simulation program and the values given by the

manufacturer in both operating modes, it can be seen These differences are caused by the increasing temperature of the working fluid, which affects the viscosity of the fluid used, as well as the increase in pressure caused by the internal resistance of the hydrostatic transducer, particulate filter and piping. The percentage differences between the compared flow rates from the simulation and the flow rates from the manufacturer are negligibly small and it can be argued that, based on the specified requirements, the designed equipment can be measured with sufficient accuracy during in-service tests.

4. ACKNOWLEDGEMENTS

This publication was supported by the Operational Program Integrated Infrastructure within the project: Demand-driven research for the sustainable and inovative food, Drive4SIFood 313011V336, cofinanced by the European Regional Development Fund. This work was supported by project VEGA 1/0155/18 „Applied research of the use of ecological energy carriers in agricultural, forestry and transport technology.” This work was supported by project KEGA 028SPU-4/2019 „ Practical utilization of design and testing knowledge of transmission systems of hydraulic mechanisms of mobile agricultural and forestry machinery.”

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