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HYDROMECHANICAL AUTOMATIC TRANSMISSION

This contribution describes some tests of hydromechanical infinitely variable transmission (IVT) on a test stand. Further, there is described a truck with installed IVT and tests of this IVT at real conditions. There is also shown a control system of the IVT.

1. Introduction

Some parts of research activity at the Department of design and machine elements are oriented on gears, gearboxes, elements of gears and also on hydraulic gear based on torque converter and hydrostatic gear in parallel and combined connection, where the power flow is split to two or more branches. There was a test stand designed for the whole transmission contained combustion engine, the front-end and tandem gearbox and other parts.

The laboratory was already used for hydromechanical gearboxes tests before, e. g. for the new Zetor tractor gearbox with Powershuttle and Powershift and the IVT 150 gearbox for special mobile machines, SUV vehicles and trucks. The experimental tests of IVT 150 were made to describe different working modes with manual electronic regulation without any automatic control system. The deal of this regulation was to achieve the maximally efficiency of the transmission.

2. IVT Principle and Test Stand Measurement

The basic principle of the IVT 150 transmission is the usage of the torque converter in the parallel connection with differential hydrostatic gear with differential at the output (Fig. 1).

This principle allows to design a product that has satisfactory efficiency at the whole drive mode scope. The idea was to develop the gearbox through an innovative approach regarding the actual knowledge base [1].

After the kinematic scheme definition and documentation preparation, the first prototype was built. The IVT placed on the test stand is pictured in Fig. 2.

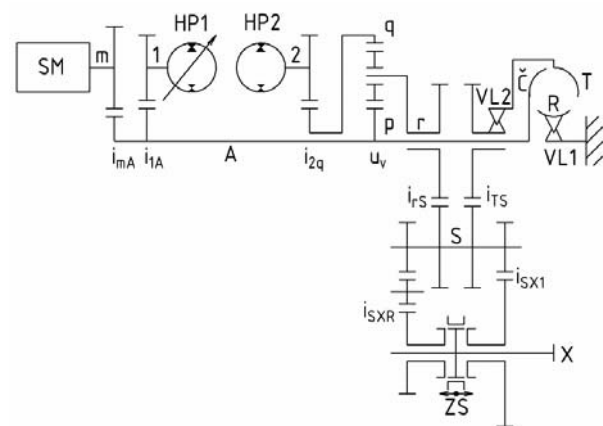


Fig. 1. IVT - Kinematic scheme of the transmission



Fig. 2. Gearbox at the test stand

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By vehicle acceleration from zero velocity, the maximum power is transmitted by the torque converter and small power is transmitted by the hydrostatic gear. This applies to gear ratio $i_{AX} = (\infty; 5)$ if

$$i_{AX} = n_{CE} / n_{OUT}, \tag{1}$$

where

n_{CE} - RPM of the combustion engine
 n_{OUT} - RPM of the output shaft of IVT 150.

While $i_{AX} = (5; 1.28)$, maximum power is transmitted by differential hydrostatic gear, the output shaft of the torque converter across freewheel does not transmit any power. The control system has to work especially at these two modes so the efficiency of the transmission gets the highest value.

The results from these measurements defined some possibilities how to control the gear ratio of the hydrostatic gear. This hydrostatic gear is operated by the electrohydraulic servovalve type MOOG. Electric current in the valve is directly proportional to the gear ratio (Fig.3).

Fig. 3 also represents the relation between the gear ratio and the current from 0 to 100 mA in regard to the displacement of the hydrostatic pump (HP1) regulation plate from -1 to +1 at maximum transmission efficiency.

This regulation curve is the base for the first design of a control system for gear change. This transmission control system needs the rpm sensor of the engine and the output shaft and the position sensor of the fuel rod. It needs neither a pressure sensor at hydrostatic gear nor a torque sensor.

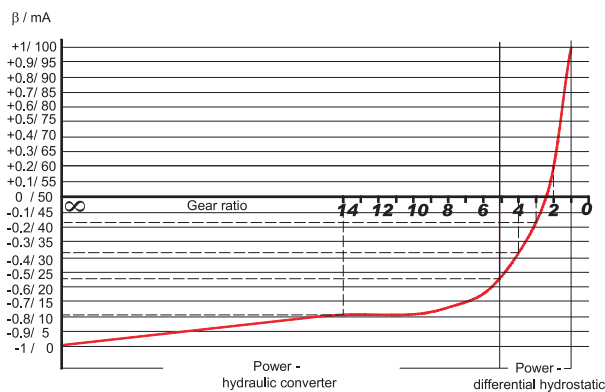


Fig. 3 Regulation curve and the current - gear ratio relation of the IVT

3. Test Truck

Installing the IVT 150 to a suitable vehicle was one of the alternatives of the transmission test at real conditions. The input

shaft of the IVT 150 needs to turn counterclockwise, maximum width of the variator is 700 mm and max. length is 960 mm. For these parameters, there was suitable an old vehicle - the Praga S5T truck, model year 1969. Its engine shaft is turning counterclockwise and the gear ratio of the fourth speed in the 4 - step manually Praga gearbox is -0,98 (according to the ratio of the test stand front-end gearbox).

The frame of the vehicle contains the Praga T912 engine. The engine parameters can be successfully simulated by the CFD analysis to obtain data for the mathematical simulation model based on Matlab Simulink platform [2]. Original is also the clutch and the 4-step gear-box working on the fourth gear only. The IVT 150 prototype was installed to the vehicle frame replacing the original propeller shaft. This solution represents the cheapest possibility how to test the IVT 150 in a vehicle with different control systems at real conditions.

Fig. 4 represents the frame of the Praga truck with the new IVT gearbox installed and Fig.5 gives the view of the overhauled truck after the first drive.



Fig. 4. The IVT 150 installed to the truck frame



Fig.5. Praga S5T - IVT test truck after the first drive

4. IVT Control system

The transmission control system contains a laptop, power electronic equipment, rpm sensors, position sensor of the fuel rod, oil temperature sensors, pressure sensors and sensor of the regulated hydraulic pump plate displacement. Data from the sensors and other parameters are recorded during the drive to the control computer. Fig. 6 represents the scheme of the control system working in the real time and developed in the Matlab Simulink Realtime toolbox.

By the first drive the truck diagnostic data recording was done. In Fig. 7 there is a data log, where:

- the red color represents RPM of the engine (scale 1:1),
- the green color represents RPM of the output shaft (scale 1:1),
- the brown color represents gear ratio i_{AX} (scale 100:1)
- the blue color represents position β of the hydraulic pump regulation plate (scale 1000:1).

The results show the continuously gear change, resp. the continuously acceleration of the vehicle by different RPMs of the combustion engine dependent on the fuel rod placement.

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- Research of kinematic a dynamic properties of runflat tyres and platform vehicle parts using the simulation - VEGA 1/3208/06

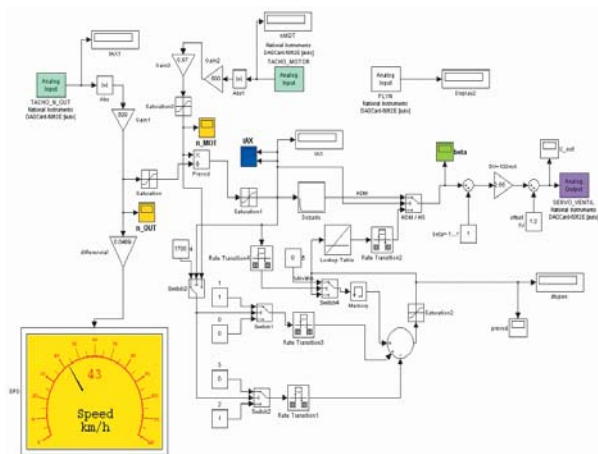


Fig. 6. View on the control panel

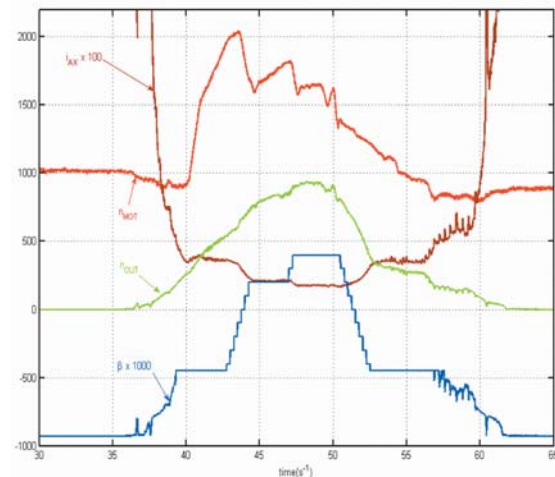


Fig. 7 Data log of the truck test

References

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[2] SOJCAK, D.: *Stirling Engine and a Simulation Possibility of its Basic Parameters by CFD*, FIK - Stirling 2007, 1-st collective volume, Zilina, ISBN 978-80-8070-788-0