THE APPLICATION AND MODELLING POSSIBILITES OF CVT IN TRACTOR

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Abstract:

The tractor transmission system has been changed from the single sliding gear type to the electro hydraulic and power shift and finally to the CVT types.

Our paper evaluates the new system and its advantages and represents the practical possibilities and the Hungarian experience of the CVT types through the examples of Fendt, Steyer, John Deere and Deutz-Fahr Systems we have already studied.

A comparison was made between the different types by the technical features and a field survey of 6 pcs tractor were used on a large-scale farm for transport, primary and secondary tillage.

Our final aim is develop a simulation model of CVT to manage the tractor-implement matching.

Key words:

CVT, Simulation, Driving system

1. INTRODUCTION

About 30 years ago, nearly all manufacturers have already conducted a series of experiments with stepless transmissions as an alternative to the Power Shift transmissions which had come to be standard in practice in tractor constructions. The reason for failure at the time lay chiefly in the poor draught efficiency.

This was changed quite suddenly in 1995 when **Fendt** presented the first large tractor with stepless transmission, the 926 Vario. Apart from the **Fendt** “Vario”, there are two further stepless transmissions for standard tractors on the market today. These are the “S-Matic” CVT/CVX transmission from **Steyr** and the “Eccom” from **ZF**. The two transmissions are currently being installed in tractors from **Case-IH** ad **Case-Steyr**, as well as from **John Deere** end **Deutz-Fahr**.

2. APPLICATION AREA

The classification of the different stepless transmissions (CVT) can be seen the next chart:

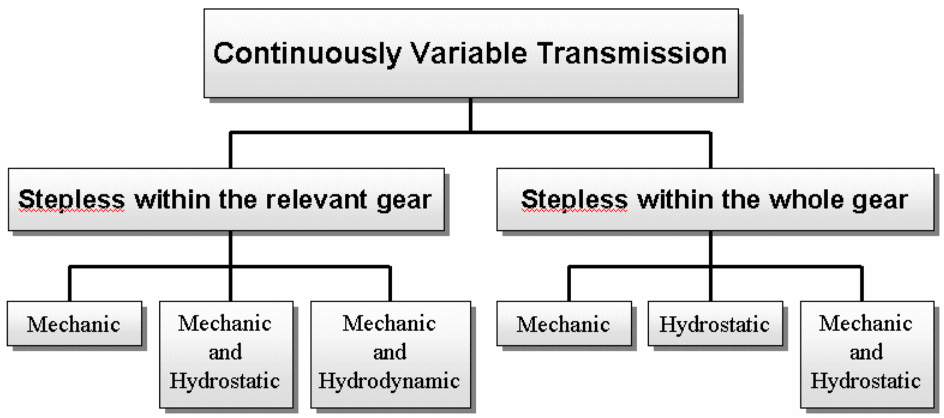

Fig. 1. Classification of the CVT's

Comparison of different types [4]:

Fendt transmission (tractor families 400,700, 800, 900)

A variable output hydraulic pump and two variable output hydraulic motors are at the core of the system. These work in combination with mechanical drive components, including a single planetary gear set on the power input side that progressively varies the proportion of drive delivered by the mechanical and hydraulic components (Fig. 2). At take-off the drive is fully hydraulic: at full speed the drive is fully mechanical.

The large hydrostat is combined with a 2-stage transmission for only two pre-selectable ranges, i.e. for fieldwork and transport work. It has only these two gears, and otherwise the hydrostat, which allows stepless speed setting from standstill to maximum speed in the relevant range, forwards and backwards.

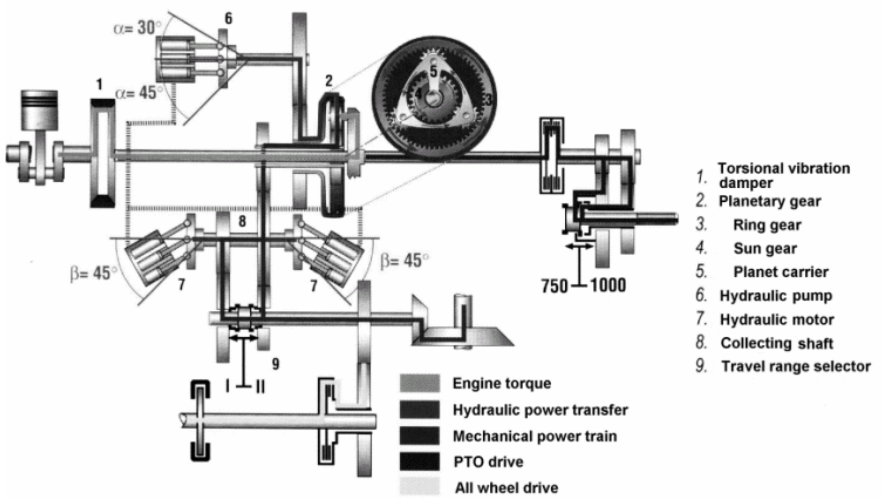

Fig. 2. **Fendt** "Vario" transmission

Steyr transmission (tractor families CVX, CVT)

The "S-Matic" transmissions are used in the types CVX and CVT by **Case-IH** and **Case-Steyr**. The four ranges are shifted at synchronous points using dog clutches. Reversing is also realized with the aid of a set of constant mesh planetary gears with direct drive during forward rides. **Steyr** and **ZF** use smaller hydrostats. The hydrostat simply has the function of modifying the speed steplessly within the relevant gear.

ZF transmission

John Deere 6420, 6620; 6820, 6920 are based on the **ZF** "Eccom" 1.5 and 1.8. The third CVT for **John Deere** 7010 has been developed by the tractor manufacturer in cooperation with Sauer-Sundstrand (45° bent axis units similar to those of Fendt-Sauer). **Deutz-Fahr** TTV tractor family.

3. RESEARCH COURSE

The investigation of driving systems of tractors is a complicated, time-consuming and costly project and can be completed by field or bench tests. Traditionally these tests are based on measurement, but the result of the new development of information technology, the simulation method (ITI SIM) can be extended to all levels of the driving system examinations (Fig. 3) [3]. This new method can be cost saving and give a chance to optimize the testing system.

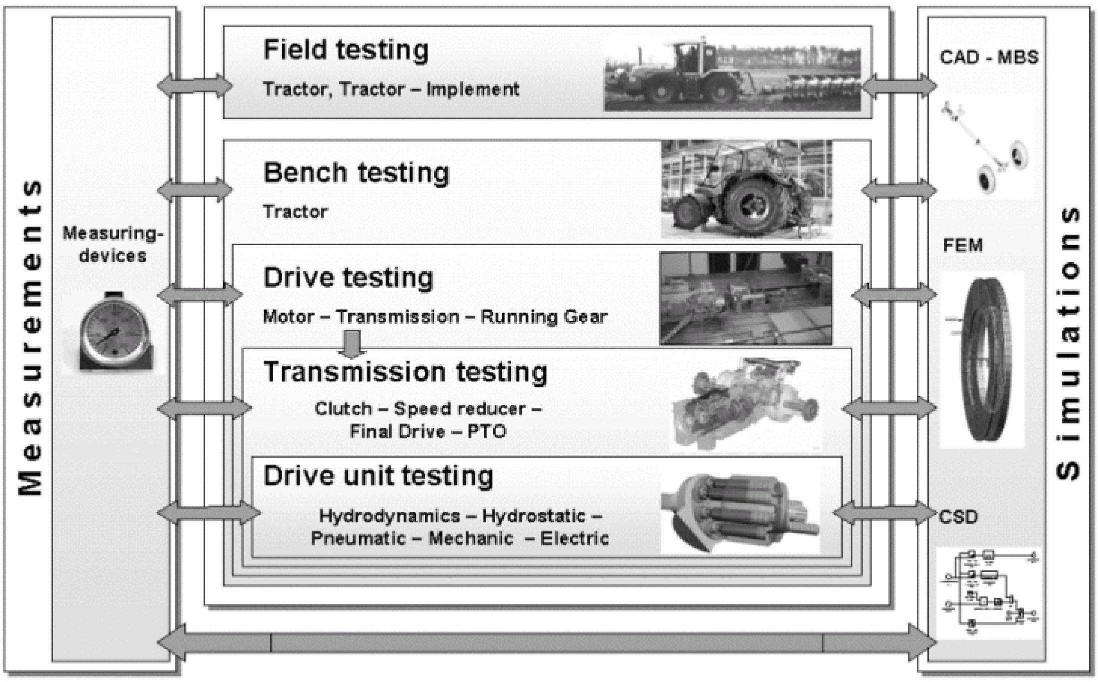

Fig. 3. Levels of the driving system testing

3.1 Results of the field testing

The survey was done with the 180-200 HP power range tractors from which 6 pcs was **Fendt** "Vario" and 6 pcs was conventional transmission (Power Shift) on the Boly Rt. between 1999-2000 years [2]. The tractors were used for transport, primary- and secondary tillage at the same condition. The results of the survey can be found the next table and charts.

Type of transmissions		1	2	3	4	5	6	Average
Power Shift	**(h)**	2115	2924	2447	1828	-	2700	12014
	(l)	70780	71025	69787	62737	-	68040	342369
	(l/h)	**33,4**	**24,3**	**28,5**	**34,3**	-	**25,2**	**28,5**
CVT (**Fendt** "Vario")	**(h)**	2713	3567	2730	2202	2199	2763	16174
	(l)	68943	72981	54064	54465	48749	62913	62115
	(l/h)	**25,4**	**20,46**	**19,8**	**24,7**	**22,1**	**22,7**	**22,4**

Table 1. Comparison of the tractors's fuel consumption.

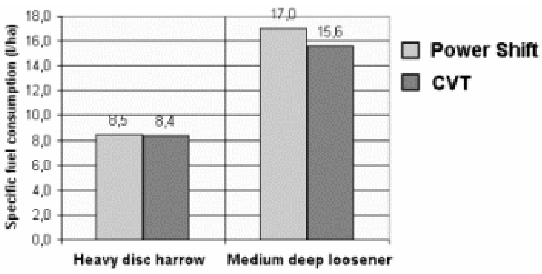

Fig. 4.Comparison of the tractors in the primary tillage

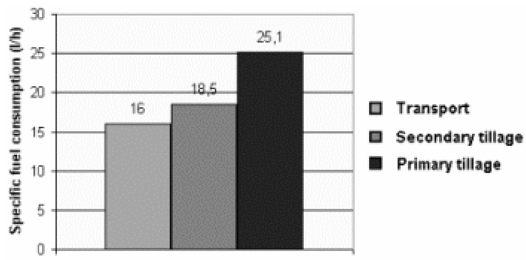

Fig. 5.Specific fuel consumption of the CVT tractors

3.2 Testing by Simulation

The CVT system should be tested completely. We investigated the effect of parameter change of the stepless speed setting done by hydrostatic unit on the elements of transmission. The model shown on Fig. 6 has 74 parameter [3]. On the chart can be seen the effect of hydrostatic pump's angle changing on the revolution of engine and the simulation mass models (Fig. 7).

Having the first result we want to develop the simulation model of engine and fuel injection system. Using this model we shell investigate and optimize the **John Deere** AutoPowr-Selector, which can be a tool to make an optimal control strategy of the different field operation (e.g.: ploughing, transport, PTO works).

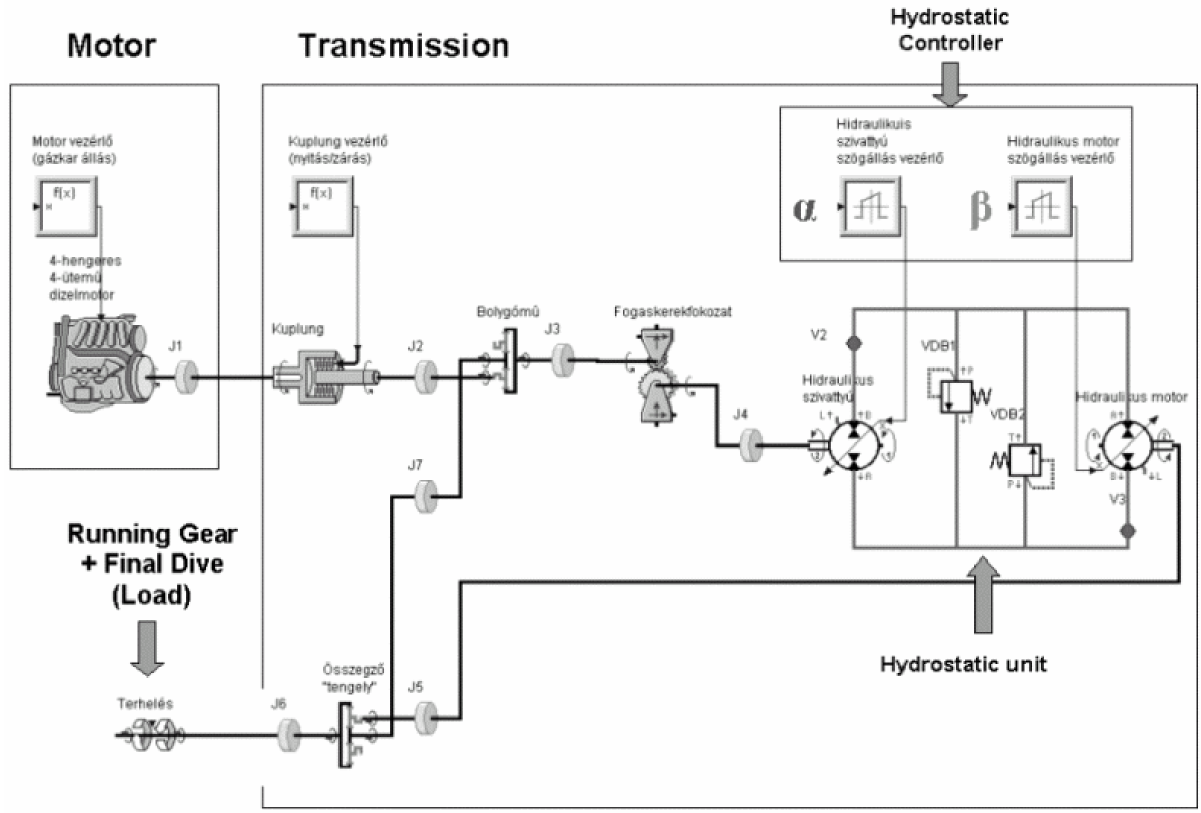

Fig. 6. Simulations model of CVT (ITI SIM)

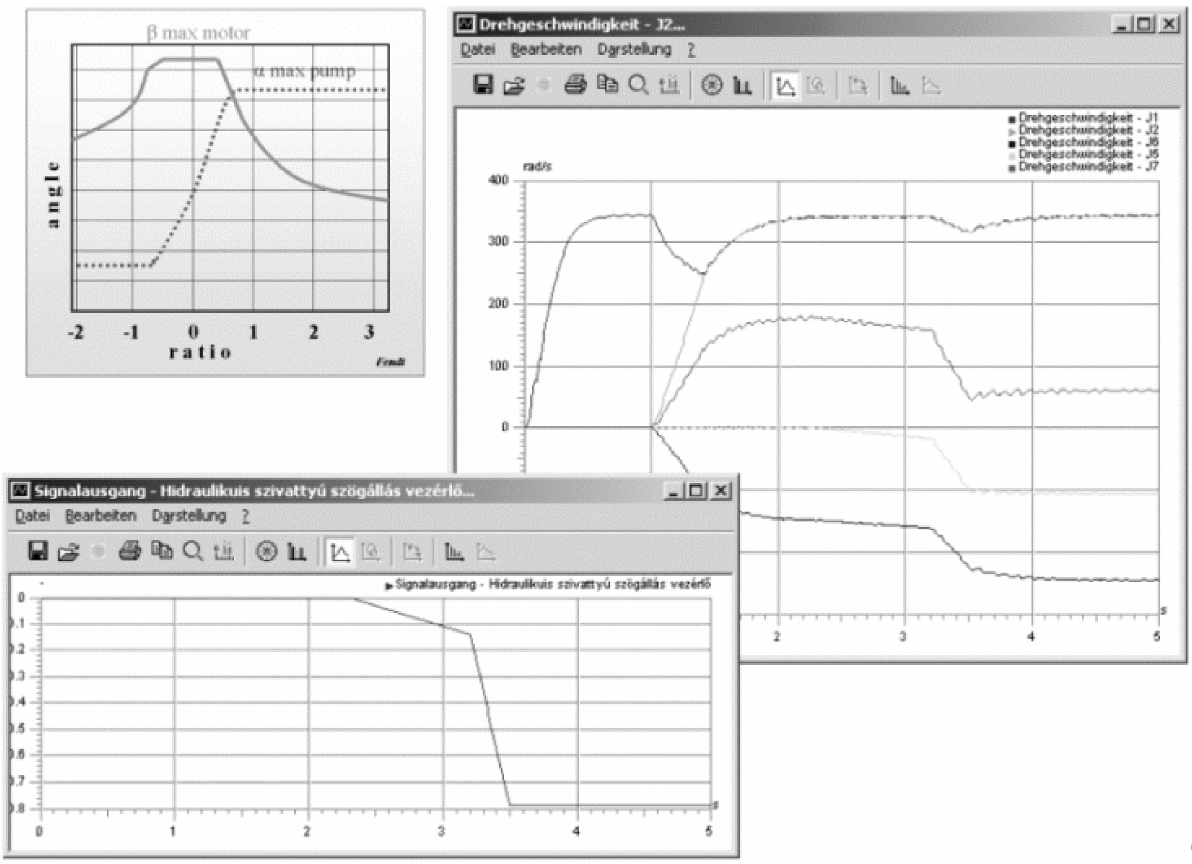

Fig. 7. Results of the simulation (ITI SIM)

4. THE CONCLUSIONS

The introduction of CVTs in tractors is making continuous progress [1]. During heavy duty pulling work on large areas and in multi-farm use, these vehicles are working significantly higher output as compared with stepped transmissions, while fuel consumption tends to be rather lower – especially under partial load.

For these advantages to be fully exploited, complex management strategies for the drive train are required. (Drive train-, Headland-, Implement management)

The following efficient management strategies for tractors with CVT s are available on the market:

- constant gear ratio (e.g. for field sprayers)
- constant engine rpm (e.g. for PTO work)
- constant speed (cruise control, e.g. for road rides)
- economy mode (e.g. for transports)
- automatic full power control (e.g. for ploughing).

These management functions have advantages: high productivity, lower energy consumption, and a reduction of the operator's workload.

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5. REFERENCES

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