Dieter Brunotte, Brunswick

Driveline strategy for the partial-load area in tractor operation

Application of a tractor management system on the Xerion system tractor

The ILF has been developing a tractor management system (TMS) over the past four years. In [1] the function and working of such a system is described in detail. The aim is the increasing of the whole system's performance capability, fuel saving and reducing driver workload. In April of this year a TMS was built into a system tractor for testing in field operations. Described in the following paper will be the vehicle alterations, the implementation of a driving strategy and the connecting-up of the partial systems engine, transmission, working hydraulics and power lift control into one field end management system.

Dipl.-Ing. Dieter Brunotte is a member of the scientific staff at the Institute for Agricultural Machinery and Fluid Technology (ILF) of the Brunswick Technical University, Langer Kamp 19a, 38106 Brunswick (director: Prof. Dr.-Ing. H.-H. Harms); e-mail: ilf@tu-bs.de.
The research project"Tractor management system" was financially supported by the German Research Society.

Keywords

Continuously variable transmission, electronic engine controller

In order to retain the condition of the Xerion tractor and its partial systems, the central electronics (CE) situated in the cabin had to be modified. The use of CAN-bus reduced cabling requirements. The activating signals from the TMS for power lift control, engine revolution control and the working hydraulics are switched on or off via appropriate adapters on the CE. Signals that are not processed from the CAN-bus are received by the TMS parallel to the control equipment. In order to be able to quantitatively assess the trial, fuel consumption and torque at the drive axles and engine drive shaft were recorded. The TMS, together with the measurement amplifier components for fuel temperature, draft power determination and torque, were mounted in the rear of the cabin. The fuel consumption measurement equipment was sited alongside the engine in the front part of the vehicle.

Mouse, keyboard and LCD flat screen monitor were installed in the cabin for servicing and optimising the management system in the field. Operating functions that the driver has to carry out on the move (e.g., speed control, or activation of the field end program) are carried out by the driver via appropriate buttons on a multi-function lever.

TMS conversion and programming

The heart of the TMS is a Total Development Environment (TDE) from the firm dSAPCE. The hardware in the form of a PC card contains a digital signal processor (DSP) upon which the measurement and control software runs. The system contains several AD and DA canals, digital inlets and outlets, as well as a CAN interface. Programming takes place via Matlab/Simulink. Over a comfort graphic operating surface, the system can be influenced during operation and recording of the measurement data controlled. In [2] more details about this tool will be supplied.

Partial load strategy

Publications up until now [3] showed a performance strategy for heavy draft work where the engine rpm are altered along the full load performance curve. The transmission ratios are so adjusted that the engine working point lies at pre-selected pressure rpm. The required engine rpm lies it this working point mostly at rated rpm. According to this, the driving speed is always produced from the actual rpm and the transmission ratio of the gearing, whereby speed variations of up to 33% can take place.

After the pre-selection of a desired speed by the driver, the partial load strategy within the TMS is reviewed and the partial load specific work for fuel saving is able to be prepared for. *Figure 1* shows the structural construction of the partial load strategy. This comprises the function blocks driving sector, engine and transmission management. The driving sector management receives the operator's desired speed over +/- buttons. Depending on field end status, the actual drive sector and desired speed is determined within the drive sector management when the drive sector automatic modus is activa-

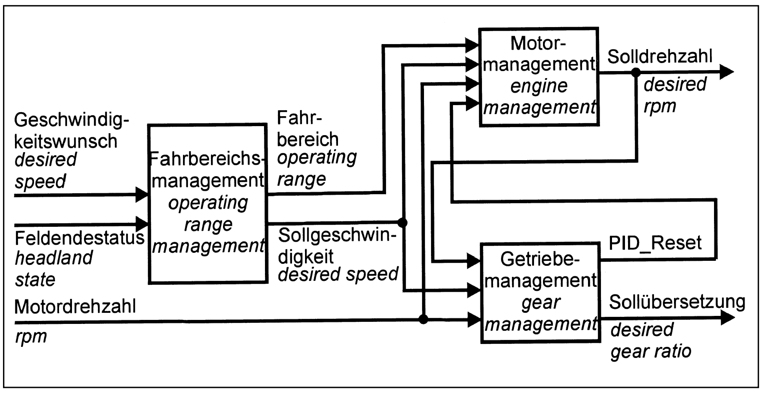

Fig. 1: Working plan of a partial-load strategy

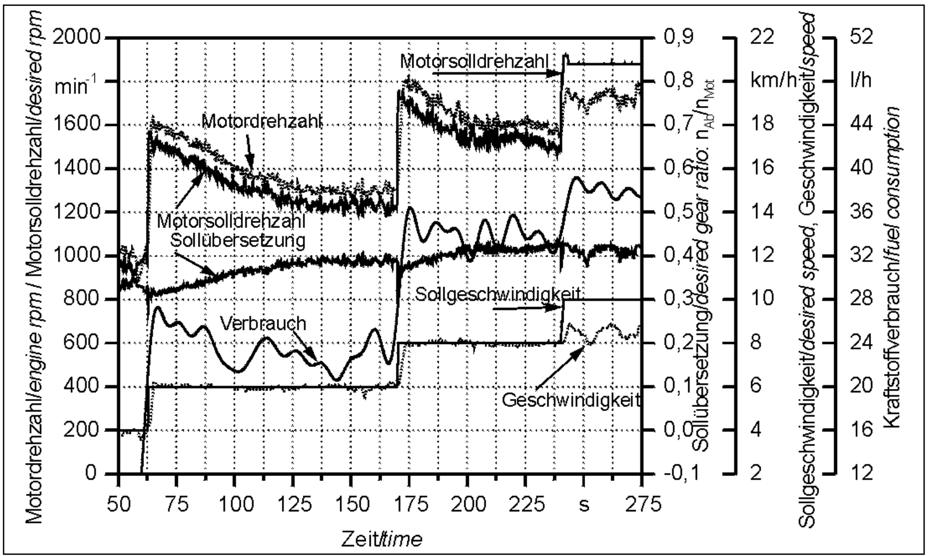

Fig. 2: Reaction of the partial load controller for the three speed sectors whilst ploughing

ted. At the headland, the applied speed is multiplied by a factor in order to carry out the turning manoeuvre either with reduced or increased speed (see field end management). The engine management calculates a desired rpm for the engine. This is dependant on the desired speed and the required performance. The drive sector switches between three performance curves in order to cater for the engine rpm for various speed areas, 0 to 14 km/h, 0 to 40 km/h and pto operation. The desired rpm resulting from the performance curves serves as target changing-up point for an under-fitted governor regulator which can be deactivated via the inlet PID reset. The conditions for deactivation of the safety regulator are greater changes in the working speed, or working conditions in which the engine is kept working at pressure for more than three seconds. A speed governor is realised within the transmission management which, as a control with target changing-up point has only the P-degree of the engine to control. Fig. 2 emphasises the behaviour of the partial load control for three speed sectors during ploughing. The active drive sector covers from 0 to 14 km/h. In the first sector the desired speed is 6 km/h. The engine is not under pressure and because of this, the engine governor decreases the desired rpm. The speed control follows with the increase of the desired transmission ratio. Through this, the fuel consumption is periodically reduced by up to 25%. The increasing of the desired speed to 8 km/h increases the engine desired rpm to around 1750 min^{-1}. The fuel savings here still lie by up to 12%. In the third sector (v = 10 km/h) the engine is under pressure. The transmission ratio of the gears is reduced in relationship to the amount of pressure so avoiding stalling.

Field end management

The field end program incorporated into the TMS relieves the driver to a great extent for in the tasks engine rpm reduction, raising the plough, turning the plough, and putting it back into the ground. All the driver has to do after the activation of the field end program is to turn the tractor. The impulse diagram (*fig. 3*), which has to be started by the operator with a push button at the field beginning or end, shows the function procedure.

After the driver has turned the tractor on the headland and the front wheel is about 2 m from the furrow beginning, he then has to activate the "field beginning" programme per push button. Following that, the transmission ratio is so set that the tractor is moving at a constant speed of 4 km/h for the insertion of the plough. Simultaneously the hydraulic valve that turns the plough into the working position is activated for eight seconds. After the turning procedure is ended, the power lift is dropped into plough working position. The front share of the plough goes into the ground while travelling at a constant speed. 2.5 seconds later, the engine rpm is increased because power demand increases with the insertion of the plough share. At the same time, the support wheel of the plough is lowered during a five second period by which time the last plough share has entered the ground thus giving a very even headland. Up to the point where the plough support wheel is fully lowered, the gear transmission ratio is so set that, despite the increased engine rpm, the tractor continues to move forward at a constant 4 km/h.

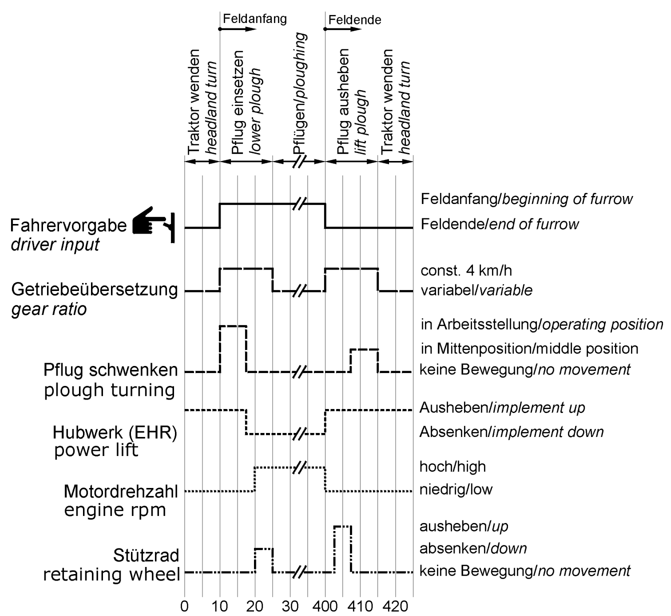

Fig. 3: Headland timing chart

Summary

This report presents the testing of a tractor management system in practical conditions. Using the example of headland operations, it clearly shows how the individual components of this system can be arranged in order to considerably relieve the driver. Also presented is a partial load strategy, the inlet parameters of which are according to the speed desired by the driver. Engine rpm and transmission ratio are so adjusted that the working point of the engine lies at 50% of capacity which leads to a fuel saving of up to 25%. A step which has to be realised in the future is an automated linking of partial load and performance strategy.

Literature

[1] *Brunotte, D.* und *J. Seeger*: Kommunikation von Motor und Getriebe über CAN-Bus. Agrartechnische Forschung 5 (1999), H.1, S. 54-67

[2] *Lang, T.*: Entwicklungsumgebungen zur schnellen Reglerdimensionierung. Landtechnik 54 (1999), H. 3, S. 150-151

[3] *Seeger, J.*: Untersuchungen von Antriebsstrang-strategien eines Traktormanagementsystems. Vortrag VDI-MEG-Tagung „Landtechnik" Braunschweig 7. / 8. 10. 1999. Tagungsband (VDI-Berichte-1503), S. 93-98; Düsseldorf, VDI-Verlag, 1999, ISBN 3-18-091503-