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Remote servicing of farm machinery

Field test results and application potential

Observations at Agritechnica 2001 showed that remote servicing had become an important development field for practically all large-scale producers of farm machinery. The first trials with a self-propelled potato harvester carried out at the Institute for Farm Machinery and Fluid Technology confirm that precise modelling and simulation of the machine is realisable. However, in this context the functions and measurements which are practical and above all economically justifiable remain to be critically investigated.

Field trials have already been presented here [1, 2] in earlier LANDTECHNIK reports. Alongside the results on the effect of ground conditions and vegetation influences of the operational data [2], characteristics related to conditions on the farm where able to be established. As expected, the differences between harvesting work and road transport were clear. An example here is the comparison (*fig. 1*) of the temperatures in the hydraulic oil during road and lifting work. Alongside the readings (available over the CAN-bus) from the tank and the circuit, leak oil temperatures were also measured at the machinery drives and drive engines. It was apparent that the tank temperature values present internally in engine and measured at the radiator for both working operations were reliably transmitted As far as harvesting work was concerned there were hardly any significant deviations, even at the other measurement points (see fig. 1, right). This allows the assumption of a very carefully-run harvesting operation with reduced engine rpm and hardly any power being required at the drive. On the other hand, road transport (left) required nearly full engine power transmitted at maximum rpm to the drive which is why the leak oil temperature in this case was increased substantially and, through varying speed and power demands (starting off, braking, up and down slopes) was also more strongly distributed. Here too the clearly increased engine demands led to a comparatively higher tank temperature. Experience has shown however that engine demands to the limit can more often occur during difficult harvesting conditions. This example showed plainly that an aggregate-specific temperature monitoring is a sensible precaution.

Figure 2 shows an example for additional function through which it is possible to measure pressure and displacement at the bunker cylinder. Pressure over displacement gives, depending on the degree of bunker capacity filled, characteristic performance lines which can serve for sampling, testing and supplementing yield measurement systems. For exact references, the extent of bunker filling should naturally be more precisely established as was possible during the rough estimation for figure 2.

Economic restrictions

The possibilities for remote servicing application presented at the Agritechnica 2001 now require practically-oriented conversion on the part of the manufacturer. Here, the

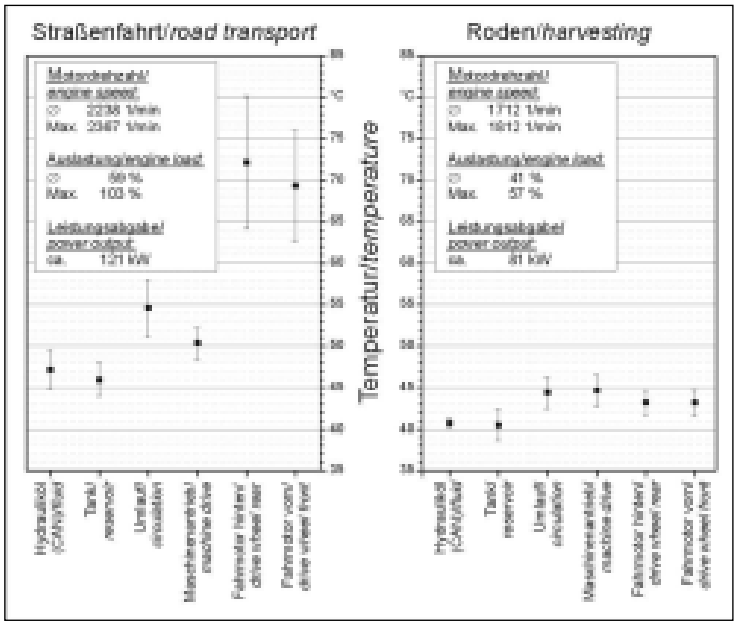

Fig. 1: Error bar diagram of measured temperatures (capture length of 5 minutes)

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Keywords

Remote service, remote diagnosis, remote data transmission

Criterion / Sensor type/ source of information	Expenses	Robustness/ life expectancy	Information content	Potential and capability for remote service application	Remarks
CAN-Bus	in general, information at no additional cost, except for auxiliary electronics	robust; durable	large amount of information; moderate resolution over time	necessary, since all the data vital to the machine control are available	possible need for additional electronic control unit
Pressure transmitter (steel membrane with strain gauges)	quite inexpensive	relatively robust; relatively durable	good resolution over time; facilitates trouble-shooting	essential, especially for complex control procedures (open and closed loop) on the machine	look-up tables and throttling orifices allow determination of flow rates by pressure
Flow meter	very expensive	susceptible to internal contamination; can lead to blockage	good resolution over time; helpful for trouble-shooting; indication of flow direction advantageous	too expensive for machines in series production, imaginable for prototyping and research	damage subsequent to blockage can become expensive; manufacturers are working on low-cost flow meters
Angle or position sensors	external: cheap up to expensive; internal: very expensive	susceptible to external contamination (dirt, debris and water)	helpful especially for cylinders out of view; good resolution over time	possible for vital applications	internal displacement measurement is further being developed
Proximity switch, also for rotational speed	inexpensive	robust; quite durable	important and substantial information for sequence- and stop-position controlled processes as well as rotational-speed measurement	allows many applications, e.g. torque measurement [3]	widely-used, also on less complex machines (without self-propulsion)
Temperature sensor	quite inexpensive	robust; durable	suited to indicate local problems or overall condition of single subsystems	for identification of local problems and for monitoring of the overall system (e.g. engine or hydraulics)	temperature of exhaust fumes from the diesel engine is desirable to measure engine wear

Table 1: Technical information sources and their evaluation

main question raised is which functions should be additionally implemented. In that most machinery is already equipped with CAN-bus and numerous sensors, it is reasonable to investigate to what extent the data gathered in this way can be used or whether the application of additional or higher-resolution sensors is necessary. In the first place here economic restrictions naturally play the decisive role. There's a possibility that at some points measurement recorders would be done away with all together in that the costs of possible errors in such areas have proved low.

In *table 1* are presented the applied information sources and these are evaluated. Here, the potential for remote service use is estimated according to costs, robustness and information content.

Evaluation of the measuring unit

It was shown that, alongside the data from CAN-bus, the application of pressure and temperature sensors as well as proximity detectors is especially practical. Displacement or angle sensors and, above all, volume flow sensors can also give valuable information but are, because of their high cost and fragility in agricultural use in their current development stage they are, however, only suitable for as standard fittings only under special circumstances. They can, however, provide useful information for prototypes and their testing. In standard machinery indirect volume flow calculation is possible over pump rpm and swivel angle or via pressure measurement and recorded performances. The generally problematical recording of hydraulic drive torques can take place through pressure measurements on the basis of the static absorption volumes of hydro motors.

Existing temperature measuring systems allow a relatively easy monitoring of whole systems and are also suitable for monitoring individual components. The innovative use of proximity detectors also can even allow torque measurements [3].

Summary and outlook

Additionally collected data should certainly be fed into the CAN-bus. This reduces the amount of cabling required and simplifies data transmission. Additionally, it minimises unavoidable electronic „masseschleifen" problems occurring with vehicles. The manufacturers of volume flow technology are working on „low cost" examples of proven sensors. These and future affordable inner cylindrical displacement measuring systems would enable an optimising of remote servicing systems. The established pressure and temperature sensors and proximity detectors allow the collection of sufficient information and additionally offer still more innovation potential through imaginative application.

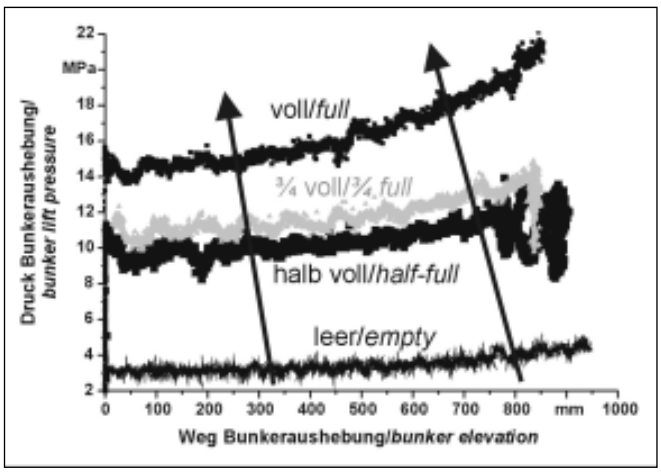

Fig. 2: Determining hopper content using characteristic curves

Literature

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