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Parameters for Yield Determination in a Mower Conditioner

For increasing accuracy in grass yield measuring in a mower conditioner, the effects of specific parameters on the measurements were determined.

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Keywords

Yield determination, mower conditioner, power requirement, grass, wind rowing device

Literature

[1] *Ruhland, S., S. Haedicke and K. Wild* : A measurement technique for yield determination of grass. In: Tagung Landtechnik 2004, VDI Verlag, Düsseldorf, 2004, pp. 317 - 324
[2] *Wild, K., and S. Ruhland* : Yield determination in a mower conditioner by means of hydraulic pressure measurements. In: Precision Agriculture. Ed.: John V. Stafford, Wageningen: Wageningen Academic Publishers, 2005, pp. 409 - 413

In recent years, a series of investigations into determining grass yield has been conducted at the working group "Landtechnik" of the University of Applied Sciences at Dresden. One approach is based on a windrowing device attached to a mower conditioner. The windrowing device transports the mown grass by means of a short conveyor belt, driven by a hydraulic motor. The input needed for the conveyor belt, which was measured by means of both a torque meter and the calculation of pressure difference in a hydraulic motor [1], was used to determine mass flow (grass yield). An inductive sensor and metal markers on the belt served to determine belt speed. The results of field and laboratory experiments show that it is possible to determine yield either by pressure difference or torque measurements [2]. The accuracy reached, however, was not always satisfactory. Thus, further investigations had to be conducted in order to be able to narrow down parameters.

The investigations were designed to determine the composition of power input required in dependence on motion resistance at hand. The source of motion resistance was initially divided into three parts. The most significant part with respect to yield measurement results from acceleration resistance of the material on the belt; at a constant speed difference it is proportional to mass flow. Further motion resistance is caused by the conveyor belt. This includes bending and rolling resistance at the driving and routing drums as well as friction between the belt and the belt frame occurring at the belt tracks between the drums. Furthermore, the bearings of the driving and routing drums supporting the conveyor belt also cause motion resistance.

Materials and Methods

For further investigations, the windrowing device was removed from the mower conditioner and installed on a test rig [1]. In comparison to earlier laboratory and field tests, extra temperature sensors were installed at the bearings of the drive and routing drums of the windrow conveyor belt.

In order to be able to classify resistance according to its cause, different types of belts were used. The belt that originally came with the 1700 mm windrowing device of the mower conditioner has a width of 730 mm and is fitted with bars at right angles to the transport direction ("Belt 1"). These crossbars are meant to facilitate transport of material but result in greater bending resi-

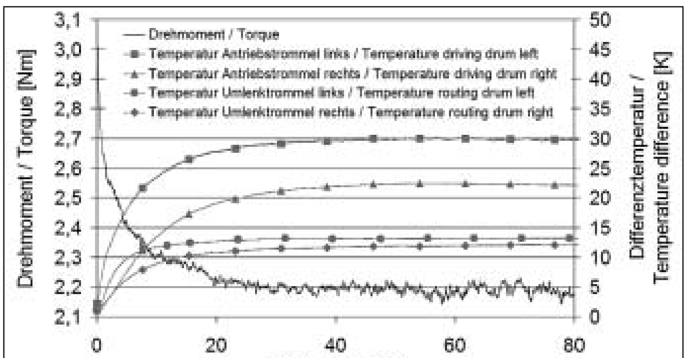

Fig. 1: Torque and bearing temperature depending on time (at the beginning)

stance at the drums. For the sake of comparison, another conveyor belt with a width of 730 mm but without crossbars was used. Its surface was studded with small raised knobs (1 mm in diameter) distributed evenly over the surface of the belt to facilitate the moving along of the material ("Belt 2"). In order to obtain a good approximation of the share of resistance caused by the bearings, other runs were made using a belt of a width of only 70 mm ("Belt 3"). It had a smooth surface and was installed in a way that no friction between belt and frame was possible.

Other parameters subject to change were belt speed and belt elasticity which could be altered by means of compression springs.

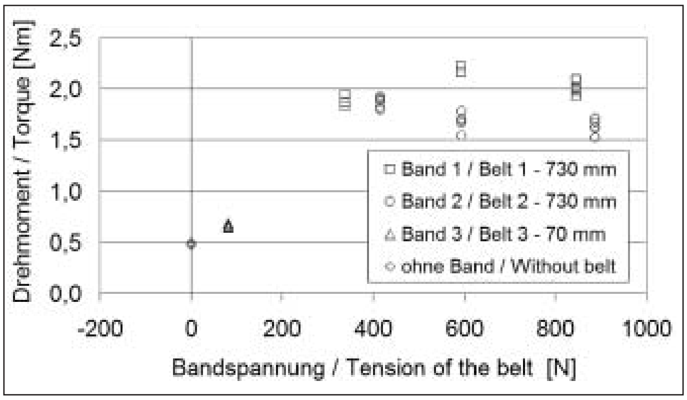

Fig. 2: Torque depending on the time for several conveyor belts

Results and Discussion

The measurements were taken in an unloaded state. It was noted that after starting up the conveyor device with the original belt, torque first dropped until establishing itself at a relatively constant value after about 30 minutes. At the same time, temperature in the bearings of both drums rose as compared to the surrounding temperature (*Fig. 1*).

This increase in temperature is caused by friction within the bearings and results in a reduction in lubricant viscosity. Motion resistance, and with it required torque, is reduced as the temperature in the bearings rise.

The difference in temperature increase between the bearings is due to their different composition. The most significant rise in temperature may be noted in the bearing which connects the driving motor to the driving drum. This bearing also exhibits a comparatively large friction surface.

In order to find out whether it may be simply the change in motion resistance of the bearings that causes the drop in torque in the running-in period, a comparative test was done with a belt width of only 70 mm. Despite of stabilized torque values after the start-up phase, 2.2 Nm versus 0.6 Nm, the drop in torque in the running-in period was comparable with both belts, 0.6 Nm and 0.5 Nm respectively.

Comparing both belts it may also be noted that the same speeds result in the same temperatures. However, the elasticity of the 70 mm belt with approximately 100 N is significantly lower than that of the original belt with about 600 N. This means that, in the area investigated, motion resistance of the bearings is independent of the stress on the bearings and thus also independent of the belt load at mass flow determination.

Looking only at the established stationary torque values, conclusions may be drawn about the belts´ share in motion resistance (*Fig. 2*).

If the conveyor device is run without belt, i.e. only the driving drum is running, the resulting values are only marginally lower than when it is run with 70 mm belt. This, on the one hand, allows the conclusion that the motion resistance of the routing drum bearings is significantly lower than that of the driving drum, and, on the other hand, that the 70 mm belt hardly causes any additional motion resistance.

If one of the 730 mm belts is used, torque required rises from about 0.6 to about 1.6 to 2.2 Nm. Thus, the part the belt plays in the motion resistance total in an idling state evidently exceeds the share of the bearings significantly. However, there does not seem to be a clear and systematic dependence of belt elasticity on the input required, even if several effects which cannot be investigated independently may be overlapping here. For instance, the bending resistance of the belt at the drums increases with the belt elasticity, while the friction between belt and the frame rather decreases due to less slack between supporting drums.

Aside from belt elasticity, belt speed was also subject to change. Disregarding the running-in period a significant alteration in torque could not be detected with changing belt speed either. Torque remains constant to a great extent. On the other hand, increasing belt speed with material transport requires greater acceleration in order to increase the importance of mass flow with respect to other parameters.

Determining the interdependence of torque, belt elasticity and belt speed is also rendered more difficult by great variations in idling torque without other running parameters having been subject to change. The experiments exhibited a span of 0.2 to 0.3 Nm.

These oscillations are probably caused by alterations in the machine. Among these may be small lateral shifts of the belt during the run, variations in lubricant distribution within the bearings or other such random changes.

Conclusions

The drop in torque in the running-in period is almost exclusively caused by temperature-sensitive motion resistance in the drum bearings. Thus, when determining mass flow, there should be a time interval of at least 20 to 30 minutes between the start-up of the belt and the beginning of the measuring, or the temperature of the bearings ought to be included in mass flow determination. Due to the imperviousness of bearings motion resistance to load, it may simply be subtracted from the determined torque and then disregarded.

Within the scope of the investigation, no significant change in idling torque may be detected with varying belt speeds so that motion resistance of the belt in the area considered is also virtually independent of load. An increase in belt elasticity in a loaded state, however, leads to greater friction between belt and belt tracks.

The variation in idling torque, which might even increase under field conditions, necessitates a constant check of idling torque while measuring mass flow, and an inclusion of actual values into mass flow determination.

For practical use, this means that the windrowing device should operate regularly and in short time intervals without material flow (e.g. while turning) in order to facilitate the determination of idling torque. In order to achieve a shortening of the intolerably long running-in period after starting up the belt, other bearings need to be tested.