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Test Rig Run for Yield Monitoring in a Mower Conditioner

The attainable accuracy of a measuring system for grass yield monitoring, as well as a number of possible influential parameters were investigated on a test rig, in order to assess the efficiency of the measuring system.

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Keywords

Yield determination, mower conditioner, power requirement, grass, windrowing 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, S. 317 - 324
[2] *Ruhland, S., K. Wild und G. Bernhardt*: Einflussgrößen bei der Ertragsermittlung im Mähwerk. Landtechnik 61 (2006), H. 3, S. 138 - 139

In the last years, various procedures for determining grass yield have been investigated. One of the approaches used by the AG Landtechnik at HTW Dresden is based on a windrowing device that is attached to a mower conditioner and forwarding the grass on a short conveyor belt. The input required for operating the conveyor belt is to be used to determine grass yield.

In addition to already completed investigations on basic characteristics of the conveyor belt and the parameters which affect its input [1, 2], a test rig was built up which allows the realisation of mass flow. This served to take a closer look at both the accuracies achieved and the parameters to be taken into account in the calibration functions.

Materials and Methods

As with previous investigations, a conveyor belt from a windrowing device was used. The belt, 1.7 m long and 0.73 m wide, was equipped with a number of sensors. The input needed was measured with a torque meter that was installed between the hydraulic motor and the driving drum. The speed of the conveyor belt was determined with a reflection light barrier and a reflection marker on the belt. Additionally, a one-way light barrier indicated whether there was material on the belt. A gradient sensor served to record the inclination of the belt.

In the test rig, an accessory conveyor supply belt of 8 m was used to create mass flow. The belt was loaded before the measuring procedure started and the material deposited onto the measuring belt in about 6 s respectively. The relative positioning of the measuring belt and supply belt to each other could be altered, allowing for a change in potential parameters. Among these were, for instance, the length of the transportation stretch on the measuring belt, the height from which the grass was dropped onto the measuring belt, and the respective directions of transport of the two belts in relation to each other. The latter affected the initial speed of transported goods in reference to the measuring belt. When the two belts are placed at a right angle to each other, the grass is at an initial speed of 0 m/s. Conversely, if both belts are transporting the material in the same direction, initial speed is almost equal to the speed of the supply belt (*Fig. 1*).

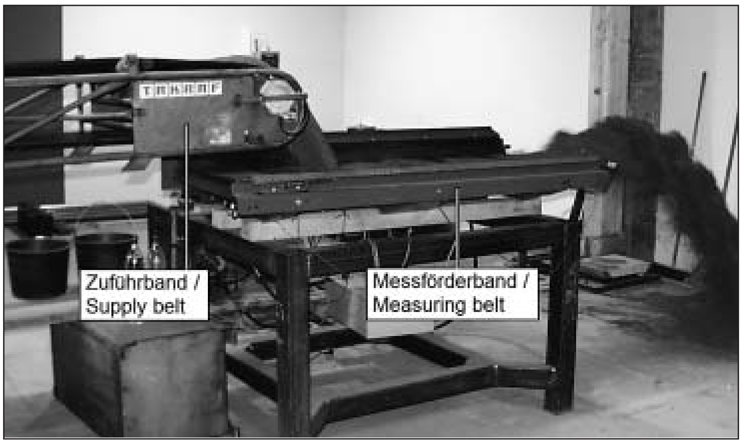

Fig. 1: Design of the test rig

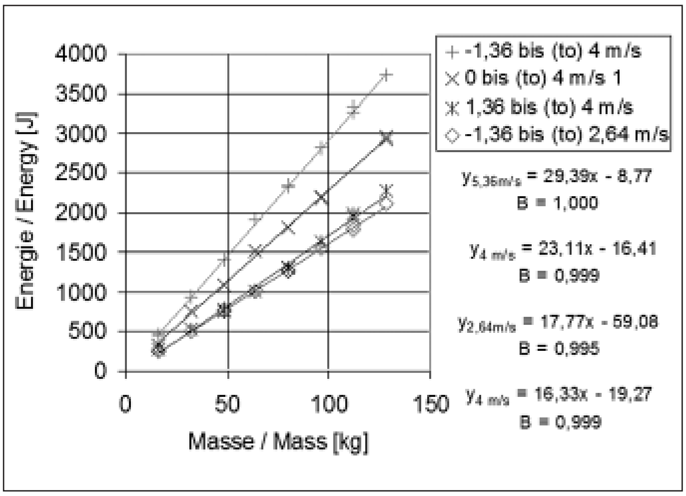

Fig. 2: Power requirement of the measurement belt for several initial and final speeds as a function of mass

Other variable parameters were belt suspension, which could be adjusted by means of two compression springs, and belt speed, which was controlled via the speed of the conveyor belt motor. The inclination of the measuring belt could be varied by raising it on one end.

The trial runs were conducted first with grass and then also with sand due to its better handling properties. To obtain calibration functions the masses used were weighed, amounting to up to 128 kg per trial. This corresponded to a mass flow of maximally 21.7 kg/s. Applied to a mower conditioner with a working width of 3 m and an operating speed of 10 km/h, this is comparable to a fresh matter yield of up to 26 t/ha.

Resulting values were averaged over whole belt revolutions respectively. Idling torque was subtracted from torque measured. The remaining share was converted into energy needed for material transport while taking into account angular positioning. A calibration was obtained by comparisons to the reference values from weighing. Calibration functions were based on at least 10 trial runs respectively, with masses between 10 and 130 kg at identical settings.

Results and Discussion

Initially, the interdependence of belt speed and transported goods was determined. The respective trial runs showed linear relationships between masses transported and input required. With most trial runs, the coefficients of determination for the regression line reached values of more than 0.99. A distinct dependence of values obtained on belt speed could be ascertained. Comparing grass and sand, material dependence was only minimal.

In the first runs, the initial speed of goods transported in relation to the direction of transport on the measuring belt was kept at approaching zero. In further trials with sand, the initial speed of the goods transported was varied (*Fig. 2*).

If initial speed is increased from 0 m/s to the speed of the conveyor supply belt (ca. 1.36 m/s), the input required decreased by 25%. At opposite initial speed, input increased by 25 %. If the goods to be transported are not accelerated from 0 to 4 m/s but from -1.36 to 2.64 m/s, i.e. with the same speed difference of 4 m/s, lower belt speed resulted in significantly lower input values required. This means that calibration should not only take into account initial and final speeds of the goods transported, but also the belt speed required in the process.

Actual required energy turned out to be significantly higher than calculated kinetic energy required. Total energy required must therefore contain other components and their dependence on possible settings was investigated in the following. For this, belt speed was kept at 4 m/s and the initial speed of the goods transported at zero.

If the material has to be raised during the stretch of transportation, the required energy increases or, with a downward slope, decreases. The inclinations investigated here were between -7.5 and +7.5 ° towards the horizontal. Results showed that a change of 5° in the area investigated yielded a change in required input of 19 %. This is both true for a decrease in input with a downward slope and increased input with an upward slope along the stretch of transportation. A dependence of the results on the kind of goods transported was not evident.

In addition, the position of supply and measuring belts to each other was altered in order to shorten the stretch of transportation from 120 cm to 80 cm. With sand, this led to a decrease in input required of about 7%, and with grass of about 20 %. Possible explanations for this are that, with constant mass, there is a greater friction between goods to transported and the frame of the measuring belt and that grass could not be accelerated fully to the speed of the measuring belt with the transport stretch being shorter. With sand, this effect did not occur to this degree since sand rests almost completely on the belt itself.

The height of fall of the goods transported was varied in two steps, at 45 cm and 65 cm. When grass was used, there was no difference between the two trial runs. With sand, the increase in height of fall by 20 cm resulted in an increase in input required of about 20 %. In comparison to grass, the components of sand may move comparatively independently of each other and therefore reach clearly different speeds in free fall. Grass, on the other hand, forms a more densely connected mesh so that the individual components may not fall freely. Small changes in the height of fall therefore hardly influence results.

Belt suspension had almost no influence on the results obtained.

Results and Outlook

The accuracies obtained in determining mass flow in the individual trial runs were very high. With constant conditions, the coefficient of determination was rarely under 0.99 %.

A number of changes in the surrounding conditions, however, clearly affect the measurements obtained. Among these, the influence of the speed of the measuring belt is especially significant. It therefore ought to be kept constant while measuring, or recorded and figured into the calibration function. For use in a moving vehicle, it is also necessary to record the angle of inclination of the measuring belt and to take it into account in the calibration.

The length of the transport stretch is more significant with grass than with sand. The height of fall only plays a role with sand, however. The direction of movement before the goods hit the measuring belt affects the input required. Yet, with suitable construction of the yield measurement device, these variables can be kept constant so that they need not figure in the calibration functions.

After having come to sufficiently accurate results with such an indirect mass flow measurement procedure on a stationary test rig, further field tests based on these results can be carried out. Due to the quality of the results obtained, applications in other agricultural machines with comparable conveyor belts are conceivable.