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Foliage Compaction

Results from Three Years of DFG-research Work

Within the framework of a DFG sponsored research project, foliage compaction in round bales in a test rig is being researched at the Institute of Farm Machinery and Fluid Technology in Braunschweig. The goal is to reduce transport costs for the foliage and to organise the entire process chain from collection to transport more efficiently. In addition to developing a suitable method, the functional interdependencies between the parameters of a foliage baler and different types of foliage were to be investigated in the test rig, working with the radial pressure compacting principle.

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Keywords

Compaction technology, compaction, foliage

The results of the three-year DFG financed study on the subject of the foliage compaction will be presented in the following. The characteristic parameters during the compaction of foliage to roll bales are determined with the aid of a testing unit, which has been in use at the Institute since autumn of 2001.

Test rig

The test, rig which was specially designed in the Institute has been presented in detail in [1] and [2]. For the sake of better comprehension the most important points will be dealt with in more detail. The testing to date resulted in a further development from the radial compaction method, as used in agriculture, to the variation shown in *Figure 1*, which ensured faultless functioning during the compaction of foliage under any possible circumstances. This variant is a fixed chamber round-baler, which is fed from the top. The compaction chamber comprises of a single belt stretched under tension over a chain with slat elevators and what is specific to this type of compactor is that the form is rounded right from the beginning of the compaction process. This is achieved by bearings attached to the outer side of the chain with slat elevators, which run in a guiding groove. The compaction chamber is 60 cm wide and has a diameter of 40 cm.

Test Parameter

The following parameters were varied during testing:

Test object:

- Type of foliage (beech, oak, chestnut, mixed foliage)
- Moisture of the foliage U (0,3 - 0,8) varying in 0,1 steps.

Test rig:

- mass flow (0,2 - 0,4 - 0,6 kg/s)
- belt speed (0,3 - 0,45 - 0,6 m/s)

Only one parameter was varied for each test in order to determine the influence of that parameter. During the tests the power requirement in the drive belt was registered with the aid of a torque measurement device and

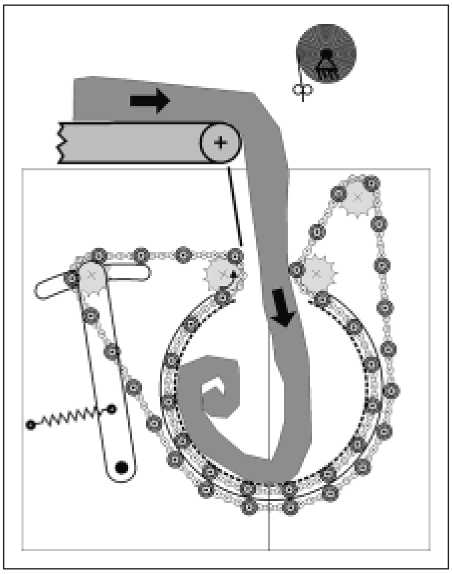

Fig. 1: Sketch of the test rig

the speed was registered with the aid of a rpm sensor. The forces acting on the ejection flap were registered at both bale chamber sides with the aid of expansion measuring strips, integrated in the closing mechanism. At the end of each test the bales were weighed and measured in order to determine the density. In addition to the mentioned measuring criteria, the measuring technique was extended for the year 2002/2003 to include the pressure on a side wall of the press chamber and to register the torque created on that side wall. In order to achieve this, a steel disc was affixed on a separate bearing block on the outside of the press chamber on one side (*Fig. 2*). The steel disc does not touch the the casing of the chamber at any point and there is only contact to the foliage within the press chamber. An aluminium cylinder, with expansion measuring strips, is integrated in the fixture for the disc. There are not only expansion measuring strips on the body for the measurement of the axial force created by the bales, but also expansion measuring strips for the torsion of the cylinder and therefore also the torque in the press chamber side wall, which, by means of the force and torque determined at the side wall, indicates the friction created on the side wall.

Results

Tests with the above described foliage compactor were carried out during autumn of the years 2001 and 2002. Varying types of foliage with varying moisture content were compacted. In all cases the compactor functioned without problems. The structured surface of the belt ensured transportation of the material into the chamber without clogging. The bales could be kept in rotation even when the foliage was very damp or very dry. The crumbling losses during all tests were as minimal, due to the fact that the chamber closes tightly. Depending on the respective type of foliage pressed, the bales had a weight of between 18 and77 kg, whereby the residual moisture varied between U = 0,32 - 0,78. This results in a damp density 210 - 820 kg/m^3 or a dry density of 110 - 320 kg/m^3.

In *Figure 3* the test data for sensor introduced for the 2002/2003 season can be seen. In the upper part, for the two tests with beech foliage the force on the side wall is indicated by the dry density. The lower part shows the resulting friction torque on the side wall. For both tests beech foliage was compacted with a moisture of U = 0,55 and U = 0,78 respectively. It can easily be seen that the more moist foliage reached a dry density of 140 kg/m^3 with less force on the side wall (160 N as opposed to 543,5 N). This can be explained by the lower internal friction of the moist foliage. The single leaves can slide past each other much easier, due to the water film between them. This means that compaction pressure brought to bear from an external source spreads within the material with greater ease and this is also indicated by a higher force on the side wall, resulting in a friction torque on the side wall. In order to rotate the bale, this friction force has to be overcome by the drive train and further via the chain with slat elevators and the stretched belt at the circumference of the bale. In the lower part of *Figure 3* the friction torque is to be seen. This shows qualitatively the same range as the side wall force. The interdependence between the side wall force and the friction torque results from the friction value μ of the friction twinning between foliage and steel on the side wall of the press. In Figure 3 a dry density of 140 kg/m^3 results from the side wall force shortly before the end of the compression process. With the aid of this data the friction value μ can be calculated for the moist foliage as well as for the dry foliage. For the moist foliage this is μ = 0,29 and drier foliage μ = 0,41. A theoretical lever of 0,15 m was assumed for the pressure point of the friction torque on the side wall. The higher compaction of the outer layers of the bale was taken into consideration. Therefore the assumption is that the theoretical lever should lie between a possible middle of (0,10 m) and a possible maximum of (0,20 m). Here too, it was confirmed that the easier sliding of the leaves on the steel wall was due to a higher moisture content, similar to the higher water content enabling the single leaves to slide past each other.

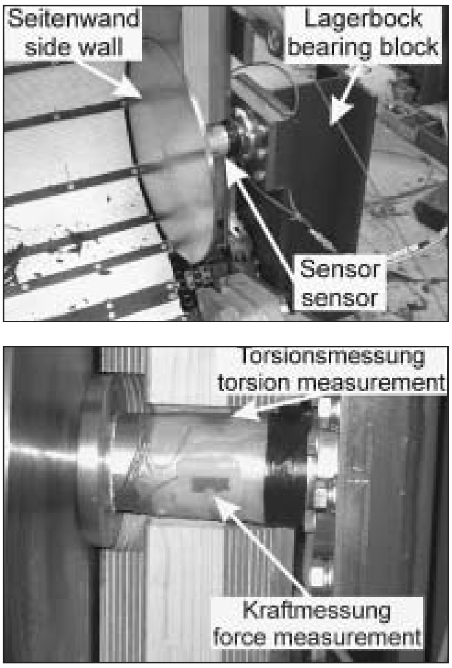

Fig. 2: Sensor for measuring side wall friction

The comparison between the various types of foliage is also interesting. It was to seen that the different types of foliage showed a varying resistance to the compression. This could be best seen for example by the rear flap force and the force on the side wall. The force created in relation to the dry density of chestnut leaves was the greatest, followed by oak and beech. This was the case with all moisture contents. This effect can be explained by the structure and the bending resistance of the various types of leaves. Chestnut foliage has a very coarse structure and a very rough surface. The leaves are of a medium size with an elongated form. Beech leaves are smaller have a smooth surface and a more round form. Oak foliage, with it's structure, size and surface is between the other two types of foliage. During the compaction process the leaves of each type of foliage must move toward each other and take a new position, sometimes getting bent. This means for example that a higher force is required for chestnut leaves than for beech leaves. The internal resistance of chestnut foliage is greater than of beech foliage.

Conclusions and outlook

The compaction of foliage into round bales has been made possible with the aid of the test rig. The basic prerequisites for the compaction of foliage on the radial pressure principal were ascertained. In order to weigh up the potential of a foliage compaction during the bringing in of the foliage, deliberation is taking place with regard to a viable integration of a foliage compactor in the present process. Further testing should take place to determine which other materials, apart from foliage, could be compacted, in order to ensure a year round utilisation of such a compactor.

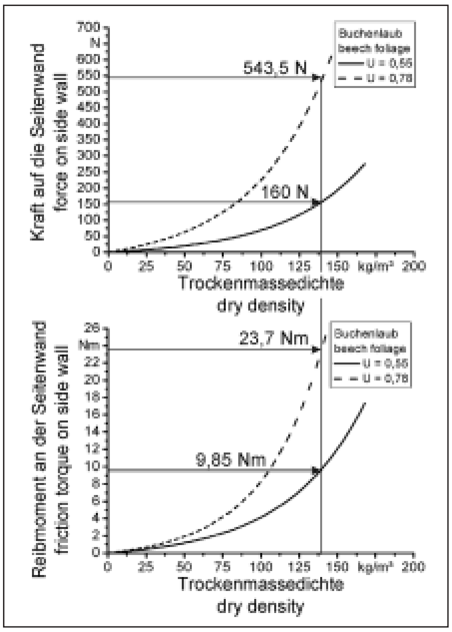

Fig. 3: Force und friction torque on the side wall of the press chamber

Literature

[1] *Bönig, I.*: Laubverdichtung. Landtechnik 56 (2001) H. 4, S. 280-281

[2] *Bönig, I.*: Laubverdichtung. Landtechnik 57 (2002) H. 5, S. 266-267