



The estimation of grass mat thickness and pressing force in press process

Algirdas Jasinskas *, Egidijus Šarauskis, Dainius Steponavičius, Edvardas Vaiciukevičius and Remigijus Zinkevičius

Department of Agricultural Machinery, Lithuanian University of Agriculture, Studentų 15A, LT-53361 Kaunas, Lithuania.

*e-mail: aljas@mei.lt

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Abstract

An attachment to measure up the thickness of grass mats and pressing force by measuring distance between press rolls was developed in Lithuanian University of Agriculture, Institute of Agricultural Engineering. For this purpose resistor sensors of displacement were used. The motion of rolls when the press was in idle running and when it was pressing mats of different thickness of macerated grass layer was registered. It is estimated that with increasing thickness of pressing grass layer from 25 mm to 55 mm the resistance of displacement sensor decreases from 614.6 Ω to 485.6 Ω . It was established, that a 20-60 mm thick macerated grass layer was pressed to produce 2.5-7.2 mm thick mats by roll press (the thickness of grass layer decreased 8 times). Pressing force of 2.2-2.9 kN was used for pressing process. According to the research results, a nomogram was charted which can be used to determine mat thickness and pressing force according to the thickness of the macerated grass layer.

Key words: Mats, grass layer, mat thickness, sensor of displacement, pressing force.

Introduction

Research was carried out in Lithuanian University of Agriculture, Institute of Agricultural Engineering (LUA, IAE), and an efficient way of intensive grass wilting by mechanical treatment- maceration and pressing into thin mat was substantiated. A great influence on mat drying is made by thickness and density which depend on mat pressing force. This research was aimed at the analysis of this impact and the search of suitable means for determination of mat thickness and pressing force.

One of the most important parameters of grass mats defining the intensity of their drying is mat thickness and density. The optimum mat thickness suggested by English, German, American and Turkish researchers varies from 6 to 26 mm, the mass is 2-3 kg m⁻² and the density of mat dry matter is 130-200 kg m⁻³ 1-4. However, it is rather difficult to establish mat density, therefore, mat thickness is estimated by different comparative analysis.

Individual mat preparation and wilting processes were already investigated in LUA, IAE 5,6. The research established the optimum red clover mat density after relaxation, which was 20-26 mm. However, to adjust this parameter precisely a broader investigation is needed. Most often the desirable mat thickness is identified according to a selected gap between press rolls; but such way of adjustment is not accurate. It would be expedient to carry out a deeper search of efficient and accurate means of adjusting and measuring mat thickness.

Great influence on mat drying is made by the degree of its mechanical handling-pressing. The maximum initial static linear pressure recommended in the literature varies from 5000 to 7500 N m⁻¹ 7,8. Hydraulic manometers are most often used to measure mat pressing force abroad. However, such measuring is only possible in presses where hydraulic cylinders are used for pressure (mat pressing). Such way of measuring pressure force is rather

complicated and expensive. Special maintenance is needed for hydraulic systems. R. Koegel proposes special materials to measure mat pressing force, these move between the rolls together with grass - they are tube filled with liquid and Fuji film. The latter served the purpose better as it did not take much volume during pressing. This cannot be said about the liquid filled tube. However, all these means are difficult to implement in practice, they are recommended only in small-scale research 9,10.

Tensometric equipment to measure mat pressing force was designed and tested in LUA, IAE 10. In the indentations of consoles holding the rolls, tensometer sensors were fixed to measure roll pressing force of tensions in a console. Even this measuring way is not accurate. It is rather complicated, sensitive, and unreliable tensometer sensors are used. The final results require a lot of calculations. Thus it is expedient to design simpler and practically convenient means to measure static mat pressing force and identify the pressing force needed to produce mats of different thickness.

The objective was to analyse and assess static pressing force of red clover mats and establish their thickness during pressing.

Methods

The grass which was used during the experiments was red clover in flowering phase, the stalks were thick, their length was 500-550 mm, and grass moisture content was 87%. The mentioned grass maceration and mat production stand was used to process the clover mechanically 5,6. The mats of different thickness were produced by supplying a layer of macerated grass of $h_1=20-60$ mm.

The mat production press is made of one central major roll and five satellite pressing rolls 10 (Fig. 1). The first satellite roll is used

to direct grass to the press and the remaining four rolls are joined into two roll pairs to press grass.

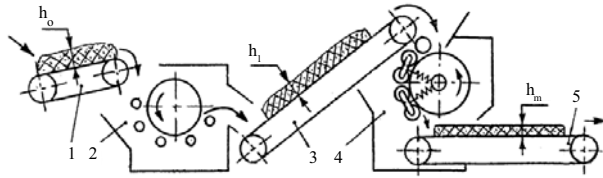


Figure 1. Schematic drawing of crop maceration and mat making: 1, 3, 5 - transporters; 2 - crop macerator; 4 - mat making press. Thickness of crop layer: h_o - untreated crop; h_1 - macerated crop; h_m - mat.

Mat thickness and the pressing force are established by measuring the distance between the central roll (7) and the second-lower satellite roll pair (6) (Fig. 2). For measuring sensors of displacement Sakae S8FLP-10A were used. Their technical data are as follows: nominal resistance is 1 k Ω ; working motion is 11 mm; nonlinearity is +2%; ambient temperature is 30+105 $^{\circ}$ C.

The displacement of pressing satellite rolls (6) is transmitted to sensor of displacement (1) through lever (5). By varying sensor position with respect to the lever it is possible to synchronize the displacement of satellite rolls with sensor working motion and achieve the maximum accuracy. In order to eliminate errors ball-bearings (2) are used in all links. For registration a digital data accumulator recorder KDI (accuracy class 0.5) is used. The sensor is used according to a standard scheme. The system is calibrated by calibrated plates. The maximum total error does not exceed 8%. Standard software is used to decode data - the software records roll movement dynamics during mat pressing. The mean values of the device readings (resistance) are calculated. The values are used to estimate mat thickness during pressing.

Mat pressing force is established according to elongation of roll pressing springs (4) (the calculated distance between pressing rolls is added to spring length during idle running). Spring tension force is established by their calibrating diagram. Selected initial force of the lower roll pair pressing (spring tension) is 1.8 kN (6 kN m $^{-1}$) and the upper roll pair pressing force is 1.2 kN (4 kN m $^{-1}$). During the experiments dynamics of the lower satellite roll movement at idle running of the press and pressing mats from 25, 35, 45 and 55 mm thick macerating grass layer was registered. Having decoded the achieved roll pair movement data, the mean

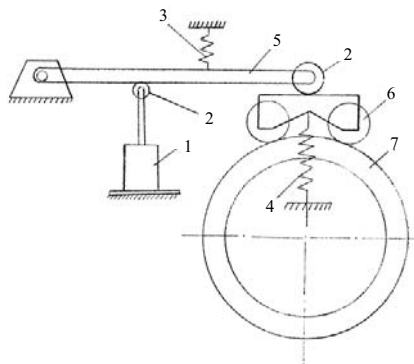


Figure 2. The scheme for measure the thickness of roll pressing mats: 1 - sensor of displacement; 2 - ball-bearings; 3 - lever pressing spring; 4 - roll pressing spring; 5 - lever; 6 - satellite roll pair; 7 - central roll.

values of displacement sensor resistance were calculated and their variation limits established.

Results

Experimental research results, given in Fig. 3, present dependence of displacement sensor resistance R_s variation on the thickness of pressed macerated grass layer h_1 . The results show, that with the increase of h_1 value from 25 mm to 55 mm, R_s decreases from 614.6 Ω to 485.6 Ω . The dependence of these parameters can be expressed by a regression equation:

$$R_s = -4.332 h_1 + 724.33; \quad R^2 = 0.999. \quad (1)$$

In order to recalculate sensor resistance values into pressed mat thickness a distance between the pressing rolls was measured. For this purpose calibrated plates of different thickness h_p were used, which were inserted between the pressing rolls and sensor resistance values R_s recorded. A stand calibration line when using calibrated plates of different thickness is expressed by the regression equation:

$$R_s = -36.53 h_p + 728.00; \quad R^2 = 0.998. \quad (2)$$

On the grounds of measurements made and using the calibration line it is possible to find out the dependence of pressed mat thickness h_m on the thickness of macerated grass layer h_1 . This dependence is linear and it can be expressed by the regression equation:

$$h_m = 0.118 h_1 + 0.142; \quad R^2 = 0.999. \quad (3)$$

Mat pressing force was established by spring tension force F_a with the change of its length l_s during mat pressing. This dependence on the lower roll pair springs can be expressed by the regression equation:

$$F_a = 0.154 l_s - 30.94; \quad R^2 = 0.999. \quad (4)$$

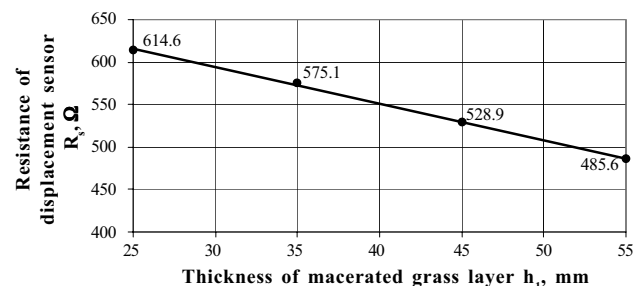


Figure 3. The indication of appliance (the resistance R_s of displacement sensor) when the mats are manufactured from different thickness of macerated grass layer h_1 .

Having evaluated the initial tension of the lower roll pair springs ($F_a = 1.8$ kN, $l_s = 213$ mm) and the elongation of the spring when pressing mats of different thickness, it is possible to establish the dependence of mat pressing force $F_m = F_a$ on mat thickness h_m (Fig. 4). This dependence can be expressed by the regression equation:

$$F_m = 0.154 h_m + 1.825; \quad R^2 = 0.999. \quad (5)$$

With reference to the results presented in Fig. 4 we can state that by pressing the layer of macerated grass of 20-60 mm thickness 2.5-7.2 mm thick mats are produced. To press them 2.2-2.9 kN pressing force is used (recalculated linear pressing is 7.33-9.67 kN m⁻¹). When recalculating into linear pressing, mat pressing force F_m is divided by coefficient 0.3.

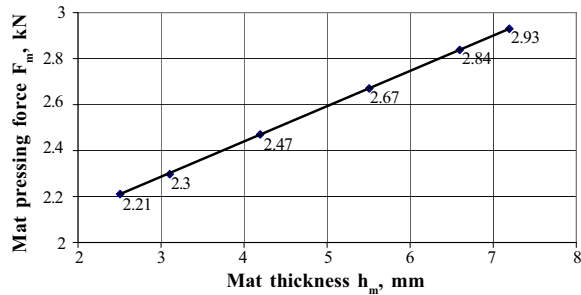


Figure 4. The pressing force dependence to the mat thickness.

According to the research results a nomogram was charted (Fig. 5). It can be used to determine mat thickness and pressing force according to the thickness of the macerated grass layer; e.g. by pressing a layer of macerated grass of 35 mm thickness a 4.2 mm thick mat is produced using 2.47 kN pressing force (8.23 kN m⁻¹). This nomogram stands only for a limited range of thickness of the macerated grass layer: $h_1 = 20-60$ mm as well

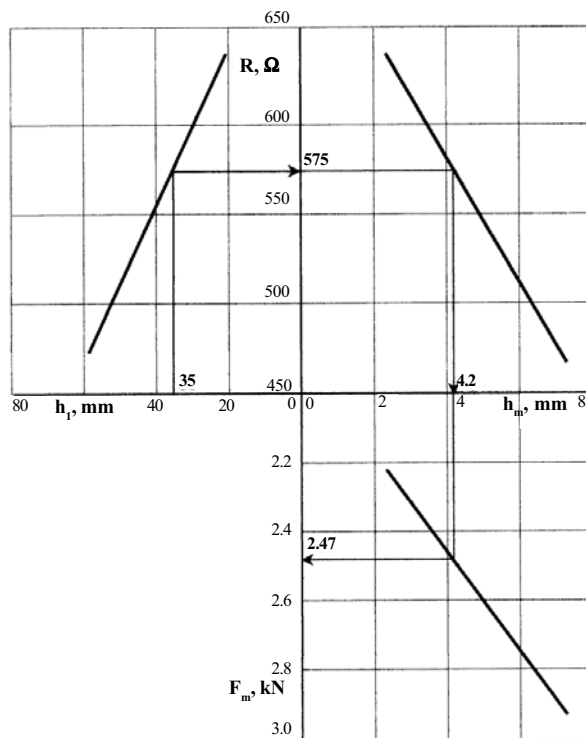


Figure 5. The nomogram for estimation of mat thickness h_d and pressing power F_m when is known stringy red clover layer thickness h_1 (the pressing force of lower rolls pair is $F_a = 1.8$ kN and the one of the upper rolls pair is $F_b = 1.2$ kN).

having selected the initial tension of the springs: the lower roll pair being $F_a = 1.8$ kN and the upper pair - $F_b = 1.2$ kN.

Conclusions

1. An attachment was developed to measure up the thickness of grass mats and pressing force by measuring the distance between press rolls. For this purposes resistor sensors of displacement were used and the motion was transferred to them through levers. To decode the data standard software was used.
2. It was established that pressing mats of 25, 35, 45 and 55 mm thickness macerated red clover layer resulted in displacement sensor resistance decrease from 614.6 Ω to 485.6 Ω .
3. Using the roll press for pressing the layer of macerated red clover layer of 20-60 mm thickness 2.5-7.2 mm thick mats are produced (grass layer thickness is reduced by 8 times). To press them 2.2-2.9 kN pressing force is used.
4. According to the research results and regression equations a nomogram was charted. It can be used to determine mat thickness and pressing force according to the thickness of the macerated grass layer.

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