ON THE IMPROVEMENT OF THE WORKING PROCESS OF THE RETRACTING ELASTIC FINGER LIFTING DRUM IN THE HARVESTING OF FORAGE CROPS

CONSIDERAȚII CU PRIVIRE LA ÎMBUNĂTĂȚIREA PROCESULUI DE LUCRU AL TOBEI CU DEGETE ELASTICE RETRACTABILE ÎN RECOLTAREA PLANTELOR FURAJERE

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Abstract. *It is well-known that elastic finger lifting drums, besides remarkable construction and functional features (simplicity of the construction, high safety in operating, low volume, and high adaptability) also have a disadvantage: a relatively specific low working capacity because of the low advance speed. In order to increase working capacity, in the conditions of maintaining quality indices at admissible levels (low loses of forage, avoiding detachment of leaves and inflorescence from plant stems, and avoiding the soiling of forage by earth) it is necessary to find solutions for the increase of the active area of the elastic fingers during the raking process.*

Rezumat. *Este binecunoscut faptul că tobele cu degete elastice pe lângă caracteristicile constructive şi funcţionale remarcabile (simplitate constructivă, siguranţă ridicată în funcţionare, masă redusă, adaptabilitate la condiţii foarte variate de lucru) au un mare neajuns: capacitate specifică de lucru relativ redusă, datorită vitezei de înaintare scăzută. Pentru mărirea capacităţii de lucru, în condiţiile menţinerii indicelor calitativi la cote admisibile (pierderi reduse de material furajer, evitarea desprinderi frunzelor şi inflorescenţelor de pe tijele plantelor şi evitarea impurificării materialului furajer cu pământ) este necesar să se găsească soluţii de creştere a zonei active a degetelor elastice în timpul procesului de greblare.*

Key word*: lifting drum*
Cuvânt-cheie*: toba de ridicare*

INTRODUCTION

This problem can be solved by thoroughly studying the working process of the folding elastic finger lifting drum that accomplishes three distinct technological operations: gathering (raking up) the forage left on the stubble field behind the mowing or mowing and conditioning machine (crushing, ravelling, etc.), gathering-tossing up machines, etc.; picking the forage from the stubble field at the height of the working machines in the technologic flow (feeding device, pre-compressing device, intermediary carrier, etc.) on which is set the gathering and picking device; pushing the forage towards the following working units of the machine on which the device is set.

MATERIAL AND METHOD

Each of these technological operations is done in a particular way through the action of the component elements of the gathering device (the elastic finger lifting drum) on the forage. The most active part of the components is elastic fingers that accomplish a complex movement, different from one operation to another and within each operation apart. The most complex operation it accomplishes is the gathering (raking up) of the forage that is close to the soil, i.e. about half the height of the stubble and spread in disorder on it. Its gathering by the

fingers is a working process made up of the insinuation of the fingers in the forage layer and of the moving of the forage over the stubble surface. (Figure 1)

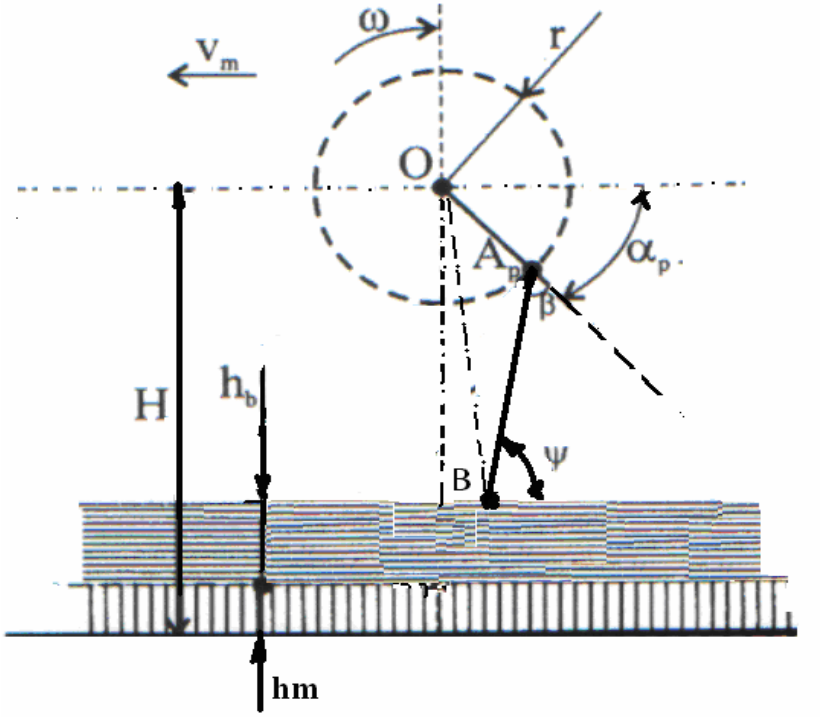

Figure 1 - Folding elastic finger lifting drum in the 1st working stage

In Figure 1, the lifting drum axis O is set at a height H from the soil level, while Ap is the lifting drum position when the elastic fingers touch with their tips the upper surface of the forage layer whose thickness is h_b. The OAB_c position radius, whose finger bar forms the angle α_p with the horizontal axis the moment the finger tips touch the forage layer. The lifting drum moves parallel to the soil surface at a speed v_m (the movement speed of the machine) and performs a rotation movement O clock-wise. The forage layer is supported by the stubble, whose average height is h_m. If the elastic fingers are set on the direction of the positioning radius of the finger-bar (the OB_c direction) or inclined backwards, such as it is in present machines, it is obvious that they push the forage layer down, which mats them in the stubble. As a result, there are high losses of forage (detachment of leaves and inflorescence from the stems – valuable nutritious components of the feeds).

RESULTS AND DISCUSSION

In order to eliminate this functional drawback, we think it fit to change the elastic finger orientation. By reorienting fingers (tips forward) we achieve a picking up effect of the forage layer and its progressive and slight compacting along the moving direction. Thus, the impact between fingers and forage is absorbed by the forage layer, without breaking the stems

or detaching leaves and flowers. Stage 2 – the raking proper – starts the moment the lifting drum's elastic fingers penetrate the stubble (the finger tips are at the average level of the stubble). During this stage, the fingers push the forage over the stubble surface by pressing, which results in an increase of the forage layer by particle agglomeration. The tension in the layer increases and varies with the pushing. The end of the 2nd stage corresponds to the moment in which the fingers get out of the stubble, i.e. when their tips B_2 reached the level h_m. The raking up is achieved along the arch B_1 B_0 B_2 of the trajectory described by the elastic fingers and covers two areas: the forage agglomeration area in front of the elastic fingers along the arch $B_1 – B_0$ and the pushing of the forage by influence along the arch $B_0 – B_2$. (Figure 2)

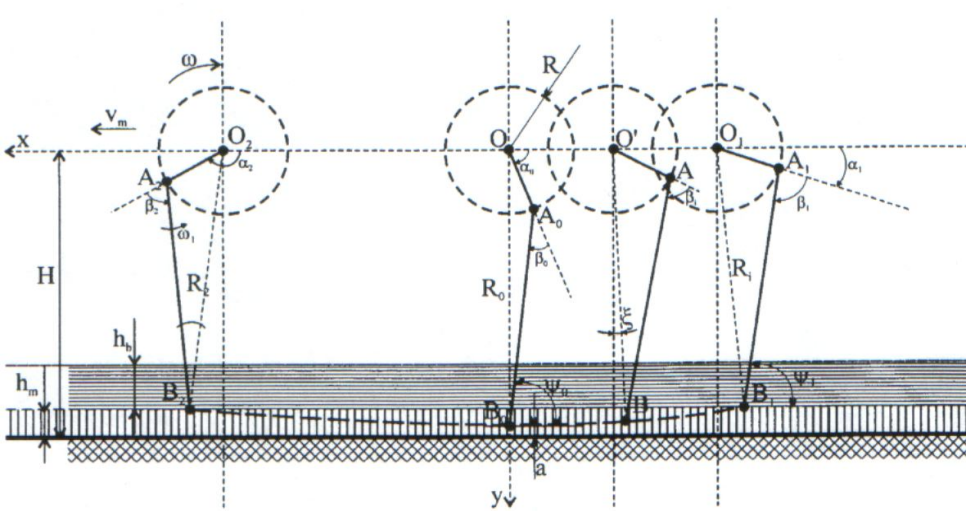

Figure 2 - Folding elastic finger lifting drum in the 2nd working stage

In the first area, the position of the elastic fingers to the direction of the position radius of the finger-bar is constant, which means that the value of the angles is $\beta_1 = \beta_0$, while the current position of the finger-bar changes during the process from α_1 to α_0. The increase of the position angle α results in a change in the penetration angle ψ. This results in a diminution of the matting of the forage in the stubble.

In the forage pushing area, along the arch $B_0 – B_2$, the position radius of the finger-bar rotates to the lifting drum axis from α_1 to α_0. Along this area, in front of the elastic fingers, there is some forage exerting steadily increasing advance resistance. The forage density increases steadily resulting in a slight compaction, because of the remains of plant stems under the influence of internal pressure. The length of this is under the influence of the value of rotation angle of the finger-bar to the lifting drum axis from the position A_0 to A_2. In order to expand this area, we think it proper to give a rotation movement to the finger-bar whose angle speed ω_1 is counter clock-wise to the lifting drum. Thus, the moment the elastic finger leave the stubble (position B_2), the direction of the finger-bar position forms the angle β_2 with the elastic fingers, an angle measured trigonometrically. Rotating the elastic fingers clock-wise to the movement direction of the machine equipped with retracting elastic fingers ensures a longer stay for the fingers on a bar over the forage layer, which increases the effective length of the raking up area.

The laws governing the movement of the fingers along the two areas of the raking up stages differ. In order to avoid the soiling of the forage with earth the protection area should be: a $\geq$ 20-25 mm.

The position radius of the fingers while penetrating and getting out of the raking up stage can be calculated using the geometrical elements shown in Figure 2 (see also CABA, 2006). It is very important to also correct the setting height of the lifting drum on the soil and, therefore, the angle-value the moment the elastic fingers penetrate the stubble (Figure 3) and the moment they get out of the stubble (Figure 4), and the angle-value of the finger-bar at the same moments, all calculated both clock-wise and counter clock-wise.

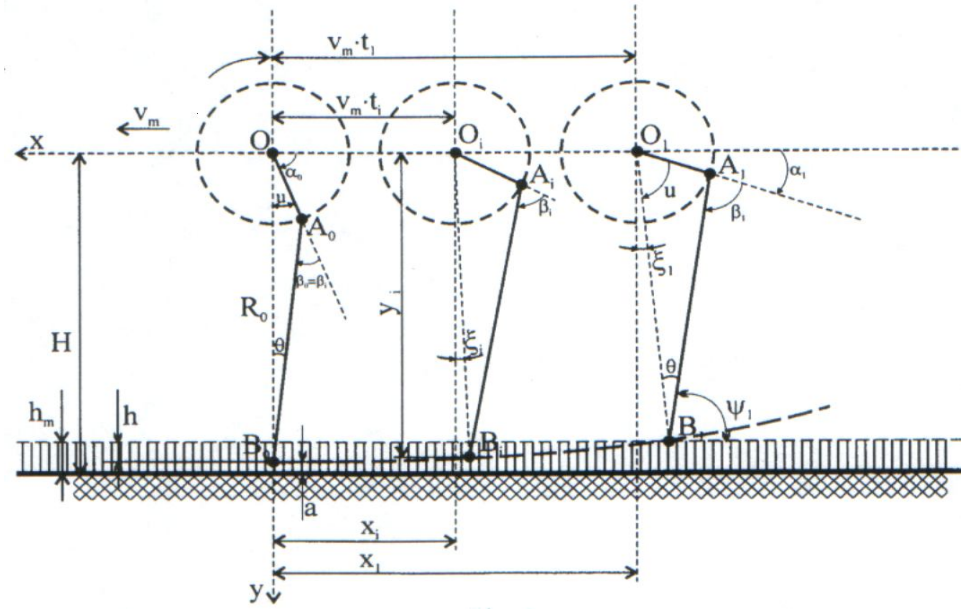

Figure 3 - Folding elastic finger lifting drum in the first half of the 2nd working stage

It is worth noting that the independent variable of all the equations allowing the calculus of the values above is time.

After the tips of the elastic fingers pass the vertical axis, starts the pushing area of the forage over the stubble surface. This process occurs as free compaction in open space, similar to the process of stacking fibrous materials. In this area, the finger-bars are subject to a supplementary counter clock-wise rotation of the lifting drum.

Figure 4 shows the current position angle of the elastic fingers and the speed and acceleration components along the two directions. The total raking up phase length is the sum of the lengths of the two areas.

If we want to avoid non-raked up areas it is necessary that there is no space between the point in which the elastic fingers on a bar penetrate the stubble and the point in which the elastic fingers on the previous bar get out of the stubble.

It is also necessary to keep the direction of the fingers to the soil surface constant along the whole forage pushing area if we want to push the forage along the whole forage

pushing area which means that the fingers push in the layer's plane. Forage gliding along the elastic fingers is also to be avoided.

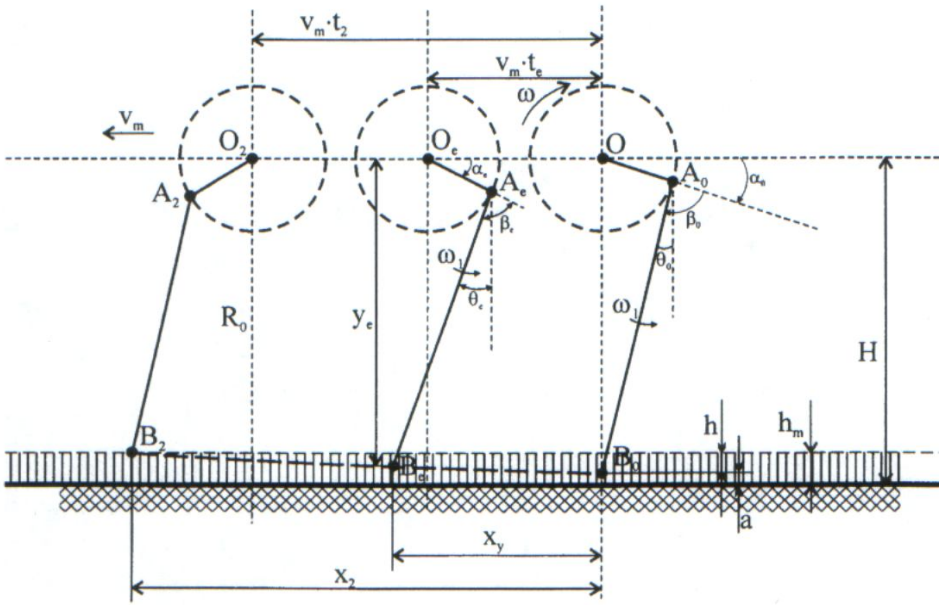

Figure 4 - Folding elastic finger lifting drum in the second half of the 2nd working stage

There is a correlation between construction and functional parameters of the folding elastic finger lifting drum and the forage state parameters.

From the point of view of the working capacity of the lifting drum, raking up phase length, whose value is influenced by a number of factors (stubble height, lifting drum diameter, elastic finger length, lifting drum's angular rotation speed, protection area height, etc.), is of particular importance.

CONCLUSIONS

The deficiencies in the working process of the folding elastic finger lifting drums for the picking up of fibrous forage made us carry out a series of theoretical and experimental research that lead to their solution and to the improvement of the working process, diminishing forage losses. Among our achievements, we can mention:

- the diminution of forage losses by rotating the fingers so that they penetrate and not kick the forage layer;
- the diminution of forage losses by maintaining the fingers for a longer period of time in the forage layer, which increases the raking up period;
- the diminution of the forage layer compaction by slightly inclining the elastic fingers counter clock-wise;
- the carrying of the fibrous forage to the feeding device without spreading or agglomerating it, this diminishing shocks and vibrations during exploitation.

LITERATURE

CABA, I., Contribuţii privind îmbunătăţirea parametrilor constructivi şi funcţionali ai organelor de lucru ale maşinilor autoîncărcătoare de strâns şi transportat furaje fibroase, Teză de doctorat, Universitatea „Politehnica" Timişoara, 2006.