THE DYNAMICS OF THE OPERATING MECHANISM OF THE CUTTING APPARATUS WITH TWO KNIVES FROM MOWING MACHINE CDC 1,5

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Abstract: *Among the mechanised works for feed production, harvesting occupies a special place, both through the role it has in animal nutrition and specific characteristics of quality. In order to maintain quality of feed and keep losses to a lower level harvesting must be executed at optimal time and in a short time A basic operation of the technological process of harvesting of feed is cutting the stems of forage plants. The quality and quantity of harvested material are decisively influenced by this operation. Also the quantity, the quality of hay obtained, the growth and the subsequent forage production in the next years are determined by the way of execution of mowing. The mowing machine is used for cutting forage plants remaining from stubble in the form of continued swath with a smaller width than the working width of the machine. The cutting apparatus with two knives with reciprocating motion cuts the forage plants by shearing. The knives are supported and guided by gantries. The operating mechanism of the cutting apparatus with two knives from the mowing machine CDC 1,5 is the type connecting rod-crank-rocker. The knife and the swinging arms form an articulated parallelogram mechanism. The studies of this work were performed on a laboratory stand. The stand for experiments includes: mechanical mower with two knives, the drive of the mower, hydraulic, mechanical transmission and electric motor drive. Different revs of the drive shaft and different speeds of the mower's knives were obtained by changing the transmitted reports.First were determined the velocities and accelerations of the forces acting on the knives in order to determine these forces. After studies have established the necessary conclusions and recommendations. In the context of an increased worldwide demand for food, is becoming increasingly important the use of technology to ensure increases of production on the same land area, while preserving biodiversity and preserving the environment.*

Key words**:** *Mowing machines, cutting apparatus, speeds, accelerations, forces, tensions*

INTRODUCTION

Being an important national treasure with productive function the grassland surface of our country, over 4.9 million ha, it also has ecoproductive and landscape functions. The contribution of grasslands to feed production it has a special importance because a good feed with a good floristic composition, with full nutritional value, having a balanced composition in protein, vitamins, salts and other substances constitutes the basic nutrition of ruminants. It is very important for livestock farmers in hilly or mountainous area that the grassland surface they operate to ensure the required fodder for the entire year. It is very important for livestock farmers from hilly or mountain areas that the grassland surface they operate to ensure the required fodder for the entire year.

In our country, especially on hilly and mountain areas, the mostly used traditional method in order to capitalize feed from pastures and forage is harvesting, the preparation and conservation of hay.

The mechanization of the production of feed is of major importance for the agricultural production in general and especially for livestock farming. During the development of mechanized agriculture, forage harvesters had a continuous development. Technical improvements were made and superior performance machines were made based on classical principles.

Nowadays in our country's agriculture different types of forage harvesters are used, from tinkers with classic cutter to modern machines, in which worldwide technical progress elements are incorporated. It is appropriate to continue to use older types of pickers because it is difficult to buy new ones and because many of these and obsolescence is relatively low.

MATERIAL AND METHODS

The main objective in the collection, preparation and conservation of feed from meadows and forage crops into hay is to achieve a final product with a food value as close to the original green fodder.

The vegetation base from natural hayfields and pastures consists of perennial herbaceous plants, grasses generally having the highest share.

Harvesting hay fields must be made in the era in which a large amount of nutrients per hectare is obtained without reducing thereby the production from the coming years. Setting the time of harvesting grassland is based on the growth phase of the dominant grasses and not by dates.

In the process of mechanized harvesting of feed on slopes mechanical mowers are required to submit stability in service to easily follow the ground level, to ensure a uniform cutting and have high reliability.

The need for cutting at small heights and the specific working conditions, led to a broad range of types of cutters.

The cutters with two knives appeared from the need to ensure the quality of the technological process of harvesting forage grass for special working conditions characterized by: high humidity, high plant density, high forward speed and low cutting height. These cutters are not clogged in fallen cultures and achieve normal cutting of natural meadows and herbs with slender and flexible stems.

The results contained in this paper are based on the experiments made on the mechanical mower with two knives CDC 1.5. On the laboratory bench experiments were performed consisting of the cutter with two blades, the drive of the cutting machine, the hydraulic system, the mechanical transmission and the electric motor as an energy source. (Figure 1)

The cutting machine with two knives with simple race has the following parameters:

- race knives s = 38 mm;
- step of blade knives p = 76 mm.

The drive mechanism of the cutting device is connecting rod-crank-rocker type. The kinematic diagram of the driving mechanism is shown in Figure 2.

From the point of view of the mechanism the mower's blades and the respective arms form an articulated parallelogram. The arms act as cranks, rods and knives. The two systems are identical in terms of construction and shifted by π rad. The shaft speed of drive cranks is n = 1400 rev/min.

The dynamic study of the mechanism requires first the determination of speeds and knives accelerations. On these axes are calculated the forces acting on blades and are established the necessary conclusions.

Figure 1. Mower CDC 1,5 stand

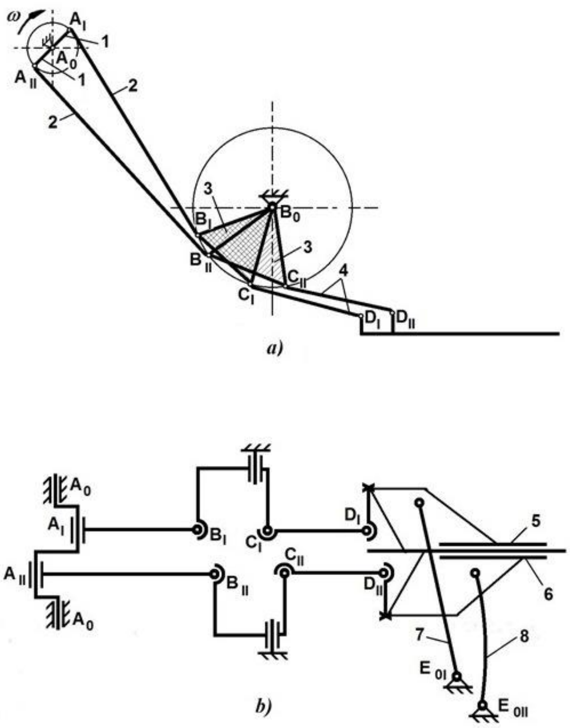

Figure 2: Scheme of the drive mechanism of the cutting device with two blades
a) front view; b) top view. I- upper knife mechanism; II- lower knife mechanism.
1-crankpins (cranks), 2-connecting rods, 3-sticks, 4-articulated connecting rods,
5-the upper knife, 6-the lower knife, 7 and 8-swings arm.

RESULTS AND DISCUSSIONS

The determination of velocities and accelerations of various points of the mechanism was done using vector equations, based on leading element, (crankpin) through to the last element of the mechanism (swing arm). The knife running a curvilinear translational motion and swings arms, which essentially are cranks, are executing a running rotation. The angular velocity of all the oscillating arms is the same, also the speed in all points of the knife is the same. Based on this reasoning, when calculating speeds and accelerations was considered only one swing arm of each knife.

The speed equation to point B is:

$$\bar{v}_B = \bar{v}_A + \bar{v}_{BA}$$

The speed of pont D is given by the vector equation:

$$\bar{v}_D = \bar{v}_C + \bar{v}_{DC}$$

The determination of accelerations was made with vector equations considering that the elements of the mechanism are running flat.

The accelerations equation for point B is:

$$\bar{a}_B = \bar{a}_A + \bar{a}^n_{BA} + \bar{a}^t_{BA} = \bar{a}^n_B + \bar{a}^t_B$$

The point D's acceleration is determined by the following equation:

$$\bar{a}_D = \bar{a}^n_D + \bar{a}^t_D = \bar{a}_C + \bar{a}^n_{DC} + \bar{a}^t_{DC}$$

The polygons of the velocities and accelerations of the higher knife drive mechanism are shown in Figure 3. Accelerations and speeds values for higher knife are summarized in Table 1 for a complete rotation of the crankpin. The calculations were made in 20 degrees' rotation of crankpin 20. Variation of speed and acceleration of point D are represented in the diagram in Figure 4.

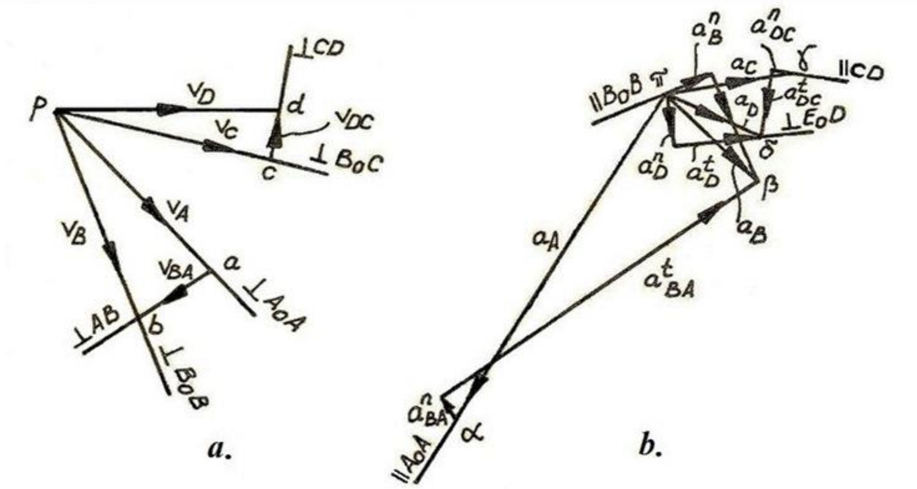

Figure 3. The velocities and accelerations of the knife drive mechanism
a) polygon speeds; b) polygon accelerations.

Table 1

Speeds and accelerations of higher knife

α [degree]	v_C [m/s]	v_{DC} [m/s]	v_D [m/s]	a_D^n [m/s²]	a_D^t [m/s²]	a_D [m/s²]
0^0	0	0	0	0	402	402
20^0	1,232	0,126	1,246	9,7	363	364
40^0	1,792	0,14	1,792	20,1	297	298
60^0	2,408	0,084	2,408	36,24	190	194
80^0	2,744	0,112	2,73	46,58	62	77
100^0	2,744	0,35	2,66	44,2	82	94
120^0	2,492	0,336	2,38	35,4	198	203
140^0	1,792	0,42	1,68	17,64	325	326
160^0	0,882	0,28	0,784	3,84	389	390
180^0	0	0	0	0	377	377
200^0	1,01	0,28	0,924	5,34	371	372
220^0	1,932	0,308	1,82	20,7	298	300
240^0	2,52	0,448	2,408	36,24	187	191
260^0	2,786	0,364	2,744	47,1	68	83
280^0	2,716	0,112	2,707	45,8	72	85
300^0	2,38	0,056	2,38	35,4	196	200
320^0	1,82	0,168	1,834	21	302	304
340^0	0,944	0,126	0,966	5,83	376	376

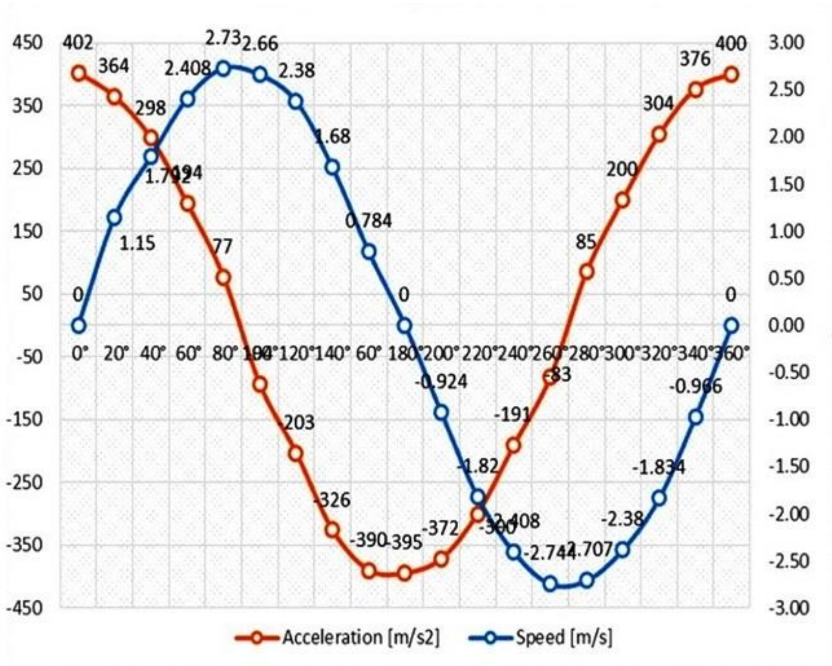

Figure 4. Diagram speed and acceleration of higher knife

Table 2

Forces that act on knives

α [degree]	$\overline{R}_t$ [N]	$\overline{F}_i$ [N]	$\overline{F}_f$ [N]	$\overline{R}_b$ [N]	$\overline{F}_D$ [N]
0^0	0	1652	273	-420	1505
20^0	0	1496	273	-220	1545
40^0	0	1225	273	-110	1388
60^0	615	797	273	-20	1665
80^0	615	316	273	55	1259
100^0	615	-386	273	140	624
120^0	615	-834	273	220	274
140^0	615	-1340	273	365	-147
160^0	0	-1603	273	390	-940
180^0	0	-1550	273	445	-1370
200^0	0	-1529	-273	240	-1562
220^0	0	-1233	-273	135	-1371
240^0	-615	-785	-273	35	-1630
260^0	-615	-341	-273	-40	-1269
280^0	-615	342	-273	-130	-669
300^0	-615	822	-273	-200	-266
320^0	-615	1250	-273	-285	77
340^0	0	1545	-273	-355	917

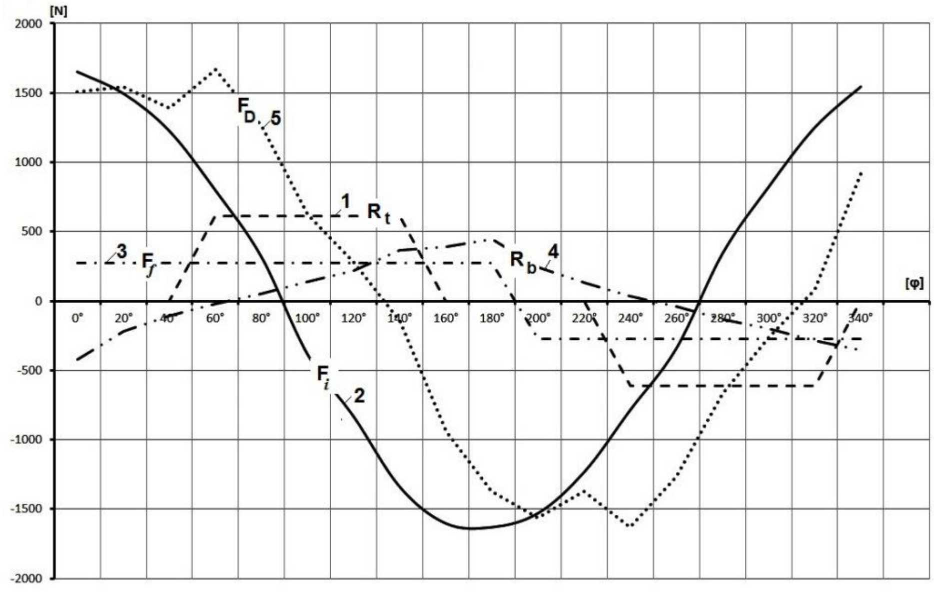

Figure 5. Diagram of forces that act on knives

Different forces act on the knives of the cutting machine:

- $\overline{R}_t$ rezistence of plants when cutting;
- $\overline{F}_i$ inertial force;
- $\overline{F}_f$ friction force between knives;
- $\overline{R}_b$ the resistance of swings arm.

The resultant of the force system acting on the blade is the vector sum of forces, that is to say:

$$\overline{F}_D = \overline{R}_t + \overline{F}_i + \overline{F}_f + \overline{R}_b .$$

The values of the forces, for one complete revolution of the cranck are summarized in Table 2. The diagram of the forces acting on blades is shown in figure 5, as follows:

- rezistence of plants whrn pruning $\overline{R}_t$ is represented by horizontal line 1;
- the inertial force $\overline{F}_i$ is represented by curve 2;
- the friction between knives $\overline{F}_f$ is represented by line 3;
- rezistence of swings arm $\overline{R}_b$ is represented by curve 4;
- the resultant of system forces $\overline{F}_D$ is represented by curve 5.

CONCLUSIONS

Since the mechanization technique of the feed grass harvest has advanced greatly in recent years, worldwide, the most important issue to be addressed relates to the selection of operating modes that best allows increasing the productivity and quality and reducing the cost of mechanized harvesting work. For this reason, a main aspect studied refers to the current state of mechanical tin. The analysis of specialized bibliographic sources reveals the concerns in the scientific research field for improving scythes in order to bring them to the ever-increasing requirements regarding the qualitative and quantitative aspects of their work.

The mower cutting apparatus has two knives with double wishbone with simple stroke. Considering the main destination of the mowers on plant harvesting forage grasses in meadows on slopes, it is considered that the type of the device of cutter is well chosen, it can provide cutting normal plants at a low height, not clog and does not destroy land with small bumps and scraps of hard bodies.

For a better functioning of the articulated parallelogram mechanism it requires that the length of the rod to be equal to the length of the base (fixed element) and cranks to have all the same length. On the mowers mechanism stands a long arm of 150 mm instead of 160 mm. Theoretically, the displacement from the base of the mechanism to the normal direction is less than 0.07 mm on the arm of 150 mm to 160 mm arm. This difference can be taken both by the games from joints and by the elastic sleeves.

One factor that can worsen the functioning of the mechanism and introduces additional large resistors, are the deviations of position of the center of arm-knife joints or arm-machine, as well as the length deviations of the arms between the center of joints from the knife and from the frame. These deviations prevent joint centers to be on the same right, and that their trajectories to be concentric circles.

Because of this, inevitably will arise additional forces both in arms and in the knife. These forces will lead to rapid wear of the joints arm-knife and the destruction of elastic sleeve. In order to reduce these forces must be properly installed additional subassemblies and perform accurate mechanism of the cutting device settings.

In order to obtain corresponding indices to technological requirements for harvesting forage plants and especially natural meadows on the one hand and to achieve a rational load of the cutting machine on the other hand, the recommended operating speed is 9.7 km / h

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