NEW CONSTRUCTION OF CUTTING UNITS IN SELECTED AGRICULTURAL MACHINERY

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Abstract: New constructional solutions of scissor-finger cutting unit and the drum cutter bars characterised by higher functioning efficiency with reference to well known constructions applied in machines for plant material’s harvesting, are presented in the paper. New constructions of the cutter bars have been designed and performed in the Division of Engineering Machines, Faculty of Mechanical Engineering of the University of Science and Technology in Bydgoszcz.

Keywords: CUTTER BARS OF MACHINES, NEW CONSTRUCTIONS OF CUTTER BARS OF AGRARIAN MACHINES, SCISSOR-FINGER CUTTING UNIT, DRUM CUTTER BARS

1. Introduction

Cutter bars constitute the basic operating units of agrarian machines designed for harvesting of plant material for consumption, fodder or power purposes. Among these machines, there may be distinguished: mowing machines, chaff cutters and combine harvesters. The specific character of their construction and the principle of operation result, among the others, in the fact, that the cutting process performed by them concerns plant materials, the structure of which is not uniform, and their physicomechanical properties have not been identified fully.

One of the very important way driving to lowering the costs of food production is, among the others, a decisive reduction of outlays necessary to obtain material for its production. It may be obtained by designing machines characterized by low energy-consumption of operation processes. In case of machines for harvesting materials of cereals or green fodder type, it concerns outlays necessary to obtain material for its production. It may be obtained by designing machines characterized by low energy-consumption of operation processes.

At the Division of Engineering Machines of the University of Science and Technology in Bydgoszcz there are conducted continuous activities aiming at drawing up of new constructional solutions of machines’ operating units. At present, new constructions of operating units of agrarian machines are being designed with particular attention paid to cutter bars, the effect of what are new scissor-finger constructions and the drum cutter bar presented in the paper.

2. Scissor-finger cutting unit

The basic operating unit occurring in many agrarian machines is the scissor cutting bar. In the process of stalks or stems’ cutting, there directly takes part cutting elements or cutting elements with crosscut edges, the shape, setting, type of movement, mode of action with reference to a machine, condition dissimilarity of constructional solutions of cutting units.

The essence of construction of the scissor-finger cutting unit consists in the fact, that the unit consists of a movable cutter bars and the immovable finger bar. The knives riveted to the cutter bar are of trapezoid shape. The cutting edges of knives are smooth or have incisions.

Fingers attached to the finger bar are used for partitioning of the cut material into portions. The fingers have cut-outs which allow for plane-return movement of knives and they narrow towards the front – in order to allow easier partitioning of material.

In certain constructions, there are liners attached to fingers, which form crosscut edges. In other constructions such a role is played by side fingers’ edges. Correct adherence of knives to liners is provided by push-buttons screwed down to the finger bar. Moreover, the cutter bar is supported on slide bearing. In fig.1. there is presented an exemplary diagram of the scissor-finger cutting unit.

The principle of operation of a scissor-finger cutting unit consists in the fact, that fingers go between the cut plants and divide them into portions. Then, individual knives crush plants’ stalks or stems to side edges of fingers and result in plants’ cutting.

In spite of big popularization of agrarian machines equipped with scissor-finger cutting units, their construction has not changed considerably for a long period of time. The experiments conducted at the Division of Engineering Machines of the University of Science and Technology in Bydgoszcz unambiguously point out at the fact, that resistance to dead movements have an important share in the process’s energy-consumption, while the share of power demand in working motion during cutting of the plant material amounts to only about 10% [5].

That is why, a new scissor-finger cutting unit characterized by decreased resistance to the cutting unit’s movements has been developed [6].

The essence of the new construction of the scissor-finger cutting unit (fig. 2) is characteristic in such a manner, that in place of standard slide buttons, innovative buttons (of new construction) having an opening in which a roller embedded on a clevis pin are located. Additionally, a cutter bar of a reduced cross-section has been applied, and the surface of the fingers, the cutter bar mates with, have been galvanized. These improvements are to allow for reduction of power demand needed to overcome the friction forces in dead movement of a cutting unit.
The scissor-finger cutting unit presented in fig. 2 is composed of two basic elements: an immovable finger bar (2) and a cutter bar (4). Double fingers (6) are attached to the finger bar, the side edges of which constitute a crosscut edge. During the cutting unit’s operation, the cutter bar (4) makes a back-and-forth motion, and together with it there move knives (5) fixed to the cutter bar (4). In the described scissor-finger cutting unit, buttons (3) of innovative construction have been applied to ensure correct adherence of knives to the crosscut edges, and these buttons are located by every second double finger. Cover plates (1) have been fixed on the surface of knives, constituting a raceway for rollers. Such a solution made it possible to eliminate sliding friction between a button and a knife (occurring in known scissor-finger cutting units’ constructions), replacing them with rolling friction between a button’s roller and the knife’s cover plate.

As a result, such a construction of a scissor-finger cutting unit results in the decrease of movement resistance coming from friction forces.

Moreover, the surface of fingers that the knives and the cutter bar move along, have been covered with chrome due to application of the galvanization process. Layers of that type on the mentioned surfaces are characterised by the increased hardness, resistance to abrasion and the effect of decrease of the friction factor among the mating elements has been achieved.

Additionally, in the new construction of the cutting unit, steel 15H for making of the cutter bar was used. This fact resulted in the increase of resistance and hardness of the cutter bar as compared to the traditional solution. Thanks to that it was possible to reduce the area of the cutter bar’s cross-section by half, the result of which is the decrease of its mass.

Changes of that type have a significant impact on the decrease of friction and inertial forces, what directly translates into the decreased demand for energy from the scissor-finger cutting unit [6].

### 3. Drum cutting unit

A drum cutting unit constitutes a basic operating unit of self-propelled, trailed and stationary chaff cutters. The task of a drum cutting unit is cutting of plant material (stalks or stems) into parts (chaff) of a specified length.

Application of a unit of that type in chaff cutters make it possible to obtain the required degree of material’s chopping.

An exemplary construction of a drum cutting unit is presented on fig. 3.

The cutting drums may be of open or closed construction. A drum of an open construction consists of a shaft on which shields with openings are embedded. Cutter holders are attached to the shields. In the holders there are fastened cutting knives. These knives, depending on a drum’s construction, may be straight or bended along the helix.

Moreover we can distinguish solid or split knives. A cutting drum is mounted in side plates of chaff cutter.

However, in a cutting drum of a construction closed on a shaft instead of few shields there is mounted a construction in the form of a closed roller on side surface of which there are located brackets with cutting knives mounted to them.

A rotary motion of a cutting drum results in translocation of cutting knives together with them. Knives moving around the immovable shear bar result at first in squashing – pressing of the plant material’s layer, and then its cutting through.

Delivery of material among the knife’s blade and the counter blade takes place thanks to the rotary movement of feeding-crushing rollers, which pre-form and compact the plant material.

The principle of the drum cutting unit’s operation lies in the fact, that the movement of a cutting drum results in translocation together with it of cutting knives. Knives moving towards the immovable crosscut bar result in cutting of the plant material’s layer. Delivery of material among the knife’s bade and the counter-blade takes place thanks to the rotary movement of feeding-crushing rollers, which pre-form and compact the plant material.

In spite of high popularization of chaff cutters equipped with drum cutting units, constructions of their cutting units have not changed in the last period of time. From the power balance (Sankey’a) consumed by a chaff cutter with a drum cutting unit it results, that power absorbed by the cutting unit clearly dominates over the power absorbed by the remaining operating units and amounts to 75-80% [3]. However, the upper and the lower crushing roller consume 15-18% of power [3].

Looking for more, from the point of view of power, effective construction solutions of the drum cutting unit, tests were conducted at the Division of Engineering Machines of the University of Science and Technology in Bydgoszcz the purpose of which was to determine the impact of selected construction features and parameters of the drum cutting unit on its use properties. The angle of material’s feeding on the unit straw cutting operation [1] was mainly taken into consideration [1].

It results from the conducted studies, that together with the decrease of the value of the material feeding angle $\theta$ the unit cutting resistance $p_\tau$, decreases, assuming the highest value for cutting off ($\theta=90^\circ$) and the lowest for skew cutting off at the angle $\theta=45^\circ$.

At that stage of analysis, the impact on the unit cutting resistance: cutting speed $v_\tau$, degree of material’s density $h/h_0$, and blade’s thickness $\delta$ were also determined.
Taking into account the obtained results from the conducted tests, a new construction of a cutting unit presented in fig. 4 has been drawn up, patented and constructed.

The essence of construction of the proposed cutting drum lies in the fact, that it is composed of a driving shaft and three shields, where the middle one has a bigger diameter as compared to side ones. Knives of straight or bended line along helix, in V arrangement, are screwed directly to the shields.

![Fig. 4. New construction of a cutting drum [own study]: 1 – shaft, 2 – external discs, 3 – knives, 4 – knives’ cutting edges, 5 – central shield](image)

Such a drum’s construction make sit possible to cut the material in a diagonally inclined manner, the effect of which there should be considerable lowering of the cutting unit’s energy-consumption.

### 4. Summary

A new construction of a scissor-finger cutting unit and a new construction of a drum cutting unit are presented in the article. The pilot tests of new types of cutting units conducted at test beds in laboratory conditions point out at their higher functioning efficiency with reference to already known solutions of cutting units, due to the fact of lower power demand of the operating unit.

### 5. Literature