RESEARCH ON THE INFLUENCE OF GEOMETRY OF CUTTING DEVICE ON HARVESTERS DURING THE CUTTING PROCESS

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Abstract

The paper presents a study of the influence of the constructive parameters of the blades on the cutting machines from the harvesters during the cutting process.The research focuses on the angle of sharpening of the cutting edges of the blades and the angle of inclination of the stalk during the cutting process. The blades used in the experiment have smooth and jagged cutting edges with a usual angle of 20° and modified angles of 10° and 15°. The tests were carried out using maize stalks (Zea mays) with tilt angles of 45° and 90°. The diagrams of variation of force, displacement and mechanical work during the cutting of maize stalks are presented and discussed.

Key words: cutting process, blades, combine harvester, maize stalks

The process of cutting corn stalks is a very complex one because they have variable and non-homogeneous textures with different properties in space and time. This process requires a considerable amount of energy and leads to a high wear on the blade wear (Baruah *et. al.*, 2005).

There is a relatively large number of parameters that influence the forces and the mechanical work required for cutting. Parameters that determine different cutting forces depend on: the knife geometry and the cutting blade, the physico-mechanical characteristics of the maize stalks, the relative position of the knife relative to the stalk at the moment of cutting.

The strains can be considered as viscoelastic materials, their elasticity vary considerably depending on the plant maturity and the degree of humidity (Dange *et. al.*, 2011). The moisture content of the stalks decreases as soon as it approaches the harvesting stage (Tabatabaee Koloor *et. al.*, 2006). The strain shear demand decreases once the moisture content decreases. Bending strength and modulus of elasticity decreases as the moisture content decreases (Esehaghbeygi *et. al.*, 2009).

The location of the cut (node/internodes) and the number of stalks (culture density) are significant factors for the cutting force values and the required mechanical work. The shear force is greatest at the straight cut at the node and decreases with two consecutive nodes (Yore *et. al.*, 2002). Increasing cutting height leads to energy saving during harvest because the strain shear force is lower due to the reduction in stem diameter (Alizadeh *et. al.*, 2011). Bending stress and modulus of elasticity decreases as the cutting height of stalk increases (Esehaghbeygi *et. al.*, 2009).

As harvesting height decreases and stem diameter increases, cutting forces, bending forces, modulus of elasticity, and power consumption increase (Tabatabaee Koloor *et. al.*, 2006).

The paper presents a study of the influence of the geometry of cutting machines on the harvesters during the cutting process according to two parameters: the angle of sharpening of the cutting edges of the blades and the angle of inclination of the maize stalk during the cutting process. For the evaluation of the mechanical work during the cutting process it is necessary to determine the cutting force and the blade movement during the cutting of the stalk. Knowing these parameters can then assess the energy consumption and wear tendency of cutting blades during the cutting process.

MATERIAL AND METHOD

Knives with smooth and serrated edges were tested with a normal angle of 20° and with modified angles of 15° and 10° (*figure 1*). *Figure 2 a* shows the blades with the smooth cut edges and in *figure 2 b* cut edges with their solid patterns.

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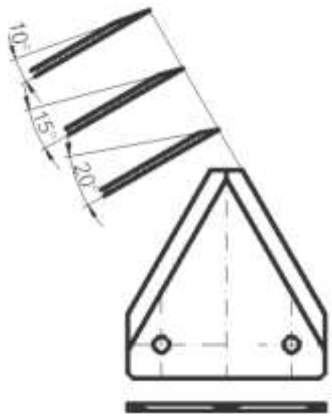

Figure 1 **The sharpening angles of the cutting edge of the blades.**

With these sets of blades we have performed cutting tests using stems of Maize (Zea mays). The stalks used were at growing stages and humidity conditions close to that of harvesting periods.

The inclination angles of the stalks during the cutting process were of 90° and of 45°.

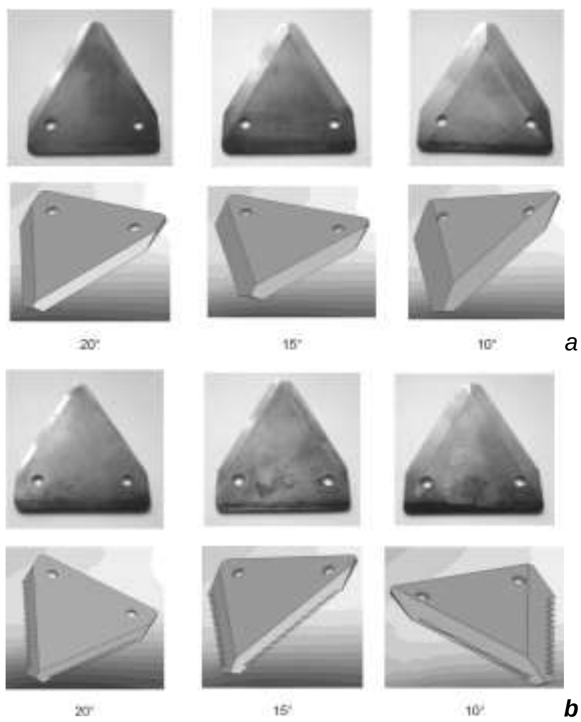

Figure 2 **Knifes geometry with three angle**.
a-smooth cutting edges ; b- serrated cutting edges

The test device with which experimental data on cutting force and blade displacement was determined during the cutting process (*figure 3*).

The measuring device is composed from: screw operating mechanism (1); linkage joint (2); force transducer (3); port blade rod (4); cutting blade (5); finger (6); displacement transducer (7); converter for displacement transducer (8); converter for force transducer (9); data acquisition card connected, via USB, to a computer using the HMI-SCADA lookout software (10) (Garbrecht *et. al.*, 2011); handle for actuating the screw mechanism (11).

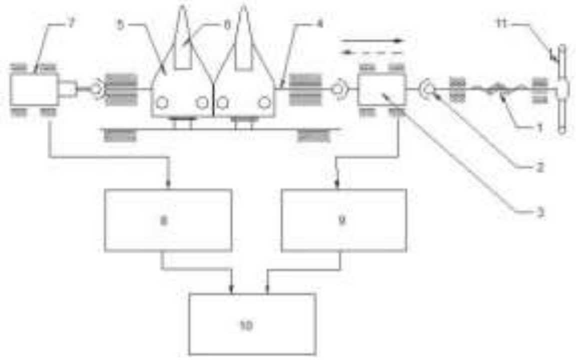

Figure 3 **The segment and the position on the knife blade**

RESULTS AND DISCUSSIONS

The forces developed in cutting the corn stalks, the knife movements and the mechanical work developed are presented as diagrams.

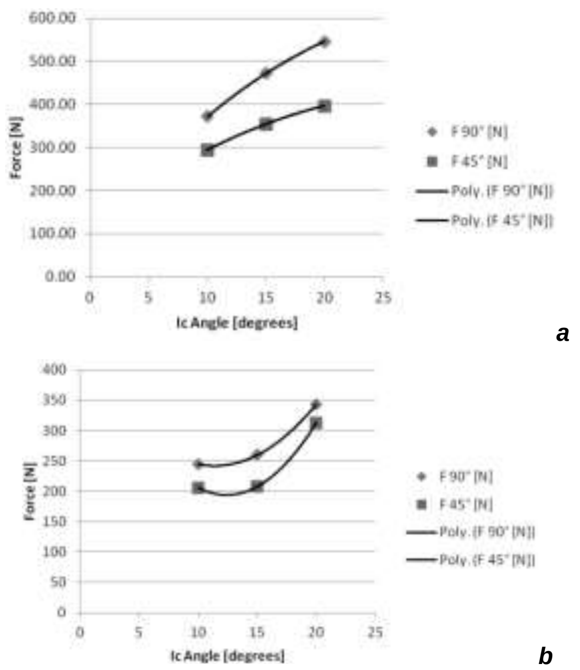

Figure 4 **Force determined at cutting of maize**
a. - smooth blades; b. – serrated blades.

From the diagrams, it is observed that the values of the cutting forces are smaller at an angle of inclination of the maize stalk of 45° to 90°. Cutting force values are higher for smooth-edged blades than for sheared blade edges for maize stalks. The cutting forces decrease as the cutting angle decreases, the smallest force being determined for all the stalks on the knives with a cutting angle of 10° (*figure 4 a, b*).

The displacements during the cutting process are generally higher for an angle of inclination of the maize stalk of 45° to 90°.

The displacements are smaller for the serrated blades than the smooth edge blades at a cutting angle of 20°, tend to be rather equal to a cutting angle of 15° and have a slow tendency to rise at an angle of 10° (*figure 5 a, b*).

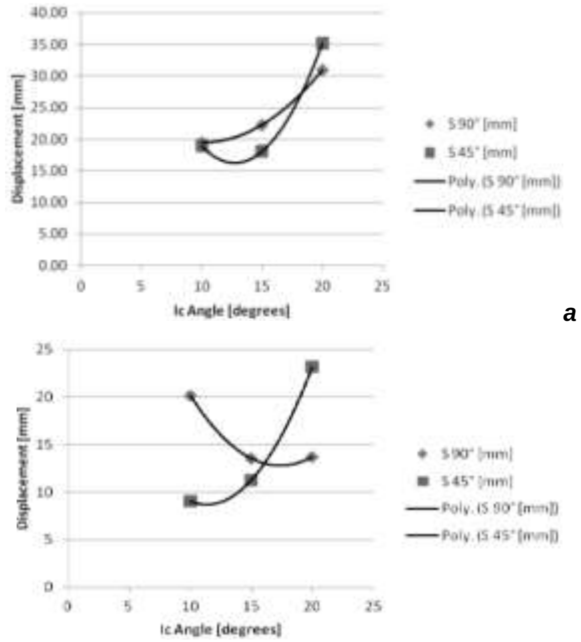

Figure 5 **Displacement measured at cutting of maize**
a. - smooth blades; b. – serrated blades

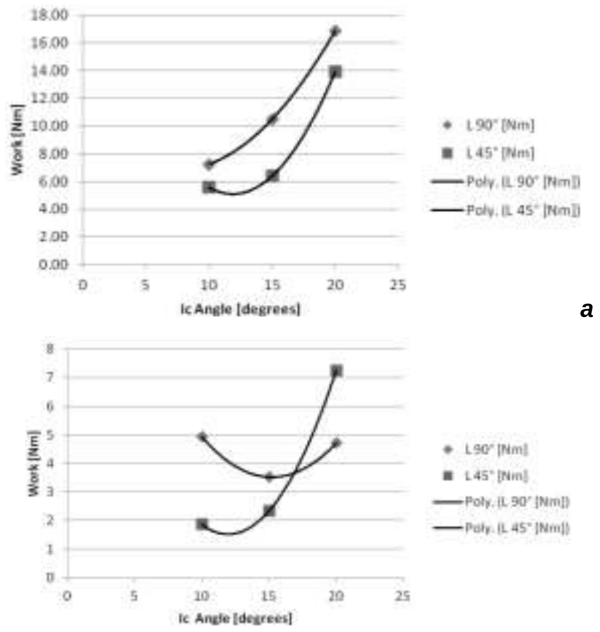

Figure 6 **Mechanical work calculated for cutting of maize**
a. - smooth blades; b. – serrated blades

The mechanical work needed for cutting is higher for smooth blades than for serrated blades. For smooth blades the mechanical work is lower for a stem inclination angle of 45° than for 90°, at a cutting angle of 20°, tends to be equal or is lower for a stem angle of 45° at cutting angles of 15° and 10°. For serrated blades the mechanical work is higher for a stalk inclination angle of 45° than for 90°, at a cutting angle of 20°, tends to be equal or is lower for a stem angle of 45° at cutting angles of 15° and 10° (*figure 6 a, b*).

CONCLUSIONS

From the analysis of the experimental results it can notice that:

The cutting forces decrease as the angle the cutting edge decreases, the smallest force being determined for all stems at the blades with a 10° cutting edge angle.

The displacements during cutting process are generally smaller for the serrated blades than that of smooth edge blades at a cutting angle of 20°, tend to be rather equal at a cutting angle of 15° and have a slow tendency of growing for a 10° angle.

It can be concluded that the reduction of the cutting edge angle of the blade from the generally used value of 20° to a value of 15° is an optimal solution, since the mechanical work needed for cutting is smaller and has the same value regardless of the stem inclination angle, also the wear tendency being lower than at smaller cutting angles. Eventually, special measures can be taken for wear reduction, such as PVD coating of blades with titanium nitride.

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