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THE EFFECT OF THE DESIGN CONCEPT OF COMBINE HARVESTER THRESHING MECHANISM ON THE MAIZE CROP THRESHING QUALITY

UTICAJ PROJEKTNOG REŠENJA MEHANIZMA ZA VRŠIDBU NA KOMBAJNU NA KVALITET VRŠIDBE KUKURUZA

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REZIME

Ispitivanjem tehničkih i tehnoloških parametara radnih uslova u kojima se odvija žetva, moguće je uticati na kvalitet rada mehanizma vršalice. Na osnovu sprovedenog poređenja između aksijalnih i tangencijalnih mehanizama za vršidbu, može se zaključiti da je aksijalni mehanizam efikasniji u pogledu kvaliteta žetve kukuruza (oštećenja zrna i gubici).

Ključne reči: kukuruz, vršidba, aksijalni mehanizam vršalice, tangencijalni mehanizam vršalice, oštećenje zrna, gubici u zrnu .

SUMMARY

Examining the technical and technological parameters of harvest working conditions enables to effect the threshing mechanism work quality. Based on conducted comparison of axial and tangential threshing mechanisms, it can be concluded that axial threshing mechanism is more effective in relation with work quality (maize grain damage and losses) when harvesting maize.

Key words: maize, threshing, axial threshing mechanism, tangential threshing mechanism, damage to grain, grain losses.

INTRODUCTION

The quality of threshing operation is effected by design concept of combine threshing mechanism related to aerobiological qualities of maize grains (Angelovič 2004; Poničan et al, 2007, 2008).

Standard *(tangential)* and *axial* types of threshing mechanism are used as the design concepts at present time.

The standard type of combine harvester threshing mechanism is based on:

- the influence of accelerative and friction forces in the threshing area (clearance),
- the indraft of the *material* into the clearance area,
- the oscillation of the *material* in the clearance,
- the repeated impacts of cylinder bars on threshed bulk,

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- ventilating effects of threshing mechanism (Mašek et al.2005, Feifer et al.2005).

In the case of the axial mechanism, the grain clearance from threshed substance is base on:

the influence of accelerative and frictional forces in the gap between the cylinder and the concaves, the individual friction of the material, the breaking the grains free through concaves by means of centrifugal forces (Mašek et al, 2005; Feifer et al.2005; Mehandžić et al, 2003, Živković, 2003).

Breaking grains free from the ears (or cobs) is effected by various kinematical factors as well as biological quality of threshed material (moisture, grain – straw rate, grain resistance to hits, etc. (Turan et al, 2002).

Threshing mechanism parameters, which affect the threshing process, include cylinder peripheral speed, clearance between cylinder and concaves, throughput of the threshing mechanism. Threshing quality is be also effected by harvester forward speed and crop parameters.

MATERIAL AND METHODS

The field experiments were conducted in maize field (*hybrid DK 4626 a DK 391*) at a farm PD Agrodivízia Selice. Tangential flow combine and axial flow combine were used for this assessment. Maize crop was characterized by agro-biological and mechanical parameters (number of plants per selected area, number of corn cobs per selected area, grain yield, moisture content in the material during the harvest).

Quality assessment of the maize combine harvesting was based on assessment of grain damage and grain losses related to cylinder peripheral speed (ranging from 9.4 to 21.4 $m.s^{-1}$), harvester forward speed (ranging from 0.5 to 2.6 ms^{-1}), threshing mechanism throughput (ranging from 2.81 to 31.7 $kg.s^{-1}$) and clearance between cylinder and concave (ranging from 24 to 40 mm).

Grain damage of harvested maize was estimated according to weight method principle (weight rate of damage grains which fell through the sieve with size of 2.5 mm to overall weight of evaluated grains, where this rate is expressed as percentage (%)). Grain losses of operating the combine harvester aggregated with the maize header were monitoring as well. The measurements were conducted at area determined by working width of the adapter and length of 30 meters. Each measurement was repeated three times while the material falling out of the threshing mechanism was captured on a sheet.

RESULTS AND DISCUSSION

Parameters of maize crop

Parameters of maize crop during the harvest are shown in *Table 1.*

Tab. 1. Parameters of maize crop

Hybrid	DK 4626			DK 391		
Selected characteristics	min	max	$\bar{x}$	min	max	$\bar{x}$
Number of plants per m^2	3.8	6.8	4.9	4.8	7.2	6.3
Number of cobs per m^2	3.8	7.8	5.0	4.8	8.4	6.6
Height of the first cobs from the ground in cm	66.3	130.3	103	79	115.5	98.3
Yield in kg/ha^{-1}	5.93	13.2	9.9	7.4	11.6	9.8
Grain moisture at harvest in %	13.1	47.7	28.8	16	31	25
Corn cob shell moisture at harvest in %	35.4	41.7	38.2	48	56	54
Stalk moisture in %	37.6	54.2	41.9	51	59	56

Work quality of threshing mechanism related to grain damage

Effect of cylinder peripheral speed on work quality of threshing mechanism (in terms of grain damage) is shown in *Figure 1.* Based on these results, it can be concluded that within the selected range of cylinder peripheral speed the grain damage increases as follows. In cease of the axial threshing mechanism increasing the cylinder speed from 9.4 to 14.5 m.s^{-1} increases the grain damage from the value of 2.1 to 2.8%. For the tangential threshing mechanism increasing the cylinder speed from 16.9 to 21.4m.s^{-1} caused increase in grain damage from 3.9 to 6.1%.

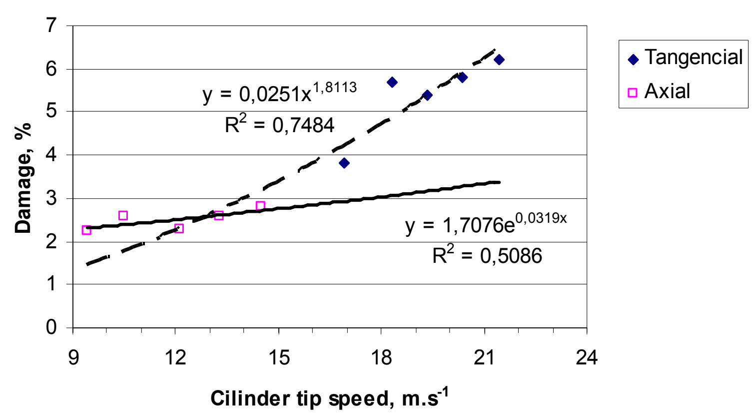

Fig. 1. The effect of the cylinder peripheral speed on the level of damage to maize grain Axial – concave clearance 32 mm, throughput 20.3 kg.s^{-1} grain moisture 19.6 -21.6%, Tangential - concave clearance 32/20 mm, throughput 10.9 kg.s^{-1} grain moisture 25%

The effect of concave clearance on maize grain damage is given in *Figure 2*. The grain damage decreases with the increase of concave clearance for both axial as well as tangential threshing mechanism. The decrease from the value of 3.8% to 2.6% was observed for the axial threshing mechanism and from the value of 4.75 to 2.8% for the tangential threshing mechanism.

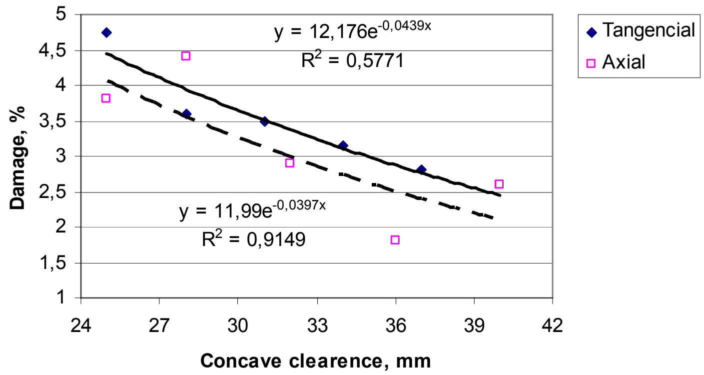

Fig. 2. The effect of the concave clearance on the damage to maize grain
Axial – cylinder tip speed 12.1 m.s^{-1}, throughput 20.3 kg.s^{-1}, grain moisture 24.4 – 28%,
Tangential – cylinder peripheral speed 16.9 m.s^{-1}, throughput 10.9 kg.s^{-1}, grain moisture 25%

The effect of threshing mechanism throughput on maize grain damage is shown in *Figure 3*. Based on the obtained values it can be concluded that increasing the throughput decreases the grain damage for axial threshing mechanism from 3.3 to 2.8%. However, the for the tangential threshing mechanism the grain damage increases from the value of 4% to 5.3 % when increasing the throughput.

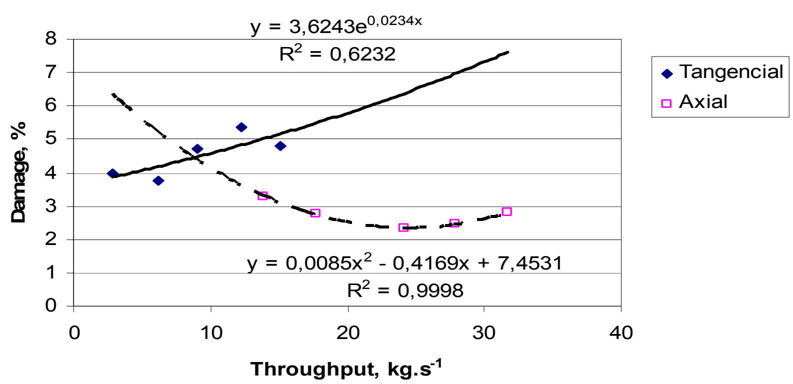

Fig. 3. The effect of the threshing mechanism throughput on grain damage
Axial – cylinder peripheral speed 12.1 m.s^{-1}, concave clearance 32 mm, grain moisture 19.2-28%,
Tangential – cylinder peripheral speed 1.9 m.s^{-1}, concave clearance 32/20 mm , grain moisture 25%

Work quality of threshing mechanism related to grain losses

Amount of threshing losses caused by setting of combine harvester threshing mechanism (cylinder peripheral speed, clearance and threshing mechanism throughput) is shown in Figures 4, 5 and 6.

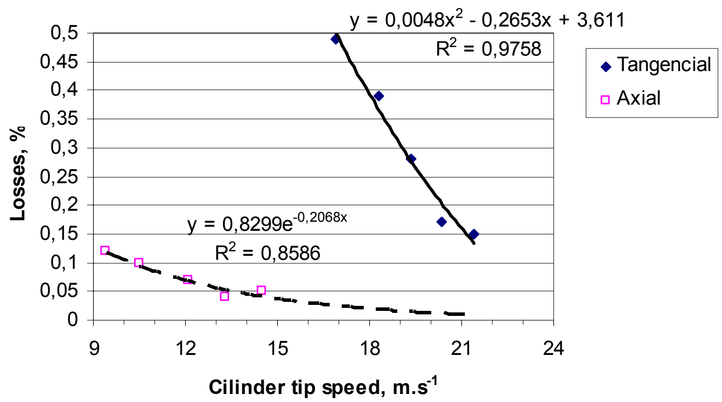

Fig. 4. The effect of the cylinder peripheral speed on the maize grain losses
Axial – concave clearance 32 mm, throughput 20.3 kg.s^{-1}, grain moisture 24.4-28 %,
Tangential – concave clearance 32/20 mm, throughput 10.9 kg.s^{-1} grain moisture 25 %

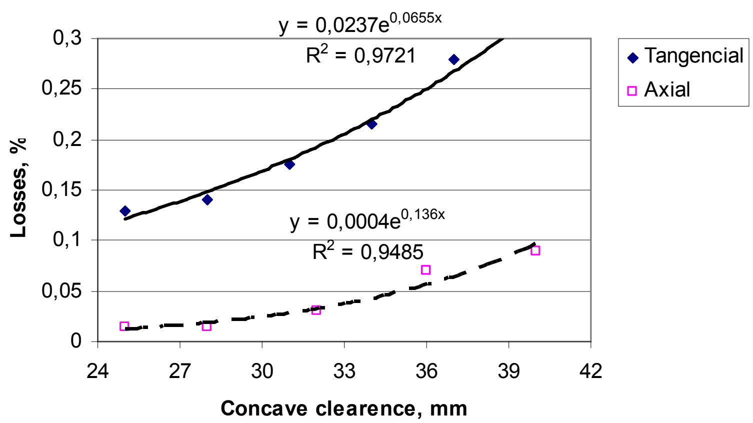

Fig. 5. Effect of concave clearance on the maize grain losses
Axial – cylinder peripheral speed 12.1 m.s^{-1}, throughput 20.3 kg.s^{-1}, grain moisture 24.4 – 28%,
Tangential – cylinder peripheral speed 1.9 m.s^{-1}, throughput 10.9 kg.s^{-1}, grain moisture 25 %

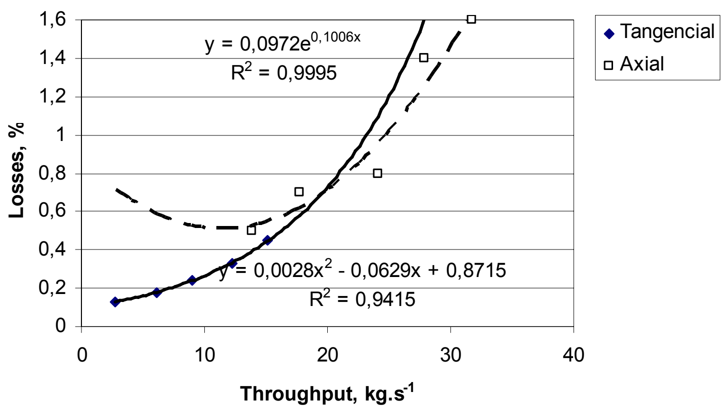

Fig. 6. The effect of combine harvester throughput on the maize grain losses, Axial – cylinder peripheral speed 12.1 m.s^{-1}, concave clearance 32 mm , grain moisture 19.2-28%, Tangential – cylinder peripheral speed 16.9 m.s^{-1}, concave clearance 32/20 mm, grain moisture 25%

Based on obtained values it can be concluded that the maize grain losses decrease with increasing cylinder speed (Figure 4). For the axial threshing mechanism increasing the cylinder speed from 9.4 to 14.5 m.s^{-1} decreases the maize grain losses from the value of 0.12 to the value of 0.05%. For the tangential threshing mechanism increasing the cylinder speed from 16.9 – 21.4 m.s^{-1} decreases the maize grain losses value from value of 0.48 to values of 0.15%.

Increasing cylinder - concave clearance from 25 to 40 mm *(Figure 5)* caused modest increase in grain losses values (by 0.05% for axial threshing mechanism and by 0.15% for the tangential threshing).

Figure 6 represents the effect of increasing throughput value on maize grain losses. Based on this results in can be concluded that increasing the threshing mechanism throughput (from the value of 2.81 to 31.7 kg.s^{-1}) increases the value of maize grain losses (for axial threshing mechanism from 0.1 % to 0.42 % and for tangential threshing mechanism from 0.45% to 0.8%).

CONCLUSION

Obtained values on maize grain damage and losses confirmed that the kinematical and technological parameters of the threshing mechanism (e.g. cylinder peripheral speed, concave clearance and threshing mechanism throughput) as well as threshing mechanism construction design (axial and tangential threshing methods) effect the quality of maize harvest.

Observed results can be concluded in following statements:

- Increasing the cylinder peripheral speed from 9.4 m.s^{-1} to 21.4 m.s^{-1} increases the values of maize grain damage (from 2.2% to 2.8% when using the axial threshing and from 3.8 % to 6.01% using the tangential threshing mechanism). However, increasing the cylinder peripheral speed decreases maize grain losses by 0.1% for axial threshing method and by 0.35% for tangential threshing method.

- Increasing concave clearance in the range from 25 to 40 mm decreases maize grain damage value at the same rate for axial as well as for tangential threshing mechanism. Increasing concave clearance increases maize grain losses (in form of untreshed heads) from 0.02 to 0.08% for axial threshing mechanism and from 0.13% to 0.27% for tangential threshing method.

- Increasing the threshing mechanism throughput (from 2.8 to 31.7 $kg.s^{-1}$) decreases the grain damage gradually from 3.3% to 2.8% for the axial threshing mechanism. However, for the tangential threshing method the maize grain damage increases from the value of 4% to 4.8%).

The effect of the increasing throughput on maize grain losses is minimal. Considering obtained results it can be concluded that the axial threshing mechanism is more effective according to maize grain damage and losses when using for maize crop harvest.

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