RESEARCH ON THE OPTIMIZATION OF THE RETRACTABLE FINGER AUGER FROM A COMBINE HARVESTER

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CERCETĂRI PRIVIND OPTIMIZAREA TRANSPORTORULUI ELCOIDAL DE LA COMBINA DE RECOLTAT CEREALE

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ABSTRACT

The paper presents research on optimizing the conveyor with retractable fingers to improve the amount of material transported by it. Initial equipment parameters were entered into an analysis program to calculate an optimal configuration.

REZUMAT

Lucrarea prezintă prezintă cercetari privind optimizarea transportorului cu degete escamotabile pentru a imbunatatii cantitatea de material transportata de acesta. Paramentrii initiali ai echipamentului au fost introdusi intr-un program de analiza pentru a calcula o configuratie optima.

INTRODUCTION

Nowadays combine harvesters are equipped with massive headers capable of harvesting large amounts of vegetable material. A very important component of the header is the retractable finger auger. For a better flow manufacturers use large diameter augers with fingers displayed on the full length of the auger.

Optimization is a way to get the best result in the given circumstances. It plays a vital role in machine design, because mechanical components must be designed in an optimal way. In designing components, optimization helps in many ways to reduce materials costs, provide a better component performance, increase production rates and many other parameters (*Narayan, 2008*).

CAE (Computer-Aided Engineering) encompasses software tools used by engineers to solve tasks such as stress resistance analysis of designed components/assemblies, simulation of operation, product optimization in the virtual model phase, simulation of the manufacturing process, planning, diagnosing project issues, etc. (Das and Pratihar, 2002)

MATERIAL AND METHOD

The angle α between the direction of the part that gives the finger eccentricity and the vertical axis influences the flow of material carried by the fingers.

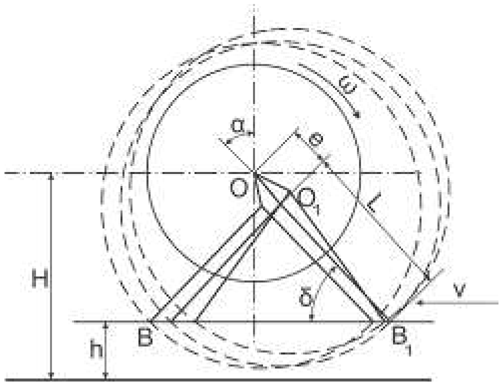


Fig.1 - The simplified model of the mechanism

L-finger length; R- drum radius; e-eccentricity; H - the distance between the center of the drum and the platform; h - the height of the material layer; δ - the angle between the finger and the surface of the vegetal material layer; ω - the angular velocity of the drum; v - speed of advancement

The angle δ between the retractable finger and the upper face of the material layer increases with the α angle, and the surface where the finger acts on the plant material decreases. When α decreases, δ decreases and the finger's surface increases.

From the image it results:

$$A = \frac{1}{2}\pi L^2 - L^2 acrsin\frac{H-h-ecos\alpha}{L} - (H-h-ecos\alpha)\sqrt{L^2-(H-h-ecos\alpha)^2}$$

The arrangement of the fingers on the drum also influences the performances of the drum with retractable fingers. The analyzed drum has 12 retractable fingers.

If b is the distance between the fingers, the transport width is 11b.

The mass of the material carried by the fingers is equal to:

$$M = 11b * \rho * 4A$$

where ρ is the density of the material

From this it results:

$$M = 11b * \rho * 4 * (\frac{1}{2}\pi L^2 - L^2 acrsin\frac{H-h-ecos\alpha}{L} - (H-h-ecos\alpha)\sqrt{L^2-(H-h-ecos\alpha)^2})$$

The above relationship was used in the drum parameter optimization procedure.

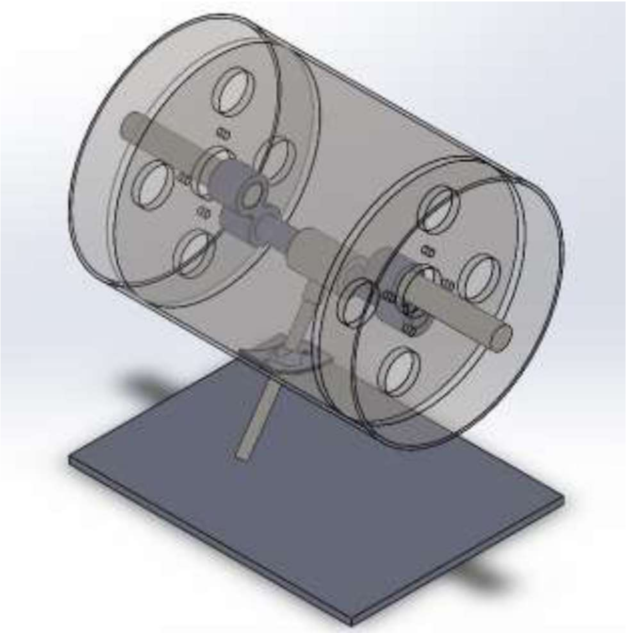
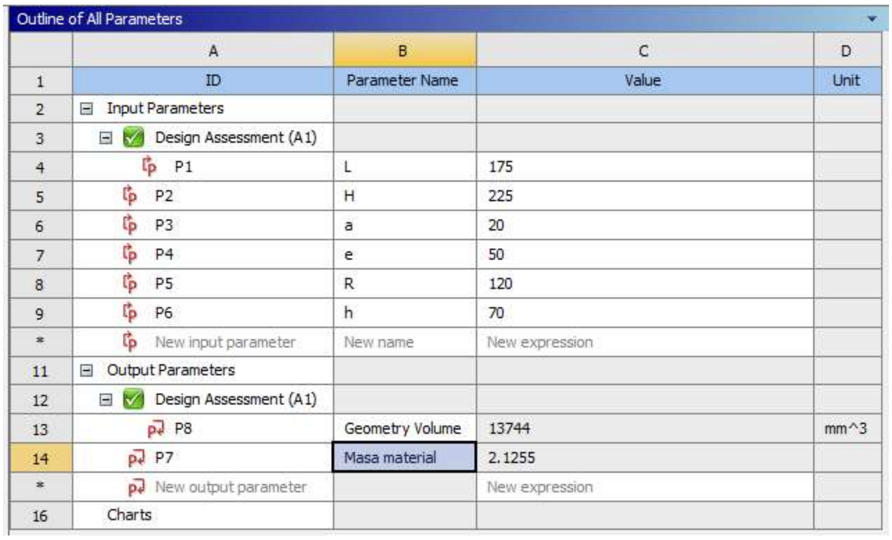


Fig.2 - The simplified model of the mechanism

The parameters that influence the amount of material carried by the retractable fingers were optimized. The analyzed drum has the following initial parameters: finger length L = 175 mm; drum radius R = 120 mm; eccentric length e = 50 mm; the distance between the platform and the origin of the drum H = 225 mm, the height of the material layer h = 70 mm and the angle α = 30 °.

Vegetable material was selected as dried wheat with a density of ρ = 30 kg / m3.

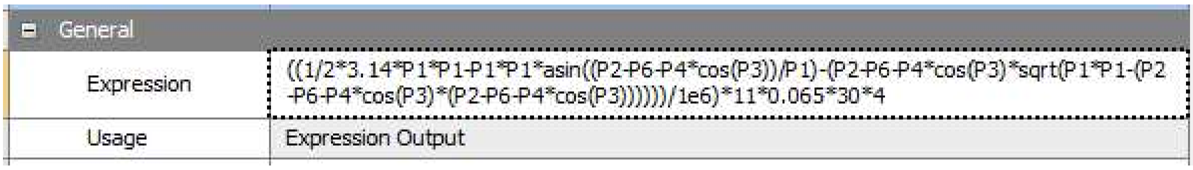
The above relationship was entered into the optimization procedure in the software Ansys. The value obtained for the initial parameters is 2.125 kg.



Outline of All Parameters

	A	B	C	D
1	ID	Parameter Name	Value	Unit
2	Input Parameters			
3	Design Assessment (A1)			
4	P1	L	175	
5	P2	H	225	
6	P3	a	20	
7	P4	e	50	
8	P5	R	120	
9	P6	h	70	
*	New input parameter	New name	New expression	
11	Output Parameters			
12	Design Assessment (A1)			
13	P8	Geometry Volume	13744	mm^3
14	P7	Masa material	2.1255	
*	New output parameter		New expression	
16	Charts			

Fig.3 - The initial parameters of the equipment



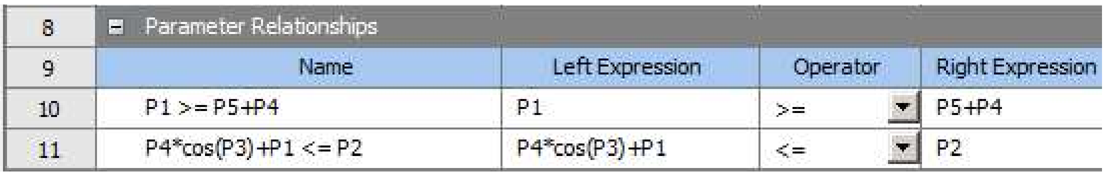
General

Expression	((1/2*3.14*P1*P1-P1*P1*asin((P2-P6-P4*cos(P3))/P1)-(P2-P6-P4*cos(P3)*sqrt(P1*P1-(P2-P6-P4*cos(P3)*(P2-P6-P4*cos(P3))))))/1e6)*11*0.065*30*4
Usage	Expression Output

Fig.4 - The relation for the vegetable material mass in Ansys

The objective of optimization is to configure the parameters of the equipment so that the mass transported by the fingers is maximum.

For the analysis, some conditions have to be met. The finger length must be greater than the sum of the drum radius and the eccentricity, L>R+e, so that your finger comes out of the drum at any point. Also, for the finger to not hit the casing, the following condition must be imposed: ecosα+L<H.



8	Parameter Relationships			
9	Name	Left Expression	Operator	Right Expression
10	P1 >= P5+P4	P1	>=	P5+P4
11	P4*cos(P3)+P1 <= P2	P4*cos(P3)+P1	<=	P2

Fig.5 - Ansys optimization conditions

Table 1

Parameters to be analyzed, as well as their lower and higher limits

Parameter	Initial value	Lower limit	Higher limit
L (mm)	175	170	180
H (mm)	225	220	228
α(°)	20	10	40
e (mm)	50	47	53
R (mm)	120	115	125

RESULTS

The procedure was set to 100 iterations from which to find 10 optimal options. The procedure was completed within 2 hours.

Table of Schematic B2: Optimization , Candidate Points

	A	B	C	D	E	F	G	H	I
1	Reference	Name	P1 - L	P2 - H	P3 - a	P4 - e	P5 - R	P7 - Output Parameter	
2								Parameter Value	Variation from Reference
3	●	Candidate Point 1	177	227	12	49	123	★★★ 3.271	0.00 %
4	○	Candidate Point 2	173	226	12.5	53	117	★★★ 3.2701	-0.03 %
5	○	Candidate Point 3	178	227	31	53	122	★★★ 3.23	-1.25 %
6	○	Candidate Point 4	177	227	19	49	116	★★★ 3.2254	-1.39 %
7	○	Candidate Point 5	178	228	38	50	116	★★★ 3.2246	-1.42 %
8	○	Candidate Point 6	176	225	25.5	52	123	★★★ 3.2226	-1.48 %
9	○	Candidate Point 7	173	227	31.5	53	116	★★★ 3.2096	-1.88 %
10	○	Candidate Point 8	175	226	38	52	122	★★★ 3.2016	-2.12 %
11	○	Candidate Point 9	176	223	31	51	117	★★★ 3.1923	-2.40 %
12	○	Candidate Point 10	179	228	31.5	48	125	★★ 3.1485	-3.74 %

Fig.6 - The best 10 options

From the figure it can be seen that the transported mass of material after optimization is 3.271 kg, with a 53% increase from the initial value of 2.125 kg.

Table 2

Parameter values before and after the optimization procedure

Parameter	Initial value	Final value	Difference	
			absolute	relative (%)
L (mm)	175	177	2	1.1
H (mm)	225	226	1	0.4
α(°)	20	12	8	40
e (mm)	50	49	1	2
R (mm)	120	123	2	2.5

CONCLUSIONS

From this study it results that analysis programs can be successfully used to optimize the parameters of agricultural machinery, in order to improve their performance.

Parameters of the retractable finger auger influence the amount of material transported. Following optimization, the mass of transported material increased by 53%.

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