THE INFLUENCE OF CONSTRUCTIVE AND FUNCTIONAL PARAMETRES OF THE BRUSHING MACHINE ON CLEANING OPERATION OF WHEAT SEEDS FOR GRINDING

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Abstract

Wheat brushing is a technological operation part of the grain seed grinding process, which aims to remove dust and adhering impurities to the surface of the wheat kernels as well as their brushes. By brushing the seeds gain a smooth and glossy surface, and the ash content is reduced by minimum 0.01%. In order to optimize the operating process a brushing installation – IPG - was designed and developed. The purpose of this study was to evaluate the effect of some functional and constructive parameters (speed of the rotor with brushes, the suction air flow rate, tapered shell type and the product feed rate) over the physical characteristics of grain seeds. The experimental results conducted using wheat kernels led to the conclusion that the percentage of broken seeds was influenced by rotor speed, product feed rate, the shape and size of the perforated shell holes of the brushing instalation drum; variations of the percentage of broken seeds up to 1.3% were recorded, depending on the constructive-functional parametres of the machine. A number of 144 experimental variants were studied in the research, the lowest percentage of broken grains being recorded at the maximum feeding rate of 600 kg/h. The optimum variants were established based on the analysis of the results referring to the percentage of broken kernels.

Key words: wheat cleaning, brushing machine, conditioning

Modern technologies for processing wheat kernels involves better use of raw materials in order to obtain products with high nutritional value at the lowest possible production costs.

Analyzing the structure of wheat kernels and the chemical composition of its different anatomical parts reveals the area of the endosperm which contains the highest concentration of vitamins, enzymes, minerals and nutritional components essential for the proper functioning of the human body is at the border between the endosperm and aleurone layer; it is for this reason that it is necessary to study the wheat conditioning process (Wheat Quality & Carbohydrate Research, 2015).

Brushing is a technological process that aims, in particular, to remove dust and other impurities form the surface of wheat kernels; when the brushing machine is placed after the dehuller in the technological flow it has the role to remove the tattered layers, produced by the dehullig process, from the surface of the grains (Costin I., 1983). Wheat brushing produces a curing of the kernels coating, curing required in the grinding process, because kernels coatings are turned into large particles of bran, easily separable by sieving. The brushing process reduces the ash content of wheat with minimum 0.01% and in the same time wheat kernels gain a smooth and glossy surface. (Iorga L, Câmpeanu G., 2004).

The quantity and quality of the dust produced by brushing depends on the grain surface condition and on the operating process of the brushing machine; the dust obtaind during this operation is a very valuable feed product for animals. Sometimes brushing can replace grain washing in order to eliminate soil, dust and other impurities from the surface of wheat kernels.

The scope of the research is justified by the fact that grain brushing operation has a significant influence over the grinding process, content of minerals in flour, separation of germs and broken wheat kernels content. (Brătucu G., 2009)

MATERIAL AND METHOD

The Glossa wheat variety from Halauceşti and Mogoşeşti-Siret, Iasi was used for this study. Grain sampling was conducted using the method stated in ISO 13690/2001. In order to carry out the researches on the work process of the wheat brushing machine,

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the grain was received, homogenized and stored.

Table 1 shows the physical and chemical characteristics of the wheat used in experimental research, based on the results obtained in laboratory tests.

The methods and apparatuses used for the analysis of wheat samples, before and after their conditioning, are presented in *table 2*.

Table 1

Physical and chemical characteristics of Glossa wheat (witness sample)

Quality parameters	U.M.	Value
Humidity	%	13,8
Density	Kg/hl	73,8
Foreign corps	%	1,5
Wet gluten	%	24,4
Deformation index of gluten	mm	3,5
Protein content	%	11,56
Ash content	%	1,604
Falling number	sec	312
Acidity	grade	4,0

Table 2

Methods and apparatuses used for wheat analysis (C.N.G.S.C., 2013)

No.	Quality parameters	U.M.	Method	Apparatus
1.	Sensorial characteristics	-	Organoleptic method STAS 6253 /1980	-
2.	Humidity	%	SR EN ISO 712:2010	Oven
3.	Density	Kg/hl	SR EN ISO 7971-1:2010	Hectoliter balance
4.	Foreign corps	%	SR ISO 7970/2001	Sieves
5.	Ash content	%	SR EN ISO 2171:2010	Calcinator
6.	Protein content	%	SR EN ISO 20483:2014	Kjeldahl installation
7.	Wet gluten	%	SR EN ISO 21415-3:2007	Oven
8.	Deformation index of gluten	mm	SR 90-2007	Thermostat
9.	Falling number	sec	SR EN ISO 3093/2010	Falling Number tester

An experimental test rig was designed and built in order to study the wheat brushing process and to optimize the constructive and functional parameters of the machine, aiming to the improvement of the quality characteristics of the grains and of the flour obtained after the grinding process.

The wheat brushing machine (*figure 1*) is a continuous operating device; wheat grains are introduced through the inlet (1) and processed due to the rubbing between the rotating rotor with brushes (2) and the perforated sheet jacket (6). The cleaned grains are removed through the outlet (10), while the light impurities are removed by suction tube (5). The heavier particles with smaller dimensions than the holes from the perforated jacket are disposed through the impurities outlet (11). The transport of the grains is achieved due to the workload of the system and the tapered shape of the perforated sheet jacket. Speed control of the rotor with brushes is achieved through the frequency converter (8) which provides also motor-overload protection (9). The transmission of movement from the rotor shaft is made through a V-belt transmission (2). The entire assembly is supported by the frame (3).

A general view of the wheat brushing installation is shown in *figures 2.a* and *2.b*.

The percentage of broken grains was calculated by taking a sample of 100 grams of wheat, after each experiment. Subsequently the samples were hand-picked and the broken kernels separated from the whole grains, and then weighed with an electronic scale of the type MH-200 accurate to 0.01 g (*Figure 3*) and with an electronic thermo-balance LSC 60 (*Figure 4*).

A total number of 144 experimental variants were developped in order to analyze the influence of constructive and functional parameters of the brushing machine over the level of broken grains and ash content. Samples were taken from all 144 experimental variants and the percentage of broken grain and ash content after were determined for each sample.

In order to study the influence of the brushing operation on the percentage of broken grains (Bs) and ash content (Cc), the following factors were taken into account:

F_1 – The shell type conical sieve, with six graduations, as follows:

a_1 – perforated sheet jacket with elongated holes of 1 mm thickness;

a_2 - perforated sheet jacket with elongated holes of 1,5 mm thickness;

a_3 - perforated sheet jacket with elongated holes of 1,75 mm thickness;

a_4 - perforated sheet jacket with round holes of 1 mm diameter;
a_5 - perforated sheet jacket with round holes of 1,5 mm diameter;
a_6 - perforated sheet jacket with round holes of 1,75 mm diameter.

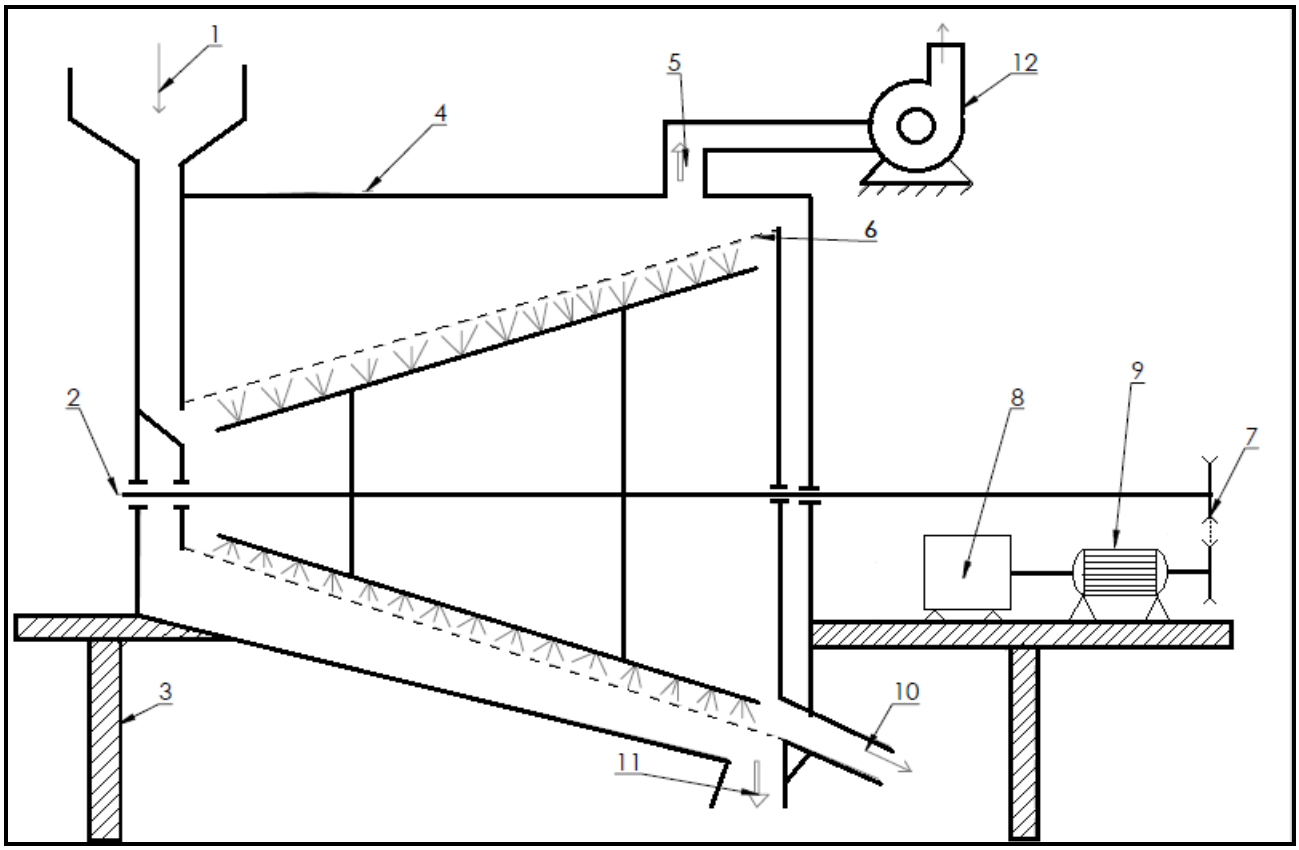

Figure 1 **Technological scheme of wheat brushing machine**: 1 – Inlet; 2 – rotor with brushes; 3 – frame; 4 – housing; 5 – suction channel; 6 – perforated sheet jacket; 7 – V-belt transmission; 8 – frequency converter; 9 – electric motor; 10 –outlet for clean seeds; 11– impurities outlet

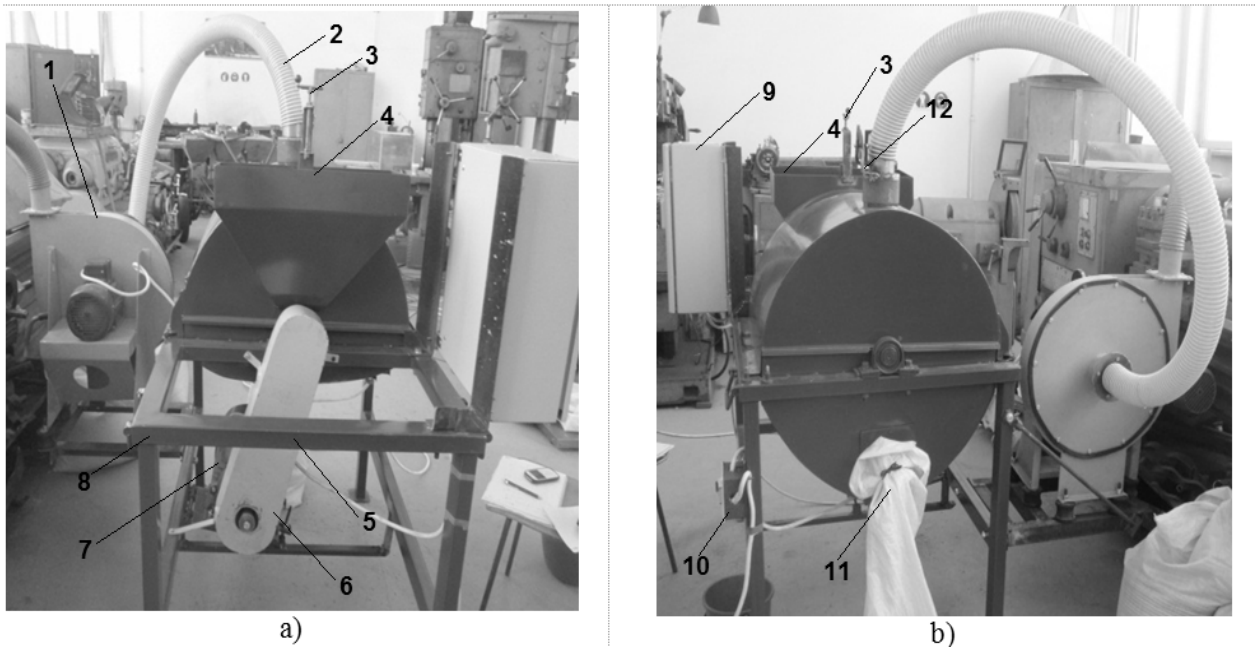

Figure 2 **Wheat brushing installation IPG**: a) Left view; b) Right view
1 - Fan; 2 – suction tube; 3 - bolt for adjusting the feed rate; 4 - hopper; 5 - frame; 6 - belt transmission; 7 - electric motor; 8 - frame; 9 - frequency converter; 10 - switch; 11- outlet cleaned grains; 12 - device for regulating the suction flow in the system

Figure 3 **Electronic scale MH-200**

Figure 4 **Thermo-balance LSC 60**
(Perten Instruments, 2014)

F_2 – The flow rate of the air suction system (Q_a), with two graduations, as follows:
b_1 – Q_a = 0,15 m^3/s;
b_2 – Q_a = 0,075 m^3/s.

F_3 – Inlet bolt position, with three graduations, as follows:
c_1 – product feed rate of 600 *kg/h*;
c_2 – product feed rate of 300 *kg/h*;
c_3 – product feed rate of 60 *kg/h*.

F_4 – Rotor speed (n), with four graduations, as follows:
d_1 – n = 100 *rot/min*;
d_2 – n = 150 *rot/min*;
d_3 – n = 200 *rot/min*;
d_4 – n = 250 *rot/min.*

RESULTS AND DISCUSSIONS

After the technological operations of cleaning and conditioning for milling are performed on wheat grains, a certain percentage of broken wheat kernels and ash content was obtained; broken kernels and ash negatively affect the grinding process and the qualitative indices of flour.

Table 3 summarizes the results obtained regarding the percentage of broken grain and ash content for all the experimental variants.

In nine of the experimental variants (Vp_4, Vp_{10}, Vp_{13}, Vp_{31}, **Vp_{34}, Vp_{37}**, Vp_{46}, Vp_{125}, **Vp_{136}**) a very low percentage of broken grains (below 0.8%) was recorded, eight of them being obtained for the case of the maximum product feed rate (600 kg/h).

When a perforated jacket with round holes was used the percentage of broken grain was lower than 0.8% for only two experimental variants, due to the fact that larger fragments fail to pass through the shell holes (the holes of the perforated sieves with round holes are much smaller and rare).

In the case of 26 experimental variants (Vp_7, Vp_{11}, Vp_{20}, Vp_{21}, Vp_{24}, Vp_{25}, Vp_{27}, Vp_{29}, Vp_{30}, **Vp_{34}, Vp_{37},** Vp_{40}, Vp_{57}, Vp_{62}, Vp_{70}, Vp_{78}, Vp_{79}, Vp_{85}, Vp_{86}, Vp_{93}, Vp_{103}, Vp_{104}, Vp_{123}, Vp_{134}, Vp_{135}, **Vp_{136}**) the ash content values were below 1.5 %, thus registering a decrease in the ash content of over 0.1% as compared to wheat which has not been subjected to the brushing operation.

CONCLUSIONS

The percentage of broken grains and the ash content are affected by:

- the form and dimensions of the holes of the perforated sheet jacket;
- rotor speed;
- product feeding rate;
- suction air flow.

The use of the screens with elongated holes is highly recommended because the experimental tests suggest that the process of removing the dust and small impurities is better achieved.

After comparing the research data regarding the optimum working process parameters of wheat brushing plant in order to obtain the minimum percentage of broken grains and ash content, three experimental variants registered very low values in both cases, namely: Vp_{34} (B_s=0,75 %, C_c=1,4763%), Vp_{37} (B_s=0,716 %, C_c=1,4576 %) and Vp_{136} (B_s=0,78 %, C_c=1,4995 %). Variant Vp_{136}, which used a perforated sheet jacket with round holes, did not ensure an optimum working process of the brushing machine because it did not achieve the proper disposal of husks.

Table 3

Broken wheat kernels percentage and ash content obtained after laboratory tests

Var.	Broken wheat kernels, B_s [%]	Ash content, C_c [%]	Var.	Broken wheat kernels, B_s [%]	Ash content, C_c [%]	Var.	Broken wheat kernels, B_s [%]	Ash content, C_c [%]
Vp_1	1,104	1,53584	Vp_{49}	0,984	1,52882	Vp_{97}	1,185	1,5616
Vp_2	1,461	1,56693	Vp_{50}	1,174	1,51831	Vp_{98}	1,285	1,5428
Vp_3	1,882	1,53942	Vp_{51}	1,553	1,56848	Vp_{99}	1,476	1,5392
Vp_4	0,742	1,57302	Vp_{52}	1,187	1,5478	Vp_{100}	1,251	1,526
Vp_5	0,991	1,50595	Vp_{53}	1,503	1,51635	Vp_{101}	1,324	1,5308
Vp_6	1,024	1,54966	Vp_{54}	1,587	1,55202	Vp_{102}	1,54	1,5054
VP_7	1,243	1,4941	Vp_{55}	0,993	1,55929	Vp_{103}	1,295	1,4584
Vp_8	1,741	1,54037	Vp_{56}	1,082	1,57008	Vp_{104}	1,385	1,4979
Vp_9	1,796	1,52595	Vp_{57}	1,163	1,49634	Vp_{105}	1,755	1,5747
Vp_{10}	0,621	1,53624	Vp_{58}	0,99	1,53264	Vp_{106}	1,115	1,5089
Vp_{11}	1,168	1,49814	Vp_{59}	1,403	1,51697	Vp_{107}	1,234	1,5811
Vp_{12}	0,817	1,50662	Vp_{60}	1,511	1,52975	Vp_{108}	1,416	1,5949
Vp_{13}	0,72	1,54372	Vp_{61}	1,039	1,51524	Vp_{109}	1,005	1,5575
Vp_{14}	0,924	1,51323	Vp_{62}	1,069	1,48987	Vp_{110}	1,07	1,5356
Vp_{15}	1,131	1,51467	Vp_{63}	1,249	1,51935	Vp_{111}	1,455	1,5726
Vp_{16}	1,245	1,51957	Vp_{64}	1,272	1,51928	Vp_{112}	0,953	1,5473
Vp_{17}	1,355	1,53117	Vp_{65}	1,291	1,55648	Vp_{113}	1,092	1,5455
Vp_{18}	1,395	1,58487	Vp_{66}	1,463	1,51979	Vp_{114}	1,424	1,5442
Vp_{19}	1,121	1,51023	Vp_{67}	1,179	1,52628	Vp_{115}	1,045	1,5851
Vp_{20}	1,102	1,36925	Vp_{68}	1,218	1,54157	Vp_{116}	1,3	1,5358
Vp_{21}	1,213	1,45919	Vp_{69}	1,358	1,56255	Vp_{117}	1,545	1,5456
Vp_{22}	0,871	1,52371	Vp_{70}	1,312	1,4648	Vp_{118}	1,015	1,5227
Vp_{23}	0,896	1,53999	Vp_{71}	1,374	1,52447	Vp_{119}	1,28	1,59
Vp_{24}	1,172	1,45286	Vp_{72}	1,449	1,5977	Vp_{120}	1,39	1,5676
Vp_{25}	1,203	1,49367	Vp_{73}	1,078	1,53734	Vp_{121}	0,925	1,5791
Vp_{26}	1,429	1,51738	Vp_{74}	1,203	1,51355	Vp_{122}	0,925	1,5159
Vp_{27}	1,438	1,49810	Vp_{75}	1,11	1,50649	Vp_{123}	1,315	1,4991
Vp_{28}	0,846	1,56299	Vp_{76}	0,998	1,55517	Vp_{124}	0,895	1,5018
Vp_{29}	0,881	1,49135	Vp_{77}	1,357	1,52418	Vp_{125}	0,795	1,5215
Vp_{30}	1,036	1,43445	Vp_{78}	1,175	1,48779	Vp_{126}	1,123	1,5568
Vp_{31}	0,757	1,52967	Vp_{79}	1,332	1,45006	Vp_{127}	0,96	1,5546
Vp_{32}	0,818	1,53051	Vp_{80}	1,659	1,51409	Vp_{128}	0,825	1,5308
Vp_{33}	0,913	1,58479	Vp_{81}	1,585	1,50308	Vp_{129}	1,165	1,5579
Vp_{34}	**0,75**	**1,47628**	Vp_{82}	1,155	1,56351	Vp_{130}	1,182	1,5891
Vp_{35}	0,825	1,52846	Vp_{83}	1,276	1,58361	Vp_{131}	1,095	1,5944
Vp_{36}	**1,122**	**1,51004**	Vp_{84}	0,897	1,59881	Vp_{132}	1,385	1,6211
Vp_{37}	0,716	1,45762	Vp_{85}	0,895	1,47011	Vp_{133}	0,885	1,5213
Vp_{38}	0,948	1,55840	Vp_{86}	0,872	1,43655	Vp_{134}	1,13	1,4844
Vp_{39}	1,094	1,51968	Vp_{87}	0,936	1,56397	Vp_{135}	1,275	1,4897
Vp_{40}	0,969	1,44952	Vp_{88}	0,995	1,53205	**Vp_{136}**	**0,78**	**1,4995**
Vp_{41}	1,046	1,53371	Vp_{89}	0,98	1,58562	Vp_{137}	1,015	1,5024
Vp_{42}	1,088	1,50163	Vp_{90}	1,056	1,53248	Vp_{138}	1,112	1,565
Vp_{43}	0,873	1,54008	Vp_{91}	1,472	1,50678	Vp_{139}	1,08	1,5234
Vp_{44}	0,97	1,52106	Vp_{92}	1,336	1,57208	Vp_{140}	1,175	1,5965
Vp_{45}	1,012	1,57884	Vp_{93}	1,449	1,4965	Vp_{141}	1,335	1,5962
Vp_{46}	0,784	1,53729	Vp_{94}	1,216	1,51602	Vp_{142}	0,96	1,5769
Vp_{47}	0,852	1,60189	Vp_{95}	1,253	1,54898	Vp_{143}	1,085	1,5923
Vp_{48}	0,943	1,57597	Vp_{96}	1,283	1,50232	Vp_{144}	1,4	1,5831

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