RESEARCH ON THE HEAT BALANCE SHEET DRYING FLUIDIZED BED WITH SOLAR ENERGY

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Rezumat. În lucrare se determină necesarul de energie privind uscarea semințelor în pat fluidizat folosind ca sursă, energia solară. Se prezintă un studiu comparativ al calității semințelor uscate folosind energie clasică şi solară.
Cuvinte cheie: uscare, energie solară.

Abstract. Work in determining the energy demand of seed drying using fluidized bed as a source, solar energy. It presents a comparative study of quality seeds dried using solar energy and classical.
Keywords: drying, energy, solar.

1. GENERAL

In the laboratory thermotechnics and Research Methods Machinery and equipment, of the Faculty of Mechanical Engineering of Craiova, was designed, developed and tested a pilot model for grain drying using two alternative sources of heat, solar energy or fuels, depending on weather conditions or where the process is drying. Studying the types of facilities and means for drying known in current agricultural practice and the literature, concluded that the conditions geo-thermics and geoclimatics from us in the country in general and the city of Craiova, in particular, can be used with much success the heat from the sun. In the case of solar and especially those used as carrier fluid heat air for storing surplus heat produced from solar captures solution bed of rocks is most favorable and economical.

Scheme of principle of the drying dual source energy, electricity and solar energy is shown in figure 1.

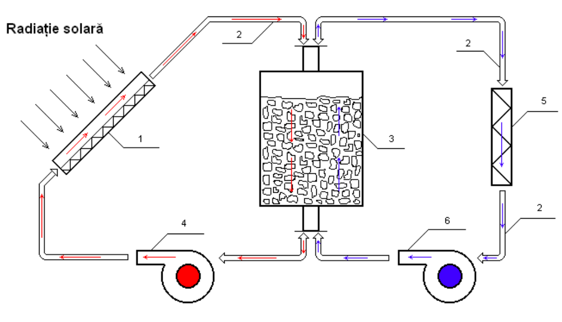


Fig. 1

Material storage of solar energy must meet certain requirements, namely:

– appropriate physical properties;
– good chemical stability and low cost as possible.

Thus it is considered that the storage material is even better, as a mass specific heat and thermal conductivity greater. Also, a role it has density material when it is the place to be located station storage (eg materials with higher densities are recommended to be used in confined spaces). Storage of materials rocks are best used, such as basalt, limestone, granite, sandstone and marble. All good properties of heat accumulation are listed and ceramic materials, but are weak in terms of heat transfer.

Rocks used as a material storage calorific energy, the physical properties listed above, and must have chemical stability, ie do not lose their qualities as a result of loss of water molecules in the constitution of micro-crystals.

Study of a thermal storage system involves the introduction of air temperature variations (as heat carrier) and the bed of rocks (such as material storage). Considering a volume element of surface S and thickness Δx (figure 2) heat balance of the soundness can be written as:

$$\rho\left(V_p / V\right)\, S\, \Delta x\, c_p \frac{\partial T_0}{\partial x} = \\ = \alpha_v\, S\, \Delta x\left(T_f - T_p\right) - k_s\, \Delta x\left(T_p - T_c\right) \qquad (1)$$

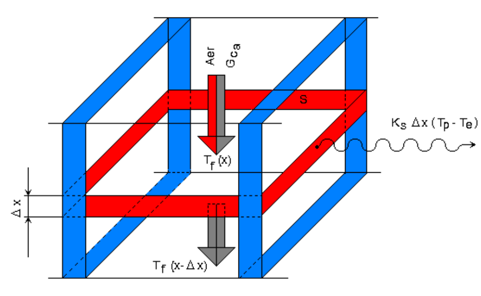


Fig. 2

Also noting with G mass flow of air and S_c catchment area, the heat balance on the fluid can be written as:

$$G\, c_f\left[T_f\left(x+\Delta x\right) - T_f\left(x\right)\right] = \\ = \alpha_v\, S_c\, \Delta x\left(T_p - T_f\right) \qquad (2)$$

Calculating the limit when $\Delta x \to 0$ and selecting terms, equations (1) and (2) become (3):

$$\frac{\partial T_p}{\partial (z/\tau)} = \alpha_v \frac{S_L}{G\, c_p}\left(T_f - T_p\right) - \frac{k_s\, L}{G\, c_p}\left(T_p - T_c\right); \qquad (3)$$

$$\frac{\partial T_f}{\partial (x/L)} = \alpha_v \frac{S\, L}{G\, c_f}\left(T_p - T_f\right) \qquad (4)$$

These are differential equations with partial derivatives proposed by Hughes, etc. on which determines the distribution of air temperatures and material storage. They are solved using numerical methods. To consider and conduct in the particulate material storage, Jefferson proposes a new form of differential equations (3) and (4):

$$\frac{\partial T_p}{\partial (z/\tau)} = N_{tu_c} \cdot \left(T_f - T_p\right); \qquad (5)$$

$$\frac{\partial T_p}{\partial (x/L)} = N_{tu_c} \cdot \left(T_f - T_p\right) \qquad (6)$$

where: z is time to begin entering the fluid (air) in the bed storage;

T_f - air temperature;

T_p - the bed temperature storage;

L - total length of the storage for the purposes of air circulation;

τ - time characteristic of the bed for storage, given by the relationship

$$\tau = \frac{\rho\, c_a\, V_p\, S\, L}{G\, c_p} \qquad (7)$$

2. SCHEME OF THE DRYING

Scheme of principle of the model plant for drying in fluidized bed with double heat source, designed and built by the author, can be tracked in Figures 3 and 4.

The model plant is composed of the following construction: box (3), which is filled with a certain amount of seeds (1) cereals, technical plants and vegetables and is equipped with a temperature sensor (2) type KTY 81 -- 210, coupled to a digital thermometer (31) AD-010 type KTY, developed by Adelaide IMPEX SRL Craiova. Bed of rocks (8) is performed in the storage box (7), in turn provided with a temperature sensor (29), identical to the sensor (2) and coupled in turn to a digital thermometer (30). Capture solar energy consists of the box (17), with interior walls painted in black, the temperature sensor (19) and support adjustable in two planes (57) and the motherboard (15) which is fixed to the support plate (39). The signal from the temperature sensor (19) is transmitted to digital thermometer (28) by means of wire connection in support of PVC (27). The three digital thermometers (28), (30) and (31) is supported by support timber (32).

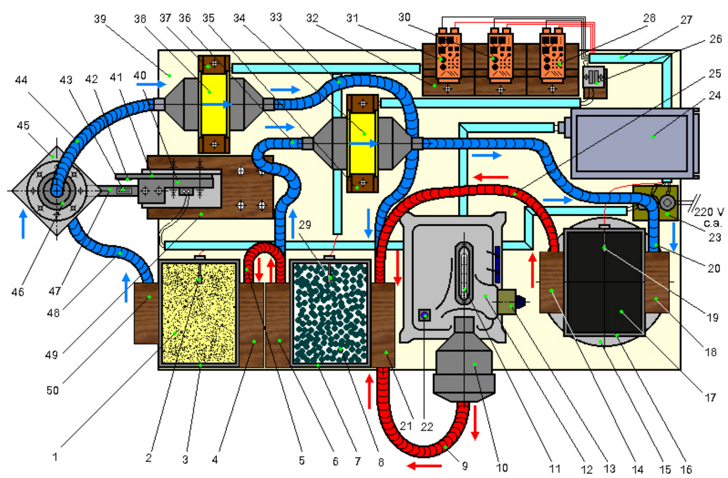


Fig. 3

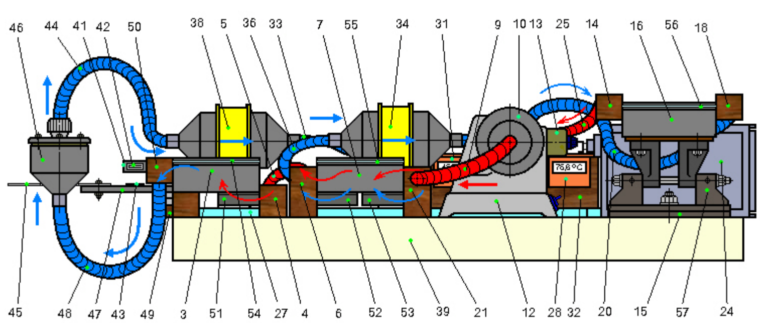


Fig. 4

To generate heat by fuels plant model is equipped with the device (12) comprising an electrical resistance, with a fan inside which connects the mouth to warm air exhaust (10) and thence through a heat insulated tube (9) to capture with rocks (7). In order to adjust the desired temperature of hot exhaust air from the fan, the device (12) is fitted with thermometer (11) and rheostat adjustment (13) which has the role to stop or start feeding termoresistence periodically, depending on air temperature hot, this state is visible light with the witness (22).

For vehicular air hot and cold on the various circuits of the power plant model, using two external fans (34) and (38), supported by stands of timber (35) and (37) and a series of tubes for achieving the two main circuits: the heating of the bed of rocks and the fluidized bed drying in the seed.

Coupling tubes in boxes are made by mouths to feed and exhaust, wood or sheet, as follows: the supply of hot air to lead the rocks is with the mouth of food (21); supply of hot air drying box is the mouth of food aid (4) and exhaust mouth (6) the lead with rocks, venting rawish resulted after drying seeds is done with the mouth of the exhaust (50), attached to the box of seeds; venting heat from solar lead is done with the mouth of the exhaust (14) and returning cold air from the heating of the rocks capture is mouth feed (18), attached to the box (16).

The two fans made external means of movement of hot or cold air as metaphorical arrows in Figures 7.2 and 7.3. To remove water from the drying process, the evacuated tubes (48) and (44), a container with a silica gel material higroscopics type (46), supported by a support plate (45) fixed on a pair of transducers blade embedded in the console (47), (41) which are located tensometrics resistive transducers (42), (43) linked semipunte and coupled to the deck tensometrics (24).

The two are captured elastic tensometrics set piece (40) which in turn is supported by two mounting screws on the support (49). Entry capture cold air with rocks, disposed in the drying box and recirculated by external fan (38), is made through the box of plates (53) located under captive through several holes.

Similarly, the entry of warm air from capture with rocks in the drying box, the box is made of sheet (51) in its bottom, ensuring in this way forming the fluidized bed of seed mass of the box (3).

Venting the cold produced by heating rock (8) box (7) is made with the box of plates (52) located under capture of rocks and cans at the coupling circuit consisting of circuit tubes with hot air supply and exhaust air cold is with mouths Intake - Exhaust (6) and (21).

Scheme electric actuation and measurement of the drying is shown in figure 5, and the measurement in figure 6.

3. DATE EXPERIMENTALE

For monitoring changes in the technological parameters of process, there were dependencies between the different sizes measured, and what follows are presented and the final extreme, both scales (Table 1) and by means of histogram made through Microsoft Office Excel 2003. To conduct complex analysis of the drying process of cereal seed and plant technical fluidized bed, the following is presented the variation of different parameters of the technological process, based on changes in other parameters. Were examined and drawn graphs of variation of air relative humidity in the immediate vicinity of the seed of wheat, depending on the temperature of the drying box and the box of rocks.

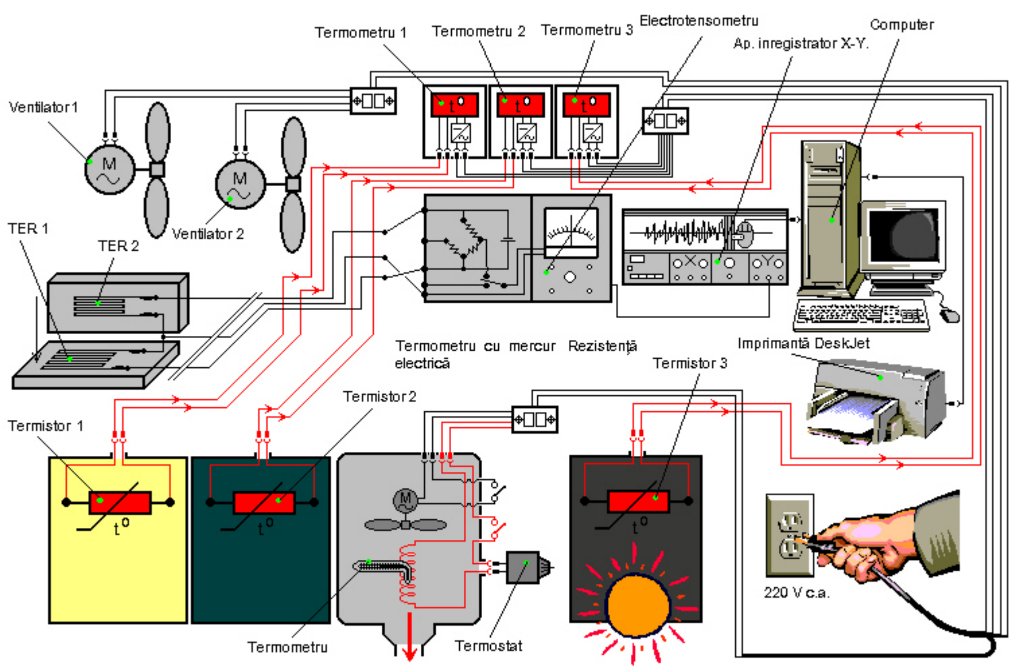


Fig. 5. Electric Drive Scheme.

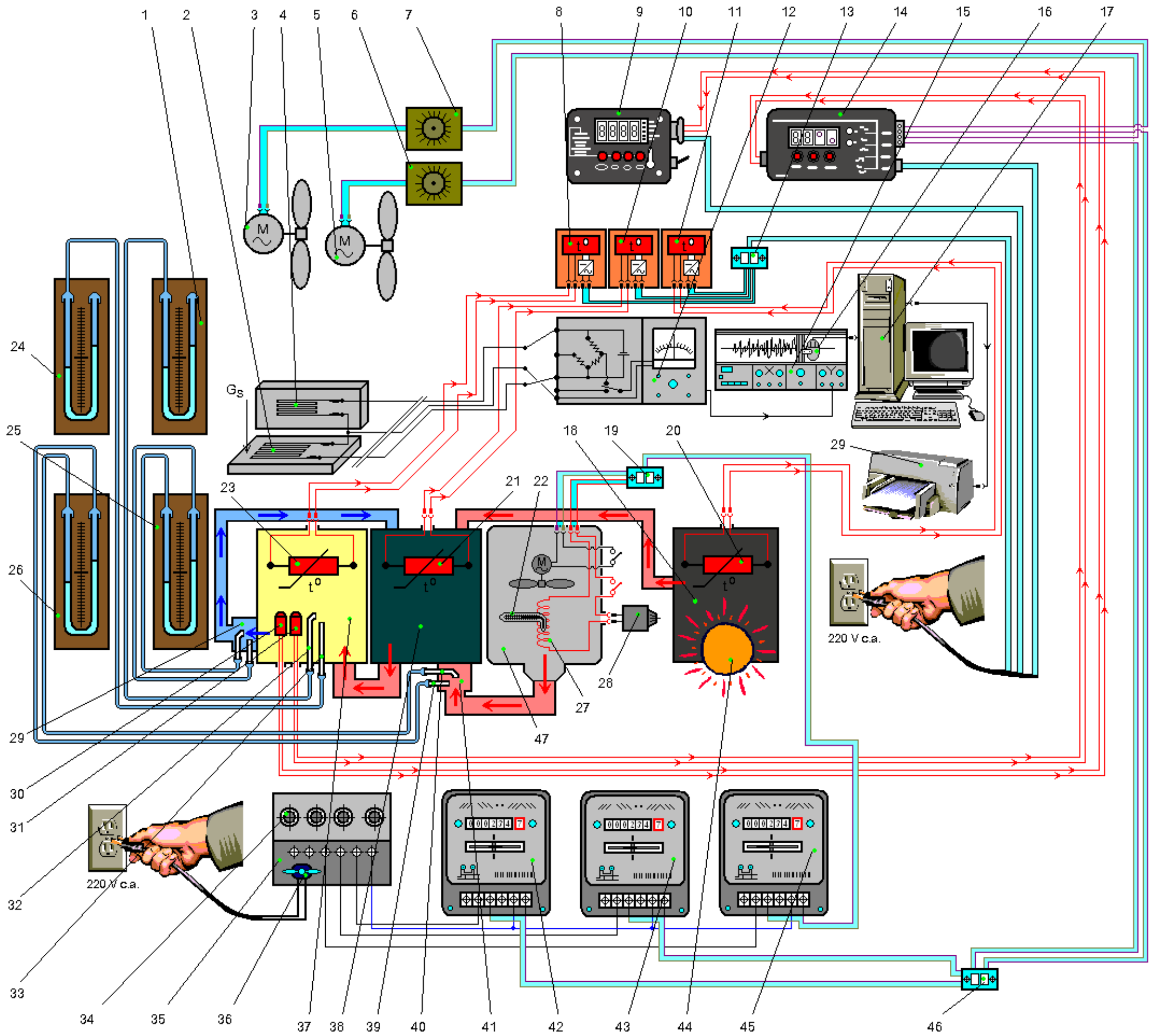
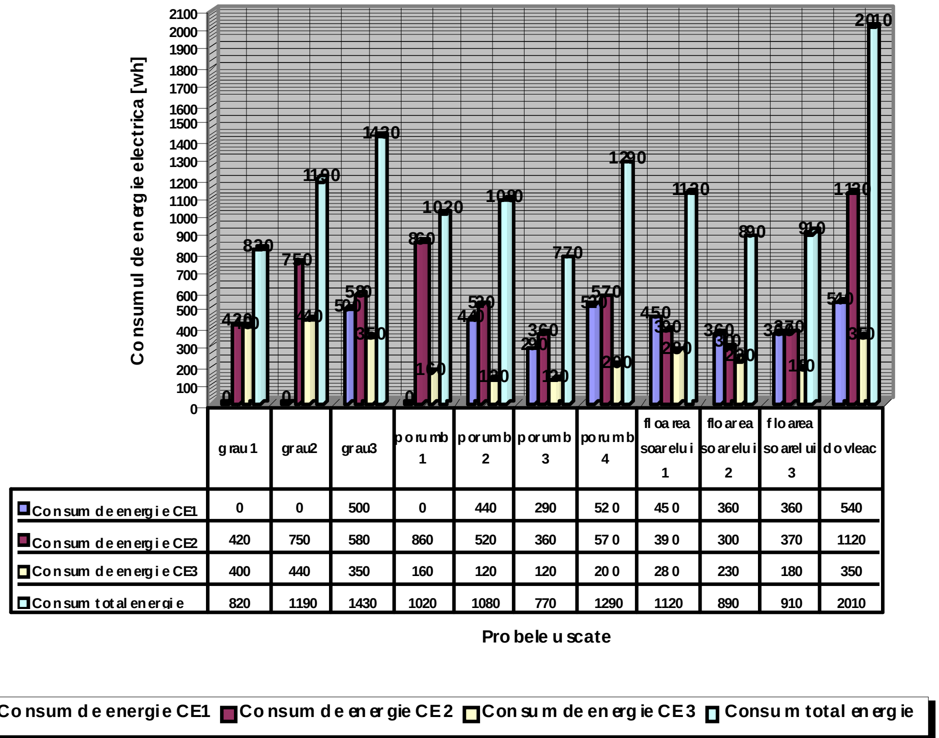


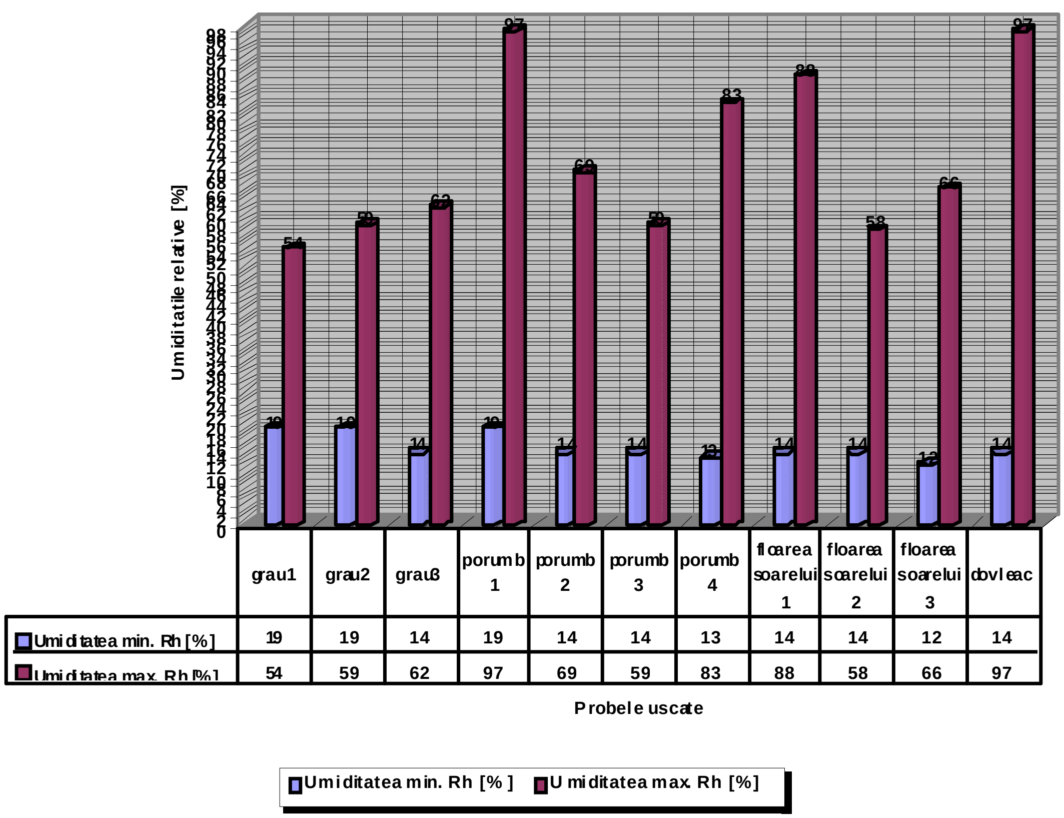
Fig. 6. Scheme of electrical measurement

Fig. 7. Model plant fluidized bed drying in dual power source.



	grau 1	grau2	grau3	porumb 1	porumb 2	porumb 3	porumb 4	floarea soarelui 1	floarea soarelui 2	floarea soarelui 3	dovleac
Consum de energie CE1	0	0	500	0	440	290	520	450	360	360	540
Consum de energie CE2	420	750	580	860	520	360	570	390	300	370	1120
Consum de energie CE3	400	440	350	160	120	120	200	280	230	180	350
Consum total energie	820	1190	1430	1020	1080	770	1290	1120	890	910	2010

Fig. 8. Consumul de energie electrică la probele uscate cu sursa de energie solară şi electrotermică, la fiecare contor şi în total.

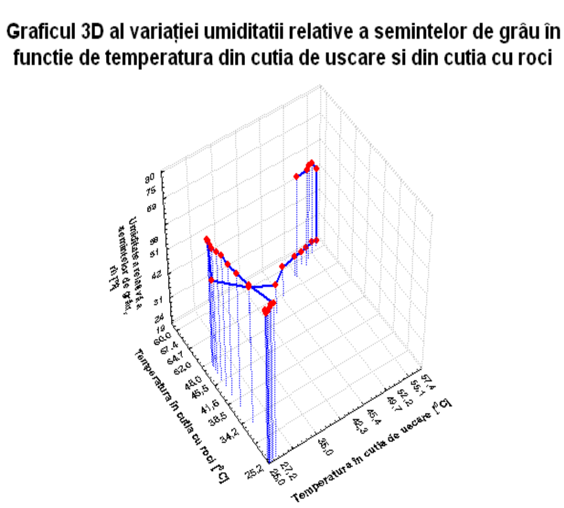


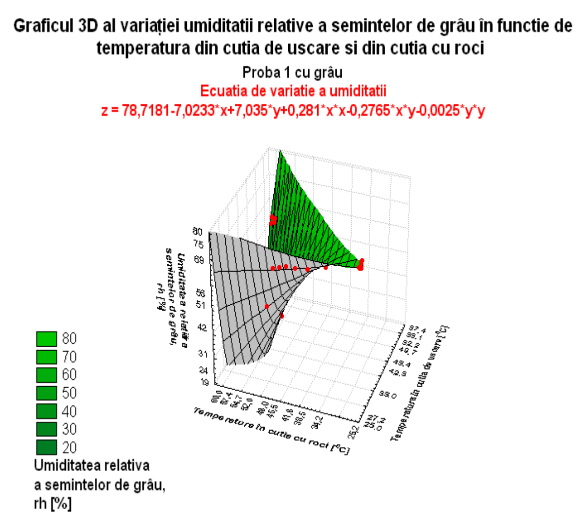
	grau1	grau2	grau3	porumb 1	porumb 2	porumb 3	porumb 4	floarea soarelui 1	floarea soarelui 2	floarea soarelui 3	dovleac
Umiditatea min. Rh [%]	19	19	14	19	14	14	13	14	14	12	14
Umiditatea max. Rh [%]	54	59	62	97	69	59	83	88	58	66	97

Fig. 9. Umidităţile relative minime şi maxime din cutia de uscare.

Table 1

Dry Sample	Temp. drying min. [gr. C]	Temp. drying max. [gr. C]	Temp. drying ΔT [gr. C]	Moisture min. Rh [%]	Moisture max. Rh [%]
wheat1	27,3	57,4	30,1	19	54
wheat2	29,3	55,5	26,2	19	59
wheat3	25,2	59,9	34,7	14	62
corn1	18,4	50,2	31,8	19	97
corn2	22,9	54	31,1	14	69
corn3	22,4	52,9	30,5	14	59
corn4	21,9	55,1	33,2	13	83
sunflower1	17,9	51,9	34	14	88
sunflower2	23,5	57,8	34,3	14	58
sunflower3	22,2	57,2	35	12	66
pumpkin	14	46,4	32,4	14	97
Sample	**Moisture ΔT Rh [%]**	**Drying Type**	**Energy consumption CE1**	**Energy consumption CE2**	**Energy consumption CE3**
wheat1	35	solar energy	0	420	400
wheat2	40	solar energy	0	750	440
wheat3	48	energy electrothermics	500	580	350
corn1	78	solar energy	0	860	160
corn2	55	energy electrothermics	440	520	120
corn3	45	energy electrothermics	290	360	120
corn4	70	energy electrothermics	520	570	200
sunflower1	74	energy electrothermics	450	390	280
sunflower2	44	energy electrothermics	360	300	230
sunflower3	54	energy electrothermics	360	370	180
pumpkin	83	energy electrothermics	540	1120	350
Sample	**Quantity ini. seeds [kg]**	**Quantity fin. seeds [kg]**	**Moisture Ini. Rh [%]**	**Moisture Fin. Rh [%]**	**Total energy consumption**
wheat1	1	0,95	81	51	820
wheat2	0,5	0,457	90	55	1190
wheat3	1	0,95	85	52	1430
corn1	1	0,92	91	80	1020
corn2	0,5	0,445	90	85	1080
corn3	0,5	0,458	89	82	770
corn4	0,5	0,451	83	69	1290
sunflower1	0,5	0,412	87	65	1120
sunflower2	0,5	0,423	86	66	890
sunflower3	0,5	0,442	80	48	910
pumpkin	0,5	0,396	90	70	2010





4. CONCLUSIONS

Data resulting from experimental determinations may loose a series of conclusions regarding the conduct of the drying process, in both solar thermal energy and the energy use electrothermics. It may be noted that if all the processes of drying, irrespective of the nature of energy and in terms of the type of seeds subjected to the drying process, the main process parameters have a roughly similar evolution.

Electricity consumption varies greatly, depending on the type of land, the two settings of measurement devices and control and of course depending on the type of energy used for heating rocks; to seed wheat, the energy source to solar drying is lower than the use electrothermics source (820 Wh from 1430 Wh drying energy electrothermics, approximately 57.3%); to seed corn consumption is lower when using solar energy but also depend on their initial moisture (compared 1020 Wh to 1290 Wh, approximately 79%); Similarly, in the case of sunflower seeds and the pumpkin, the energy out of the initial moisture of the product.

Energy consumption in pumpkin seeds, from which the final moisture was much higher than other products, it is observed that the highest, which shows that the drying of such products requires an initial antedrying.

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