ROTATION-PULSED FLUIDIZED BED APPARATUS FOR SESAME ROASTING

Todor G. Djurkov

University of Food Technologies
Plovdiv, BULGARIA
todordj@plov.omega.bg

Abstract

The conventional methods for sesame roasting used in ground baked sesame-seed production have been discussed.

The application of the rotation-pulsed fluidized bed apparatus for roasting of high-moisture content sesame seeds has been grounded.

An installation for sesame roasting in rotation-pulsed fluidized bed implemented in production has been described.

The Sesame seed is a fruit of the annual plant Sesamum indicum. It is used for oil production, and in sugar-processing industry for the production of halvah (ground roasted sesame-seed sweet).

The baking of sesame-seeds is the main operation in the production of ground roasted sesame-seed. On it to a great extent depends the final product quality.

At present the process of roasting is done in cradle roasters (Elenkov et al, 1985) with discontinuous action which have a low performance and occupy a large area. Because of the characteristics of passing the energy to the seed, the operation duration (approximately 4 hours) and the immediate contact of the product and the air in the premise, the roasted sesame quality is very low. The surface of the seed becomes dark, it is crashed and turns oily. The method described possesses also other disadvantages - the moisture evaporated from the roasters is separated directly into the environment, the operations on loading and leading away the product from the apparatuses are manual and cannot be subjected to mechanization.

When using other well-known construction of roasters - screw, shaft or with conventional fluidized bed (Elenkov, 1988), a part of the disadvantages enumerated can be escaped, but these apparatuses are not suitable for processing of sesame separated by the wet method. By using the wet method the sesame-seed is husked by means of special roller equipment after which the nuts are separated from the husks by soaking in salt solution. During the last operation the sesame humidity increases to about 40-50%. Because of the presence of a considerable quantity of surface moisture, during the next operation - roasting, the separate sesame-seed are stuck together and form aggregates of particles. This leads to deterioration of the particles contact with the drying agent (in the shaft and fluidized bed apparatuses) and with the heat surface of the screw roasters and from then, to ununiform processing of the product.

The preliminary experiments that have been carried out on a laboratory-type equipment with rotation-pulsed fluidized bed (Djurkov et al, 1989; Elenkov and Djurkov, 1992) have shown that the sesame-seed roasted by this technology has a high quality - the final product has a light color, without oiling and crashing, with pleasant aroma and flavour. The process duration has sharply shortened to 25-30 min.

After the preliminary experiments a roaster for roasting wet-separated sesame and having a performance of 150 kg/h of raw material, has been constructed, produced and implemented into operation. The total projection, working out and introduction into operation has been done by “Membrane Technology” Ltd., under the direct supervision of the author who has occupied the position of a General Manager of the company.

The equipment for wet-separated sesame roasting in a rotation-pulsed fluidized bed consists of the main elements, as follows (Fig. 1):

– drying chamber, including gas-distributing chamber 1, driving wheel 2, gas-distributing disk 4, immovable supporting grid 5, working chamber 14, separation chamber 8, screw feeding mechanism 7 and leading away unit for the final product.

– a system for the heating up of the drying agent, including electrical 12 and steam 25 air-heaters;

– system for treatment of the waste drying agent, including cyclone 10, valve 17 and hopper 18;

– system for injection and delivery of the drying agent through the installation, including fan 17, sucked air cleaning filter 23, valves, flaps and connecting air-pipes;

– power supply and automatic process control system.

The installation works on a discontinuous mode principle, in the following way:

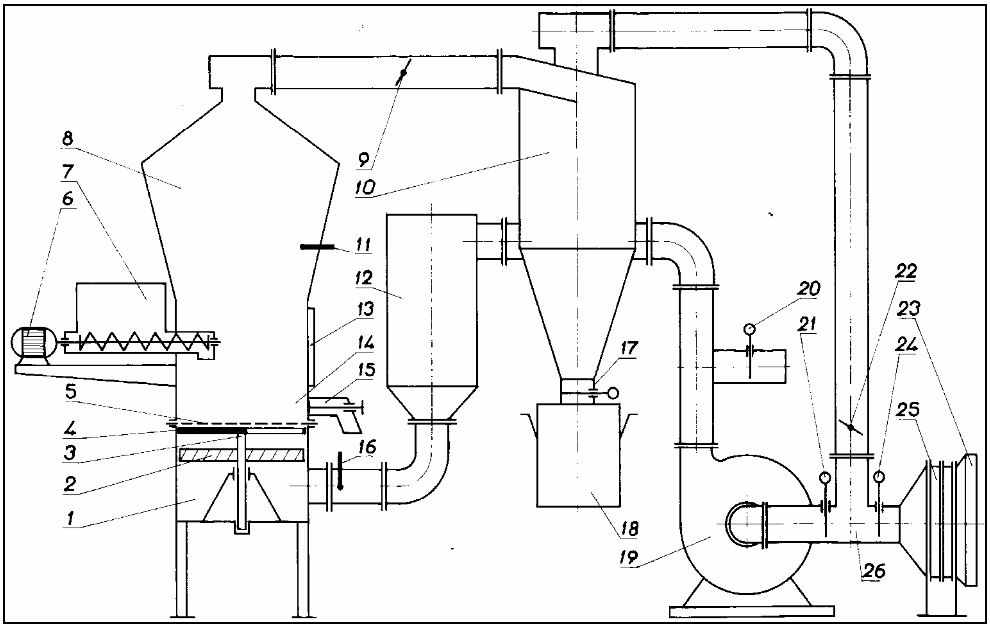


Fig. 1

The processed wet product should be poured into hopper 7, whose capacity has been measured up in such a way that it could take one batch of the material. By means of the screw transporter situated in the hopper bottom, the product enters the working chamber 14 upon immovable supporting grid 5. The roasted mass is lead out of the working chamber by means of unit 15.

The drying agent is sucked by the environment by using fan 19, then it is filtered from mechanical admixtures by passing through filter 23, and is heated up in the steam air- heater 25, then it is mixed with the recirculated air in the mixing chamber 26, and enters the electric air-heater 12 for a final heating up. By using a temperature at the entrance of the drying chamber is automatically controlled in the range of 120-200^{0}C. The air heated up in that way enters the gas-distributing chamber 1, then it passes consecutively through the turbine wheel blades 2, through the sector opening of the rotating gas-distributing disk 4, through the apertures of the immovable supporting grid 5, and after entering the chamber 14, it fluidized the product bed and together with this it dries and roasts it. The waste drying agent passes through the separation chamber 8, where part of the particles taken away by it are separated and fell into the bed again, through the cyclone 10 for the purpose of a final separation of the finer particles, and enters the mixing chamber 26 to be mixed with the fresh air into a set ratio.

When passing through the turbine wheel blades 2, the drying agent starts rotating it and by means of the driving axle 3 transmits the motion of the rotating gas-distributing disk 4.

The ratio between the recirculating and fresh air is adjusted by means of the valves 20, 21, 24 and the flap 22. The degree of sesame roasting can be determined by measuring the output drying agent temperature by means of sensor 11.

The gate 13 has two functions - it gives access for the maintenance staff to clean up the working chamber inner surface at idle state of the installation and allows a visual process observation during operation time, because a sight glass has been mounted on it.

During the process of implementation of this installation at “Golden Trakia” Ltd. - Harmanli, temperature curves of the process have been recorded at various conditions of carrying out the experiment. The conditions of the experiment have been described in (Djurkov and Elenkov, 1999). The measurement results have been presented on Table 1, and on Fig. 1 to 11.

Table 1

Parameter	Experiments (1 - 11)					
	1	2	3	4	5	6
t_B, ^0C	116.3	158.6	173.9	182.5	182	188
t_C, ^0C	51.8	59.7	61.9	75	71.4	70.3
δt_{max}, K	64.5	98.5	112	107	110.6	117.7
	7	8	9	10	11	
t_B, ^0C	143	145.5	167.1	158.5	158.6	
t_C, ^0C	58.4	69	71.8	68.6	69.3	
δt_{max}, K	84.6	76.5	93.3	89.9	95.3	

The type of temperature curves (Fig. 2 - 12) gives reason to divide the roasting period into three stages:

First stage, with duration of 3 - 4 min, that is characterized by decrease of drying agent temperatures at the input of the drying chamber (within the pre-grid space) t_B and after the layer t_C. That is the period of feeding the working chamber with material. The gradual material quantity increase in the chamber decreases the drying agent temperature, but the utilized temperature drop of $\delta t = t_B - t_C$ is almost constant and is equal to maximum δt.

Fig. 2

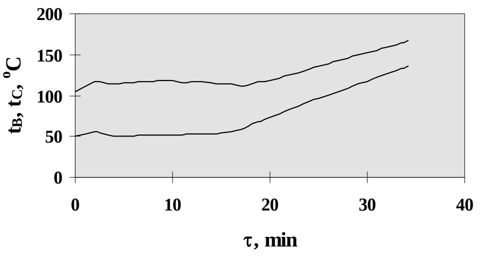


Fig. 3

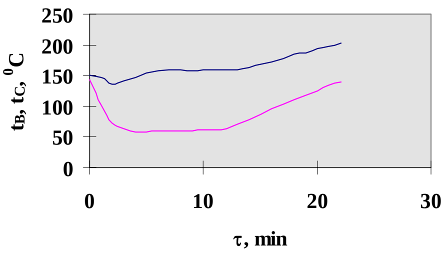


Fig. 4

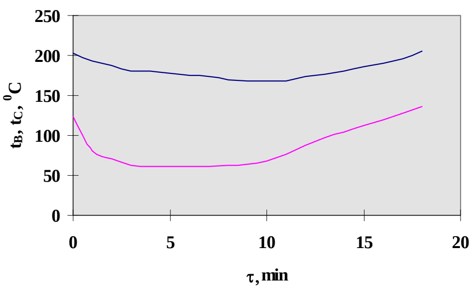


Fig. 5

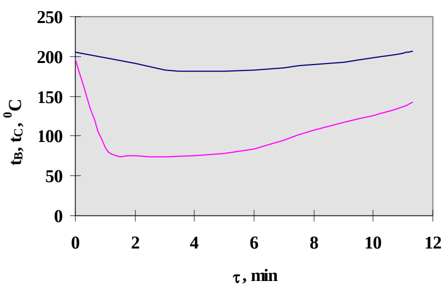


Fig. 6

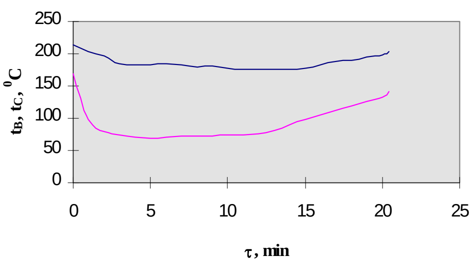
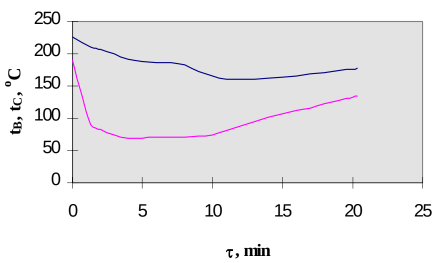
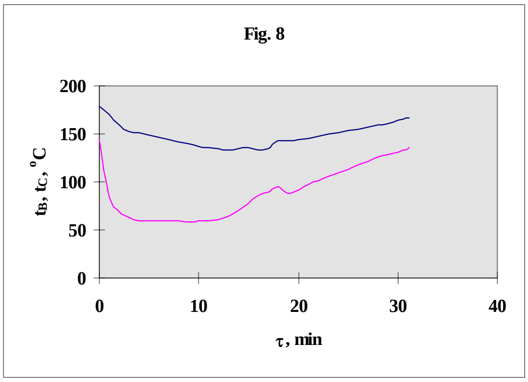
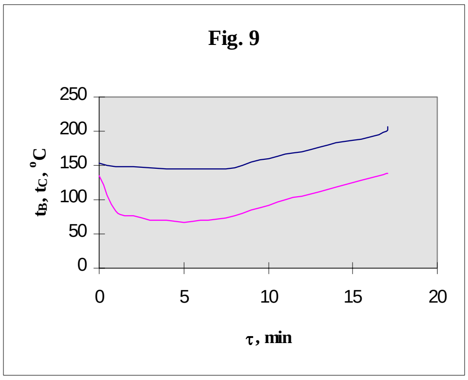
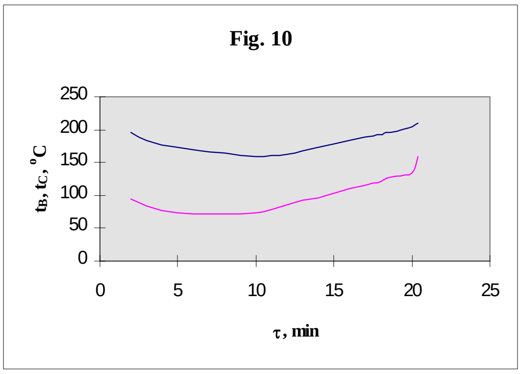


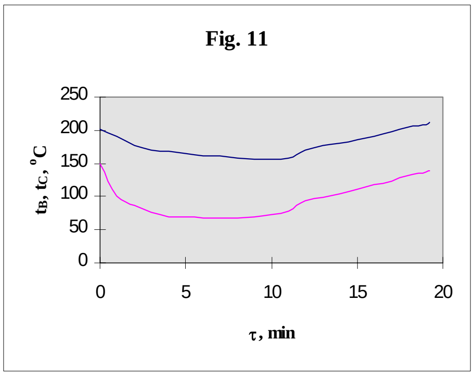
Fig. 7

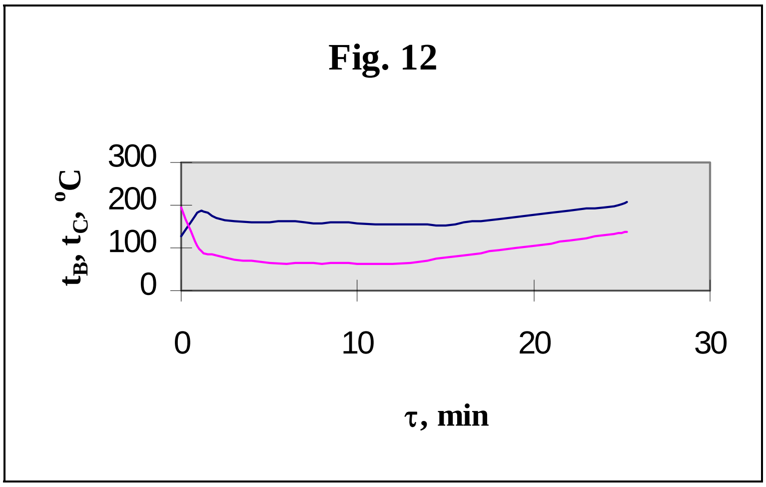












The curve at the second stage is characterized by a constant temperature of the waste drying agent and almost constant temperature difference t_B - t_C = δt_{max}.

That is the period of separating the free moisture; the air is saturated by almost 100% and the whole input heat quantity is spared for evaporation. Table 1 presents the averaged values of drying agent temperature t_B before supporting grid and after the material bed t_C, as well as the maximum utilized temperature drop of δt_{max} for the first drying period.

The third sector of temperature curves is characterized by increase of temperatures t_B and t_C. The temperature t_C starts increasing a little bit earlier than t_B, immediately after passing to the second period of drying. The initial moment delay of temperature increase t_B and the lower speed of its increase can be explained by means of t_B dependence on energy consumption for drying installation heating in non-steady-state condition mode.

The installation described has been successfully in operation for six years now.

Notation

t - temperature, ^{o}C
δ – difference
τ - drying time, s

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