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Experimental Analysis of Inner Fittings Running Test in the Rotary Drum Dryer

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Abstract

The herein work contains the results of the experimental researches regarding the running tests of inner fittings of helical pipe, aiming to increase the contact surface between materials, gases and heated surfaces and material convey to the exit. Drying time has a maximum value which is a function of the slope angle of the drum revolution, inner fitting type, surface roughness, diameter, drum length, gas pressure, etc.

Key words: *rotary drum dryer, inner fittings out, retention time.*

Foreword

Rotary drum unit applications arose as a consequence of general technical evolution and have determined a continuous development in the field for over a century [3].

The cylinder rotary drum dryer on continuous running belongs to these types of rotary drum units. It consists of an iron plate cylinder, revolving slowly around its axle, and seldom slightly tilted against the horizontal axis. The material is continuously supplied at one end of the drum and conveyed to the other end due to the revolving motion and drum tilting. Hot gases cross the drum, generally a counter current flow, and rarely in the flow direction [1].

The revolving motion of the heater determines the mixing of the material, thus enabling its even drying [4].

The most frequently used constructive types of dryers are those using direct heating, provided with various inner fittings (for example helicoidally metallic strap), which on one side lift upwards the material and let it drop down in the gas flow, even if it increases the exposed surface of the material, and on the other side it provides material convey inside the cylinder [2].

Description of the Experimental Unit

The running model (fig. 1) consists of a drum *1*, supporting frame *2*, actuation device made of crow *3*, gearing *4*, pinion *5*, wheels belt conveyer *6* (three steps) and the motor *7*. Supporting reels are up hold by bearings *8*. Material is introduced in the dryer by means of vibrating supply device *9*. The drum is limited at the supply end by the end chamber *10*, and at the exit end by the end chamber *11*. The unit is supported by a joint upper plate, at one end, and the support end

is placed on the foundation plate *12*. The angle adjusting between the two plates is obtained by two bolts *13*, square thread, placed at the end facing the joint (on the narrow side of the plate).

Unit characteristics, required for the retention time calculation, are as follows:

- drum length L, m …….. 1.,5
- drum diameter D_i, m.....0.24
- revolution n, rot/min.....0.56÷1.15
- slope δ, degrees.....0°÷4°30'
- length of unit supporting plate L_p, m..... 2.,21

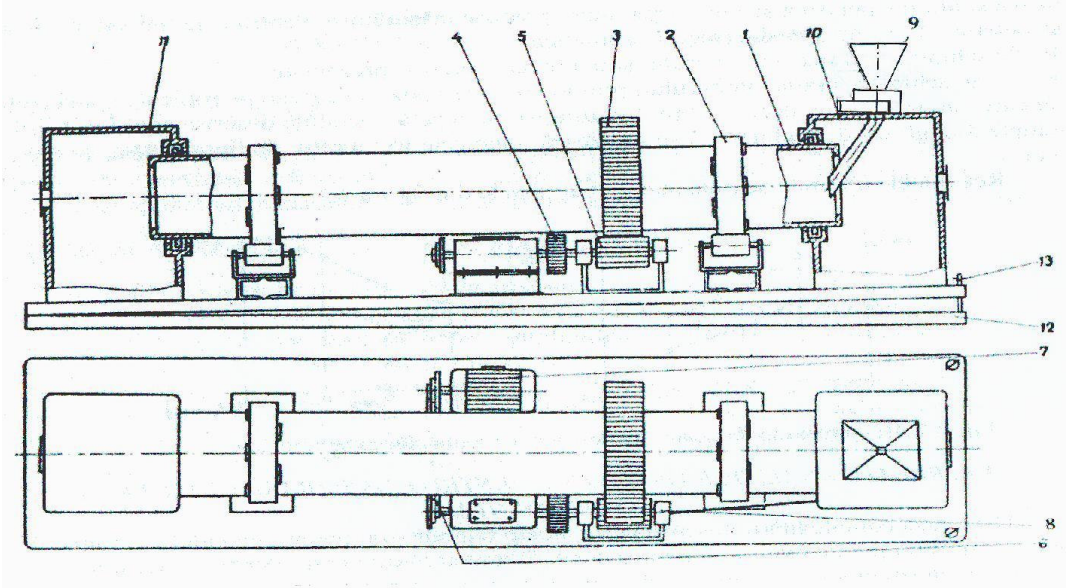

Fig. 1 Rotary drum dryer – drawing

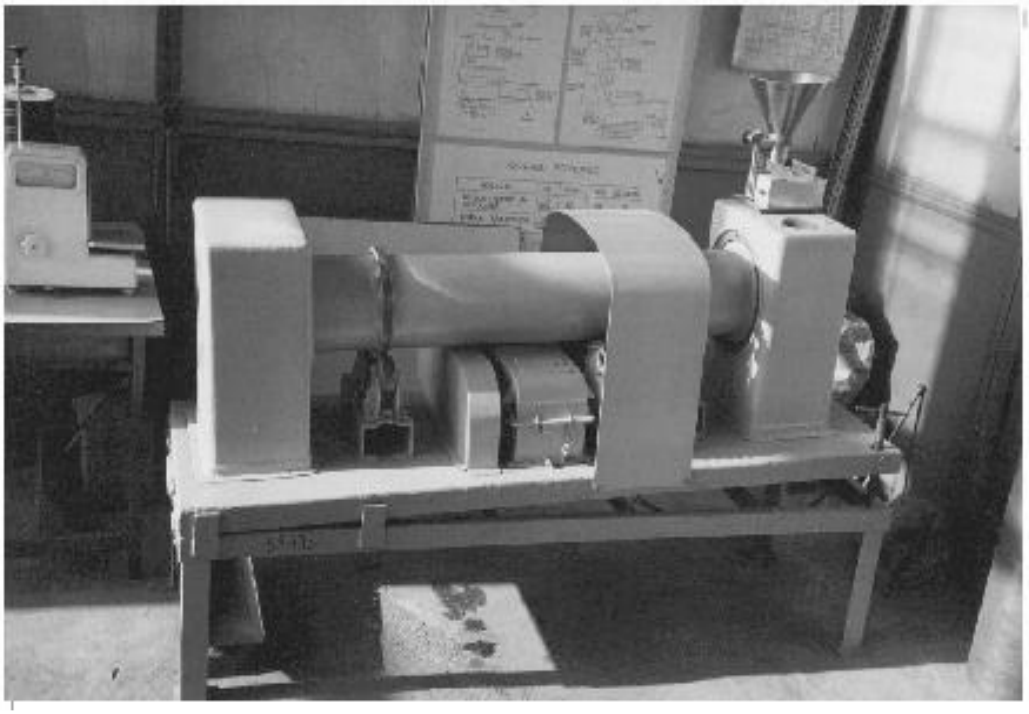

Fig. 2. Side view of the rotary drum dryer

Establishing the Drying Time for the Drum Made of Helicoidally Plate Steel

Three angles of the slope ($\delta_1 = 2°40'$, $\delta_2 = 2°10'$, $\delta_3 = 1°55'$) and three different revolutions values (n_1 = 1,4235 rot/min, n_2 = 0,982 rot/min, n_3 = 0,5405 rot/min) have been considered [6].

The test has been performed for each revolution aside with the three slopes, witness samples were used, and the retention time of materials in the drum was registered.

Test results are illustrated in (n, t_r) diagrams (figs. 3 and 4), where the curves obtained vary exponentially. The materials used were sand and slag.

Retention Time Determination for Helicoidally Plate Steel Inner Fittings Drum

The same sand and slag materials and witness samples have been used. Three revolutions and three slope angles have been used both for sand and slag.

All test results are illustrated in (n, t_r) diagrams (fig. 5 for sand and fig. 6 for slag). Curves vary exponentially.

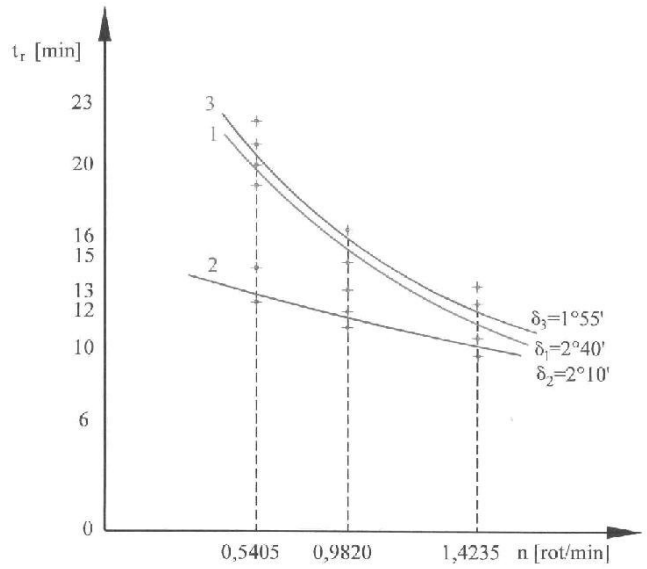

Fig.3. Diagram (n, t_r) of experimental results. Plane drum loaded with sand: n - revolution [rot/min]; t_r - retention time [min]; δ- angle of the slope. Equation of line 1: $y=28{,}845e^{-0{,}3466x}$; Equation of line 2: $y=17{,}376e^{-0{,}3095x}$; Equation of line 3:$y=34{,}909e^{-0{,}3095x}$

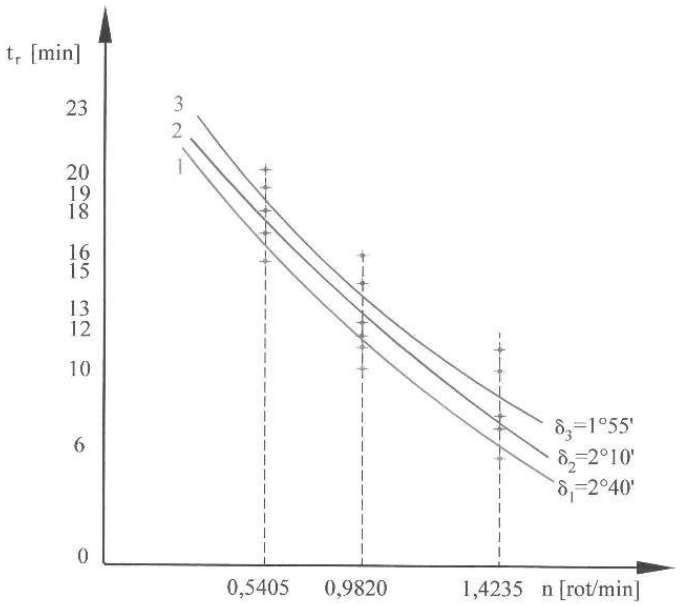

Fig. 4. Diagram (n ,t_r) of experimental results. Plane drum loaded with slag:
n - revolution [rot/min]; t_r - retention time[min]; δ - angle of the slope.
Equation of line 1: $y=25{,}224e^{-0{,}4133x}$; Equation of line 2: $y=24{,}137e^{-0{,}4581x}$;
Equation of line 3: $y=25{,}019e^{-0{,}3769x}$

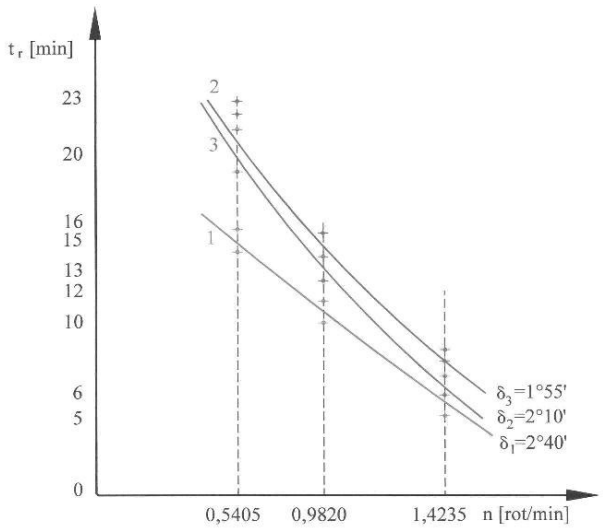

Fig. 5. Diagram (n, t_r) of experimental results. Drum made of helicoidally plate steel with sand:
n – revolution [rot/min]; t_r - retention time [min]; δ - angle of the slope.
Equation of line 1: $y=22{,}016e^{-0{,}4236x}$; Equation of line 2: $y=32{,}578e^{-0{,}4993x}$;
Equation of line 3: $y=34{,}909e^{-0{,}48256x}$

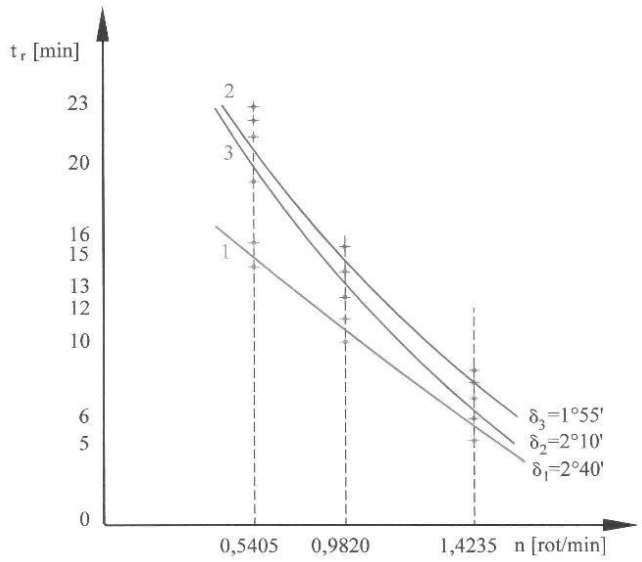

Fig.6. Diagram (n, t_r) of experimental results. Drum made of helicoidally plate steel with slag: n – revolution [rot/min]; t_r - retention time [min]; δ - angle of the slope.
Equation of line 1: $y=22{,}016e^{-0{,}4236x}$; Equation of line 2: $y=32{,}578e^{-0{,}4993x}$;
Equation of line 3: $y=34{,}909e^{-0{,}48256x}$

Interpretation of the Experimental Results Obtained on Drum Made of Helicoidally Plate Steel Inner Fitting Loaded with Sand and Slag [6]

- Retention time increases as the angle and revolution of the drum have lower values.
- Using inner helicoidally plate steel it resulted that for the drum loaded with slag, retention time is greater than retention time for sand. Slag particles with a higher density than sand have a slower motion over the propeller
- At maximum revolution and with the highest gradient of the slope, the smallest retention times were obtained, since the particles move faster.

Suggestions for the Applications of the Experimental Results [6]

The dryer with rotary drum usually is installed inside various metallic devices (curves) which have the purpose of increasing the contact surface between the materials that are to be dried, gases and the heated area.

Up to the present, there have been created and used numerous systems of displaying the curves inside the drum, depending on the material to be dried.

The proposed inner fittings of helicoidally plate steel present the advantage of a smaller retention times and larger contact surface with material dried due to the continuous guiding function of the material from input to output.

These experimental results verify the results obtained by using theoretical research formulae and will be applied for the sizing and rational running of rotary drum dryers.

Furthermore, these experimental results complete the information field of the present technology, offering significant data for constructive optimization of rotary drum dryers.

The experimental analysis performed on the rotary dryer with the inner fitting suggested how the obtained results can be extended to the industrial field.

Considering the practical importance of the experimental results obtained, here are some proposals of applications:

- provision of as short retention time as possible, but ensuring a even drying of different granulose materials;
- shorter retention time enabling to reduce the drying process of the small dryers by 14%, percentage resulted from the ratio: t_r plane drum / t_r inner fittings drum, thus optimizing the space;
- provision of a higher heat transfer and a even drying in the material mass;
- material is easier conveyed owing to the helical pipe devices and to those made of helicoidally plate steel.

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Analiza experimentală a comportării în exploatare a amenajărilor interioare în uscătorul cu tambur rotativ

Rezumat

În lucrare sunt prezentate rezultatele cercetărilor experimentale referitoare la comportarea în exploatare a amenajări interioare din bandă elicoidală al cărui scop este mărirea suprafeței de contact dintre materiale, gaze şi suprafața încălzită şi transportarea materialului către ieşire. Timpul de uscare are o valoare maximă care depinde de unghiul δ de înclinare al tamburului, de turație, de tipul de amenajări interioare, de rugozitatea suprafeței, de diametru, de lungimea tamburului, de presiunea gazelor, etc.