The experimental installation for continuous drum granulation

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Introduction

On the grounds of preliminary study conducted in batch-wise drum granulators with various drum diameters as well as on the basis of experience, the following principles have been adopted for the process project:

- the range of drum rotational speed variation resulting from the cascading motion typical for the granulation process (ensuring rolling, possibly tumbling of the filling grains upon the free surface on condition that the bed remains continuous) as wel l as the effect associated with the phenomenon of material spill through the aperture in the front of the lid on the one hand, and the effect exerted by the optimal conditions of granular filling moistening, adhesion to equipment wall and the optimal capacity of the process, on the other hand, has been determined. A specific range of variation in the rotational speed was approved
- The dimensions of the equipment were set relative to the variations in the volume of the bed consequent upon the course of the process. It was suggested that the drum be removable in order to perform a comparative analysis of the effects of the granulation as achieved by means of equipment with various diameters
- the variation range of the degree of the drum filling with bulk material has been set in accordance with the potential variation of the bulk density thereof consequent upon the addition of the damping liquid as well as the course of the process
- the variation range for the following process parameters has been set:
  a) working liquid pressure.
  b) air pressure.
  c) reagents temperature.
  d) liquid flow intensity.
  e) air flow intensity.
  f) process capacity.

The following parameters were treated as variable in the course of the study:

- drum diameter D.
- drum filling coefficient k.
- drum rotational speed n.
- air flow intensity Qp.
- liquid flow intensity Qc.
- damping liquid type.

During the trial the course of the process was observed under different working conditions and the effect obtained was subjected to comparative analysis.

In order to establish the parameters of the operation of the system feeding the system with damping liquid the characteristic features of pneumatic nozzles were scrutinised. The fundamental aim of the study was to determine the effect of the operational parameters (air and liquid flow rate) as well as the construction properties of the nozzle on the degree of liquid stream disintegration.

On the grounds of preliminary tests, it was assumed that the optimal mode of feeding liquid, either water or molten detergents, to a tumbling bed of granular material in the granulator drum, is its atomisation over the free surface of the filling by means of pneumatic nozzles. In the course of the tests it was found with respect to the granulator drums applied that a single nozzle may be used interchangeably with a set of nozzles in a serial design to obtain uniform moisture distribution. The research equipment deployed ensured the delivery of both reagents to atomising nozzles (gas and liquid) with operating parameters as specified for the experiment (temperature, pressure, flow rate).

Pneumatic nozzles of different makes were employed in the study:

a) manufactured by Spraying System Deutschland GmbH.

The said nozzles are fitted with removable heads of various liquid discharge diameters and allow the installation of different spray nozzles that ensure the cross-flow of liquid and air at the angle of 45° or 60°

b) nozzles designed and manufactured by the Chair of Process Equipment, Technical University of Łódź.

The said nozzles provided the option to conduct research with respect to the diameter of the escape hole of liquid of the scope d = 0.75 – 4 mm

For all constructions investigated, the clash of the air and liquid streams occurs outside the nozzle. The atomisers produce an atomised stream with a circular or flat cross-section that seems beneficial when damping fine-grained materials in the process of granulation in tumbling equipment.

For the given head-atomiser system, tests were conducted for the parameters of the stream obtained with respect to variable volumetric liquid and air flow values:

- liquid flow rate, controlled by means of liquid flow regulator within the range of Qw = 0 - 300·10-3 m3/h from a single nozzle
- air flow rate delivered by means of a compressor set within the range of Qp= 0 - 30 m3/h.

A constant air pressure of p = 0 – 0.5 MPa was applied.

A series of trials of filling granulation inside the drum was conducted at variable parameters concerning the operation of atomiser nozzles and under various granulator operation conditions.

The results obtained and the observations made in the course of the study allowed to suggest the narrowing down of the process parameters applied in order to design the process and equipment for continuous granulation.

Installation characteristics

The main principle of the construction of a drum granulator operating in a continuous mode is to create a compact technological line. A design must be an integrated whole, successive elements are coupled together in order to form a continuous passage for the material starting from the dust container on to the finished granulate with the desired grain diameter. Apart from utility tasks, the equipment is to serve research purposes. It is for this reason that control options within particular ranges of some of the process and equipment parameters have been anticipated, namely:

a. rotational speed.
b. drum filling coefficient.
c. residence time.
d. inclination angle.
e. drum length.
f. outlet nozzle diameter.
g. air and damping liquid flow rate as well as the pressure thereof.

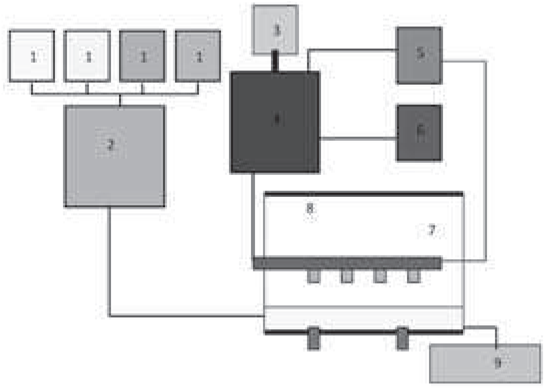

Fig. 1. The experimental installation for continuous drum granulation 1 – feeders; 2 – mixer; 3 – engine; 4 – pressure vessel with water jacket; 5 – compressor; 6 – thermostat; 7 – nozzle set; 8 – granulator drum;9 – screens

The installation contains the following sets according to the design principles (Fig.1):

- dust material mixer

Fig. 2. The mixer of raw materials

- dust material feeder

Fig. 3. Feeders

- granulator drum along with drive

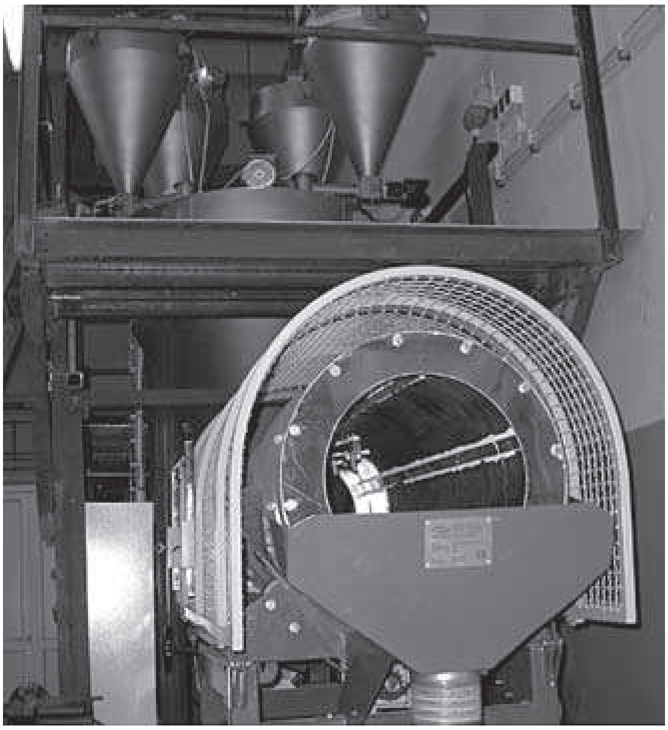

Fig. 4. Drum granulator

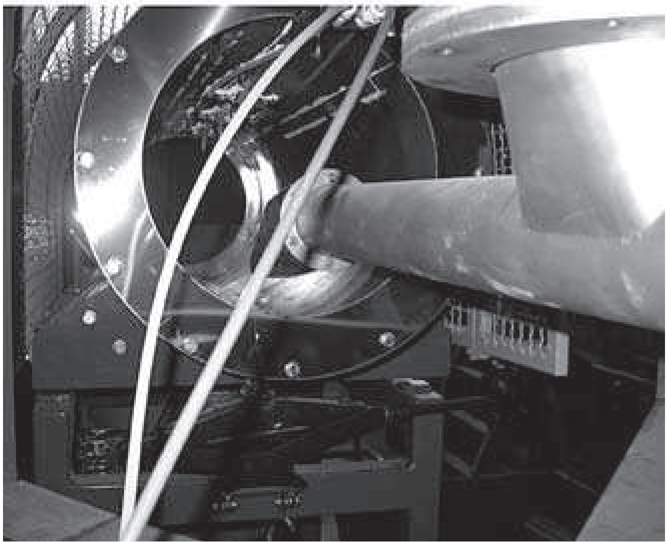

Fig. 5. Drum granulator

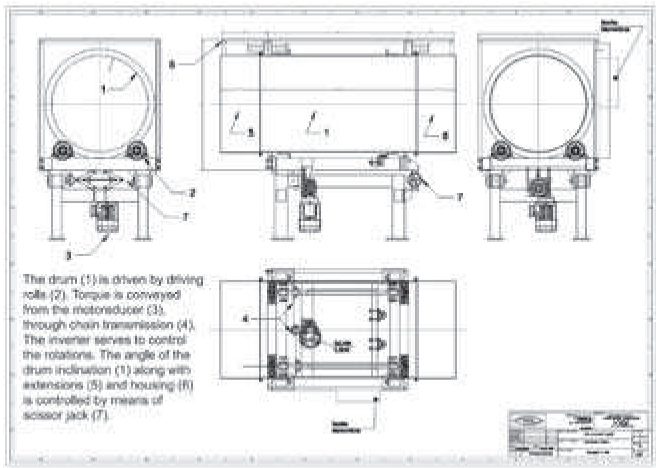

Fig. 6. Drum granulator

- screen

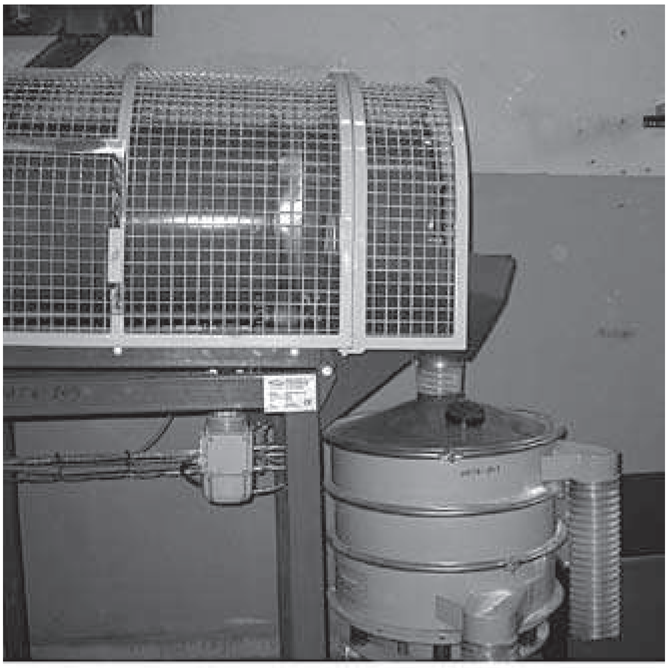

Fig. 7. Screen

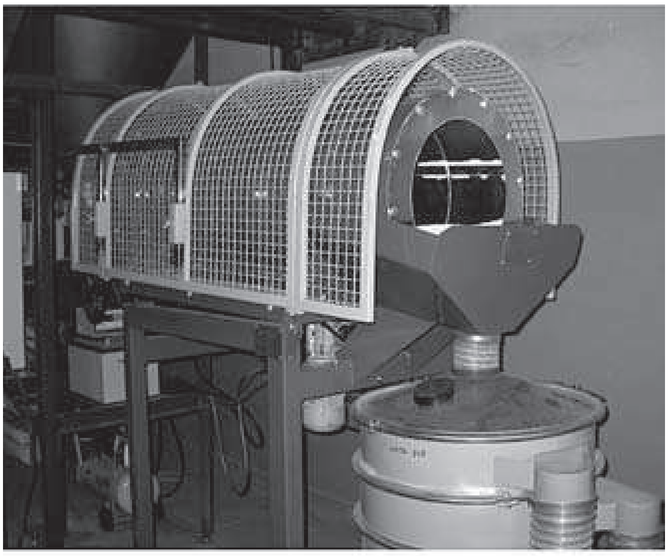

Fig. 8. Screen

- product container

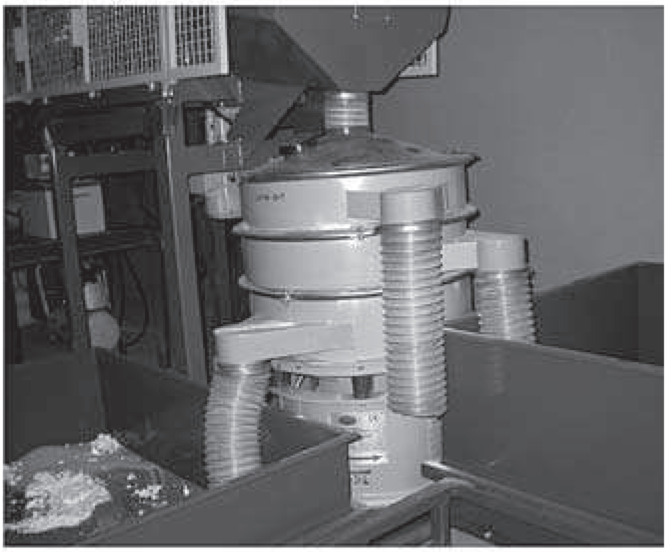

Fig. 9. Trays

- damping set

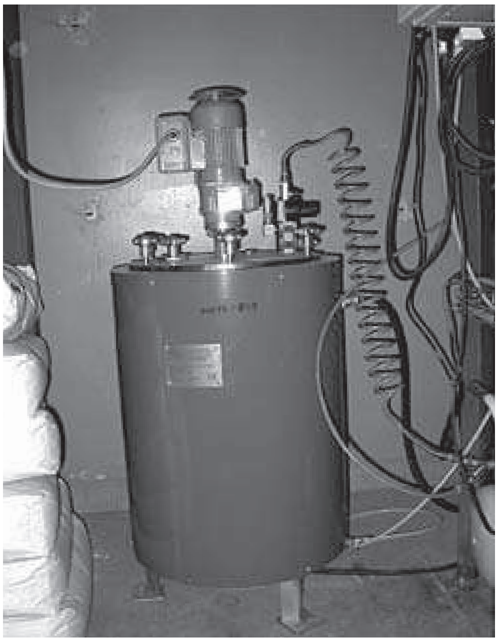

Fig. 10. Pressure vessel

- measurement module.The measurement module was constituted by a laser particle size analyser
- frame bearer.

The dry material subjected to granulation is fed from dust material containers into the mixer through feeders. The capacity of the feeder is determined within a range allowing substrate mixing in appropriate proportions. The inverter serves to ensure the control of the drum rotational speed. The range of variations in the rotational speed has been set at n = 0 – 30 rpm.

The time that the material remains within the granulator is controlled by means of the intensity of the raw material delivered via the feeder, the change in the length of the drum as well as the angle of its inclination.

It was assumed that the installation capacity shall change relative to variable parameters.

Thus:

capacity Q = up to 500 kg/h

drum diameter D = 500 mm

The angle of the inclination of the equipment has been set within the range b = 0-10 degrees. The angular position of the granulator is controlled through the attachment of one of the edges of the supporting frame on two articulated supports and of the other - on roll supports as well as the application of scissor jack.

The power consumed by the granulator driver comprises the following:

- the power to raise the material within the drum to the angle of natural repose,
- the power to mix the material
- the power to overcome friction at the pivots of the power transmission system
- the power to overcome the rolling resistance of the power transmission system.
- The power required for the granulator driver was estimated at N = 3 kW.

The bed tumbling in the granulator is to be dampened by the damping liquid (e.g. water or molten detergent) at fixed stream parameters. It is essential for the liquid inserted as small droplets to change the bed moisture in accordance with the desired parameters of the target product and not to cause adhesion to the inner wall of the equipment nor to produce extra expenses resulting from long-term product drying.

The alteration in the air flow rate as well as the damping liquid flow rate are to be performed by means of the selection of the diameter of atomisers (2-4 mm) and the parameters for nozzle delivery parameters.

The following ranges of the variations in the flow rate of media have been established:

Air Qp = 1 – 10 m3/h, Damping liquid Qc = 1 – 50 l/h.

The flow rate of both media may be controlled by means of rotameters or set on the basis of preliminary tests. Data have been provided for single nozzle only. The installation enables the replacement of nozzles and alternate use of nozzles with various operating parameters.

Conclusions

The installation for continuous granulation under discussion allows to program the process of continuous drum granulation of a multiple-component bed and provides the means to design the composition of the product for four distinct raw materials. By virtue of the possibility to establish different delivery rate of four respective feeders, different component ratios may be set. The mixer guarantees bed homogeneity even prior to its delivery to the granulator drum. The further installation of a hydraulic nozzle provides the option to insert atomised liquid component into the mixer. The installation allows a fluent alteration in the angle of the granulator drum inclination and the alteration in the applied rotational speed of the equipment thanks to an inverter. Damping liquid is delivered to the drum by means of a set of pneumatic nozzles. Various types of damping liquids may be deployed with variable composition, temperature and the parameters of the stream delivered to the nozzles. The installation also allows to modify the drum length stepwise, thereby allowing to program residence time when taking into account the above-mentioned possibilities. The granulate obtained may be transferred to the screen that segregates it into the target product, oversized and undersized material and directs it to adequate containers.

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