

CONSTRUCTION OF A CASCADE FLUID-BED DRYER WITH TWO IMPELLERS

Marek Tomalczyk, Andrzej Heim

Department of Process Equipment, Faculty of Process and Environmental Engineering, Technical University of Łódź

Keywords: fluid-bed, sugar, dryer

The paper is next in a series dedicated to the construction of sugar dryers and coolers designed in the Technical University of Łódź, presented at subsequent BEMS conferences.

Detailed design solutions providing answers to technical problems that appear while scaling up the system of the capacity ranging from 800 to 1200 tons product per day are discussed in this study. The proposed, fully original construction of a cascade fluid-bed dryer equipped with two impellers is a subject of patent claim no. P-78744.

The cascade sugar dryer of capacity 1200 tons per day, designed and made in 2005 passed its practical test in a sugar campaign last year in Werbkowice Sugar Factory. It was assessed favourably by the Factory both in view of meeting the assumed technological parameters and high reliability of operation.

INTRODUCTION

The competition in the sugar market contributes to the permanent increase of requirements related to sugar quality. The quality largely depends on the final technological functions, *i.e.* the processes of drying and cooling. They determine the humidity and final temperature of sugar but also affect the content of fractions of the grains of the smallest diameters and the crystal surface status. The market situation would call for storage of sugar in highly capacious silos, which in turn demands a considerable decrease of sugar temperature and reaching a low final humidity. The described new original structure of the cascade sugar dryer belongs to the family of fluid-bed dryers and coolers previously presented in articles [Heim & Tomalczyk, 1998; 2000].

The essence of changes in Polish sugar industry is consolidation of the production in selected factories of high capacity. The ongoing changes generate the demand for devices whose capacity exceeds far the production level of ten thousand tons daily. Popular in Poland dryers with one impeller in fluid-bed layer, belonging to the above mentioned family, were basically constructed in three varieties: SFM300, SFM500 and SFM700, of the capacities respectively 300, 500 and 700 tons of products daily, which matched the diurnal production of sugar in existing sugar factories.

GENESIS OF THE CASCADE DRYER WITH TWO IMPELLERS

In dryers with fluid-bed impellers a relevantly long time of the material's stay in the impeller operation zone is essential.

The time should be long enough, so that after this zone is left the fluidization of the dried material does not require any mixing support. For the construction of a dryer of the set capacity this primarily means the maintenance of an appropriate proportion of the screen surface over which the impeller operates to the entire surface of the screen. Besides, obviously the total surface of the screen and height of thresholds determining the fluidal layer thickness are significant.

With increasing scale of the device, the total surface of the screen increases as well, including its part over which the impeller works. Therefore, the impeller's diameter also increases, along with the following disadvantageous phenomena: (1) higher differentiation of the linear velocity of blades placed on the ends of arms and near the impeller's hub; (2) more than proportional increase of unitary demand for power with increasing diameter of the impeller.

The authors' practical experience leads to the conclusion that the above mentioned phenomena constrain the impeller's maximum diameter to approx. 2100 mm. For dryers with the contemporarily required capacity one impeller of such diameter appears to be insufficient. This forces the use of at least two impellers, which creates a problem of assuring their proper mating.

Tangent positioning of both spherical surfaces of the screen under the impellers gives rise to "dead zones" between them, where the mixing-unaided granular material does not fluidize. Building these zones up with elements of relevantly steep walls, where the drying material would not settle, is impossible because of the need to assure a free flow of the material between both spherical surfaces of the screen.

Overlapping of spherical surfaces of the screen situated in one plane under the impellers is admissible but requires

a reliable synchronization of rotations of both impellers. In practice this means the use of a chain transmission or atypical motor reducer with two slow-running output shafts. Both these solutions are expensive and troublesome in operation.

The above mentioned defects do not apply to the cascade fluid-bed dryer with two impellers, described below and submitted to the Patent Office of the Republic of Poland under number P-78744.

Situating the impellers on two levels allows for overlapping of the screen spherical surfaces projections onto the horizontal plane, without the need for synchronization of the impellers' rotations. In the cascade dryer the material is poured from the upper chamber of one impeller to the chamber of the other impeller. It enables the contact of the solid phase with the gas phase under different conditions, as compared to those occurring in the fluid-bed layer and as results from the experience it is advantageous for the drying process.

CONSTRUCTION OF A CASCADE DRYER WITH TWO IMPELLERS

The dryer (Figure 1) consists of three combined chambers: 1, 2 and 3, containing in their lower part the perforated partitions 4, 5 and 6 which constitute their bottoms. Chamber 1 with ferrule 7 situated in the upper part, bringing the humid granular material, and chamber 2 have steel jackets of cylindrical shapes, in which from the top, on radially derived brackets 8, impellers 9 and 10 are seated with vertically situated shafts driven by separate motor reducers 11 and 12. Shaft necks at the bottom are settled in seats mounted to the device's carrying structure. Chambers 1 and 2 are in the lower part dimensionally adjusted to the size of the impellers seated in them.

The first impeller 9 has a hub mounted in the lower part of the shaft. The hub is equipped with perpendicularly derived arms 13 with blades 14 fastened at the bottom and molded arcwise or flatly. Below the blades on the extended shaft of the other impeller 10 a hub is mounted, equipped with arms 15 with blades 16. Drive shafts of both impellers are spaced so that the arms partly overlap during the impellers' rotation.

The blades of the first impeller are set in such a way that during the arms rotation the granular material is rejected sideways towards the cylindrical jacket, whereas the blades of the other impeller are set opposite the first one and cause – at the same rotation directions – gathering of the material into the chamber.

The blades of the first impeller form a dihedral acute angle α between the planes tangent to the blades and the planes perpendicular to the arm, towards their rotation, whereas the blades of the other impeller form between the planes tangent to the blades and the planes derived perpendicularly to the direction of their rotation a dihedral obtuse angle reaching from 120° to 150° . In the lower part near the impellers, at the chambers contact site, thresholds 17 and 18 are set. The thresholds are profiled arcwise and close wide at the bottom the space combining adjacent chambers. The thresholds structure enables to lift them, e.g. in the final phase of production to completely empty the device of the material subjected to fluidization.

The perforated partitions situated just under the impellers are shaped like disks and divided into four equal segments of circular sectors shape, in which canopy perforations with hole outlets directed towards the rotating impellers are made; outlets of adjacent segments holes are situated perpendicularly to each other. Instead, the partition of chamber 3 has hole outlets basically directed towards ferrule 19 discharging the dried material and mounted at the bottom on the rear wall. At the end of the chamber the out-

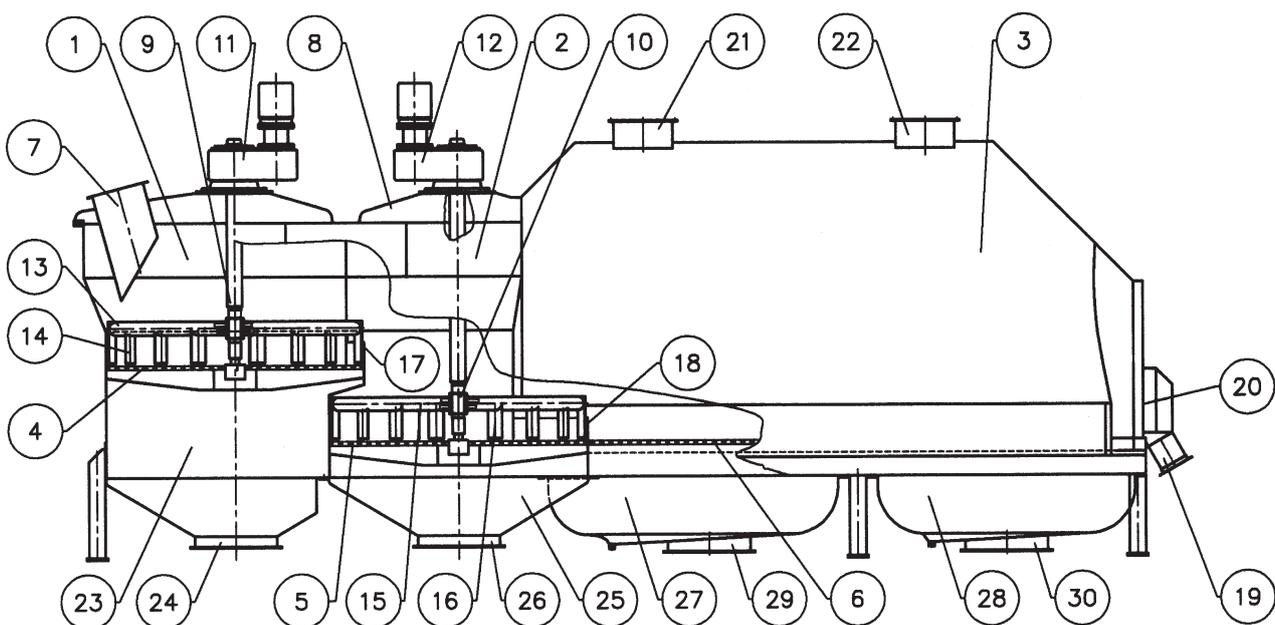


FIGURE 1. Cascade fluid-bed dryer with two impellers.

lets of the partition holes are situated perpendicularly to the other holes, which facilitates homing of the material onto threshold 20. Orientation of the hole outlets in form of small arrows, in particular partitions, is presented in the figure. The flow chamber is shaped like a prism positioned horizontally. The prism at the top has an arcwise profiled jacket, the anterior and posterior walls being inclined at the top. In the upper part in the arcwise shaped jacket, beside the elongated chamber, two spaced ferrules 21 and 22 are mounted, discharging the humid gas during drying. Adhering to the bottom of perforated partition 4 is chamber 23. Chamber 23 is fastened to the device's carrying structure and ended at the bottom with ferrule 24, while partition 5 is adhered by chamber 25 ended in the lower part with ferrule 26. At the bottom of the perforated partition 6 two chambers adhere: 27 and 28, fastened to the carrying structure and equipped in the lower part with ferrules 29 and 30. Ferrules 24, 26, 29 and 30 are designed for gas connection.

FUNCTIONING OF THE DRYER

In the drying process the humid granular material inserted by ferrule 7 drops through the first rotating impeller 9 onto the perforated partition of chamber 1. At the same time the gas brought by ferrule 24 to chamber 23 flows through partition 4 and through the layer of humid material in chamber 1, causing its fluidization and circumferential circulation induced by the impeller's rotation and appropriate situating of canopy holes in the partition.

A proper positioning of blades 14 on arm 13 of its impeller makes the material be directed towards the chamber's cylindrical jacket and its dislocation over threshold 17 to adjacent chamber 2 in which it drops, through the below situated second impeller 10, onto perforated partition 5.

Gas brought by a separate ferrule 26 to chamber 25 passes through the perforated partition and again the material in

chamber 2 is subjected to fluidization and circumferential circulation, which causes continuation of the drying process.

The appropriately selected height of thresholds 17 and 18 to some extent regulates the time of the material's stay in chambers 1 and 2, and thereby its proper drying at this stage of the drying process.

At a later stage, under the effects of the gas flux introduced through partition 5, while flowing over threshold 18 the material gets into chamber 3. Subsequently the material – under the impact of gas brought by ferrules 29 and 30 through chambers 27 and 28 under the perforated partition 6 – flows along the chamber towards the outlet ferrule 19 situated on the rear wall. The humid gas flows out through two top ferrules 21 and 22. In front of the ferrule receiving the material, threshold 20 is positioned, the change of the height of which regulates the time of the material's stay in the device and its final humidity.

CONCLUSIONS

The cascade sugar dryer of 1200 tons daily capacity, designed and made in 2005, passed the practical examination in the sugar campaign of that year in Werbkowice sugar factory. The tests carried out on industrial scale indicate that it is characterised by a great flexibility and reliability of work. It tolerates well the pulsatory feeding of sugar and instantaneous overloads without the loss of assumed technological parameters.

REFERENCES

1. Heim A., Tomalczyk M., Construction of sugar dryers with impeller in fluid-bed. ZN PB, NT nr 120, Design and operation of machines, 1998, 5, Białystok, pp. 145-154 (in Polish).
2. Heim A., Tomalczyk M., Construction of vertical sugar dryer with impeller in fluid-bed. ZN PO, 254, Mechanics, 2000, 60, Opole, pp. 85-89 (in Polish).

KONSTRUKCJA KASKADOWEJ SUSZARKI FLUIDALNEJ Z DWOMA MIESZADŁAMI

Marek Tomalczyk, Andrzej Heim

Katedra Aparatury Procesowej, Wydział Inżynierii Procesowej i Ochrony Środowiska, Politechnika Łódzka

Referat jest kontynuacją cyklu prac prezentujących konstrukcje suszarek i chłodziarek cukru projektowanych w Politechnice Łódzkiej, przedstawianych na kolejnych konferencjach BEMS. W pracy zaprezentowano szczegółowe rozwiązania konstrukcyjne, które są odpowiedzią na problemy techniczne pojawiające się podczas zwiększania skali urządzenia w zakresie wydajności od 800 do 1200 ton produktu na dobę. Omawiana, w pełni oryginalna konstrukcja kaskadowej suszarki fluidalnej z dwoma mieszadłami jest przedmiotem zgłoszenia patentowego nr P-78744. Kaskadowa suszarka cukru o wydajności 1200 ton na dobę, zaprojektowana i wykonana w 2005 roku, zdała egzamin praktyczny w kampanii cukrowniczej tegoż roku w cukrowni Werbkowice. Została pozytywnie oceniona przez zakład wdrażający, zarówno pod względem spełnienia założonych parametrów technologicznych, jak i wysokiej niezawodności pracy.