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## Fluidised bed and steam drying news\*

### Neuerungen bei der Wirbelschicht-Verdampfungstrocknung

The drying of pressed sugar beet pulp in a pressurised fluidised bed with superheated steam is widely used in the sugar industry and can be considered to be state of the art for energy-efficient drying concepts in combined plant systems. The process has been used on a large scale in the sugar industry for more than 20 years.

In the past campaign, BMA subjected existing drying systems at various locations to a number of refinements. These systematic, process engineering modifications allow the driers to work more efficiently and reliably.

Feeding pressed pulp into a fluidised-bed drier is a critical phase in the drying process and can lead to malfunctions. The ability to determine the fluidisation conditions in the first drier cells provides more detailed insights into the process so that critical situations can be detected at an early stage and therefore malfunctions can be avoided.

Further investigations have shown that the height of the fluidised bed has a considerable effect on adequate product transport and on the degree to which the heat from the circulated steam is utilised and, consequently, on water evaporation.

**Key words:** sugar beet, pulp drying, fluidised bed, superheated steam

#### 1 Introduction

The drying of pressed sugar beet pulp using superheated steam is widely used in the sugar industry and can be considered to be state of the art for energy-efficient drying concepts in combined plant systems. The process has been applied on a large scale in the sugar industry for more than 20 years, tracing back to the implementation by NIRO [1].

According to the process principle, pressed sugar beet pulp is fed into a stream of superheated steam where it is fluidised but not discharged together with the steam (Fig. 1). During fluidisation, the pulp absorbs the heat from the superheated steam, which causes the water contained in the pulp to evaporate. The fluidisation and drying steams are led in a cycle via a heat exchanger to be superheated.

With ongoing water evaporation, the beet pulp is dried, while the fluidisation properties change together with the size and shape of beet pulp. Below the fluidised bed inside the drier, the steam distribution plates in the individual cells have therefore been adapted to the varying fluidisation properties.

The crucial factors for the functioning of the fluidised-bed

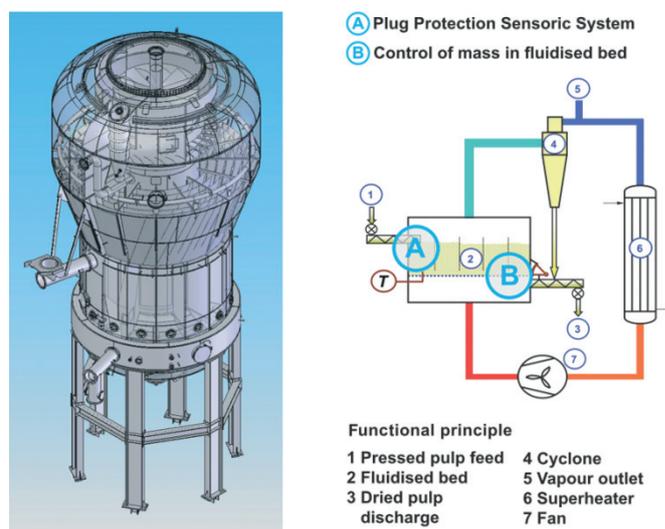
Die Trocknung von Zuckerrübenpressschnitzeln in der druckaufgeladenen Wirbelschicht mittels überhitztem Wasserdampf ist in der Zuckerindustrie eingeführt und kann in Hinblick auf energieeffiziente Trocknungskonzepte im Anlagenverbund als Stand der Technik bezeichnet werden. Das Verfahrensprinzip wird in der Zuckerindustrie seit mehr als 20 Jahren großtechnisch angewendet.

BMA hat in der vergangenen Kampagne an verschiedenen Trocknerstandorten Neuerungen an bestehenden Systemen umgesetzt. Diese systematischen, verfahrenstechnisch begründeten Modifikationen führen zu einer höheren Effizienz und zu einer höheren Zuverlässigkeit.

Der Eintrag von Pressschnitzeln in den Wirbelschichttrockner ist verfahrenstechnisch kritisch und kann zu Betriebsstörungen führen. Durch Erfassung des Fluidisierungszustands in den ersten Zellen erhält man einen erweiterten Einblick und kann kritische Situationen frühzeitig erkennen und Betriebsstörungen vermeiden.

In weiteren Untersuchungen zeigte sich der deutliche Einfluss der Wirbelschichthöhe auf die Ausnutzung der Dampfüberhitzung und damit auf die Wasserverdampfung.

**Schlagwörter:** Zuckerrübe, Schnitzeltrocknung, Wirbelschicht, überhitzter Dampf



**Fig. 1:** Principle of fluidised-bed steam drying with measures for enhanced efficiency and reliability (A) Plug Protection Sensoric System (B) Control of mass in fluidised bed

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steam drier are a constantly reliable fluidisation of the particles in the fluidised bed and a stable particle transport. The particle fluidisation can be monitored using the BMA-developed Plug Protection Sensoric System (Fig. 1, A). Another feature of the system allows the mass contained in the fluidised bed to be controlled, and thus the efficiency of drying (Fig. 1, B).

## 2 Plug Protection Sensoric System

The Plug Protection Sensoric System determines the fluidisation status of the fluidised bed on the basis of comparative temperature measurements. Under normal operating conditions, the temperature of the superheated steam flowing through the fluidised bed decreases over the entire height, but it does not reach the saturation temperature at the upper boundary of the fluidised bed (Fig. 2; temperature curve during normal operation). The temperature profile here depends on the ratio between product mass in the fluidised bed and the steam mass flow.

If there is a high product mass in the fluidised bed together with a reduced steam mass flow, the steam temperature clearly decreases already near the distribution plate, reaching the saturation temperature inside the fluidised bed (Fig. 2; temperature curve in a critical condition). In the extreme case of plug formation, the steam mass flow is very strongly reduced, and the saturation temperature is already reached near the distribution plate (Fig. 2; temperature curve in a critical condition). The Plug Protection Sensoric System works with temperature measurements above the distribution plate that are compared with the inflow temperature below the distribution plate. Thanks to its closeness to the plate, the system reacts in a clearly more sensitive way to changes of the fluidisation status

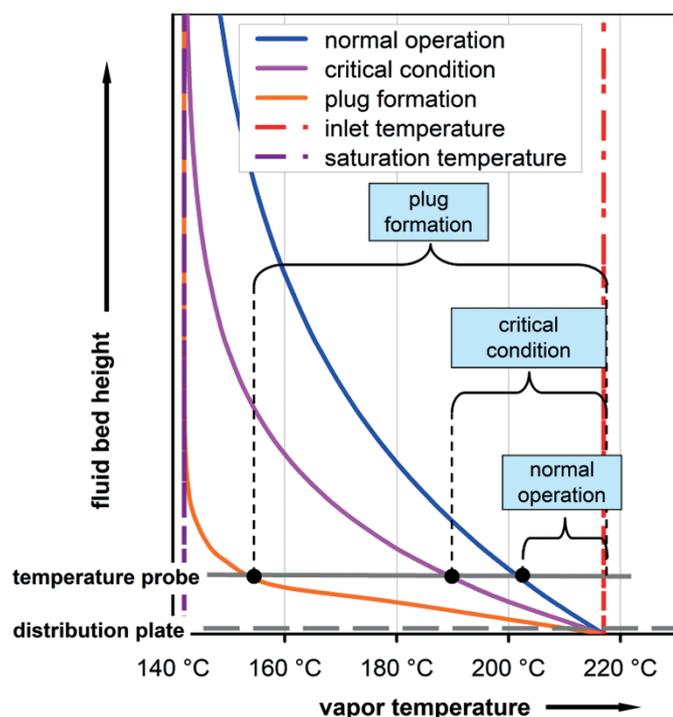


Fig. 2: Temperature curve across fluidised bed at normal operation, critical condition and plug. Temperature of saturated steam = 142 °C, steam inlet temperature = 217 °C

than it would using only a steam temperature measurement above the fluidised bed (Fig. 2). A deviation of the temperature difference from the temperature difference obtained under normal operating conditions indicates – independently from the process conditions – a deviation of the fluidisation status. As shown in Figure 2, an increased temperature difference can be defined for critical fluidisation conditions, which occurs clearly before the plugged status.

Figure 3 demonstrates the functional principle of the Plug Protection Sensoric System with temperature probes below and above the distribution plate. In practical operation it could be shown that critical situations are indicated early by the varied temperature difference, leaving enough time to counteract further impairments of the fluidisation status up to plugging. The recovery of the uncritical operating status is typically achieved by temporary reduction of the pressed pulp supply (Fig. 4). After the critical situation has been overcome, the recovered normal operating status can be verified on the basis of the further course of the temperature differences.

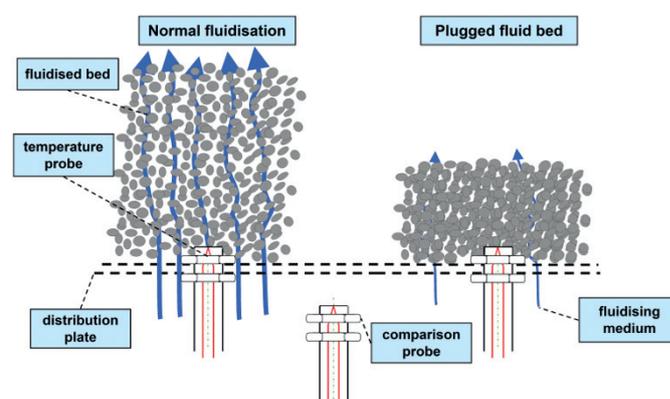


Fig. 3: Functional principle of Plug Protection Sensoric System (left: normal fluidisation, right: plugged fluid bed)

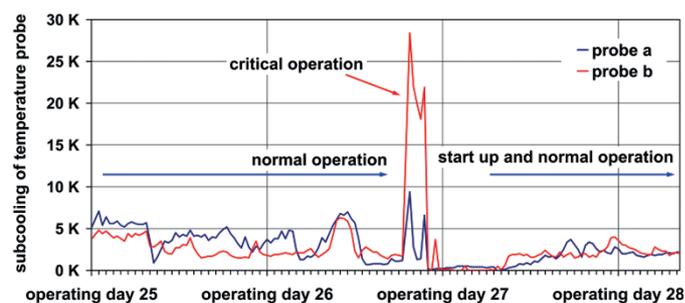


Fig. 4: Measured temperature differences at two probes of the Plug Protection Sensoric System in a fluidised bed steam drier with phases of normal and critical operation

## 3 Control of mass in fluidised bed

During drying in the fluidised bed, the pressed pulp shrinks and loses weight, which changes the fluidisation properties in the individual drier cells. For a certain pressed pulp throughput, the distribution of the circulated steam to the individual cells is defined by the pressure loss of the distribution plate and the particle mass. From process-technical view, it is important for a constantly optimal operation to maintain the pressure loss conditions of distribution plate and fluidised bed independently from the throughput. The system presented

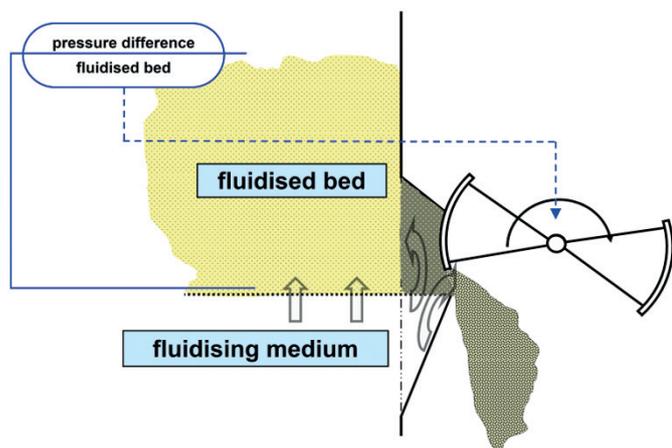


Fig. 5: Functional principle of control system by rotating weir

continuously controls the pressure loss of the fluidised bed by adjusting the product outlet opening. Figure 5 shows the measured pressure loss of the fluidised bed, which is directly proportional to the fluidised-bed mass, together with the control of the outlet weir.

The outlet weir for adapting the outlet opening is executed as rotating weir (Fig. 6). The rotational principle prevents the product from getting caught in the outlet opening. In addition, an automatic lump discharge is realised, which is done by a brief total opening of the outlet opening. In case of malfunctions in downstream equipment, the weir is closed and the fluidised bed is stabilised.

Controlling the fluidised-bed mass ensures a steadily sufficient resistance by the product, independently from the pressed pulp supply, in order to safeguard the necessary steam distribution to the individual drier cells (Fig. 7). This helps to feed more steam into the first cells, where fluidisation of the still wet pulp is challenging.

Moreover, controlling the fluidised-bed mass allows to influence the residence time of the product in the drier. The time of contact between pressed pulp and circulated steam when flowing through the fluidised bed determines the maximally possible water evaporation rate. The possibility to increase the fluidised bed height allows for a more efficient utilisation of the drier with an increased water evaporation performance. In addition, the risk of plugging is reduced. A controlled operation with maximum performance can thus be realised more reliably.

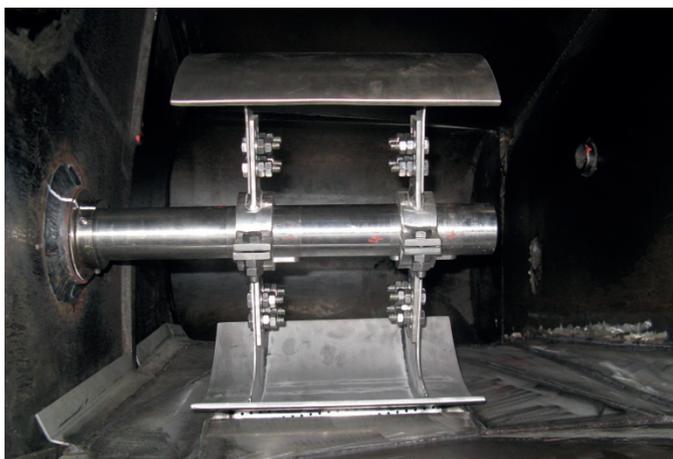


Fig. 6: Top view of the rotary weir (closed position)

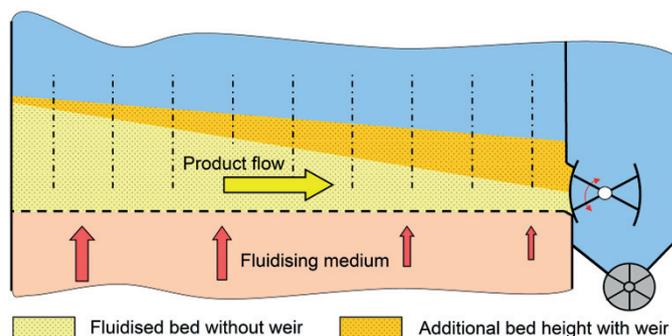


Fig. 7: Pulp and steam distribution in fluidised bed at open and closed position of rotary weir (principle)

In practical operation, it turned out that a more even product discharge is advantageous for the operation of downstream equipment, such as for molasses dosing or throughput control of the pellet presses.

#### 4 Conclusions

The fluidised-bed steam driers have been optimised in many years of development, but it is still possible to implement further improvements by applying intelligent measurement and control technology. Through the installation of additional temperature probes near the distribution plate, the fluidisation status of the particles can be locally monitored. Thanks to this information, countermeasures can be taken early in case of irregularities, in order to avoid serious operating conditions including plugging.

In addition, the control of the particle mass in the steam drier ensures a reliable steam distribution to the cells, a more even product discharge from the drier and an improved utilisation of the heat from the circulated steam. Thus, a higher water evaporation rate and better drier performance are achieved. With the installation of the Plug Protection Sensoric System together with a bed mass control, the drying plant operator is definitely offered a higher safeguard against standstills.

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#### References

- 1 Jensen, A.S.; Brons, N.; Bruhns, M.; Bunert, U. (1996): Schnitzeltrocknung mit überhitztem Dampf. Proceedings 20th General Assembly of C.I.T.S., Munich 1995, Verlag Dr. A. Bartens, Berlin, 348–381

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