Low-energy pulp drying in a high-capacity Fluidized-Bed Steam Dryer

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The conventional method of producing dry pulp from pressed sugar beet pulp is a thermal process using the principle of high-temperature drying, low-temperature drying, or a combination of these two methods. High-temperature drying is widely applied throughout the world, and will normally be encountered as the classical method in directly fired drum dryers. The energy content of the fuel employed for drying can in these installations be used but once (figure 1).

Fig. 1: Integration of a pulp drying plant into an energy system of a sugar factory

To date, the benefits of linking high-temperature drying with sugar production for purposes of energy utilization are relatively low and are limited in that only the boiler exhaust gas is available for further use. About 10% of the energy requirements of the drying process can be covered by this exhaust gas, while the remaining energy has to be made available in the form of fossil fuel. Although the exhaust gas leaving the high-temperature drying system has a high energy content, the temperature level remains low, which is why it cannot be put to further use in an efficient way.
When using pulp drying as a desuperheater stage and integrating it into the sugar factory heating system, almost complete economies can be made on the fuel requirements for this process (figure 2).

![Diagram of fluidized-bed steam dryer integration into a sugar factory heat system]

Fig. 2: Integration of a fluidized-bed steam dryer into a heat system of a sugar factory

This benefit in terms of energy efficiency at the same time goes along with a substantially reduced environmental impact, which is due to the reduced CO₂ emissions.

The fluidized-bed steam dryer (FSD) is a technical solution that has been available for these purposes for some time. In this unit, the pressed pulp is dried in a circulating stream of superheated steam.

When used as a desuperheater, the FSD does, except for minor radiation losses and degassing losses, itself not require any thermal energy. This presupposes, however, that the thermal energy used in the FSD as heating steam is completely made available again in the evaporator station in the form of drying vapours. The energy losses resulting from thermal energy transformation to a lower temperature level can, however, not be avoided. Since the dryer is operated in parallel with the turbine, the heating steam consumed by the dryer automatically reduces the amount of electric power produced in the factory. The additional energy required to drive the FSD is transferred by approx. 99% to the circulation steam in the dryer.
The characteristics of the tried and tested functional principle of the FSD are depicted in figure 3. Technologically, the FSD has the following components:

- Fluidized bed with product inlet and outlet
- Cyclone dust separator
- Side cyclone to discharge separated fines
- Heat exchanger to superheat the circulation steam by means of heating steam
- Fan rotor with drive
- Distribution plate to distribute the circulation steam in the cellular fluidizing bed

In the fluidized-bed steam dryer, these components are extremely compact. In addition to the energy that the heat exchanger transfers to the circulation steam, further energy is transferred into the bed via heating panels. This direct contact of the pressed pulp with the heating panels provides for most efficient heat transfer.

The bed of fluidized pressed beet pulp forms in an annular space surrounding the central heat exchanger in 15 cells. The stream of circulation steam required for this purpose is generated by a fan rotor arranged below the heat exchanger. In the 16th cell, the dried pulp is discharged from the dryer by means of a screw conveyor.

In March 2001 BMA acquired an exclusive worldwide licence covering the manufacture and sale of a high-capacity fluidized-bed steam dryer for the sugar industry. Of this type of dryer,
which the licensor Niro A/S had hitherto been selling to the sugar industry as well, 12 units are installed at European and US sugar factories. At the end of September 2001, which was just a few months after the know-how had been taken over, BMA was awarded an order from Nordzucker AG, Braunschweig, Germany, for the supply of a type-12 fluidized-bed steam dryer (FSD) for pressed sugar beet pulp, which went on stream at the Uelzen sugar factory in the 2002 campaign (figure 4).

Another type-12 fluidized-bed steam dryer is currently being erected and will be put into operation at Nordzucker’s Clauen plant for the 2003 campaign.

Compared with the dryers previously installed by the licensor, the dryer design has in the meantime been subjected by BMA to a number of modifications. This refers, in particular, to its drying capacity which at a water evaporation of 50 t/h in the new size-12 unit is higher by 25% than that of the largest size which was previously installed. Since unlike most of the other large items of sugar factory equipment the FSD is a pressure vessel, this largest dryer unit that has been produced to date represents a major challenge not only respecting its design and manufacture, but also with respect to transport and assembly of the dryer segments.

Fig. 4: BMA FSD-12 at site – Lifting of superheater (Uelzen sugar factory)
The diagram in figure 5 is a typical mass flow balance of a size-12 fluidized-bed steam dryer operating at an absolute heating steam pressure of 26 bar. At a water evaporation of 50 t/h, the dryer can, therefore, process 75 t/h of pressed pulp containing 30% dry substance into dry pulp containing 90% dry substance.

Generally, the integration of an FSD in an existing sugar factory is of interest when the balance between power generation and steam requirements can be compensated. This applies in such cases where the steam requirement due to the production profile is relatively high and electrical energy can be purchased at relatively favourable conditions. These two aspects are applicable to Uelzen sugar factory. As an alternative, the employment of an upstream turbine can contribute to a compensation of the energy balance.

BMA’s progressive development of the dryer is focussed, in the first place, on improving its availability during the campaign. Essential modifications, besides other design details, are the following:

- In previously installed dryers, the direct mounting of the fan rotor on the shaft of the driving motor resulted in numerous motor failures, largely caused by the excessive transfer of heat from the dryer compartment via the motor shaft into the motor compartment. Such defects considerably reduced the availability of the dryer, as the motor replacement involved complete detaching of the motor with
the directly attached fan rotor along with the dryer cover. As this also required the dryer to be opened, this was only possible after decompression and a prolonged cooling phase over several hours. Subsequent reheating of the dryer was extremely time-consuming. To avoid such disadvantages, mechanical and thermal disconnection of the driving motor from the fan rotor was developed. For this purpose, a separately carried fan rotor shaft is connected at its lower end via a coupling with the motor. Moreover, for lubrication and cooling purposes, this fan rotor shaft has an independent circulation oiling system with external oil / air cooler. This configuration reduces the likelihood of thermally induced motor failures. It also means that the dryer need not be opened in the event of a failure. Another advantage of this modification has to be seen in the fact that a standard motor can be used.

- A new diameter/height ratio has optimized the fan rotor for the operating point.
- The previously plane distributor plate is now curved to improve pulp fluidization in the fluidized bed. This also improves the transport of oversize pressed pulp.
- Based on the proved operating principle, the design and size of inlet and outlet locks have been adapted to the size-12 dryer to cope with the higher pulp throughput.
- Two feeder screw conveyors now supply the pressed pulp into the first bed cell to reduce the danger of choking in this area.

The dryer modifications have in the previous campaign been demonstrated to be successful. In particular, this now concerns homogeneous fluidization of the pressed pulp in the first dryer cells.

In a performance test made during its first campaign, the size-12 FSD supplied for the Uelzen sugar factory has proved to meet the promised performance parameters. For technological reasons, it was necessary throughout the campaign to add leaves and fragments to the pulp which had been pressed off to an average dry substance content of 30%. Consequently, the actual dry substance content of the wet material fed to the FSD was between 25 and 26%. During the campaign, were temporarily accomplished water evaporation rates well above the rated capacity of 50 t/h. For energetic utilization, the vapor produced by the dryer is fed to the 1st evaporator effect (figure 6).
For this purpose, the 1st effect was converted into a falling-film evaporator with two calandrias. In the upper calandria, the FSD vapor is condensed; the lower calandria is fed with turbine exhaust steam. For proof of the water evaporation rate of the FSD was measured the condensate quantity in the upper calandria of the evaporator.

A size-12 fluidized-bed steam dryer can process all the pressed pulp resulting from a beet slice rate of 10,000 t/d into dry pulp. For smaller drying capacities BMA can supply sizes 8 and 10, the design of which has also been optimized. The principal water evaporation rates of the different dryer sizes subject to the heating steam pressure are shown in figure 7.
Considering the great interest, worldwide, in the fluidized-bed drying technology for pressed pulp, it is of great importance that BMA has the certification for manufacture according to AD Code of Practice HP 0 and to ASME with "U" stamp for pressure vessels, and is thus qualified for the realization of complete FSD projects.

Fluidized-bed steam drying, in addition to high-temperature and low-temperature drying, now enables BMA to offer a complete range of new and conventional pressed pulp drying technologies. For the customer this opens up the possibility to choose one technology and the associated equipment from this range and to have it optimally adapted to his specific requirements such as the sugar factory's processing rate or energy balance. BMA is the customer's competent partner in providing advisory services to elaborate an economically and technically perfected solution.