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Steamdrying of Beet Pulp.

Background for the design, Energy saving, Beet pulp as the only fuel.

The technical background for the design of a steamdryer.

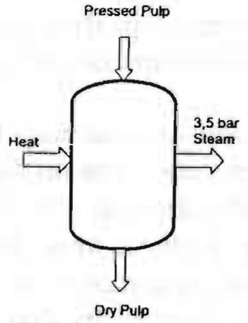


Figure 1

Steamdrying is basically very simple. You continuously feed the pulp into a pressure vessel and add the necessary heat. Then you discharge the dried pulp, and bleed off the water that was in the pulp as a useable steam at e. i. 3,5 bar. You will then avoid any air pollution, and the drying does not consume any energy. It only borrows the energy which, after the drying, is available as steam to be supplied to the juice evaporators.

Unfortunately it is not that simple. The large energy supply needed must be brought right into the centre of the particles, and for that there is only a limited time, as it is a race against the Maillard reaction, that at 3,5 bar after 5 minutes starts to run fast, and will reduce the pulp quality. Before then the pulp should be dried and out.

If you will bring the heat to the pulp through contact surfaces either mechanical moved or heating surfaces in a fluid bed, you can theoretical calculate the surface size based on the available temperature difference the practical heat transfer coefficient. You will then find that you need a very big area of which each square feet shall be in contact with a certain quantity of pulp. Then you can calculate the amount of pulp in the dryer, and thereby the retention time. The calculations will show that it is not possible to do the drying within the allowed time. You can thenconclude that the main part of the necessary energy must be transferred by a large circulating flow of superheated steam. Therefore all steamdryers for beet pulp in principle must be as shown on figure 2.

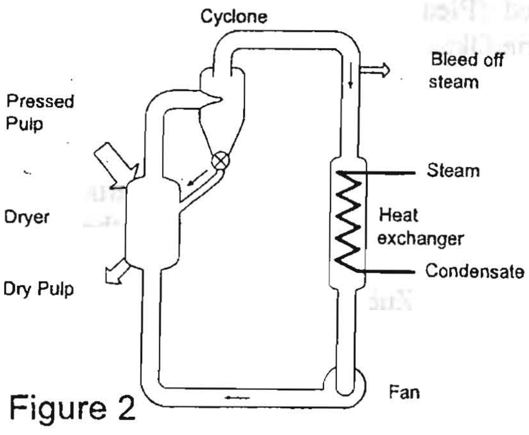
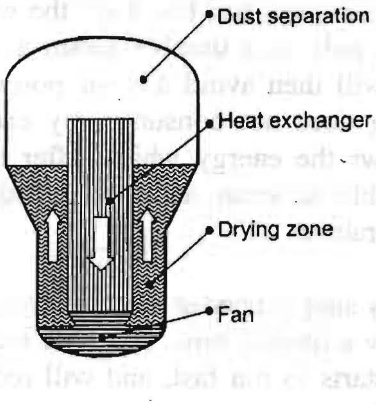


Figure 2

Figure 2 shows the necessary main components, which are: 1) a fan circulating superheated steam through 2) a dryer after which there must be 3) a dust separation before the circulating steam is reheated in 4) a heat exchanger. After the dust separation the steam evaporated from the pulp can be bled off.

Based on the principle of figure 2 you can have various versions of the dryer itself and the whole set up. One possibility could be to let the steam pass down through a bed of pulp lying on a steam permeable belt as known from low temperature dryers drying with hot air. Unfortunately the drying time for such a type of dryers is so long that the Maillard reaction will go too far. But by reducing the pressure in the drying chamber to 1,0 – 1,5 bar, and thereby the temperature of the wet particles, can the Maillard reaction be kept within an acceptable level. In that case the possibilities to reuse the steam from the dryer are reduced, and the volume of steam to be circulated in the dryer will be about 3 times bigger, and thereby will the electric power consumption be increased correspondingly.

That leads to look for a fast drying process, and the solution is a fluid bed, where the pulp is kept moving by a circulating superheated steam. Then the 4 process steps illustrated on figure 2 shall be put together in a practical and convenient way, which is illustrated on figure 3.



Figur 3. Steamdryer

The most obvious way to build the four process steps on figure 2 is to assemble them in a pressure vessel. Figure 3 shows this. In the vessel the dust separation is in the top. The heat exchanger in the centre. The fan in the bottom, and finally the drying chamber(s) around the heat exchanger. Today there are two steamdryers on the market based on two different patents.

The first steamdryer of this type was the one I, together with a group at Danisco, developed in the 1980s. The patent for this belongs today to Niro A/S Denmark.

In the first half of the 1990s NIRO DDS A/S and later NIRO A/S supplied 10 such dryers for 8 European sugar factories. The selling stopped mainly for two reasons:

1) Problems with the rotary valves1993 to 1995.
2) The dryer was expensive.

The problems with the rotary valves was solved (Please see Arne Sloth Jensen's paper presented at CITS in Munich 1995, Zuckerindustrie Okt. 1995). Today the availability on the German sugar factories are in general 97 to 100%.

The new Steamdryer from EnerDry ApS.
Based on a new patent (US 6,154,979) the new steamdryer from EnerDry is available. This new dryer has about 40% more capacity for the same money. That has brought the price for steamdrying so far down that it pays to remove water from the pulp by steamdrying, than to press the pulp to more than 28% DS. (See ASJ's paper in Zuckerindustrie Okt. 1999). Figure 4 shows the new steamdryer.

The new steamdryer differs from the 1980s dryer mainly in two areas:

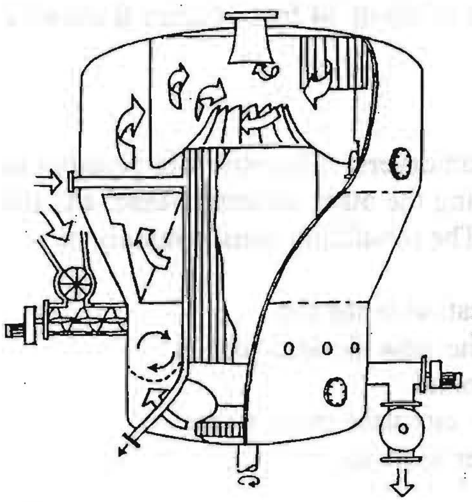


Figure 4

1) The "old" has the drying chamber divided in high vertical cells. That has shown to be a disadvantage especially if there are many coarse particles in the pulp, as the medium size particles will be over-dried before the larger particles are dry. The perforated plate in the bottom of the cells is horizontal and flat. The EnerDry drier has a low ring shaped fluid bed with a curved bottom. That gives a very stable fluid bed that can handle large capacities and pulp with large particle size.
2) The dust separation in the top of the new dryer is completely different. The steam with dust particles has to first pass around outside the real cyclone until it arrives over the last section of the drying chamber. Thereby a pre-separation of dust and an after drying takes place before steam gets into the cyclone for the final dust separation. With this dust separation it is possible to circulate more steam in the drier.

The increased steam circulation gives an increased capacity of the drier, and the more stable fluid bed with the curved bottom allows the larger pulp quantity to be kept "alive" in the fluid bed. 20 to 25% more capacity is achieved in a dryer with the same diameter. The more compact dryer from EnerDry is 10 to 15% lower in price and thereby about 40% more capacity for the same money.

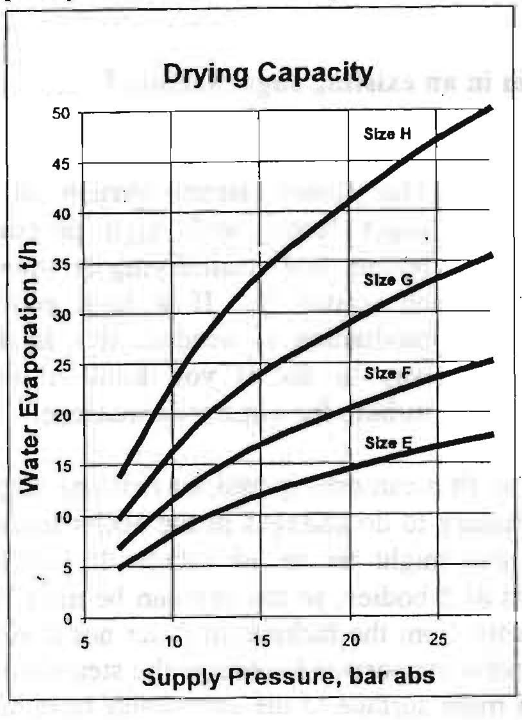


Figure 5

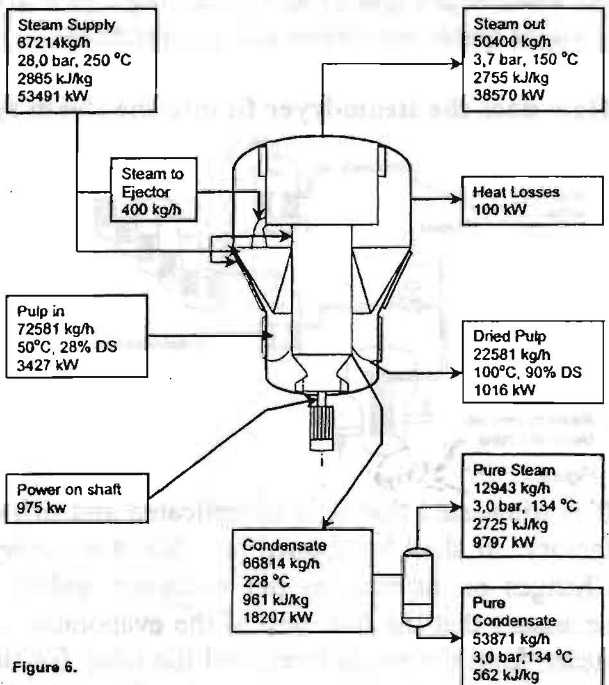


Figure 6.

MASS AND ENERGY BALANCE

Dryer size H
Evaporation 50 000 kg/h
Supply pressure 28 bar

All pressures are in bar absolute

The capacity of the dryer is dependent of the pressure of the steam supplied. A higher pressure will bring the circulated steam to a higher temperature and thereby a higher potential for drying. Figure 5 shows the 4 drier sizes. The biggest, size H, can go up to 50 t/h water evaporation. The diameter of the top is a little over 10 m or about 34 feet. Figure 6 shows a mass and energy balance for a size H at max. load.

Rebuilding existing dryers.

It is possible to apply the new ideas also on existing steamdryers. Thereby it is possible to run the dryer stable at an increased capacity. By a rebuilding the outer pressure vessel and the super heater in the centre of the dryer remain as they are. The rebuilding consist mainly in:

1) A complete new design of the dust separation in the top.
2) A new bottom of the fluid bed with the new design, that is curved and not any longer flat and horizontal.
3) Increase of the speed of the impeller to circulate more steam. The motor size must be increased in order to do so.

Out of the 8 sugar factories in Europe having steamdryers, the 5 have or are about to have their dryers rebuilt by EnerDry in order to increase the stability/availability and the 3 of the 5 in order to have the capacity increased. For example has the sugar factory in Miranda in Spain (Ebro Agricolas SA) increased the capacity by 20 %. The dryer there, originally a size 8, can now dry all the pulp from 6400 metric tons beets per day.

You can, as mentioned, increase the capacity of existing dryers, but it is not possible to reach the same high capacity as by building a new dryer from EnerDry. Then it is possible to install a super heater with more and shorter tubes.

How does the steamdryer fit into the steam system in an existing sugar factory?

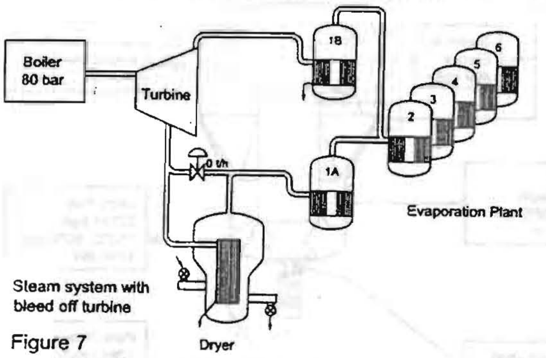
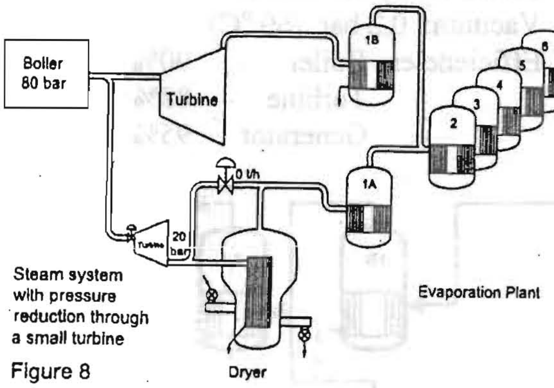


Figure 7

The classic steam system in a sugar factor with high pressure boilers and steamdrying is shown on figure 7. If a high power production is needed, this is the way to do, if you build a new turbine for some other reasons.

It is often said that it is complicated and difficult to fit steamdrying into an existing sugar factory. It shall be pointed out that it is *never* necessary to do changes in the boiler house. Changes on turbines is not necessary either, but this might be an advantage. It will be necessary that the first step of the evaporator consist of 2 bodies, so the one can be used for steam from the steamdryer, and the other for the steam from the turbine, in order not to mix impurities in the boiler feed water. If there is no suitable evaporator to receive the steam from the steamdryer this might be the opportunity to add more surface to the evaporator train and thereby either bring the pressure/temperature down or by adding a step in front to reduce the condenser losses.

In existing factories it should from case to case be studied how the integration of the steamdrying should be made. If you have high pressure boilers, and no steam outtake on the turbine a proposal could be to supply the dryer through a small turbine, that brings the pressure down to the pressure needed for the dryer. At the inlet of the turbine you regulate the pressure to the dryer, and the turbine can drive a power generator, which is coupled to the grid in the factory. Please see figure 8.



Steam system with pressure reduction through a small turbine

Figure 8

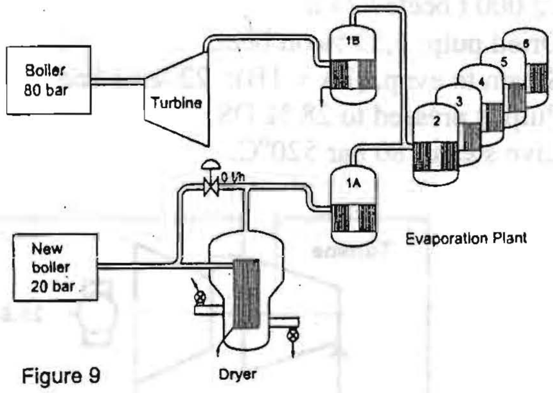


Figure 9

If you increase the size of a sugar factory you might need more boiler capacity. If you have a high pressure boiler you could buy a low pressure boiler to supply the dryer, and accept to buy power if the own production is too small. Please see figure 9.

When you introduce steamdrying, you will normally save about all the fuel needed for the alternative drum drying. The possibilities for power production are in general reduced. You do not loose any energy. You only loose the possibility to transform a part of this energy into power. Any fuel savings will reduce your possibility to produce power. If you save fuel by optimising the evaporation and the sugar house, you will loose relatively more power production than by introducing steamdrying. Please see Arne Sloth Jensen paper from ASSBT in Orlando 1999.

If you drum-dry the pulp you loose all the energy from the used fuel, also the part that could have been converted into power.

Beet Pulp, the Future Bio-Fuel.
The price on dried beet pulp has over the years continously decreased. It is not any longer that attractive business it was, so drying of beet pulp may be considered as a necessity for getting the pulp away. An alternative could be to use the pulp as fuel. If all pulp is steam dried and ¾ of the pulp is fired in the boilers, there will be energy enough for the whole factory.
The pulp is a good bio fuel. When dried, the lower heat value is approx. 7320 Btu/lb (17000 kJ/kg). That is on level with dried lignite. But the sand content is lower, and the beet pulp is a "washed" fuel, as it has passed the extraction. Thereby, the content of K and Na and other salts has been brought down. That indicates, that the pulp should be a quite good fuel even for boilers producing high pressure steam. It could be fired with a spreader stoker and burn out on

a moving grate or a cooled vibrating grate. Many boilers could be rebuilt for firing dried beet pulp.

Figure 10 shows how the steam system in the factory could be. All the pressed pulp is steam dried and combustioned in the boilers. That gives a surplus of steam. Therefor the turbine has a low pressure part bringing this steam down to moderate vacuum. A sugar factory processing 12 000 t beets/24 h will without supplementary fuel be able to produce 25,6 MW_e. This is based on the following data:

12 000 t beets / 24 h
Dried pulp: 5,53 % on beet.
Steam to evap. (1A + 1B): 22% on beets.
Pulp is pressed to 28 % DS.
Live steam: 80 bar 520°C.

Steam to dryers: 22 bar.
Vacuum: 0,2 bar (60 °C)
Efficiencies: Boiler 90%
Turbine 88%
Generator 95%

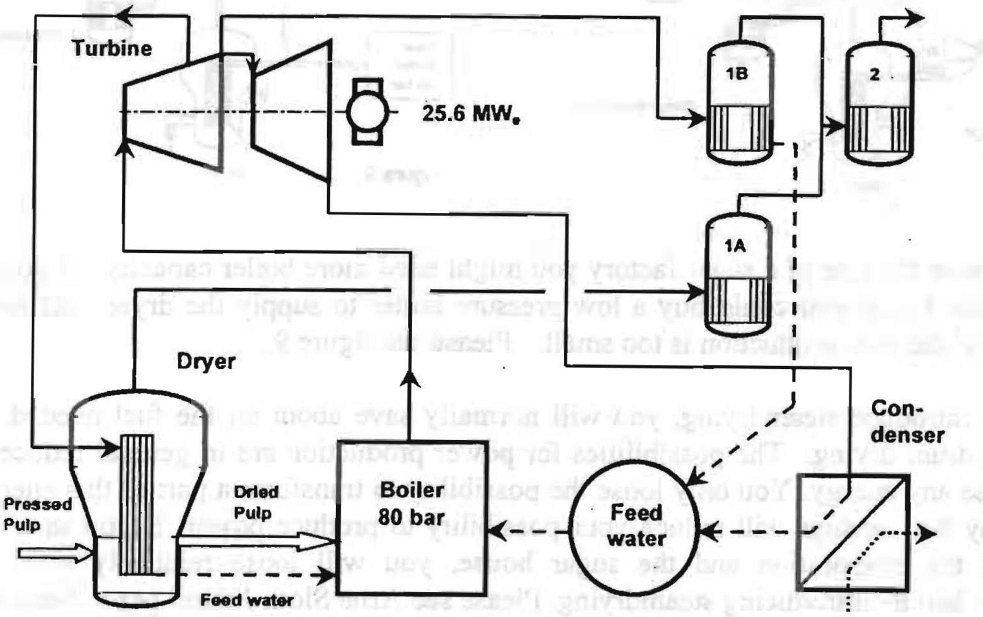


Figure 10. Steamdrying and firing all pulp in a 12000 t/day sugar factory.

For the time being the price for pulp pellets is 70 US \$ per ton and has a lower heat value about 7300 Btu per lb. Heavy fuel oil costs 165 US \$ per ton and has 156000 Btu per gallon. That gives about the same price per Btu.
Beet pulp is considered as a bio fuel. That means, that the CO_2 emission from the combustion will not be taxed, as the CO_2 is neutralised by the reverse process the same year. A tax on CO_2 emission from fossil fuels can change the economical balance. There could also come a simple demand for a CO_2 reduction. First of all steamdrying in itself could reduce the CO_2 emission. Burning the pulp is then the next step to do, and thereby the fossil CO_2 emission can be reduced to 0.
It has become more and more common in many countries, that the big power companies are obliged to have a certain part of the electric power produced as "green" power. Power production according to figure 6 is green power production. May be a co-operation with a power company is possible.

Conclusion:
The new steamdryer technology from EnerDry gives you more capacity for a smaller price. Taking the advantages by steamdrying in consideration it is the way to dry beet pulp. It will be an error to install drum dying. The new technology is proven through rebuilding the steamdryers on 5 out of 8 sugar factories in Europe. The dryer has also improved the availability, so this today is between 97 and 100%.

Integration of steamdrying in an existing factory never demands changes in the boiler house. Changes in the turbine station is not necessary, but might be an advantage. The juice evaporators shall have the first step divided in 2 bodies. If not already it could be an opportunity to get some more sq ft surface and thereby bring the pressure and temperature down.

The dryed pulp is a good fuel. By steamdrying the pulp a sugar factory will get more fuel than needed to run the whole plant. If all the pulp is burned, there will be so much steam that a factory slicing 12000 t/day can produce 26 MW_e power.

As always steamdrying offers: No air pollution. No product loss. Nearly 100% energy savings. No fire risk. Compact design. Low maintenance. Automatic control from central control room.

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