Steam Drying of Beet pulp.
Latest development

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The first ideas are from my time at Danisco 25 years ago, where the first big steps in the development took place. But the development never stops. Especially the last 7 years within EnerDry ApS important development has taken place: New patents and rebuilding of existing dryers to larger capacity and higher availability. The price of steam dryers compared to capacity has gone down. Now the higher fuel-prices make it pay, to scrap well working drum dryers and replace them by steam dryers.

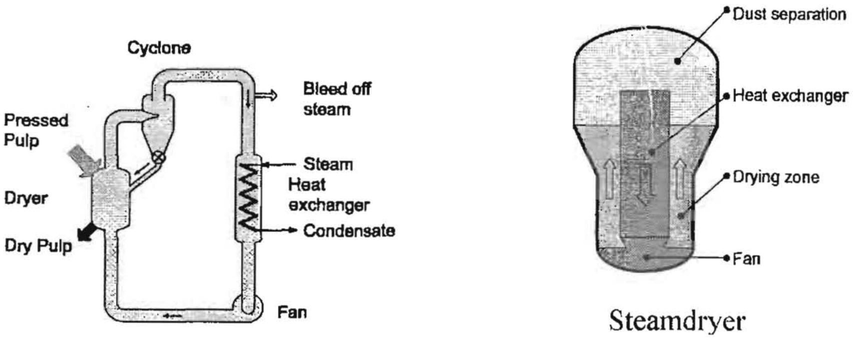


Figure 1.
Working principle of the steamdryer.

On figure 1 you see **the principle of a steamdryer**. In a closed system superheated steam under pressure is circulated up through a fluid bed where the pulp is dried. The steam pass on to a cyclone, where the dust is separated. The steam is then reheated and returned by a fan to the fluid bed. The water that was in the pulp has become steam and is bled off at a pressure useable as supply to the juice evaporators. All those functions are built into a pressure vessel as illustrated to the right in order create a compact and simple design.

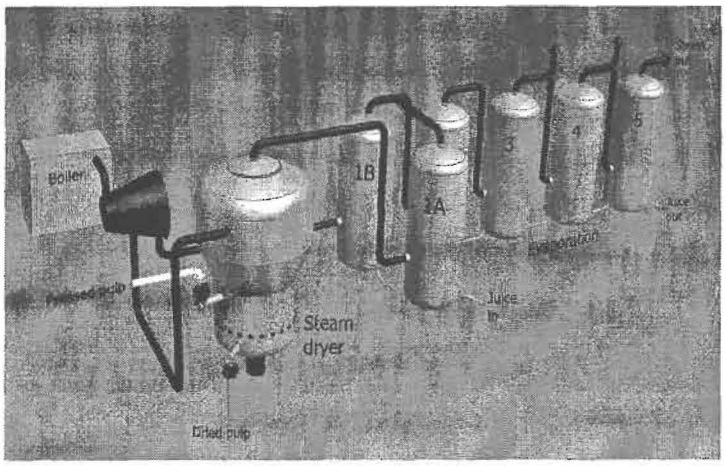


Figure 2
Implementation in a sugar factory.

The figure 2 shows how the steamdryer can be fitted into a sugar factory with a high boiler pressure. The dryer is supplied from an outtake on the turbine. In most American factories, boiler pressure is lower, so the live steam will fit to be used directly as supply to the dryers.

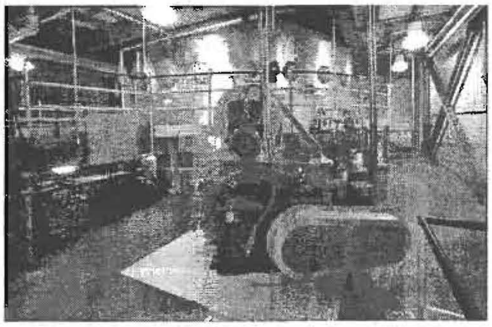
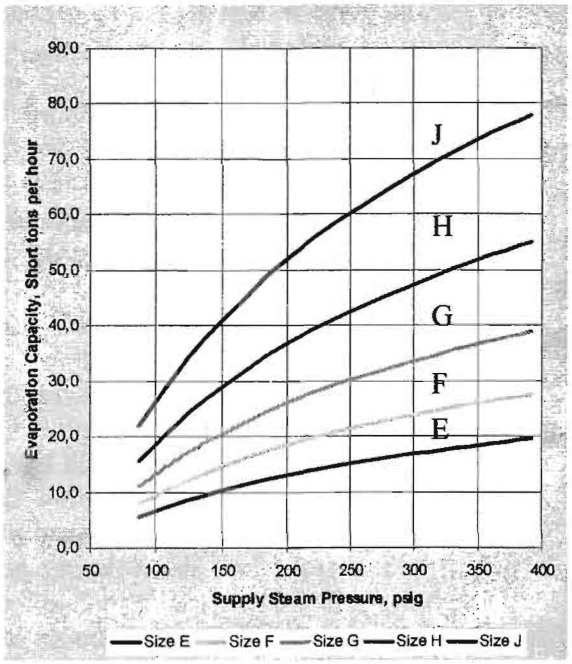


Figure 3.
Dryer at the Minn-Dak Farmers Coop.

EnerDry supplied a **steamdryer size H to Minn-Dak Farmers Coop.** in North Dakota. The dryer was commissioned in September 2003. The factory staff did the engineering and the planning themselves supported by EnerDry. The time schedule was followed, so the installation was nicely painted and ready for the start of the campaign.

The dryer is guaranteed to evaporate 55 short ton per hour (50 metric t/h) from the pulp when supplied by 390 psi (27 bar g). But the factory has only 250 psi available, which gives a guaranteed evaporation of 42 short tons per hour. 110% capacity has been proved under a test.
The new patented design has shown an improvement of the product quality. The pulp is more evenly dried than on any other steamdryer. It has a light color and the capability to reabsorb water is high. And as on all other steam driers there is no burning or loss of product.

At **Southern Minnesota Beet Sugar Factory Coop.** the first 2 steam dryers in USA were installed in 1999. Since then the factory has increased slicing, and the dryers were not any longer able to dry all the pulp. In 2004 before the campaign these dryers were rebuild using the EnerDry technology, whereby the capacity was increased enabling the factory to dry all the pulp. As side effects the product has become lighter in color, and the coarse particles better dried. This has especially importance, when frozen beets are sliced in slabs.



New and larger size of dryer.
Based on the experience from the new dryer, EnerDry has decided to bring a larger dryer on the market. It is marked size **J.** It has a top diameter of 12.4 m (40 feet and 8 inch). The capacity is 70.7 metric t/h water evaporation = 78 short ton evap. per hour. On figure 4 is the capacity for the different dryer sizes shown as a function of the supplied pressure.

Figure 4. Dryer capacities.

Energy usage.

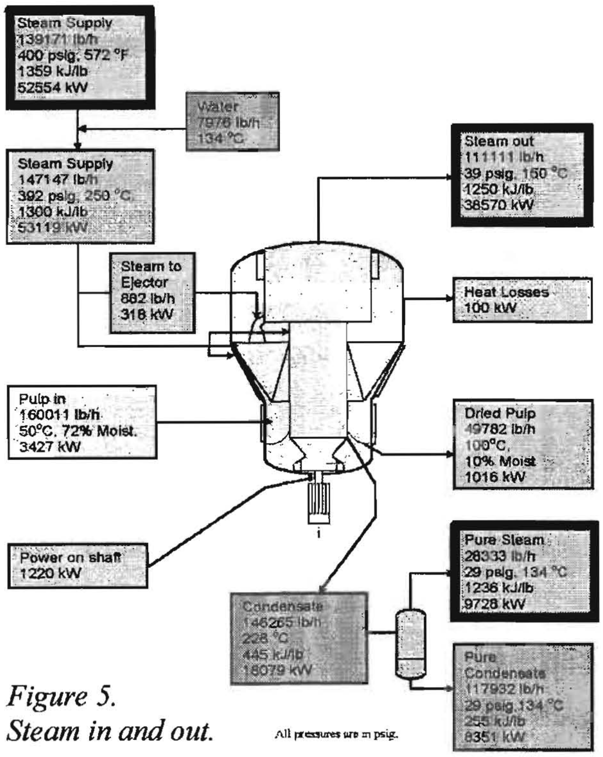


Figure 5.
Steam in and out.

Figure 5 shows the balance for a drier size H suitable for a factory with a slice of 11000 short ton per day. The steam in and out is marked with fat frames, and it should to be noticed, that the amount of steam leaving the dryer is slightly larger the amount supplied in the actual example. Further to the steam returned to the factory there will be the high value hot clean condensate that can be used to increase the capacity of the boilers. It should also be noticed that the amount of steam supplied is larger than the evaporation in the dryer. This is because the evaporation heat is smaller at the higher supply pressure than at the lower pressure, where the drying takes place.

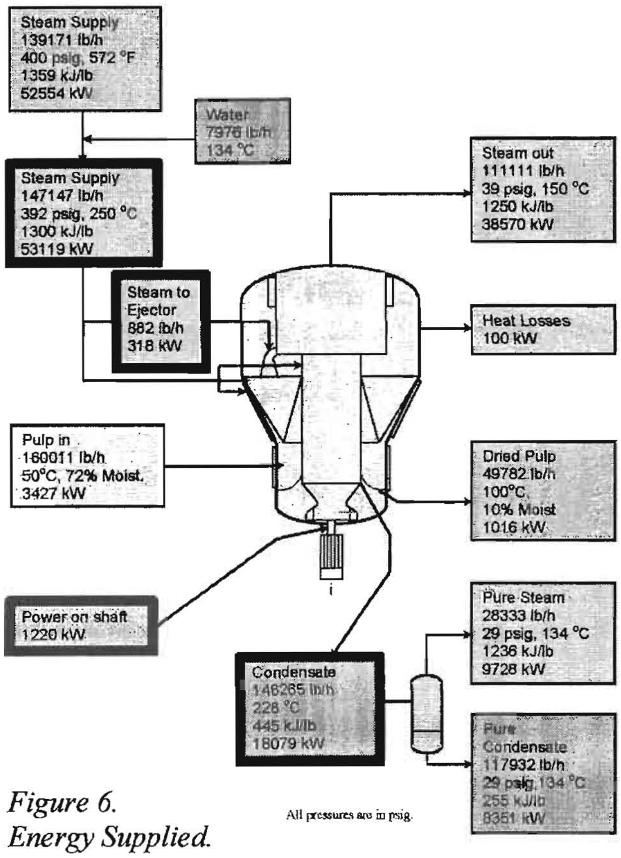


Figure 6.
Energy Supplied.

Figure 6 is the same balance as figure 5, but with supplied energy marked with fat frames. The condensate leaving the superheater is subtracted to show the net supplied energy. From this it is calculated that the amount of energy supplied is only 1076 Btu per lb evaporated (598 kcal/kg evap. = 2501 kJ/kg evaporated). Typically a drum dryer will use 1400 Btu per lb evaporated (764 kcal/kg evap. = 3196 kJ/kg evaporated). The steamdryer use less, as there is no heat wasted to heat air. Further to the supplied heat there shall be supplied 1220 kW on the fan shaft, which is more than normally needed for a drum drying plant. But if the drum drying plant shall fulfill high demands on gas cleaning the power consumption will be nearly the same.

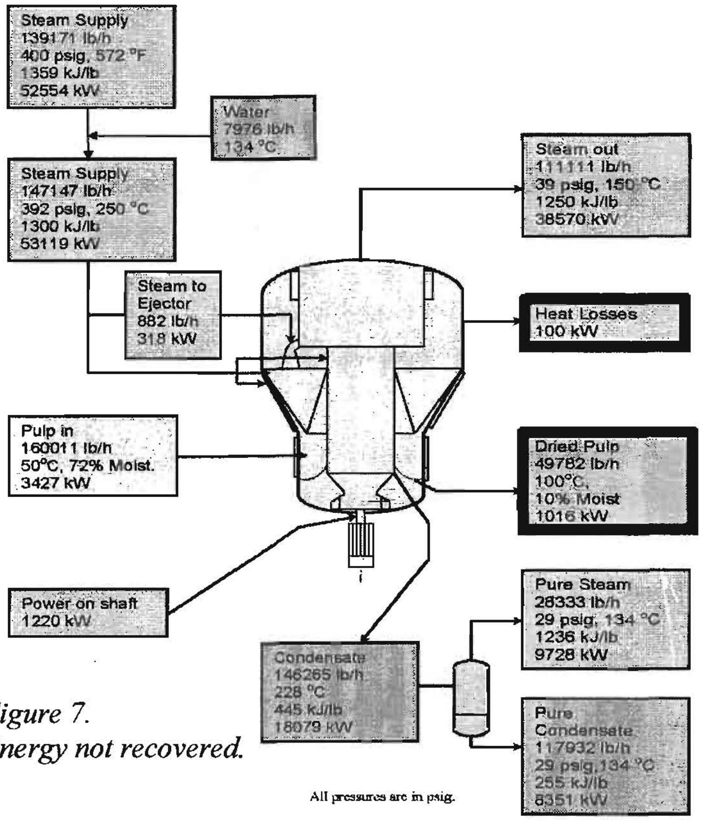


Figure 7.
Energy not recovered.

Figure 7 shows again the same balance now with the non recovered flows of energy marked. The pulp leaves the dryer at 100°C and came in at 50°C, so half the enthalpy in the product is lost. Further more the heat transfer through the insulation is also lost adding up to a total loss of 608 kW. Related to the evaporation it becomes 19 Btu per lb evaporated (11 kcal/kg evap. = 44 kJ/kg evap).

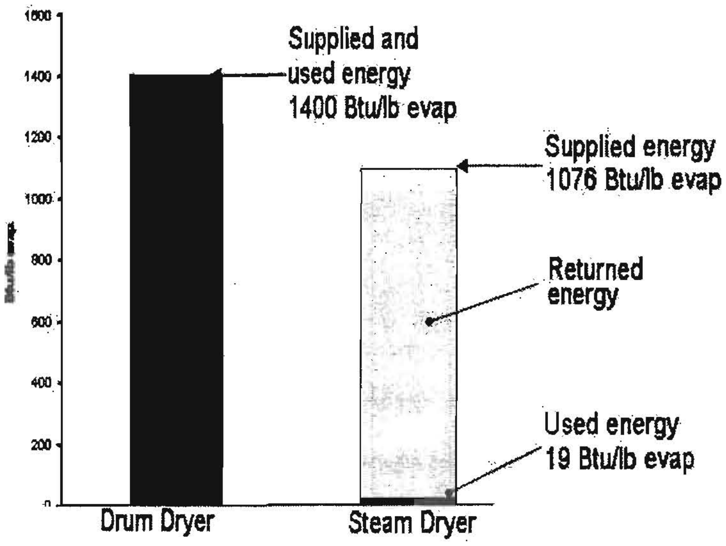
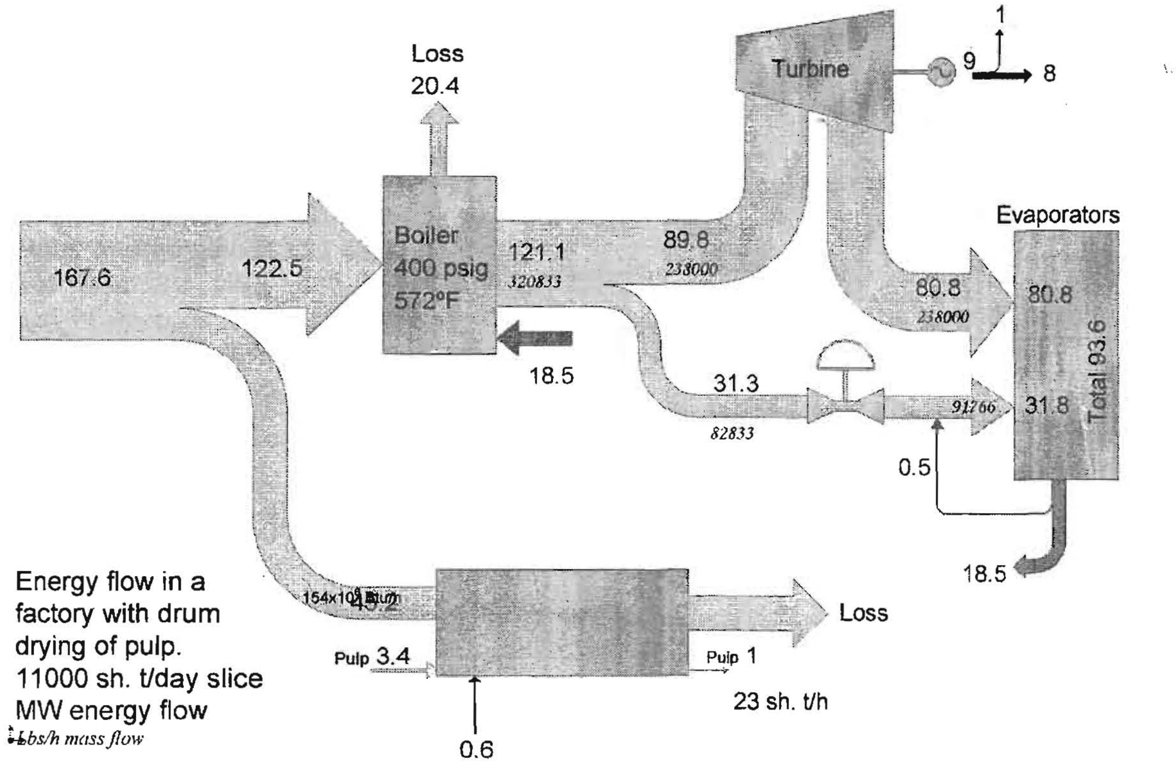


Figure 8.
Energy Consumption.

The left column shows the energy consumption of a drum drier and the right column of a steam dryer. In the right column at the bottom is seen the only amount of energy that is not recovered when you utilize steam drying.

Energy flow in a sugar factory.

Figure 9 / 10 shows energy flow in a beet sugar factory with drum drying respectively steam drying.



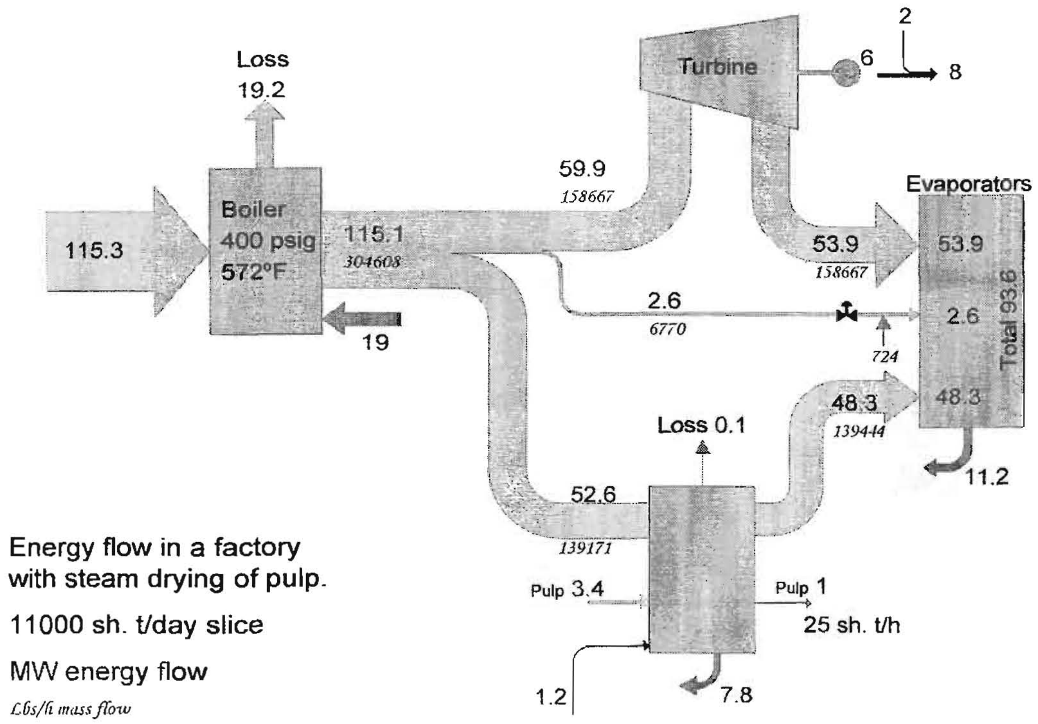


Figure 9 and 10: Energy flow in a beet sugar factory.

Figure 9 is an example of energy flow through a sugar factory with power production and drum drying. The number shows the flow in MW, and some steam flows are indicated with smaller letters in lb per hour as well. The energy consumption is as common in an American sugar factory. The factory produces 9 MW power in this case and consume 8 MW, so 1 MW is sold.

Figure 10 shows how it will be with steam drying in stead of drum drying. The evaporation stations receive the same flow of Energy as before. The amount of steam directly from the boilers is reduced to a minimum. The steam flow through the turbine is also reduced, so power production has gone down by 3 MW. But the savings are not only the 45 MW that the drum drier use but even the amount of energy to the boiler house has gone down by 7 MW. This 7 MW comes partly due to the reduced power production, but also from the energy in the 50°C hot pulp supplied to the dryer. This energy is in the dryer lifted to a higher level, so it can be used in first step of the dryer.

Increased pellet production.
It is well known that pulp is partly burned in drum driers. On figure 11 you will see a microscope photo of beet pulp. To the left you have steam dried pulp, and to the right you have drum dried. The steam drying causes no burning. The drum dried pulp has burned edges, and what is burned completely can of cause not be seen. The loss due to this burning is a function of the inlet temperature in the drying drum. The losses depend also on other things so exact values are difficult to give, but on figure 12 is shown a range, within which the losses can be expected. Those losses do not take place by steamdrying, and therefore the production will be larger.

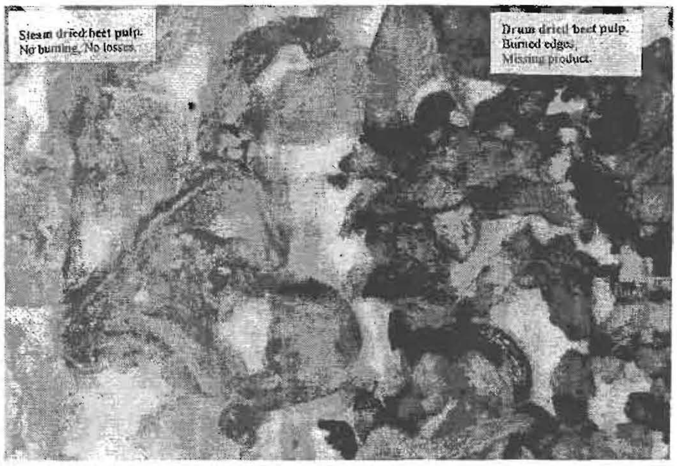
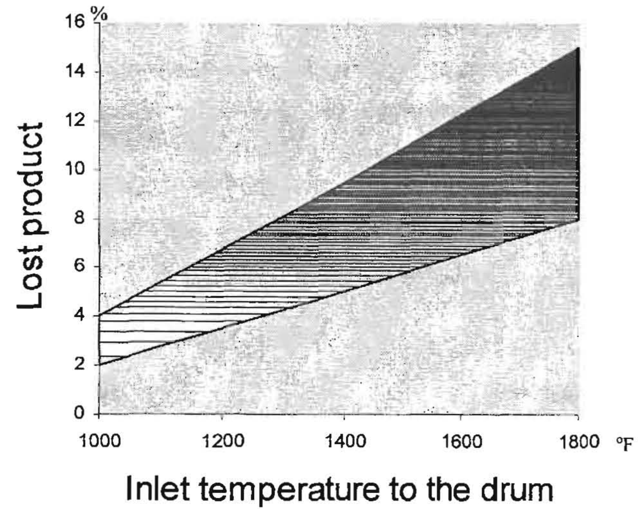


Figure 11 (Photo) and 12 (product loss).



Economy

The economical gain by steamdrying compared to drum drying for a sugar factory slicing 11000 short tons per day in 200 days per year can be calculates as follows. The number from figure 9 and 10 are used.

Fuel savings	
$573x10^6 – 394x10^6 = 179x10^6$ Btu/h	
Per campaign with gas price $6.5 per mill Btu	+5.585 mill $/y
Power	
1 MW not sold 3¢ / kWh	-0.144 mill $/y
2.6 MW more bought 5¢ / kWh	-0.624 mill $/y
More pellets for sale (+7%); 75$ per ton pellets	
0.07 x 25 x 24 x 200 x 75	+0.630 mill $/y
Saved operational staff; 1 man per shift	+0.240 mill $/y
Yearly gain	5.687 mill $/y
A budget for the installation can be:	
Dryer size H ex works	6 mill $
Installation and related changes in the factory	4.5 mill $
Total	10.5 mill $

Beet pulp as biofuel.
Beet pulp is a good fuel. It is low in K and Na salts as it has just been "washed" in the diffuser. It has about the same heat value (7320 Btu per lb) as lignite and less sand than most lignite. It is good for even high pressure boilers. With a pellet price of 75 $ per ton the pulp as fuel has a price of 5.12 $ per one million Btu – which is cheaper than gas.

The quantity is more than enough to keep an economical sugar factory running. Please see figure 13.

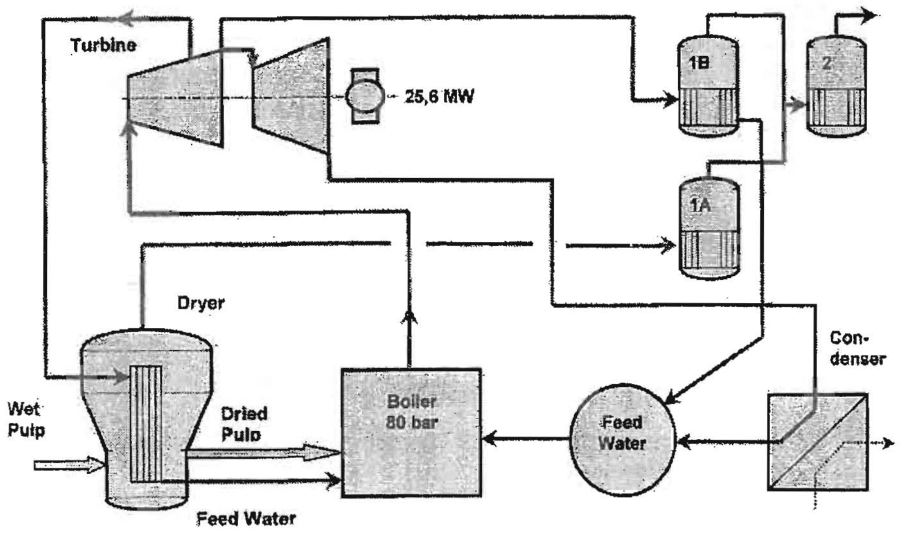


Figure 13
Steam system in a factory burning all its pulp.

The steam system shown is for a sugar factory with a slice rate of 13200 short ton beets per day. All the dried pulp (5.53 % on beet) is burned. And that will produce more steam than needed for the factory. The surplus of steam goes through the last part of the turbine down to a moderate Vacuum (60°C). With a live steam of 80 bar and 520°C there can be produced 25.6 MW electric power.

Conclusion:
Steam drying of the pulp is the future solution for drying of beet pulp. It gives:

Saving of fuel
More product
No dust.
No smell.
No VOC.