Latest development in steam drying of beet pulp*

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Abstract

One of the most effective ways of reducing energy consumption in beet sugar factories with drum-drying of pulp is to introduce steam drying. This does not require changes in the boiler house, but the power production will be affected negatively. This can though be partly compensated by an economizer built into the steam dryer. With reference to case studies of installations of EnerDry's steam dryers in factories in Europe and Japan, this paper highlights, in particular, reduction in total energy consumption by one third. Further, the installation of EnerDry's steam dryer also prevents the loss of beet pulp dry matter that is prevalent with drum dryers where high temperatures cause losses through combustion. Pulp dry matter losses in drum dryers are usually around 5-7 %, but can be very high in some cases.

Keywords: ***steam dryer, beet sugar factories, pulp drying, energy consumption, EnerDry***

Introduction

Over the last 40 years the energy consumption in beet sugar factories has been reduced from some 300 to 180 kWh/ton beet. Additionally, there is demand for energy to dry beet pulp, which is 90 kWh/ton beet making a total of 270 kWh/ton beet. In order for a factory to reduce energy costs further, a steam dryer is needed. In one step a steam dryer will save the energy used in the drum dryer. Installing a steam dryer requires no changes in the boiler house, and the boiler does not need to produce more steam than before. The only drawback by installing a steam dryer is that it is not possible to produce as much electricity as it was before installing the steam dryer. This is because the steam dryer uses higher pressure steam as energy source, and it returns all the energy as useful 3.5 bar steam on the back side of the turbine. EnerDry has approached this electrical challenge by developing an economizer. By installing this economizer on a steam dryer, the temperature of the high pressure condensate will be reduced considerably. This will create less flash steam, and in the end the turbine will produce more electricity.

Figure 1 is an example of a 10,000 ton/day beet sugar factory. The factory uses app. 300 kWh/ton of beet. One third of the energy from the fuel goes to the steam dryer and the remaining 2/3 goes to the boilers. In this example the factory uses 8 MWe which is all produced by the turbine.

The steam dryer is integrated the following way: High pressure steam is used as energy source for the steam dryer. This steam is condensed in the super heater. This condensate is subsequently flashed, producing 10.812 kg/h of flash steam. The remaining condensate is pumped back to the boiler. The water that was in the beet pulp is turned into useful steam by the steam dryer. This steam goes to a parallel first step evaporator. After installing the steam dryer in figure 2, the factory's total energy consumption increased from 8.0 MWe to 8.6 MWe. This is because the steam dryer uses more electrical energy than the drum dryer (+0.6 MWe) - the factory is short of 3,9 MWe. This means that electricity must be purchased from the local grid. To buy from the grid has a cost, but it should not be forgotten, that for each MWh bought power there will be saved about 1.3 MWh fuel, which in this case is app. 5 MW fuel saved in the boilers. So by installing the steam dryer the energy saving will be 40 MW fuel from the drum dryer plus 5 MW from the boilers. Therefore the 3.9 MWe purchase must be compared with 45 MW of fuel saving.

The system according to figure 2 saves all the energy otherwise used by the drum drier. This has reduced the factory total energy consumption by 1/3. The boiler uses a little less energy than before.

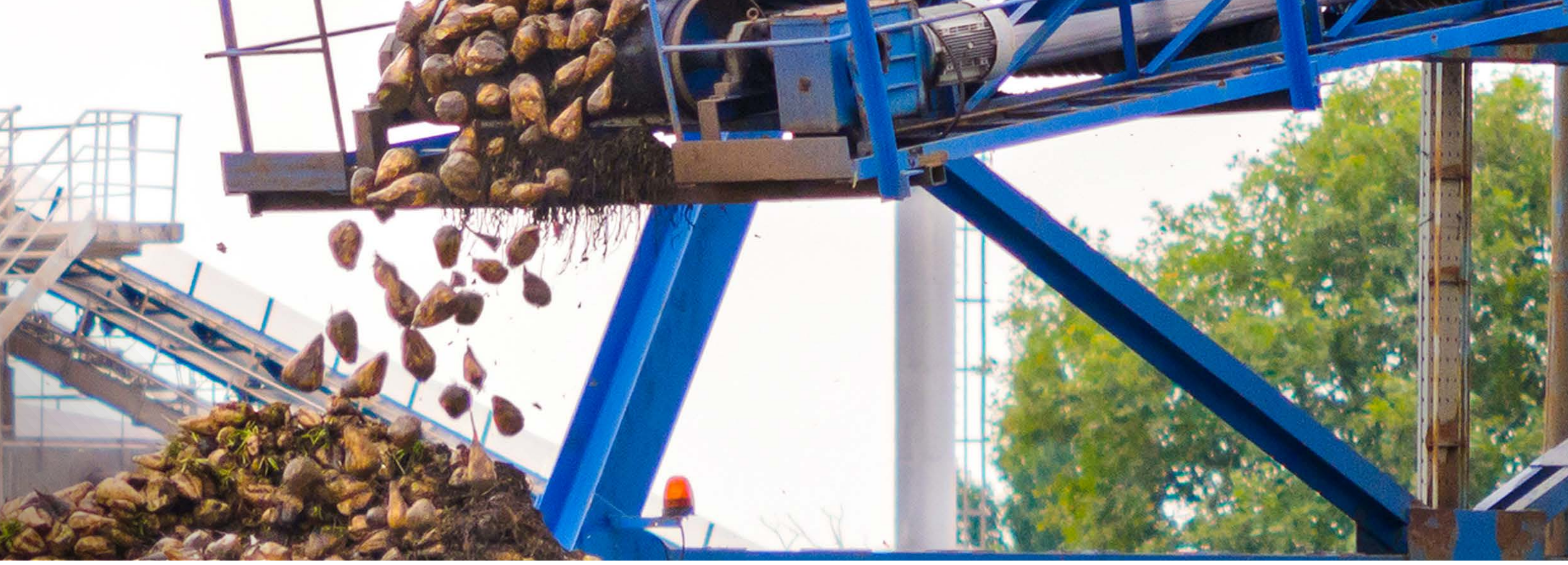


Figure 1. A 10,000 ton/day beet sugar factory with drum drying of beet pulp.

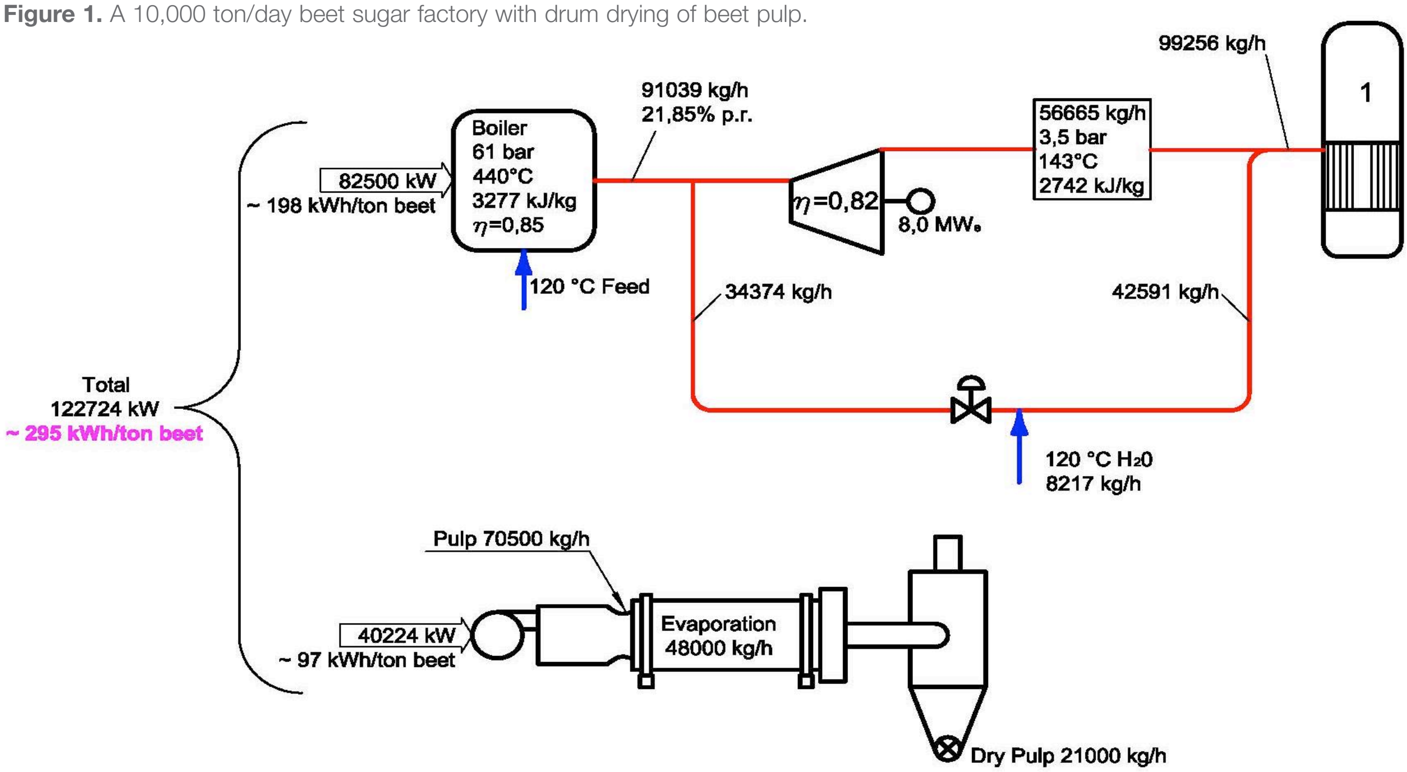
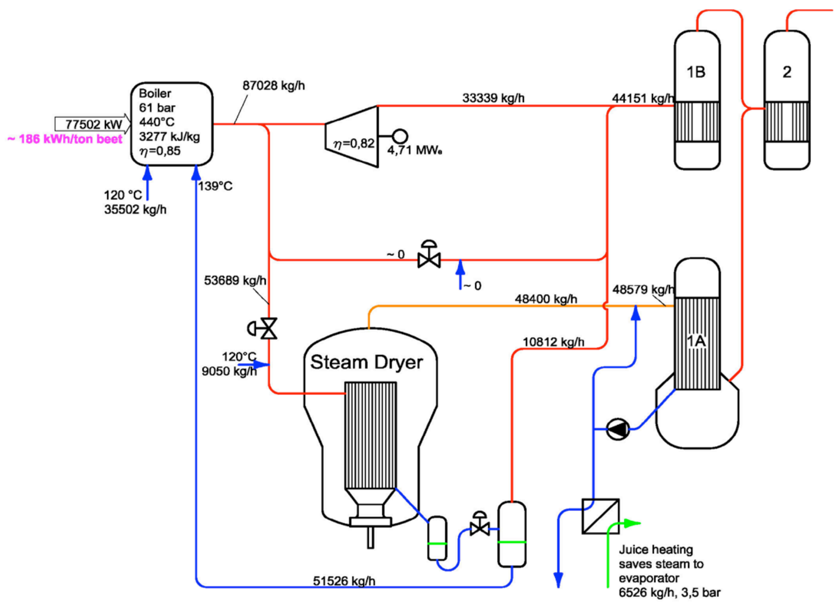


Figure 2. A 10,000 ton/day beet sugar factory with steam drying of beet pulp.



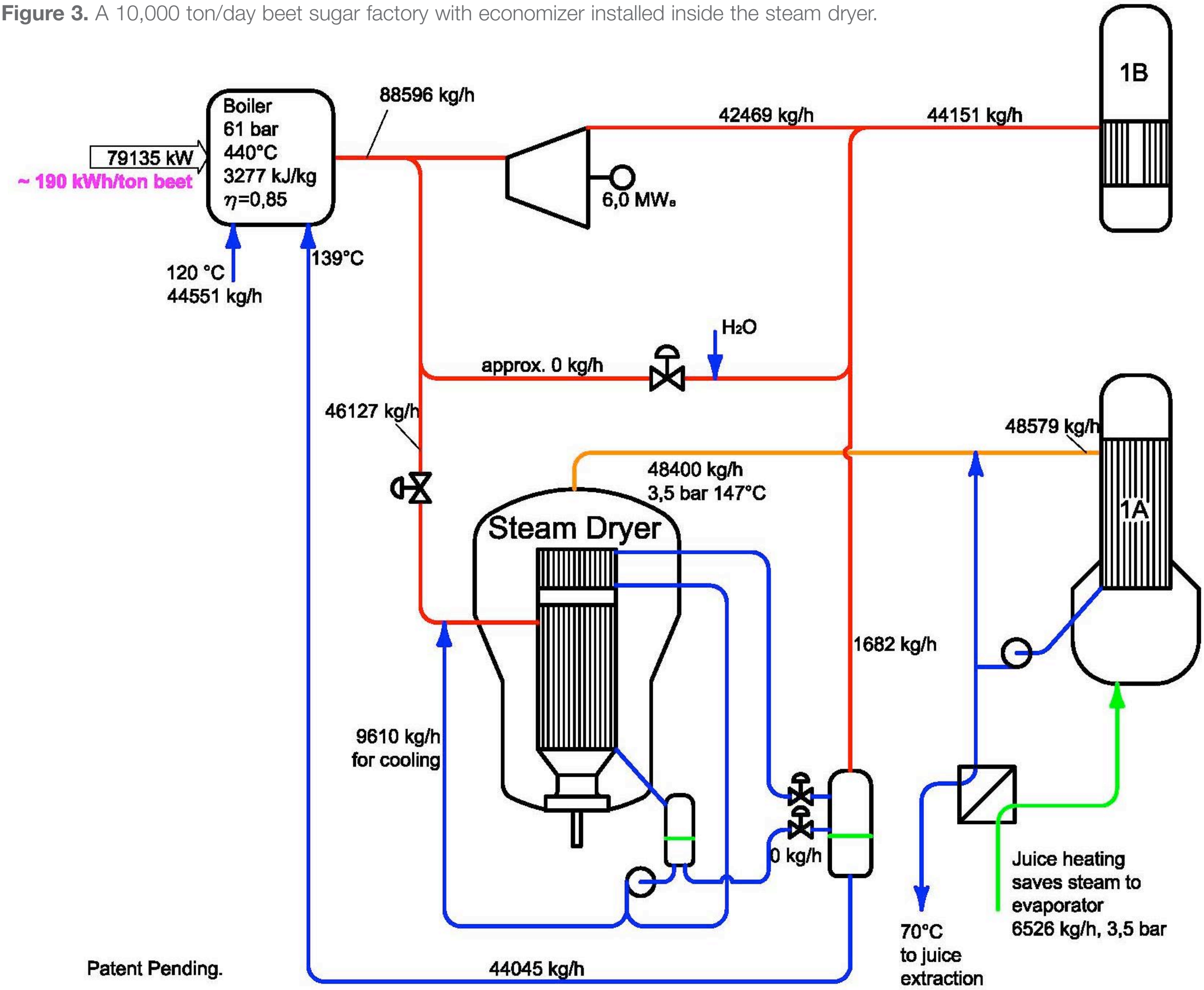
This is due to the following:

1. The energy in the 50°C pressed pulp is used in the steam dryer and "lifted" to the 3.5 bar steam level.
2. The electrical energy used on the main fan of the steam dryer becomes heat in the steam dryer and made usable.
3. The turbine is producing less electricity.

Figure 3. A 10,000 ton/day beet sugar factory with economizer installed inside the steam dryer.

In figure 3, the patented economizer has been installed at the same factory. The hot, high pressure condensate coming from the steam dryer super heater, is pumped into a heat exchanger (the economizer), placed on top of the super heater. By doing this, the condensate is cooled down, by the circulating steam inside the steam dryer. After being cooled the condensate is flashed, but since it is colder than before the amount of flash steam is reduced to 1.682 kg/h. With less flash steam, more

Figure 3. A 10,000 ton/day beet sugar factory with economizer installed inside the steam dryer.



steam is forced through the turbine, and the electrical production is increased to 6.0 MWe. The use of the heat from the condensate will also reduce the need for supply steam to the dryer as can be seen in the figure. By installing the economizer the purchase of electrical energy is reduced by 1.3 MWe to 2.6 MWe.

The savings in this case are 40.2 MW before used by the drum dryer plus 3.4 MW saved in the boiler house, but 2.6 MWe must be bought from the public grid, which is close to 6% of the fuel saving.

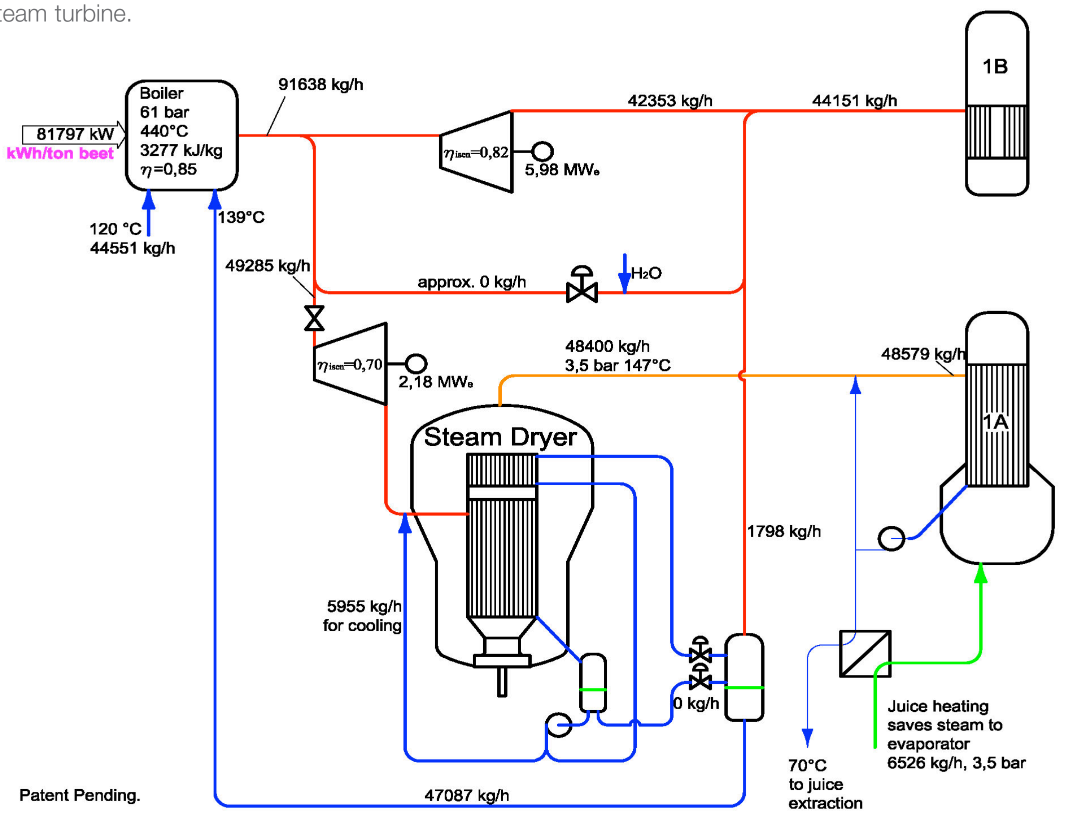
The economizer can also be retrofitted on existing steam dryers, but of course detailed energy balances must be made for each specific project.

In figure 4, in addition to the steam dryer with economizer, a turbine supplied with superheated steam at 60 bar is installed. This turbine produces electricity from the steam going to the steam dryer. By doing this, the factory will, with the two turbines produce about 8.2 MWe. By installing the second turbine, the power production has been optimized. It can also be seen that the boiler uses more fuel, this is due to a higher electrical power production. The business case for installing a steam dryer is very much dependent on the local energy prices for a given factory. At high electricity prices, the installation of economizer will be fairly cost effective. Besides the big saving from reduced energy consumption, there is another benefit from installing EnerDry's steam dryer - pulp dry matter loss is checked. As can be seen in the example in figure 1, drum dryer produces a loss of 1.5 ton beet pulp dry matter/ hour. That is (70.5 - 48 = 22.5 t/h,) only 21 t/h comes out, the rest is lost in the drum. This is largely due to combustion of some of the beet pulp in the drum dryer where high temperature features. If the factory in this example has a 120 day campaign, there will be by installing a steam dryer, (1.5 ton/h x 24 hours x 120 days/campaign) 4320 tons extra dried beet pulp to sell per campaign.

Energy flow

Another way of looking at the factory energy flow is by an arrow diagram, where the width of the arrow represents the amount of energy. Figures 5, 6 and 7 shows the same 3 cases noted in figures 1, 2, and 3. In figure 5 it can be seen how the energy going to the drum dryer is used (and lost). It can also be seen how energy consumption is divided between the different

Figure 4. A 10,000 ton/day beet sugar factory with steam dryer economizer and a 60 to 27 bar steam turbine.



end-users. Since the evaporators pass on the energy, they account for a relative small amount of energy consumption.

In figure 6, the steam dryer is implemented, just as in figure 2. Relatively large amount of energy goes to the steam dryer, but it is all given back to the evaporators. The reason that more energy comes from the steam dryer, is due to electrical power used in the main fan becomes heat in the steam dryer and the energy in the pressed pulp is "lifted" up to the 3.5 bar level. 3.9 MWe is purchased from the public grid.

Figure 5. A sugar factory with drum drying of beet pulp.

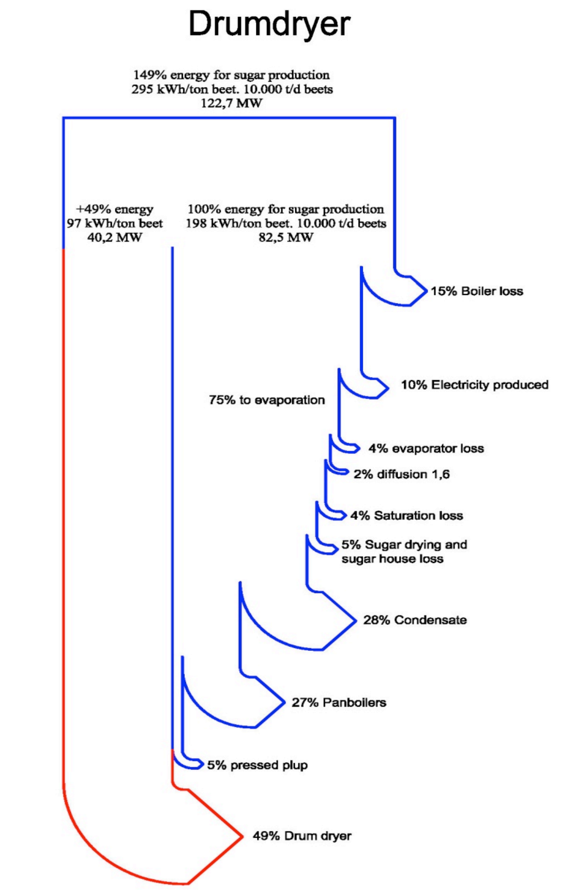


Figure 6. A sugar factory with steam drying

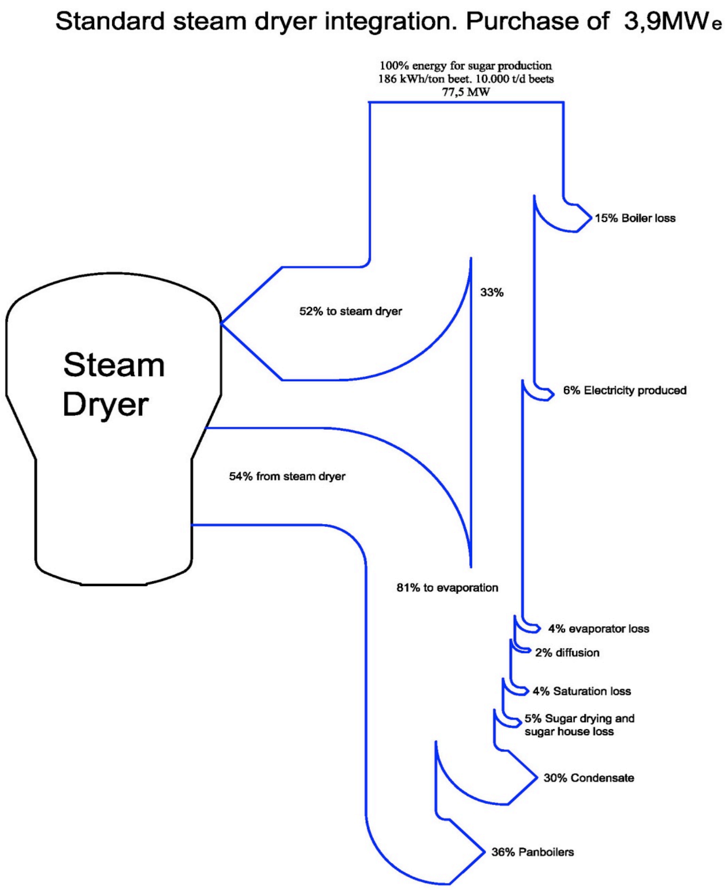
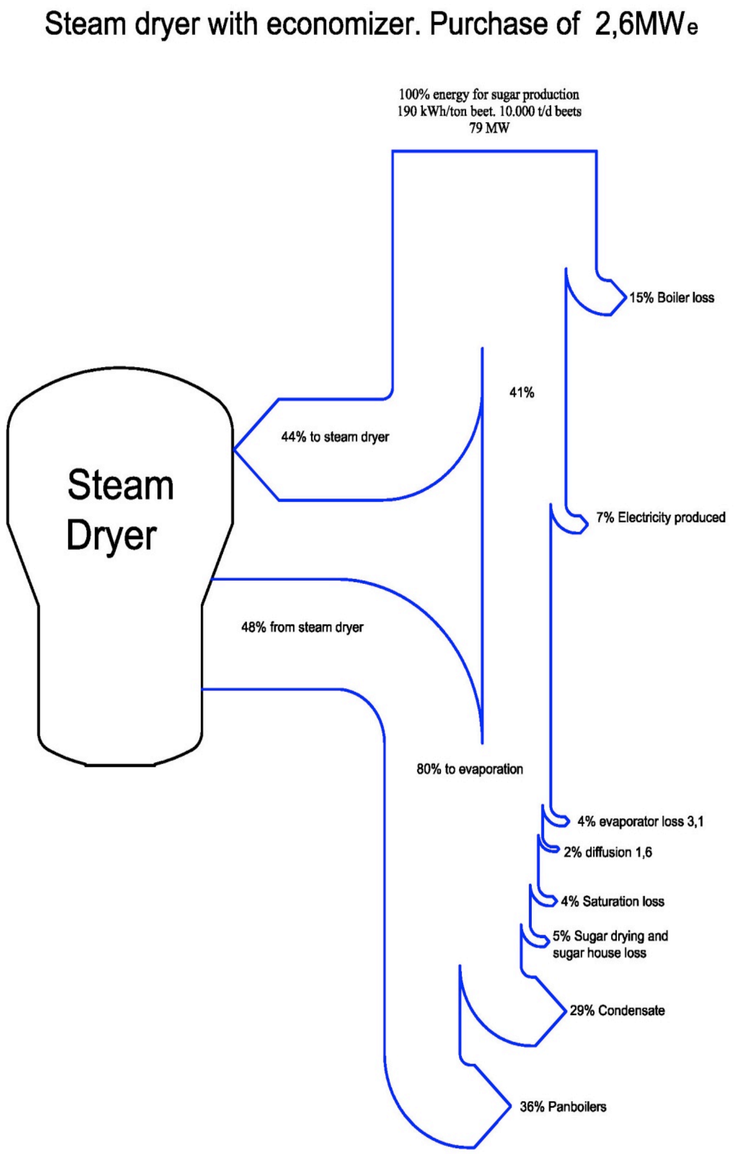


Figure 7. A sugar factory with steam dryer equipped with economizer



In figure 7 the steam dryer has been equipped with an economizer. It can be seen that the power production goes up, due to more steam through the turbine. This means only 2.6 MWe needs to be purchased.

Latest installations

Since 1990 when the first steam dryer was sold outside of Denmark, steam dryers have been installed around the world.

Table 1. Installation of EnerDry's steam dryers in sugar factories

Country	Company	Factory	Dryer size	Evaporation	Start-up
Serbia	Sunoko	Pecinci	H	50 t/h	2013
Denmark	Nordic Sugar	Nakskov	J	71 t/h	2013
Japan	Nitten	Memuro	2 x F+	2 x 30 t/h	2014
France	Lesaffre Fréres	Nangis	G	35 t/h	2015
Russia	Agrosnabsahar	Yelets	H	50 t/h	2016

Today the total installed capacity for the steam dryers has passed the 1000 t/h water evaporation. 27 steam dryers have been installed. During the last couple of years, the EnerDry's steam dryers have been or scheduled to be installed in beet sugar factories in Europe and Japan (table 2).

Case studies of steam dryer installations at three beet sugar factories

Installations of steam dryer at Pecinci (figure 8), Nakskov (figure 10) and Memuro (figure 13) are described and discussed briefly. This will illustrate 3 different ways in which steam drying has been chosen to fit into the steam system of the existing factories.

Figure 8. the Pecinci steam dryer
Factory: Pecinci
Capacity: 8500 ton/day
Dried pulp: 34.000 ton/y
Boiler pressure: 40 bar

In figure 9 it can be seen how the steam dryer was integrated in the sugar factory. To maximize the power production a 40 bar to 20 bar steam turbine was installed. This turbine makes approximately 1.2 MWe. The dryer only requires 20 bar steam supply, because the evaporation demand is approximately 40 t/h. In case the factory needs to expand capacity, the supply pressure can be increased to 28 bar, and the dryer will be able to evaporate 50 t/h.

Figure 10 shows the installed Nakskov steam dryer. (The black pipe hanging from the walkway around the dryer at the sight glasses, has nothing with the dryer per se. It is a CO2 pipe from the lime kiln going to the factory.) The whole project was supplied as a turnkey. This means that EnerDry delivered the complete dryer and building, with everything inside of it. Since the order came late it was necessary to preassemble as much as possible in the workshop, while civil works was done at the same time on the site. Figure

11 shows the delivery of one of the big components arriving at the factory. It is the bottom part of the steam dryer, weighing about 115 tons.

Figure 10. The Nakskov steam dryer
Factory: Nakskov
Capacity: 13.800 ton/day
Dried pulp: 69.000 ton/y
Boiler pressure: 60/40 bar

Figure 11. Delivery of components to Nakskov sugar factory

Figure 9. Steam dryer integration on the Pecinci factory

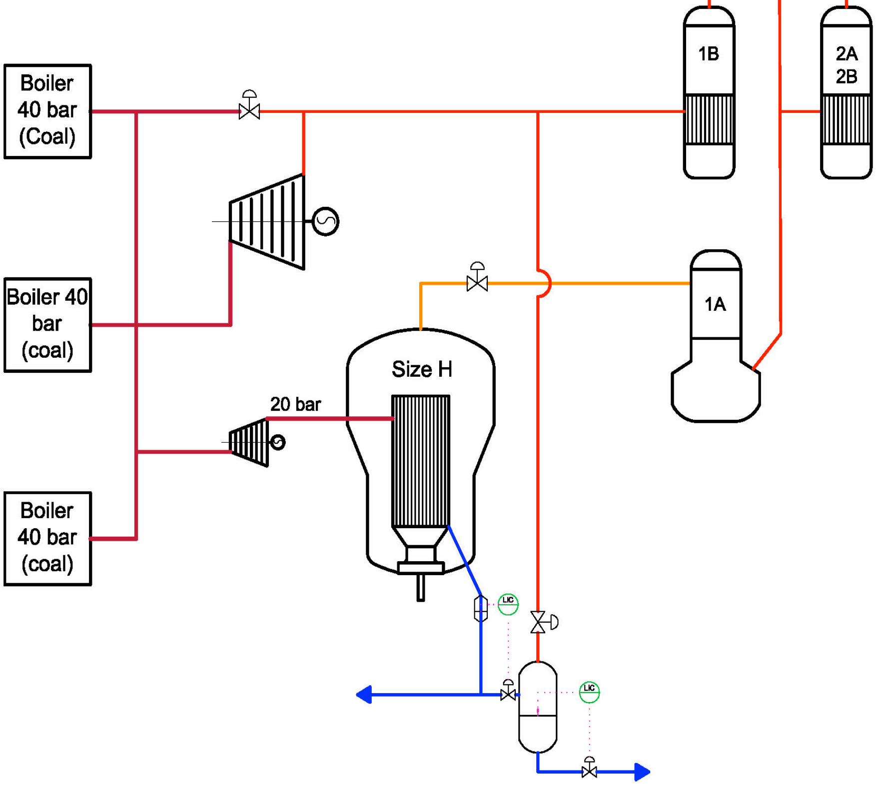
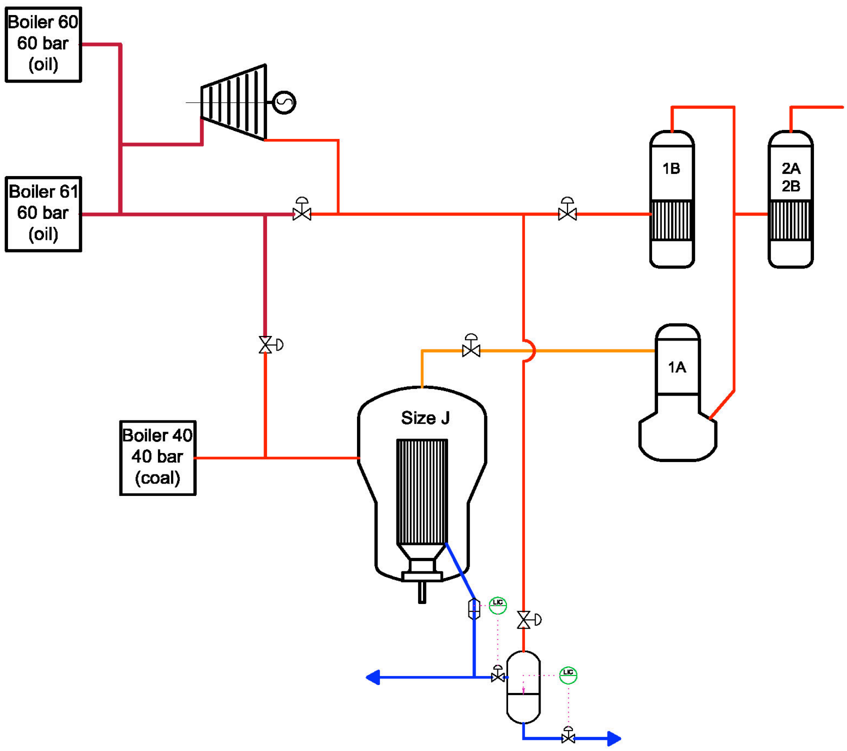


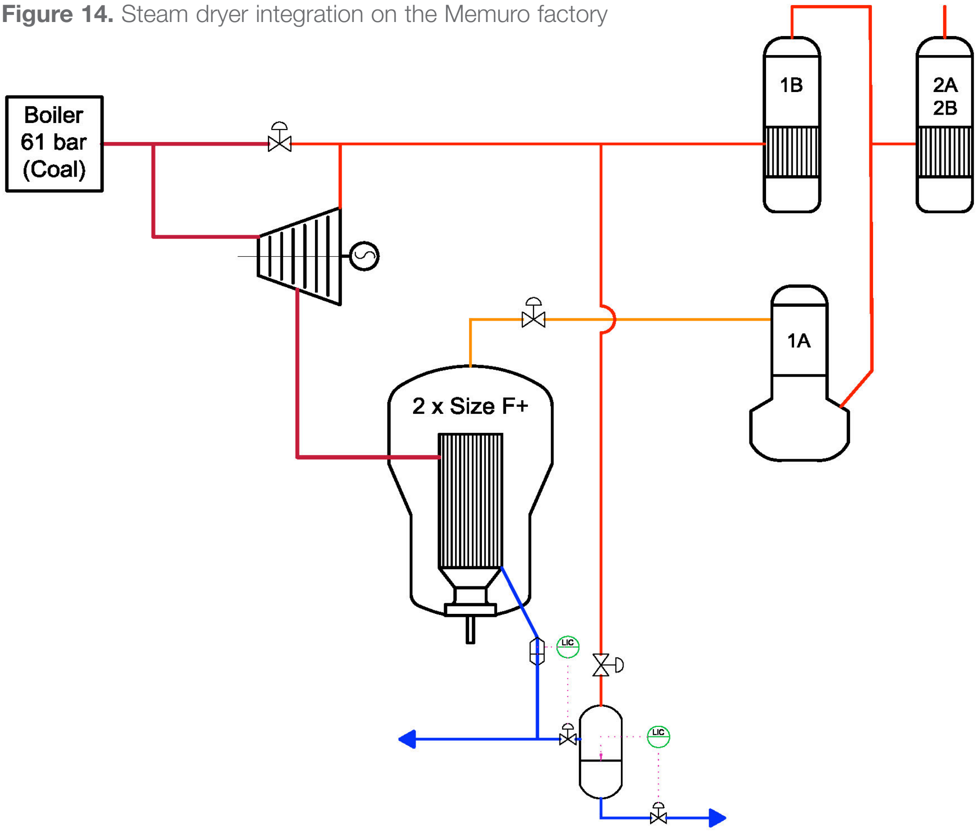
Figure 12. Steam dryer integration on the Nakskov factory



In the Nakskov factory there are two high pressure systems, as seen in figure 12; a 60 bar system and a 40 bar system. Before the steam dryer was installed, there was a 60 to 3 bar turbine and a 40 to 3 bar turbine. It was decided to remove the 40 to 3 bar turbine, and then take the steam to the steam dryer from this system. The 40 bar boiler is a coal boiler and the two 60 bar boilers are heavy oil fired boilers. Unfortunately the 40 bar boiler does not have enough capacity to supply the steam dryer, so some steam is taken from the 60 bar system. Installing the steam dryer has led to a reduced power production, but after calculating the economics, it was found that compared to the fuel saved on the existing drum dryers (coal fired) the extra costs for purchasing electricity was relatively small. Before installing the steam dryer the factory was producing all electrical power needed, but after installing the steam dryer, purchase of some 6.6 MWe was required. Since electrical power is purchased and it goes into the energy system, the oil boilers are less loaded, this has reduced the oil consumption correspondingly by 0.62 ton oil pr. Hour. The dryer

Figure 13. The Memuro steam dryers during erection.
Factory: Memuro   Capacity: 8.500 ton/day   Dried pulp: 54.000 ton/y

Figure 14. Steam dryer integration on the Memuro factory



has a guaranteed capacity of 71 t/h water evaporation, which has been proved. Normally it is operating close up to this capacity.

The Memuro factory has one coal fired boiler operating at 61 bar (figure 14). The steam produced goes into a turbine with an outtake for the steam dryers. By using such a turbine, the electrical power production is optimized. This is because the steam, which goes to the steam dryer, produces electricity from 61 bar to 27 bar before going to the steam dryer. The steam going to evaporator 1B will produce electricity from 61 bar to 3.8 bar. The factory had already prepared for the steam dryer by installing this new boiler and turbine some years ahead of the steam dryer installation.

Conclusions:

- The first step for saving energy in a beet sugar factory that has drum dryers is to introduce a steam dryer. This will reduce the energy consumption by 1/3
- Steamdrying of the pulp is necessary if a sugar factory wish to use less than 220 kWh/ton beet including drying of the pulp.
- Steamdrying of the pulp will not affect the boiler house; the need for steam might even go slightly down.
- Power production will be affected negatively by steam drying of pulp, but the new economizer in the steam drier improves the power production.
- Compared with drum dryer, an installation of EnerDry's steam dryer results in checking combustion, and thereby preventing loss, of up beet pulp dry matter. This will increase the pellet production of usually 5-7% but sometimes higher
- How much electric power a sugar factory needs to buy when steam drying of the pulp is installed varies from case to case. It can be from 0% to 9% of the energy saved as fuel.

**This is the amended version of the paper presented at the 2015 American Society of Sugar Beet Technologists conference in Clearwater Beach Florida*