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The Development of Large Pressurized Fluid Bed Steam Dryers from Fundamental Research to Industrial Plants

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Large industrial drying of particulate material (water evaporation 5 to 100 t/h) in air causes air pollution, and uses large energy supply. If the drying instead takes place in a closed system, under pressure in its own vapor, it will be possible to recover nearly 100% of the supplied energy as the energy leaves the dryer as a steam, which can be used as process steam for other purposes or be recompressed and used as an energy source for the same dryer. This will make it a heat pump dryer. Using the steam from the dryer means that air pollution with dust and volatile organic components (VOCs) will be fully avoided. That was the vision for the development over seven years starting with fundamental research followed by a pilot plant and a prototype. The ambitious goal has been reached. Thirty dryers have been built or are under construction. One dryer is currently evaporating 70 ton/h water saves 200 tons coal per day and does the drying without air pollution.

Keywords CO₂ reduction; Drying in steam; Large industrial drying; No air pollution; Pressurized drying

INTRODUCTION

By producing sugar form sugar beets, the beets are cut into thin strips called cossettes from which the sugar is extracted. The almost sugar free cossettes are pressed in screw presses to a pulp with about 28% dry substance, which then either (1) can be used as cattle feed within 24 hours, (2) can be stored free from air as ensilage, or (3) can be dried to a high-value cattle feed with 10% moisture and pressed to pellets that are easy to transport, store, and used by the farmers. The pellets have a price that follows the price of wheat or higher. An average size sugar factory has about 100 t/h pulp with 28% DS. Some factories must dry all pulp, and others only a part of the pulp.

The traditional way to dry the pulp is in rotating drums (Fig. 1). In front of the drum, there is a furnace where gas, or another fuel, is burned. The hot exhaust gas is introduced into the rotating drum together with the material to be dried. At the other end of the drum, the dried material is separated from the now cooled gas. This gas contains the main part of the used energy in the form of vapor mixed with air, dust, and volatile organic components (VOCs). Only a part of the energy can be recovered, and that at a low temperature, so it does not pay. Drum-drying creates a heavy pollution of dust and VOCs, and gives off a bad smell 20 km away.

THE VISION

The dream and the vision was that the drying could be done in a closed vessel under pressure, as in Fig. 2. This would have big advantages. The material should be fed continuously into the vessel, and heat shall be added. The dried material shall be taken out, and the water that was in the material can be tapped from the vessel as a steam with the pressure that has been chosen to have in the vessel. A sugar factory needs large quantities of 3.5 bar steam, so using this steam from the pressure vessel can lead to near 100% recovery of the used energy, and all air pollution is avoided. The big question was to find out what should be inside the pressure vessel in order to make this to function in a large scale. That vision was the background for the development.

THE DEVELOPMENT

It started with fundamental research in the lab. It was necessary to study the following:

- Pressurized steam influence on the product
- Drying time
- How to transfer the heat to the product
- How to get product in and out

Lab models were built to examine what happened to the product in steam under pressure during the drying process. In a small chamber under 3-4 bar pressure, superheated steam could be sent through pulp during batch drying. It was difficult to do the batch drying in small scale due to condensation, when the batch was put in or taken out; but the test showed the first important thing: due to the Maillard reaction, the material starts to take color after only 5 min at the desired pressure, so the first conclusion
was that the drying should be so fast that the material is out before 5 min has gone by.

The heat could be transferred to the pulp particles either by blowing superheated steam down through a fixed bed of pulp particles, or up through the particles and form a fluid bed. Due to the Maillard reaction, the fixed bed could not be used, as the drying time is too long. The need for a quick drying made it necessary to go for a fluid bed.

In a fluid bed, the energy for the evaporation of water from the pulp is transferred to the product partly by the fluidizing medium—the superheated steam—and partly from the heating surfaces, which can be inserted into the fluid bed.

Beet pulp particles are far from uniform and are uneven in size, and therefore not straightforward to fluidize. All known information about traditional fluid beds could not be used. The fluidizing process was therefore studied in different forms of fluid beds with jet effect and variation in percentage of open area in the distribution plate. Air was used as fluidization medium in those many different test units. In those fluid bed models, there could also be inserted dummies for contact heating surfaces in the form of tubes or plates in order to find out how many m² heating area there could be placed in one m³ fluid bed without plugging the fluid bed.

The next step was to make a fluid bed with steam with approx. 0.5 m² distributor plate (Fig. 3). Steam was supplied from a 4 bar boiler blown up through the fluid bed with a controlled flow and temperature. The pressure in the bed could be controlled as well. The steam went only once through the fluid bed drier, and after a cyclone it was vented to the free, so it was a highly energy-consuming test dryer, but it could give data to be used for the next step. Hereunder data for how much heat it would be possible to transfer through the inserted heating surfaces. This information, combined with the information about how much area it would be possible to build in a fluid bed, which is sized for max 5 min retention times, made it possible to calculate how much heat, it would be possible to transfer through contact heating surfaces. As that was only approx. 10% of the needed heat, the 90% has to be transferred from the fluidization medium—the superheated steam. With practical possible f. ex. 210°C at 3.5 bar (corresponding 139°C sat.) steam, the flow through the fluid bed can be calculated, and the conclusion was that the drier must have huge internal circulation of steam that must be cleaned from dust and reheated inside the pressure system included the dryer.

THE PILOT PLANT

After 2 years with lab tests, it was time to build a pilot plant, which is seen under construction in Fig. 4. This was built according to the diagram shown in Fig. 5.

The drier is seen to the left in Fig. 5, with a rotary valve to bring the pulp particles into the pressurized dryer. They
also passes out through a rotary valve. The drier was approx. 7 m high, and the evaporation capacity was around 1 t/h water evaporation. The circulated steam leaving the drier first passes a cyclone for dry dust separation and then a scrubber, so the steam is rather clean before it is reheated in a shell and tube heater and then by a fan returned to the drier. The excess heat leaves the system through the heat exchanger under the scrubber in the form of clean steam.

A lot of data were collected from installation, and work was done to develop a good dust separation inside the top of the dryer. After that, the dryer could be simplified to what is shown in Fig. 6.

With the internal dust separation, as shown in Fig. 6, it was possible to omit the dry and the wet dust separation. After collecting further data, it was possible to design the prototype. The fan should be built into the bottom of the dryer and the heat exchanger in the center; thereby the large external piping could be avoided, and a feasible large scale drier was possible. As shown in Fig. 7, the large heat exchanger is lowered through the top of the prototype drier. The size is illustrated by the man on the top guiding the heater down.

Due to the product quality, it was important to get the retention time down. It was a positive discovery to find that the needed retention time for drying in steam under pressure could be brought down below 5 min with a Δt of only 40–70°C due to the higher density of the steam under pressure. The retention time was measured in full-scale plants by chock dosing 10 kg pulp mixed with a Li salt; samples of product leaving the dryer were taken every 20 s and were analyzed for Li-content. The result is seen in Fig. 8. It is interesting to do a parallel to drying in a drum drier for beet pulp. This will need be for 30–60 min and will have a Δt of 600–800°C in the beginning, decreasing to may be 20°C.

Drying in steam has the following advantages:

- Almost 100% energy saving is possible, and thereby large reduction of CO₂ emission
- No air pollution, no VOCs, and no dust
- No oxidation and no product loss
Drying under pressure has the following advantages:

- Short drying time
- Less power to circulate the superheated steam, as the volume of the steam is less
- Compact design

The disadvantages are as follows:

- The process to get the pulp in and out of the pressurized dryer requires special equipment.
- The higher temperature of the wet particles is not acceptable for some products.

The prototype dryer was able to work from the beginning, but not at the expected capacity of 6 t/h evaporation, and there were many stops due to plugging of the dryer, material sticking inside the dryer, etc. It took 3 years to get a good operation and up to 8 t/h water evaporation.

One of the things that took still many years to figure out was the method to bring the pulp into the 3 to 4 bar steam atmosphere, and to get it out again. Different technologies were examined and tested, but we chose the rotary valves.
of a design similar to that earlier used in the paper industry for feeding wood chips into the pressurized cooker. Concerning the feeding into the dryer, the problem was the heavy condensation of the pulp in the pockets. The wet pulp made it impossible to empty the pockets, and the remaining pulp in the pockets plugged the pressure release pipe, and the feeding stopped. The problem was solved by mixing a little air with the steam used for pressurizing the pockets, so the condensation was slowed down. The problem with the outlet rotary valve was wear. When the pockets, with a mixture of steam and dried particles, were released it created speed of sound, which caused the wear problems. This problem has been solved over many steps during the last 10 years.

After the invention was published, many visitors came to Stege in Denmark to see this installation, which led to the installation of a three times larger dryer (25 t/h evaporation) in Nangis, France. Later followed further development, and today 30 dryers are built or under construction in Western and Eastern Europe, USA, and Japan. The two largest dryers (Size J) are installed in Nakskov, Denmark, and in Idaho, USA. They can evaporate 71 t/h water. The one in Idaho saves 200 ton coal per day, and thereby approx. 600 ton/day CO₂ emission is avoided. The development is still ongoing today, whereby the liability has become near to perfect and the capacity is increased inside the same size of pressure vessel.

**HOW THE FINAL INDUSTRIAL DRIER WORKS**

The drying takes place in a fluidized bed driven by superheated steam blown up through the pulp. It is all included in a pressure vessel with, for instance, 4 bar also containing a dust separation, a heat exchanger, and a fan (see Fig. 9).

As shown in Fig. 9, the pulp is fed through the rotary valve (1) to the screw (2), which brings the pulp into the pressure vessel (3) filled with superheated steam. The only moving part in the dryer is the impeller (4), which circulates this steam up through the perforated curved bottom (5) into a low, ring-shaped fluid bed (6) where the pulp is kept "fluid" swirling around as the arrows show. Guiding plates (not shown) make the pulp move forward in the ring
around the heat exchanger (12). The lighter particles are blown up between the plates (7) radiating from the heat exchanger (12) outward toward the conical vessel wall without reaching this. Due to the reduced velocity, the particles fall onto the forward inclined plates, slide down on those, and pass the gap between the plates and the conical vessel wall. In this way, the lighter particles also pass forward around in the dryer, arrive to the discharge screw (8), and pass the rotary valve (9).

The circulating steam arrives into the upper part of the dryer, where dust is separated in the main cyclone (10). The dust passes by means of an ejector out through the pipe (11) and goes out with the dried product. The dust-free steam goes down inside tubes in the heat exchanger (12) where it is reheated, as steam is supplied through the pipe (13). The supply steam is condensed and leaves the dryer through the pipe (14).

By a higher supply steam pressure, a higher temperature of the circulating steam is achieved, and that will again increase the drying potential of the steam, when it is again blown up in the ring-shaped fluid bed (6) by the fan (4). Therefore the capacity of the dryer will increase with increased supply pressure. This is illustrated on the curves Fig. 10 for the evaporation capacity of the different sizes of driers.

The example of a balance, Fig. 11 shows a version of a dryer, where the hot condensate from the main heat exchanger is used to preheat the circulating steam in an extra heater placed above the main heater. That reduces the need for supply steam, and the amount of usable steam leaving the dryer is even slightly higher than the supply steam.

**HOW DOES THE STEAM DRYER FIT INTO THE SUGAR FACTORY?**

Figure 12 shows how the steam drying of pulp can fit into the steam system in a sugar factory. The dryer acts as a kind of evaporator placed in front of the juice evaporators. The steam leaving the dryer, which is the water evaporated out of the pulp, goes to the first step of the juice evaporator. Here the steam is used in a separate evaporator as the condensate cannot go back to the boilers, but it is good for, e.g., freshwater for juice extraction. The clean condensate from the heat exchanger in the dryer goes back to the boiler house.

**ENERGY SAVING BY INTEGRATION IN A SUGAR FACTORY**

A general rule is that steam drying will give a saving of 95% of that fuel, which is needed for the same drying in a drum drier. In fact it is theoretically possible to get more savings. See Figs. 13A and 13B, which are an example taken from a plant in the USA that produces sugar from 10,000 tons of beets per day.

Figure 13A is an example of energy flow through a sugar factory with power production and drum drying. The numbers and the width of the arrows show the energy flow in MW. The energy consumption in the factory is high, as is common in an American sugar factory. In America, there is a large need for energy because of frozen beets, and many factories have sugar extraction from the molasses, which also demands energy. The factory produces 9 MW power in this case (Fig. 13A) and consumes 8 MW, so 1 MW is sold. American factories often have a low steam pressure (15–28 bar).

Figure 13B shows how it will be with steam drying instead of drum drying. The evaporation stations receive the same flow of energy as before. The steam flow through the turbine is reduced, so power production has gone down by 3 MW. The savings are 52.3 MW as fuel to the boiler, and not only the 45 MW that the drum drier use, but a further 7.3 MW.

This further savings of 7.3 MW comes from three sources:

1. Less power production requires less fuel to the boiler house.
2. The power supplied to the fan in the drier is recovered in the steam leaving the steam drier in opposition to drum drying, where all energy supplied is lost.
3. The energy in the 50°C hot pulp supplied to the dryer is in the steam dryer lifted to a higher level, so it can be used in the first step of the evaporation.
FIG. 11. A balance for a dryer size H.

FIG. 12. Integration in a sugar factory.
ENVIRONMENT

The steam-drying of beet pulp takes place in a closed vessel. There is therefore no emission of dust and no direct primary emission of vapor from the drying. The steam leaving the dryer has a very small amount of dust, which can be found as suspended solids in the condensate formed by condensing the steam in the evaporator, where the energy is used. This is usually 2 ppm by weight, and never above 10 ppm. The non-condensable that leaves the evaporator is dust-free, as the mentioned small amount of solids will go into the liquid phase and go out with the condensate. There is therefore no dust emission at all.

There can be a secondary emission of VOCs and thereby smell if this is not taken care of. This was one of the subjects at the yearly steam dryer seminar in Copenhagen in 2005 held by EnerDry for its clients.

There are two ways that the vapor with VOCs can get escape:

1. Emission of non-condensable gasses from the evaporator, where the steam from the dryer is used
2. Waste steam from the rotary valves and conveyors

Most steam-dryer installations—especially earlier ones—had the non-condensable gasses from the steam-dryer steam going directly out from the evaporator, where the steam is condensed. This should never take place, both in order to recover the energy, but also in order to avoid the emission of VOCs evaporated from the pulp. The main component in the VOCs is acetic acid; there are also other organic acids and some CO. The acetic acids and the other VOCs are easily dissolvable in water and have a vapor pressure that decreases drastically, when the temperature

FIG. 13. (A) Energy flow in a sugar factory with 48 t/h evaporation from the beet pulp by drum drying. (B) Energy flow with steam drying of the beet pulp. Evaporation from the pulp is 48 t/h.
is brought down. Also, the vapor pressure is at all temperatures lower than for water. The solution to avoid emission of the VOCs is therefore to use the vent from the evaporator at a low temperature, whereby those organic components will end up in the condensate and not in the atmosphere. Alternatively the VOCs emission can be removed in a simple small scrubber with cold water. The amount of non-condensable gas from 50 t/h evaporation, when cooled to 20°C, is 100–200 m³/h and mainly consisting of N₂. This amount can be sent to the boiler in a 50 mm pipe and burned. If led to the atmosphere, the emission will be 25 g C/h, out of which the most is CO, which is negligible.

The waste steam from the rotary valves is condensed on the pressed beet pulp in the heating screw for beet pulp going to the dryer. Thereby the emission comes down to the level coming from any other pressed pulp conveyor.

The condensate arising from the dryer vapor can be used for juice extraction. But that does not change the fact that the factory will have more water going out, which could be condensate from the evaporators. If the steam dryer condensate goes directly to the factory waste water plant, it will increase the biological oxygen demand (BOD) load on the plant by about 2%.

**PRODUCT QUALITY**

By steam drying, there is no oxygen present, and therefore no burning of the product, in opposition to what happens in classic drum dryers. In Fig. 14, the product to the left is steam dried. The drum-dried product is seen to the right. It is visible that the drum dried product has burned edges, and some of the material is missing or has become free carbon, which cannot be digested. The loss can be 2–10%, depending of the temperature in the drum. The steam dried product is not burned at all. Therefore, the production of fodder is larger than by drum drying. It has taken a slight yellow color from beginning the Maillard reaction.

Under drying, the wet particles receive the temperature that corresponds to the saturation temperature at the pressure in the drying chamber. If the pressure is higher, the particles are exposed to a higher temperature. The higher the pressure is, the darker the product will be.

The treatment by the superheated steam improved the digestibility as fodder for cattle, as it is partly transformed into hemicellulose. Furthermore, the steam dried product is not contaminated by any pollution from flue gas from the furnace as by drum drying. This is especially severe if the furnace is coal fired.

**GREEN SUGAR PRODUCTION**

Steam drying of the beet pulp could be the first step toward a sugar factory operating on its own beet pulp, as illustrated in Fig. 15. Thereby the sugar factory operation will be CO₂ neutral like the cane sugar factories, and will be able to sell electric power.

The dried beet pulp has a lower heating value of 17,000 kJ per kg, similar to lignite. The pulp has less sand than lignite and less sulfur. The amount of K and Na salts is low, which gives less risk for scaling in the boiler. The amounts are low because they have just been „washed” by the sugar extraction.

The illustration in Fig. 15 is based on the following parameters:

- Factory size: 10,000 ton beets per day
- All pulp is burned in the boiler.
- Boilers produce 85 bar steam at 525°C.
- Boiler efficiency: 88%
- Isentropic efficiency of turbine: 85%

![Steam-dried beet pulp](image-url)
Efficiency of gear and generator: 95%
The condenser temperature is as high as 60°C.
Lower condenser temperature and a larger turbine could increase the power production.

PRODUCTS SUITABLE FOR DRYING IN STEAM UNDER PRESSURE

Drying in steam has the following advantages:
- Possibility of almost 100% energy savings, and thereby large reduction of CO₂ emission
- No air pollution, no VOCs, and no dust
- No oxidation and no product loss

Drying under pressure has the following advantages:
- Short drying time
- Less power needed to circulate the superheated steam, as the volume of the steam is less
- Compact design

The disadvantages are as follows:
- The process to get the pulp in and out of the pressurized dryer requires special equipment.
- The higher temperature of the wet particles is not acceptable for some products.

The technology was developed for drying of beet pulp to produce cattle feed. It is especially interesting for drying large bulk materials, when the alternative drying is very energy consuming and polluting. The interesting range is from 5–100 t/h water evaporation. One group of products is by-products from other production processes:
- Beet pulp
- Mash from beer brewing
- Distillers grain from ethanol production
- Solids after production of starch from wheat or corn
- Solids from fruit juice production

Another group of products suitable for steam drying are wet fuels:
- Wood chips
- Bark
- Sawdust
- Bagasse
- Brown coal

Wet fuels should always be dried before burning in the boilers. If burned wet, there will be used primary energy to evaporate the water from the fuel. The water vapor takes up a large volume in the combustion chamber and the gas cleaning system. The boiler capacity will go down, and it is not possible to get high temperature of the produced steam, whereby the potential for power production is reduced. By steam drying of the fuel, the energy for the dryer can be recovered. A power plant based on wet (50% moisture) wood chips can produce 15% more electricity out of the same fuel by steam drying the fuel before the combustion.

The steam dryer shown in Fig. 16 dries wood chips (forest waste, Fig. 17) in a plant for combined power production and district heating in Sweden. The dried wood...
chips go directly to combustion in boilers producing steam, which passes through turbines for power production. The exhaust steam from the turbines and the steam from the dryer are used for the district heating.

**DRYING OF WASTE WATER SLUDGE**

Sludge from a waste water plant in a starch factory was dried. Sludge cannot form a fluid bed; therefore it was necessary to back-mix dried product into the sludge coming from a press. The dried product was screened. The fine fraction was used for back-mixing. The largest particles were slightly milled and also mixed back into the fresh pressed sludge. Thereby wet granules were made to feed the dryer. The final product was evenly sized dried granules, as it was only the middle fraction from the screening see Fig. 18).

**STEAM COMPRESSION (HEAT PUMP DRYING)**

When the dryer is used in industries having a need for 3–4 bar steam, the dryer can easily be fit in, whereby full energy recovery can be obtained. In some cases there is no use for the steam leaving the dryer. The steam can then go to the atmosphere. Then there will only be an energy

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**FIG. 17.** Wood chips (forest waste).

**FIG. 18.** Sludge from waste water plant.

**FIG. 19.** Steam dryer combined with steam compression.

**FIG. 20.** The dryer size J under Construction in Nakskov, Denmark, February 2013.
saving of approx 20% compared to traditional drum drying. There will be almost no dust emission, but some odor from what might be evaporated out of the product. The advantages can not pay for the dryer, but it may be interesting to use steam compression.

The steam leaving the dryer is recompressed and used as energy supply for the dryer (Fig. 19). It might be necessary to use clean steam in the compressor. If so, the steam from the dryer can then be converted in a heat exchanger of a design like an evaporator, as used in many industries for concentration of juice, milk, etc. By this kind of heat pump drying, an energy savings of 80–85% of the energy needed for an alternative drying can be saved, but the remaining 15–20% must be supplied from a motor to drive the compressor. The mechanical (electrical) energy is in principle not lost, as the same amount of energy can be recovered from the hot condensate leaving the plant.

**ENERGY SAVINGS AND REDUCTION OF CO₂ EMISSION**

The largest driers so far built are two size J. One is installed in Nampa, Idaho, USA, and the same size drier began operation in Nakskov, Denmark, in 2013 (Figs. 20 and 21).

The steam dryer in Nampa replaced three old, coal-fired drum driers from the 1950s. Major maintenance and reduction of the environmental impact were necessary. To fulfil the demands from the environment authorities, it was decided to have the steam dryer installed, which at the same time could give a daily savings on 200 tons of coal

FIG. 21. The dryer in Nakskov, Denmark, in operation November 2013.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Comparison of three ways to reduce CO₂ emission showing the yearly reduction of the emission for each invested million €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nampa steam dryer</td>
<td>An ethanol factory on wheat</td>
</tr>
<tr>
<td>Coal not fired: 200 t/day</td>
<td>Production: 8000 hl/day = 210,000 gallon/day</td>
</tr>
<tr>
<td>Avoided CO₂ emission: 600 t/day</td>
<td>Avoided CO₂ emission: 1200 t/day</td>
</tr>
<tr>
<td>In 120 days per year</td>
<td>CO₂ emission from cultivation and transport: 250 t/day</td>
</tr>
<tr>
<td></td>
<td>CO₂ steam boilers (average 487–789): −600 t/day</td>
</tr>
<tr>
<td></td>
<td>Net CO₂ reduction: 350 t/day</td>
</tr>
<tr>
<td></td>
<td>In 340 days a year</td>
</tr>
<tr>
<td>72,000 tons CO₂ reduction per year</td>
<td>119,000 tons CO₂ reduction per year</td>
</tr>
<tr>
<td>No in-going product</td>
<td>2200 tons/day corn or wheat is used</td>
</tr>
<tr>
<td>Investment: 10.6 million €</td>
<td>700 tons/day DDGS is produced</td>
</tr>
<tr>
<td>6792 tons CO₂ yearly reduction per million € invested</td>
<td>Investment: 200 million €</td>
</tr>
<tr>
<td>595 tons CO₂ yearly reduction per million € invested</td>
<td></td>
</tr>
</tbody>
</table>
and an increased production of pellets, as there would no more be burned-away product. The project was an investment of $16.5 million (US). That covers all costs for the total project, including building, conveyors, piping, electrical installations, etc. The project was very well received by the public, as expressed through television and newspapers, due to the important and large reduction of the pollution of dust and smell, which would no longer be coming from the old drum dryers.

CO₂ REDUCTION

There are various technologies that reduce the CO₂ emissions. Here, three of them are compared:

1. The steam dryer in Nampa saves the combustion of coal by 200 tons per day. Thereby the emission of CO₂ is reduced by approx. 600 tons per day.
2. By using ethanol in cars instead of gasoline, the CO₂ emission is reduced, as the growing of the corn or the wheat will absorb CO₂. But there is spent fuel for the tractors in the fields and for transportation as well as fuel for the steam boilers in the ethanol plant, so the net saving of CO₂ emissions is limited (350 t CO₂/day).
3. Money can also be invested in windmills for power production. For €12 million, four large windmills can be installed with a capacity of 4 x 2.0 MW. They will, on average, over a year produce 23% of the installed capacity. The power production from the four windmills reduces the production of power from coal-fired power plants, and thereby reduces CO₂ emissions by 36 t/day for the 4 windmills.

Those three possibilities to reduce CO₂ emission are compared in Table 1, where the CO₂ reduction is related to the investment. This comparison is not for expressing anything negative to other initiatives for CO₂ reduction, but only for relating the CO₂ reduction to the investment.

CONCLUSION

The pressurized steam drying technology is mainly interesting when a larger quantity of water will be evaporated and/or a pollution problem will be solved. The technology was developed for drying of beet pulp and is also available for other products. The main advantages are as follows:

- Possibility of more than 95% energy savings
- No air pollution with dust or VOCs
- Up to 80 t/h evaporation in one dryer
- More reduction of CO₂ for the money than most other investments
- No oxidation of the product
- Compact installation

ACKNOWLEDGMENTS

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