Arne Sloth JENSEN.

The Innovative Separation of Water from Beet Pulp – Steamdrying.
Development by rebuilding old dryers.

Introduction:
Sugar technology has a long history of development that continues today and will continue into the future as we strive to be competitive against new challenges. It is amazing how much change has occurred. It is hard to believe we are the same industry when we look at figure 1.

As you can see, the juice had to be concentrated just like today, but it took place in direct fired pans, where the primary energy from burning bagasse or wood was used once and only once. There was no capture of the vapour being generated as the need was to just concentrate the juice. Today, you would never think of concentrating the juice in anything but a multiple stage evaporator. The energy waste in a single concentrating evaporator could not be tolerated. Further, to improve energy utilization in the evaporators the high pressure steam would have produced electrical power before being used at the evaporators. Direct steam from the boiler house would not supply steam for pan boiling and juice heating, this would only come from the evaporator station after multiple kg of water had already been removed from the juice with that single kg of steam from the boiler. Reduction of energy and effective operation is natural - But what are we doing when we dry our beet-pulp in a conventional drum dryer? We are spending our fuel on evaporating water in one step. We make no electrical power, and the vapour is of no practical use. Instead this vapour is pollution, and the process burns between 3 and 15% of our product. We can reduce much of the air pollution by scrubbing, but you will still have smell, and the scrubber has only moved the air pollution to the water. This water will require treatment. Both processes use additional energy to move the pollution. Is it really amazing how far we have come in energy conservation? - Yes because steam drying the pulp solves those energy and pollution problems. It conservatively saves 90% of the fuel you need for drum-drying.

The drying of pulp is a separation of water from the fibers. The traditional drying is:

\[ \text{Wet pulp} + \text{a lot of energy} \rightarrow \text{Dry pulp} + \text{Vapour} \]  \hspace{1cm} (A)

Why not

\[ \text{Wet pulp} + \text{a little energy} \rightarrow \text{Dry pulp} + \text{Water} \]  \hspace{1cm} (B)
The process B is to prefer, and that is what is done in the first stage by pressing the pulp. A lot of studies have been done in order to improve the pressing technology. 50 % DS is by special means possible. But in practical use is only 26 – 32 % possible by presses with slow rotating spindles. Having in mind that the final result should be dried pulp and water it would be fine if the vapour could be turned into heat at a high exergy level. The classical drum drying does not respond to that as the vapour – mixed with air and dust – can only be condensed at a temperature level of no value in a sugar factory. But if you could dry in steam without air at a pressure that fits for recovery in a sugar factory you can indirectly come to the formula B. You will use a lot of energy, but that will all be possible to recover by condensing the steam leaving the dryer, and the water from the pulp will come out as condensate.

The development by Danisco
The development of the technology took place in the eighties at Danisco in Denmark. The development is described in earlier papers by Arne Sloth Jensen as well as recently in the International Sugar Industry, February 2003 issue. The prototype was build at Stege Sugar factory. The first dryer was sold by Danisco and installed in France. In the summer of 1990 the technology was transferred from Danisco to Niro A/S along with Arne Sloth Jensen. In the following years, further seven different factories in Europe installed steam dryers supplied by NIRO. In 1997 Niro decided to stop investing and developing steam drying. Arne Sloth Jensen left Niro and later founded the company EnerDry.

The development by EnerDry
In 1997 the steam dryers that attempted to operate at loads higher then 2/3 of the maximum design still encountered problems. They could not reach the rated capacity, and the operation was not steady. The availability of the steam dryer was far too low. In most cases the availability was between 80 and 90%. Coupled with factories desiring higher capacities the steam dryer needed improvements or a good concept might be lost. That task was taken up by EnerDry in close cooperation with owners of existing steamdryers.

One problem was that a highly loaded fluid bed would lose fluidization and plug randomly and the job to clean it up took several hours. It was necessary to improve the fluidization. The perforated bottom support plates for fluidization were rebuilt in several steps from 1998 to 2001 on dryers in France, Spain and Holland. This new perforated bottom design is curved. The distribution of the holes in the perforated plates was changed and some jet effect was added.

Figure 2. The steam dryer in Cagny, France. It has been rebuilt by EnerDry.

In many cases the dryer has become too small for the increased capacity required by the factories. Those factories asked EnerDry to develop dryers with a larger water evaporation capacity. Only EnerDry had the know how and the necessary patented technology.
A larger capacity was only possible by circulating a larger steam flow in the dryer. That could not work with the old design as too much wet dust would fly into the cyclone at the top of the dryer. A new design was therefore necessary. The first version was installed at Nangis factory in France in 1999. It has been further optimised in the years thereafter. The concept was to make a pre-separation of the dust along with a post-drying in the top of the dryer, outside the main cyclone. This was accomplished by letting the steam circulate outside the main cyclone before it could pass into this cyclone mainly over the last part of the cyclone, and only at the top of this. The risk of this design could be accumulation of pulp in the bottom for the cyclone, but that has never taken place.

Figure 3. The new dust separation in the top of the dryer.

The fluid bed should also be more robust, so it can handle the larger amount of pulp. That need was already covered by the development and installation in Cagny, France.

The larger circulation of steam needed for these improved evaporative capacities then demanded a larger fan and motor. The new design obtained up to 25% more capacity.

Also the dividing of the fluid bed in high vertical cells is a hindrance for the increased capacity. The division in high vertical cells was the main claim in the patent for the Danisco/Niro/BMA dryer. Thereby a new dryer, not divided in cells, was created and is patented or patent pending world wide.

**Actual results.**
The largest and latest rebuilt dryer was the size 10 dryer at the Suiker Unie factory in Puttershoek in Holland. The internals in the dryer were replaced. The outer pressure vessel, and the large heat exchanger in the centre of the dryer was still the same. The main fan and the drive was replaced by a larger. It would have been a process advantage to put in a new heat exchanger. However, this was not justifiable based on the installation cost and expected economic gain.

**Comparison of the Puttershoek steam dryer before and after the rebuilt**

<table>
<thead>
<tr>
<th>Steam dryer description</th>
<th>Input</th>
<th>Output</th>
<th>Evaporation rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old style dryer</td>
<td>54 tons per hour of pulp with 29 % DS.</td>
<td>17.4 tons of dried pulp per hour.</td>
<td>36.6 tons per hour of water evaporation.</td>
</tr>
<tr>
<td>New Steam dryer rebuilt by EnerDry</td>
<td>68 tons per hour of pulp at 29 % DS.</td>
<td>22 tons of dried pulp per hour.</td>
<td>46 tons per hour of water evaporation.</td>
</tr>
</tbody>
</table>

The supply steam was only 22.5 bar g. At a higher pressure the capacity would be higher.

Five of the eight sugar factories in Europe having the Niro steam dryer have had their dryers rebuilt by EnerDry.
Figure 4. Capacity curves for the steam dryer in Puttershoek and the new EnerDry dryer size H.

The new dryer from EnerDry.

Figure 5. The dryer from different angles.
The new dryer from EnerDry is more compact and has a higher capacity. Therefore it can be offered at a better price especially when compared on cost per ton of evaporation.

Figure 6 shows a balance for a size H dryer with its guaranteed capacity. With the latest results from the steam dryer in Puttershoek, Holland, an additional 10% higher capacity is expected or over 55 ton evaporation per hour. That is enough for drying all the pulp from a 10 000 t/day factory when the pulp is pressed to 28 % DS.

**Rotary valves.**
Another development has occurred. The rotary valves used for getting the pulp in and out of the pressurized vessel have been improved over the last 6 years by implementing a new design by EnerDry. The availability has improved and the lifetime of the new wear parts has been doubled. The original valves with the 3 chambers were a design used in the Swedish paper industry. The steam supply to set pressure in the chamber was described in a paper by Arne S Jensen presented at the CITS general assembly in Munich in 1995 and published in Zuckerindustrie in October 1995. The form and the material of the wear parts have been improved. Today the inlet rotary valve can operate 3 to 4 campaigns without maintenance. The outlet rotary valve has got a completely new design of the rotor, and a new material for the tightening blocks (shoes). The lifetime is now doubled. The new EnerDry design is registered.
Figure 7. Inlet rotary valve. The form of the inlet and the outlet for steam is very important for reduction of the wear.

Figure 8. The outlet rotary valve with the EnerDry designed rotor (registered) that reduces wear by 50%.

Figure 9. Drwg H 01 005 demonstrates how all the waste steam/vapour from the rotary valves is recovered, and pollution is avoided.
Environment.
By introducing steam drying in stead of drum drying the big flume will disappear. Also small leaks of steam from the rotary valves are taken care of. They are brought back and condensed on the incoming pulp. Please see figure 6. The steam leaving the dryer shall be used in the juice evaporator station. The non condensables shall go to a lower temperature in f. ex. a juice heater. Thereafter the amount of non condensable is negligible compared to the rest of non condensables from the factory and can go out.
The condensate has a pH between 4,5 and 5,5. It has some organic acids mainly acetic acid (300 ppm) and NH3 (20 ppm). The BOD can be up to 500 ppm. The amount of solids will be less the 10 ppm. The data will vary depending on the beet quality and how the diffuser is operated. The condensate is on some factories used as freshwater for the diffuser on others in the beet washing plant. The sugar factory will then have more surplus of condensate from the evaporators, which must go out.

Economy
Steam drying will provide more income to a factory. How much will depend on the particular factory and their individual set ups, so budgets must be set up for each individual factory. An example for the gain by exchanging a gas fired drum drier by a size H steam dryer loaded to 50 t/h evaporation is the following:

<table>
<thead>
<tr>
<th>Description</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Saving on gas</td>
<td>1 674 000 € per year.</td>
</tr>
<tr>
<td>No lost product</td>
<td>383 000 € per year.</td>
</tr>
<tr>
<td>Saving on labour</td>
<td>150 000 € per year.</td>
</tr>
<tr>
<td>Saving on maintenance</td>
<td>150 000 € per year.</td>
</tr>
<tr>
<td>Gain</td>
<td>2 357 000 € per year</td>
</tr>
</tbody>
</table>

There could be some negative effect on the own power production, which will reduce the gain.

It is assumed:
Campaign: 100 days
Natural gas: 16 € per MWh
7% losses on the old drum dryers.
Pellets: 95 € per ton.

A budget for a size H dryer installation could be.

<table>
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<tbody>
<tr>
<td>Dryer ex works</td>
<td>3,8 mill €</td>
</tr>
<tr>
<td>Transport and erection</td>
<td>1,2 mill €</td>
</tr>
<tr>
<td>Dryer in place</td>
<td>5,0 mill €</td>
</tr>
<tr>
<td>Foundation, Building</td>
<td></td>
</tr>
<tr>
<td>Conveyors, piping, electric supply, modification to the evaporator station</td>
<td>2,5 mill €</td>
</tr>
<tr>
<td>Total</td>
<td>7,5 mill €</td>
</tr>
</tbody>
</table>

Dryer for Minn-Dak Farmers.
EnerDry have sold a dryer to Minn-Dak Farmers Coop. in Dakota that will be operational in September 2003. Minn-Dak Farmers total budget is 9,3 million $ (approx. 8,1 million €). The
cooperative expects a pay back on the investment in 3.3 years. At the same time the air pollution will disappear. No monetary value has been placed on this.

Figure 10 shows how the dryer shall be placed in the new building.

Figure 11. A recent photo taken mid March at the site in North Dakota.
Conclusion.

A steam dryer based on new patents is now available from EnerDry. This dryer gives more capacity for less investment. As always, the steam drying installations reduce the energy usage at the drying station by at least 90% compared to drying in conventional drum dryers. Additionally it saves on labour and maintenance. No product loss occurs…and it solves the air pollution problem for good.

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Arne Sloth Jensen

EnerDry