ONE DESIGN, THREE PANS
A LARGE FLEXIBILITY OF USE

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ABSTRACT

In 1996, the new CCTW continuous vacuum pan replaced the older CCTR pan. The new continuous vacuum pan has clearly improved performances. Its design allows installation of mechanical agitation. Two variants of the CCTW continuous vacuum pan, a double pan - the CCTWD, and half pan, (the CCTO), allows a great flexibility of use, for example, two strikes in the same equipment, or two pans running in parallel, or the possibility to make continuous vacuum pans of very small capacity.

INTRODUCTION

The first true continuous vacuum pan used in sugar mills dates back to 1967. It was the FCB prototype installed in the Sugar refinery in Nassandes, France. Since then FCB has built and installed 150 continuous vacuum pans (CCTR type) in every strike of beet and cane sugar mills throughout the world.

Since 1996 a new continuous vacuum pan, the CCTW, has replaced the old CCTR models. Thirty CCTW pans are already in operation or in course of installation. This new model marks significant progress relative to the older one.

DESIGN BASIS

Efficient Calandria

Calandria is formed of horizontal steam tubes organised vertically in rows. Simulations have proved that this type of calandria offers the best trade-off between the heat exchange coefficient and the head loss. The ratio of the exchange surface to the massecuite volume is normally 10m²/m³.

Circulating the steam in three passes enables the entire surface of the calandria to be swept systematically. The steam always circulates fast enough to ensure the complete expulsion of the condensate and the noncondensable gases. The extraction of noncondensable gases is rigorously controlled, since the extraction point is located just at the end of the steam circulation.

Very Low Hydrostatic Load

The cross-sectional geometry of the calandria is specially designed to ensure the lowest possible maximum hydrostatic load (vertical distance between the level of the massecuite and the lowest point in the calandria). This effect is enhanced by the sloping top of the calandria, which facilitates the recirculation of the massecuite at the same time that it places the calandria as high as possible within it.

The gain relative to the former CCTR vacuum pans is from 400 to 900 mm, according to the size of the pan. This corresponds to a practical gain in Δt in the range of 2 to 4°C.
Wide Passage for Recirculation

The lateral recirculation passages have been made as wide as possible in order to facilitate the natural recirculation of the massecuite. By way of comparison, note that the width of these passages, expressed in terms of the diameter of a central downtake in a batch vacuum pan, is equivalent to 55% of the diameter of the shell, whereas the ratio for batch pans generally runs from 30 to 40%.

Large Overflow Threshold

By sloping the top of the calandria toward the side passage it is possible to employ a maximum exchange surface while facilitating the recirculation of the massecuite toward the passage. This arrangement reduces the hydrostatic load on the calandria at the same time that it maintains a high overflow threshold onto the side passage (almost equivalent to the width of the recirculation passage itself), thus achieving an excellent recirculation flow.

A large overflow threshold is a necessary condition for obtaining high recirculation flow. When the top of the calandria is horizontal and the height of massecuite over the calandria is kept low in order to minimise the hydrostatic load, that inhibits the recirculation of the massecuite, whose flow rate is a direct function of the cross-section of the overflow. This is evident if we imagine a very low height of massecuite over the calandria (close to zero). In these conditions the hydrostatic load is obviously reduced to the height of the calandria. However, it is equally obvious that the recirculation flow is also close to zero.

Installation of Mechanical Circulation

The bottom of the shell is conceived so as to allow the optimal installation, in each compartment, of propeller for mechanical agitation: that is to say, under the calandria, in the centre of and perpendicular to the calandria, without dimensional constraints.

A large flexibility of installation is possible: it is indeed possible to install mechanical stirrers just in the last compartments, or in the last half of the pan, or even in the whole pan.

The consumed power by mechanical agitation in the last compartments are in the order of 0,5 to 0,6 kW/m³ (massecuite A in Vietnam), 0,65 kW/m³ (massecuite B in Vietnam), 0,5 to 0,65 kW/m³ (massecuite C in Vietnam) and 0,5 to 0,65 kW/m³ of massecuite (CCTW 2000 hl - impellers Ø 900 mm - massecuite B in Argentina).

STANDARD PAN CCTW

Thus we end up with the schematic conception in figure 1. The shell surrounds the calandria leaving a large recirculation passage on the side, which narrows slightly toward the bottom (load increase), and which closes gradually toward the centre underneath the calandria.
The CCTW continuous vacuum pan is a horizontal pan divided into thirteen volumetrically graduated cells, constructed with a longitudinal partition, running the entire length of the pan, and transversal partitions.

The magma is fed into the first cell, and the massecuite flows from cell to cell by means of openings located alternatively in the upper level of the calandria and underneath it. The final massecuite is drawn off from the last cell. The syrup/liquor feeds into the bottom of each cell.

Given the excellent natural circulation of the massecuite, it is not necessary to add steam agitation. This fact has been verified.

Mechanical agitation is an optional feature, but it permits substantial gains in At and exhaustion, as we demonstrated on the continuous vacuum pan (CCTR type) in the second strike of the French sugar mill at Colleville (1) (Figure 2). Adding mechanical agitation permits operational gains in the range of 20 to 40 %.
Main Advantages

Fig. 2: Pan with Mechanical Agitations

In summary, the CCTW vacuum pan incorporates the following advances relative to the CCTR:

- Much lower hydrostatic loads,
- Wider recirculation passages (+25% on the average),
- Better condition for natural recirculation,
- Easy installation of mechanical agitation.

These advances make the following gains possible:

- Significant reduction of At,
- Improved exhaustion,
- Improved granulometry,
- Elimination of steam agitation
- Less sensitivity to fouling.

Results in Low Grade Product

The first two pans CCTW were operating in 1997 to the entire satisfaction of their users. The first pan started in June 1997 in cane low-grade product at the Cruz Alta sugar mill in Brazil. The second started in July 1997 in Quentin low-grade product at the Jaen Beet Sugar factory in Spain. Nine other pans started in cane in 1998: three in India on A, B and C massecuite, three in Vietnam on A, B & C massecuite, partially with mechanical agitation, two in Brazil on B and C massecuite and one in Argentina on B massecuite, with mechanical agitation on the last half of the pan.

In India and Vietnam pans are controlled by conductivity. In all other cases the pans are controlled predictively, i.e., by controlling the entry (namely, the flow of feeding syrup, or liquor). A permanent calculation of the pan’s materials balance keeps the final brix of the massecuite at a constant level.
The Cruz Alta vacuum pan has a useful volume of 150m³ with a heat exchange surface of 1504m². It does not use mechanical agitation. The proportion of magma is approximately 30% of the flow of the produced massecuite, which is in the range of 30 to 40 tons/hour. We measured the performances of this pan during two periods: after about two months of operation, then after three months, when the pan was fouled and needed cleaning.

Table 1 below illustrates the average balance (for four days) in August 1997. Table 2 illustrates the average balance (for three days) in September 1997.

Table 1: Average Balance in a Semi-fouled Pan

<table>
<thead>
<tr>
<th>Semi fouled pan</th>
<th>footing magma</th>
<th>molasses</th>
<th>massecuite</th>
<th>evaporat</th>
<th>vacuum water</th>
<th>calandria</th>
</tr>
</thead>
<tbody>
<tr>
<td>flow (t/h)</td>
<td>9.2</td>
<td>27.9</td>
<td>31.9</td>
<td>5.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>brix (%)</td>
<td>90.0</td>
<td>79.1</td>
<td>95.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>purity (%)</td>
<td>71.6</td>
<td>60.7</td>
<td>61.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tempt°C</td>
<td>62.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pressure (bar abs)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Table 2: Average Balance in a Fouled Pan

<table>
<thead>
<tr>
<th>Fouled pan</th>
<th>footing</th>
<th>molasses</th>
<th>massecuite</th>
<th>evaporat</th>
<th>vacuum water</th>
<th>calandria</th>
</tr>
</thead>
<tbody>
<tr>
<td>flow (t/h)</td>
<td>10.0</td>
<td>26.8</td>
<td>31.7</td>
<td>5.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>brix (%)</td>
<td>90.0</td>
<td>79.0</td>
<td>95.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>purity (%)</td>
<td>71.4</td>
<td>61.3</td>
<td>64.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tempt°C</td>
<td>62.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pressure (bar abs)</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Table 3: Illustrates the exhaustion obtained

<table>
<thead>
<tr>
<th></th>
<th>average August 1997</th>
<th>average September 1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>apparent massecuite purity</td>
<td>62.23</td>
<td>63.70</td>
</tr>
<tr>
<td>apparent molasses purity</td>
<td>42.44</td>
<td>43.10</td>
</tr>
<tr>
<td>purity drop</td>
<td>19.79</td>
<td>20.60</td>
</tr>
</tbody>
</table>

Considering that the Cruz Alta mill was very poorly equipped for mixing low-grade product, with no means of cooling, this exhaustion can be considered excellent.

DOUBLE PAN CCTWD

Two Pans in One

he basic idea is to extend longitudinal partition up to the top of shell in order to completely separate the 2 symmetrical sides of the pan. This longitudinal partition, calculated by finite elements, is thickened and reinforced so as to support atmospheric pressure on a side and deep vacuum on the other one.
It results, that with the same equipment, two equivalents and distinct symmetrical volumes can be separately operate. Of course, the calandria is also separated in two parts in accordance with separate volumes. For each pan, i.e. for each side, massecuite circulation is linear from an extremity of the equipment to the other one. The number of compartments is reduced to 10 or 11.

For instance, the two volumes can operate with two different strikes: A and B or B and C. The benefit is compactness of installation and an investment cost reduction.

Fig. 3: Double Pan CCTWD

Two Parallel Pans

This type of equipment permits also, with a reasonable additional cost, to operate with two pans in parallel on the same strike.

This configuration allows to easily reduce the rate to 50% if required. It is also possible to continue to operate at 50 to 60% of nominal, with only half a pan, during momentary stop of the other half for cleaning purpose.
Logically following CCTWD pan spirit, it is natural to think to separate the 2 halves of the pan. This results in a pan with an ovoidal shape illustrated by figure 4: the CCTO pan.

Application cases for this ovoidal pan are more or less the same as CCTW and CCTWD pans. However, to cut a pan in two half parts leads to half volumes. It is very easy to obtain small pan capacities, especially adapted to small factories and/or refined strikes attached to a cane mill. CCTO capacities range 110 to 1000 hl in standard (11 to 100 m³).

Like with CCTWD pans, the number of compartments of CCTO pans is 10 or 11, in accordance with his length.

OUTLOOK FOR THE NEW CONTINUOUS VACUUM PAN RANGE

Drawing on these preliminary results, we can project the performances that can be expected from this new vacuum pan. For any immediately foreseeable applications, these may be summarised in four areas:

- Thermal performances.
- Exhaustion.
- Granular Quality.
- Energy savings.

Thermal Performances

We customarily characterise heat exchange in terms of the evaporation rate, expressed as the kg of water evaporated per hour and per m² of exchange surface (TEV in kg/h,m²), and set in relation to the total Δt (the total Δt is the difference of temperature between the calandria and the vacuum). Figure 5 shows the relation between TEV and total Δt for CCTW in Brazil and Jaen in Spain.
By way of comparison, we show on the same graph the performance curve of the former CCTR type vacuum pans (with an average fouling). The performances of the new vacuum pan appear as a net improvement on the former model, since its operating results are clearly above the former model’s, even when its calandria is fouled.

Two operating results are also shown for the VKT continuous vacuum pan in Aarberg (2). One result concerns cells 1-2, and the other, cells 3-4. We observe a global lower performance compare to CCTW pan, in spite of mechanical agitation in the 4 cells of the VKT, unlike the CCTW pan.

Exhaustion

Very good exhaustion is obtained at Cruz, Alta and Jaen (cf. table 3 above). As with the improved heat exchange, this is due to better circulation and mixing of the massecuite in the equipment. The measures of massecuite temperatures demonstrate the excellent circulation. Indeed, our measures show that there is virtually no hydrostatic temperature elevation in the calandria.

This improvement in the circulation and mixing of the massecuite will necessarily promote optimal exhaustion.

Granulometric Quality

Granulometric quality in a multi-celled continuous vacuum pan is related to the main parameters:
- the granulometric quality of the footing magma
- the number of compartments
- the quality of the mixing of the massecuite in each compartment
The CCTW continuous vacuum pan has thirteen cells; 10 or 11 for CCTWD and CCTO pans. These values are a good compromise, sufficiently high to minimise the dispersion of residence time, yet low enough to keep the pan and its process control simple.

A definite improvement has been obtained in the quality of the mixing within each compartment, relative to the former CCTR vacuum pan. Considering that granulometric performances of the former continuous vacuum pan were already good, like illustrated by table 4 hereafter. It is clear that those of the new one will be even better.

Table 4 : Grain Characteristic in CCTR PANS

<table>
<thead>
<tr>
<th></th>
<th>St Germainmont 1988 (France)</th>
<th></th>
<th>La Rinconada 1996 (Spain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M. A. (mm)</td>
<td>0.66</td>
<td>0.68</td>
<td>0.53</td>
</tr>
<tr>
<td>C. V. (%)</td>
<td>26.1</td>
<td>26.6</td>
<td>28.2</td>
</tr>
<tr>
<td>Hill mark</td>
<td>130</td>
<td>128</td>
<td></td>
</tr>
</tbody>
</table>

**Energy Savings**

In its present design, the new CCTW vacuum pan already, shows excellent heat exchange performances, as we have just demonstrated. These performances can be significantly enhanced. The standard surface to volume ratio is 10 m²/m³; the vacuum pan is designed to allow this ratio to increased to 13 m²/m³ or +30%. The expected heat exchange performances permit very low Δt between the calandria and the vapour space, for instance from 20 to 25°C with high purity massecuite.

Given this, several ways of saving energy are possible:

- Steam bleeding for crystallisation can be deferred to the fifth or sixth effect. For instance, with a vacuum at 250 mbar abs (65°C), the necessary pressure for the calandria is in the neighbourhood of 700 mbar abs (90°C).
- It is relatively easy to operate vapour recompression with a compression ratio of about 3 (for example 250 to 750 mbar abs).

![Fig. 6 : Crystallisation in double effect](image)
Crystallisation in two effects can be envisaged, as in the schematic example given in figure 6.

This process can be used both in first strike or refined strike of sugar mills. The vapoursteam produced by the second continuous vacuum pan is condensed in the first pan calandria, where it produces a second evaporation.

This type of arrangement allows significant energy savings, since it cuts the steam required for crystallisation by about half.

CONCLUSIONS

This new continuous vacuum pan shows significant advances in every area of crystallisation. We believe that this type of pan is particularly well adapted to cane sugar mill and refinery, where its features can offer excellent exhaustion and granulometric quality at the same time as energy savings, which thus mean lower operating costs.

REFERENCES


UN DISEÑO, TRES TACHOS-UNA GRAN FLEXIBILIDAD DE USO

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RESUMEN

En 1996, el tacho nuevo de vacío continuo, CCTW, reemplazó el tacho viejo, CCTR. El tacho nuevo de vacío continuo claramente ha mejorado su función. Su diseño permite instalaciones de agitación mecánica. El tacho de vacío continuo, tipo CCTW, posee dos variantes que permiten una gran flexibilidad de uso; éstas son, el tacho doble, tipo CCTWD, y el tacho medio, tipo CCTO. Su flexibilidad se refleja, por ejemplo, al permitir hacer dos templas en el mismo equipo, o dos tachos operando en paralelo, o posibilidad de hacer tachos de muy baja capacidad.

El primer tacho de vacío continuo usado en ingenio de azúcar se remonta a fecha del año 1967. Este fue del tipo construido por la compañía FCB y fue instalado en una refinería de azúcar en Nassandres, Francia.

Desde esta fecha, FCB ha construido y instalado 150 tachos de vacío continuo (tipo CCTR) en cada templo de cristalización de azúcar de remolacha y caña a través de todo el mundo. Desde 1996 el tacho nuevo de vacío continuo tipo CCTW, ha reemplazado los modelos viejos tipo CCTR. 30 tachos de tipo CCTW existen ya en operación o en proceso de instalación. Este modelo nuevo marca un progreso significante en relación a los modelos viejos.
UN DISEÑO, TROIS CUITES, UNEGRANDE FLEXIBILITÉ D'UTILITÉ

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RÉSUMÉ

En 1996, la nouvelle cuite continue CCTW a succédé à l'ancienne cuite CCTR. La nouvelle cuite présente des performances en très net progrès. Sa conception permet l'installation d'agitateurs mécaniques. Deux variantes de la cuite CCTW, une cuite double, la CCTWD et une demi cuite, la CCTO permettent une grande souplesse d'utilisation comme par exemple 2 jets dans le même appareil, 2 cuites exploitées en parallèle ou la réalisation de très petites capacités.