

EVALUATION OF A REFINERY PAN STIRRER

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Abstract

The effect of a stirrer fitted to a refinery pan boiling third massecuites was assessed by boiling the pan for periods of about two weeks with and without the stirrer. The percentage of conglomerates decreased from 84 without stirring to 55 with stirring, and there was a corresponding decrease in the Karl Fischer moisture of the sugar. No difference in sugar colour was noted but turbidity decreased by 50%. The stirrer improved the steam balance by eliminating the use of movement water.

Introduction

In 1985 3 Ekato-designed stirrers were installed in the refinery pans at Noodsberg. In this paper the performance of the Ekato stirrer is assessed on a third refinery boiling.

The main purposes of the work were to determine the effects of the stirrer on:

- refined sugar colour
- conglomerate count
- moisture content (both Karl Fischer and oven moisture) of sugar
- conditioning behaviour of dried sugar, and
- heat transfer, as well as
- to measure the power input to the stirrer

In determining the effect of the stirrer it was necessary to boil the pan for a few weeks with the stirrer on and for a few weeks with the impeller removed.

Description of pan and stirrer

The refinery pan station comprises four pans, numbered 1 to 4. Pans 1 and 2 are used only for 1st boilings, pan 3 for 2nd boilings and pan 4 (the pan under test) for 3rd and 4th boilings. Each pan strikes into a single strike receiver from where the massecuite flows directly to the centrifugals. The specifications of the pan under test are given in Table 1.

Table 1
Pan specifications

Strike capacity (m ³)	42,5
Heating surface (m ²)	305
Tube diameter (mm)	101,6 (ID)
No. of tubes	808
Tube length (mm)	1 277
Downtake diameter (mm)	1 828

The pan was fitted with a Ziegler oversaturation monitor (Boiling point elevation type) which controlled the flow of steam and water via pneumatically operated valves. In addition, the pan consistency (which was determined by measuring the current through the stirrer motor) was used to control the feed to the pan.

The steam supply to the pan was Vapour 1 at an average pressure of 45 kPa gauge. The stirrer specifications are shown in Table 2.

Table 2

Stirrer specifications

Make	: Ekato
Type	: HWL 5140 - A
Electric motor	: power 45/30 KW : power supply 550 V; 3 phase; 50 cycles : speed 1 486/989 rpm : protection class IP 54
Agitator shaft	: length 8 950 mm, dia 140 mm : speed 58/39 rpm
Impeller	: 5 bladed; detachable : diameter 1 650 mm

The electric motor drives the stirrer via a V-belt and gearbox arrangement with an overall speed reduction ratio of 25,6. The stirrer is designed to run at 58 and 39 rpm. The higher speed is activated when the stirrer is started at the beginning of a strike. The lower speed is automatically activated when maximum load is drawn by the stirrer at the higher speed. Speed variations are possible by changing the pulley on the drive, but this was not tried. The tripping set point (from high to low speed) can be selected as desired.

The five blades of the stirrer are detachable and can be removed through the manhole. During operation, the stirrer produces a downward thrust and five equally spaced baffles are arranged above the impeller to prevent a vortex being created in the downtake. The position of the impeller in the downtake is shown in Figure 1.

Experimental procedure

At the outset, the boiling technique had to be clearly defined. It was necessary to have two boiling techniques; one for the stirred boiling and the other for the unstirred boiling.

Stirred boiling technique

A graining charge of about 20 m³ of jet 2 was fed into the pan and concentrated. The stirrer was started and worked at the higher speed. The pan was grained at 42% oversaturation, using about 200 ml of slurry. Immediately after the slurry was admitted into the pan, the steam to the calandria was manually shut and circulation was induced entirely by the stirrer. This lasted until the pan boiler was satisfied with the crystal size which was normally about 20 minutes. At this stage the steam supply to the pan was manually opened. During the remainder of the boiling time, the steam and water feeds were controlled by the oversaturation meter while the pan feed was controlled by the current through the stirrer motor (ie pan consistency).

Unstirred boiling technique

The technique was the same as that for the stirred pan except that the boiling was controlled entirely by hand and the steam was not shut off after graining. Movement water was normally introduced to the pan during graining to facilitate circulation.

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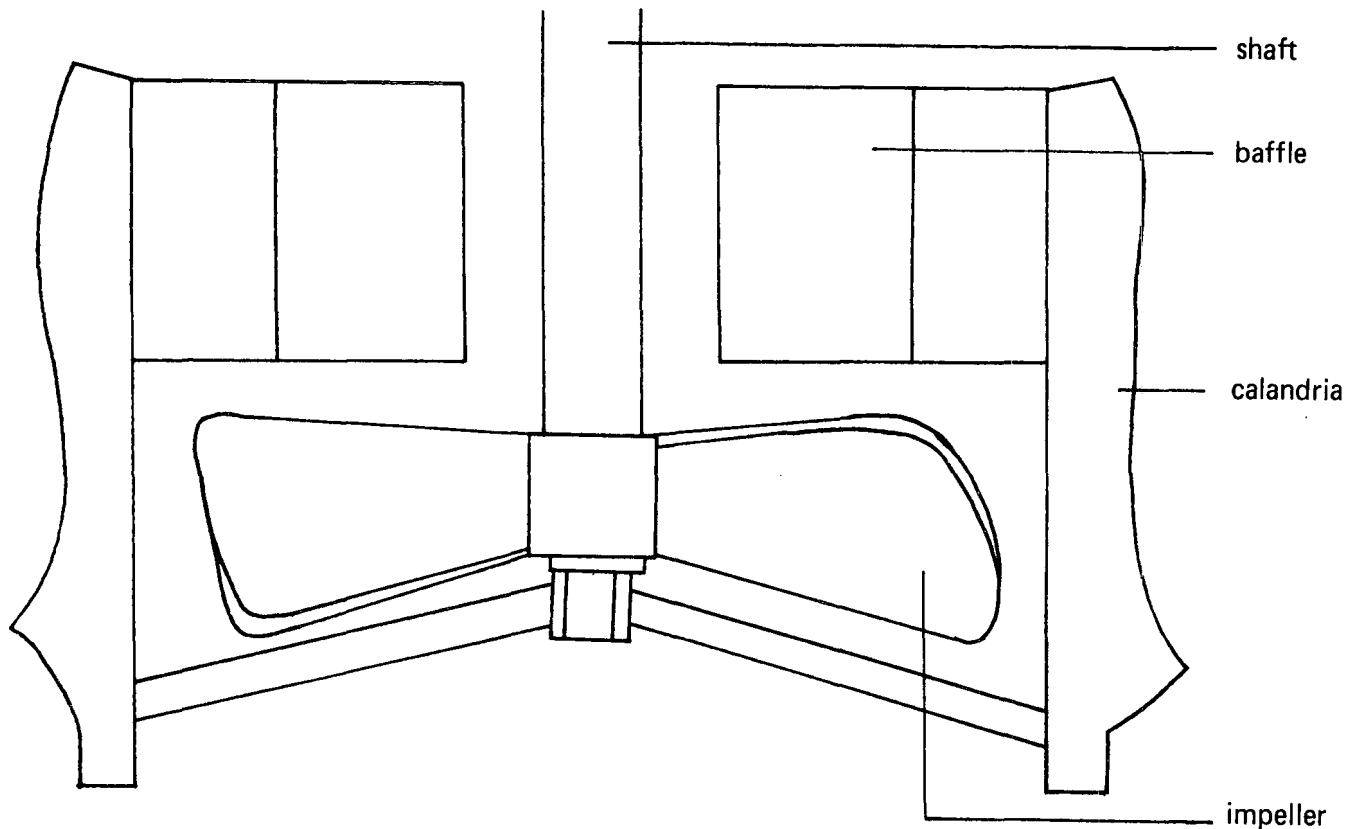


FIGURE 1 Position of the impeller in the downtake.

Sampling procedure

The comparison was conducted in June and July, during which time the pan was boiled for two weeks without the stirrer (ie the impeller was removed). The sugar samples were taken as the sugar left the fluidised bed drier. In order to get only the sugar that was boiled in pan 4, it was necessary to stop curing the other strikes and to allow 30 minutes to displace the sugar from the drier before the samples could be taken. The sugar was then sampled from the belt conveyor by catching samples of about 200 grams every minute for 15 minutes and storing in a sealed 5 litre plastic bucket.

This sample was riffled, subsampled and analysed at the Sugar Milling Research Institute (SMRI), except for Karl Fischer moistures which were determined at the Noodsberg laboratory. Samples for the conditioning tests were taken separately over the same 15 minute period.

As this sampling procedure required that the other boilings (1st, 2nd and 4th) could not be cured for about 1 hour, it could only be done when the factory was relatively empty. As a result samples could not always be obtained daily.

Conglomerate count

The Kontron particle size analyser was used to count the proportion of conglomerates in a sample of sugar. This is purely a visual method with the sample on the slide glass being projected onto a visual display monitor. The total number of crystals on the screen and the number of conglomerates are counted manually. There are, in all samples, some borderline cases which are a matter of opinion. For this reason, the same person performed the count in all the tests so that although the results may not be absolute, they are comparative.

Conditioning tests

The conditioning tests were done at Noodsberg in the pilot silos as described by Excell.¹

Evaporation rates

Evaporation rates were obtained indirectly by measuring the flow of steam condensate from the calandria, using a weir tank with a pneumatic pressure transmitter and bubbler system.

Results and Discussion

Sugar quality

The average quality parameters of the sugar from the stirred and unstirred pans are shown in Table 3.

Table 3
Sugar quality from stirred and unstirred pans

	<i>Stirred</i>	<i>Unstirred</i>
Karl Fischer moisture	0,075 (n=9)	0,104 (n=7)
Oven moisture	0,03 (n=10)	0,02 (n=7)
% conglomerates	55 (n=8)	84 (n=7)
ICUMSA 420 colour	72 (n=10)	69 (n=7)
Turbidity	8 (n=10)	16 (n=7)

The results show that the Karl Fischer moistures of the unstirred sugar were higher, indicating a higher conglomerate count, which was confirmed by the crystal counts. Sugar colour was the same in both cases but unfortunately feed colour was not measured and it may have been responsible for the apparent lack of influence of stirring. It was intended to monitor the colour transfer later in the season but this could not be done as the refinery was running at full capacity and could not be slowed down for the tests. The turbidity of the stirred sugar was half that of the unstirred.

Crystal size

The average crystal size results, shown in Table 4, indicate that no differences exist between the crystal size of sugar produced by the stirred and unstirred pans.

Table 4
Crystal size

	Stirred	Unstirred
Specific grain size	0,52	0,50
Coefficient of variation	0,60	0,60
Mean aperture	34	37

Conditioning tests

The results of the conditioning tests are shown in graphic form in Figure 2. The arrows mark the points at which there is no further significant drop in Karl Fischer moisture and the sugar is considered to be conditioned.

The average conditioning time (taken from Figure 2) for the stirred pan sugar was 32 hours and the average Karl Fischer moisture after 32 hours conditioning was 0,061. In the case of the unstirred pan sugar, the conditioning time and Karl Fischer moisture were 50 hours and 0,068 respectively. These results therefore indicate that the sugar from the stirred pan is much easier to condition than the sugar from the unstirred pan.

Evaporation rate

The evaporation rate results, shown in Table 5, indicate that the heat transfer coefficient for the unstirred pan is higher than for the stirred pan. However, Table 5 also shows that the volume of circulation water used in the unstirred pan was about twice that of the stirred pan. The effective steam

usage (the calculations are shown in Appendix 1) was 69% in the case of the stirred pan and only 50% in the case of the unstirred pan. This means that in the case of the stirred pan 31% (ie 100-69) of the steam was used to evaporate water that was added to the pan, while for the unstirred pan 50% of the steam was used for this purpose.

Table 5
Evaporation rates

	Stirred	Unstirred
Ave evap rate (kg m ⁻² h ⁻¹)	35,0 (n=43)	37,6 (n=15)
Vol water used per strike (m ³)	4,8	10,3
Heat transfer coeff (W m ⁻² °C ⁻¹)	573	616
Boiling time (h)	1,8	1,8
Effective steam usage (%)	69	50

It should be noted that towards the end of the season the stirred pan boiling technique was further improved so that the pan could be boiled without any addition of movement water. The effective steam usage had therefore increased to 100% by the end of the season.

In Table 5, the boiling time shown for the stirred pan includes the 20 minutes when the steam during graining was shut to the pan.

Power input to the motor

The power input to the motor during a typical boiling is shown in Figure 3.

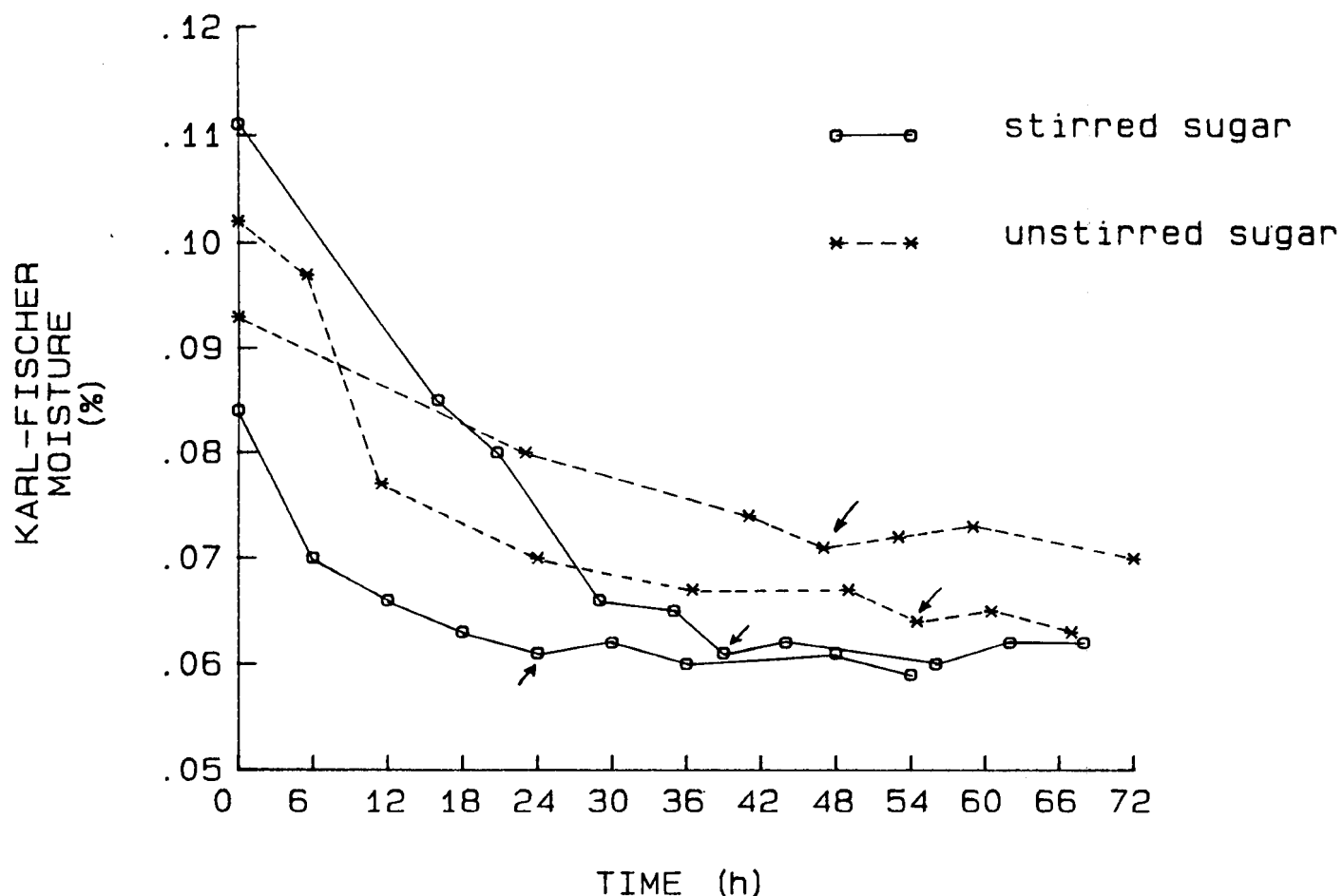


FIGURE 2 Sugar conditioning tests

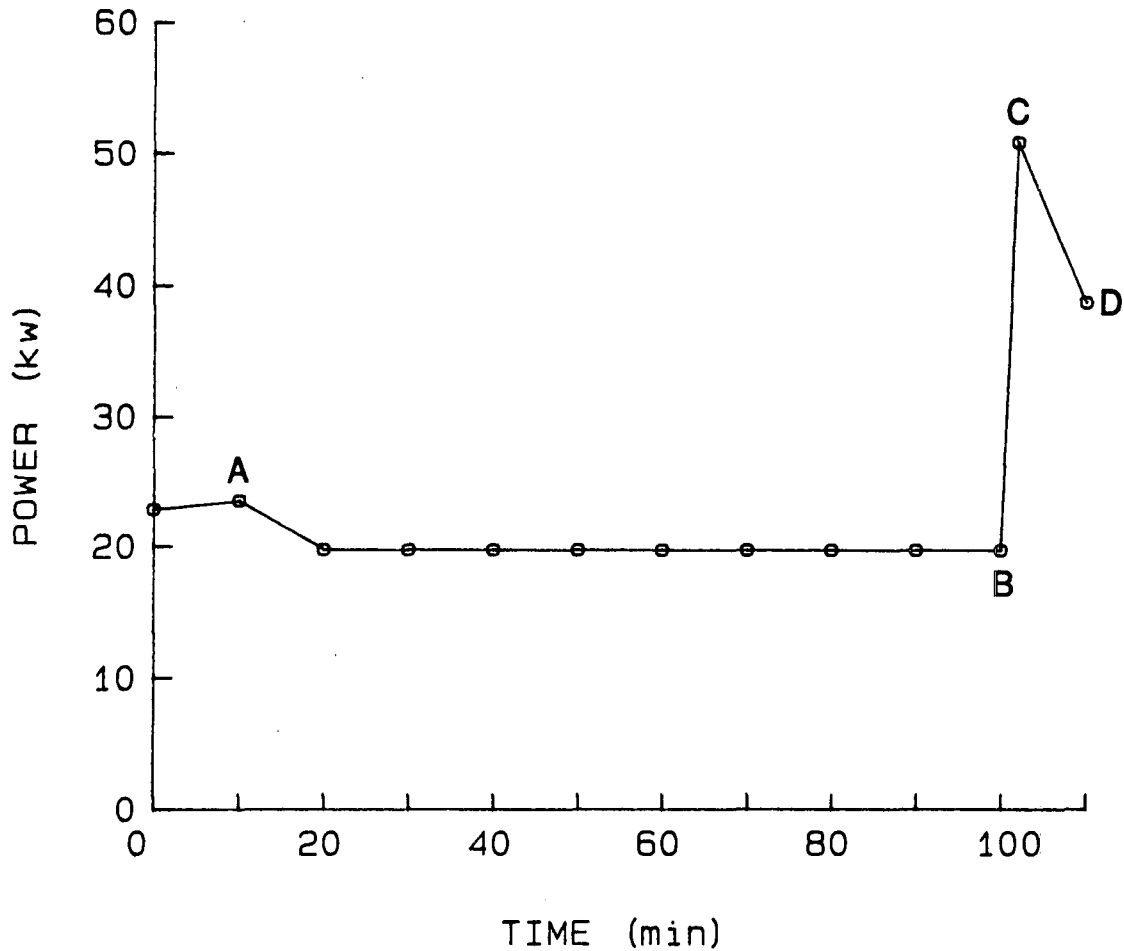


FIGURE 3 Power input to the motor.

“A” denotes the point at which the pan was grained, “B” the start of brixing and “C” and “D” the points at which the stirrer tripped at the high and low speeds respectively.

Effect of installation of stirrers in the refinery pans at Gledhow

Stirrers were also installed in the refinery pans at Gledhow during the 1986 season. Although their effects were not monitored by the SMRI, the results obtained before and after the installation of the stirrers are reported because of the additional information which they provide. The average results listed in Table 6 were obtained from routine analyses carried out by the Gledhow laboratory. They indicate that there were significant gains in both yield and colour with the stirrer.

Table 6

Average of Gledhow refinery analysis

	Stirred	Unstirred
Sugar yield (kg sugar/m ³ mass.)	658	529
Sugar colour:		
1st boiling	18	27
2nd boiling	38	43

Conclusions

The results show that on 3rd boilings at Noodsberg the Karl Fischer moisture was reduced from 0,104 to 0,075 while the conglomerates decreased from 84% to 55% with the stirrer.

No difference in sugar colour was found but turbidity decreased by 50%.

The stirrer did not affect the crystal size of the sugar in any way.

The average conditioning time was reduced from 50 hours to 32 hours, a gain of about 35% in time.

The stirrer improved the energy balance of the pan floor by eliminating the use of movement water.

The results reported by Gledhow on 1st and 2nd boilings showed that higher sugar yields and improved sugar colour were obtained with the stirrer.

The only major mechanical problem at Noodsberg occurred when the shaft coupling the motor to the gearbox sheared. This occurred two weeks before the season closed.

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REFERENCES

1. Excell, T. L. (1983). Conditioning experiments on Noodsberg refined sugar. SMRI Technical Report No. 1364, (6 Dec), 2-3.

APPENDIX I

Calculation of steam efficiency

A. *Stirred pan*

Since the steam to the stirred pan was shut off for 20 minutes,
the effective boiling time = $(1,8 - 0,33)$ h
= 1,47 h
volume water evaporated per strike = $(35 \times 1,47 \times 305/1000)$ m³
= 15,7 m³
volume water added = 4,8 m³
volume water evaporated from M/C = 10,9 m³
Effective steam usage = $\frac{10,9}{15,7} \times \frac{100\%}{1}$
= 69%

B. *Unstirred pan*

Volume water evaporated per strike = $(37,6 \times 1,8 \times 305/1000)$ m³
= 20,6 m³
Volume water added = 10,3 m³
Volume water evaporated from M/C = 10,3 m³
Effective steam usage = $\frac{10,3}{20,6} \times \frac{100\%}{1}$
= 50%