ASSESSMENT OF A STIRRER INSTALLED IN A LOW GRADE PAN AT NOODSBERG

By L. BACHAN* and B. WEBB**

**Sugar Milling Research Institute*

***C.G. Smith Sugar Ltd. Noodsberg*

Abstract

A brief description of the stirrer and the performance of the stirred pan compared to that of an exactly similar unstirred pan are given. The comparison was carried out over the entire season under normal industrial conditions. The effect of the stirrer on boiling time, evaporation rate, crystal quality and massecuite exhaustion were investigated. The stirrer improved pan capacity by up to 32% but had no effect on the crystal size distribution and final molasses purity.

Introduction

The C-station at Noodsberg comprises 42m³ pans, numbered 7, 8 and 9. Pan 7 has a dual function of graining B- and C-seeds while all the C-massecuite produced at Noodsberg is boiled in two identical pans, 8 and 9. Noodsberg has a split pan floor, thus allowing strikes from pans 8 and 9 to follow different streams, each having its own crystallisers, reheater and centrifugals.

The lack of C-pan capacity and apparent long boiling times (which forced Noodsberg to reduce their strike volumes) coupled with the occurrence of false grain on striking, motivated the installation of a stirrer at Noodsberg. The stirrer was installed in May 1984 in pan 8.

In this assessment, the performance of the stirred pan (pan 8) is compared with the unstirred pan (pan 9). The main purposes of the work were to determine the effect of the stirrer on:

- boiling time and evaporation rates
- crystal quality
- massecuite exhaustion.

Description of pan and stirrer

The specifications of the stirrer are shown in Table 1.

TABLE 1

Stirrer specifications

Make	Ekato	
Type	HWL 5160-H	
Electric motor	power	75/50 kW
	power supply 525V, 3 phase, 50 cycles	
Shaft seal	Ekato stuffing box	
Agitator shaft	length	7550 mm
	diameter	160 mm
	speed	48/32 rpm
	material	mild steel
Propeller	no. of blades	5
	diameter	1700 mm
	material	mild steel

The stirrer was designed to run at two speeds, viz. 48/32 rpm but it was decided to run it initially at lower speeds of 41,2/27,5 rpm before progressing to the higher speeds. Speed variations were possible by changing the pulley on the drive.

The five detachable blades of the impeller are arranged angularly and can easily be removed through the manhole. In operation, the stirrer produces a downward thrust which forces massecuite away from the impeller. Five equally spaced baffles are arranged on the suction side of the impeller to prevent rotation of massecuite in the downtake. The position of the stirrer in the pan is shown in Figure 1 and that of the impeller is shown in Figure 2. It should be noted that there is no bearing on the stirrer shaft inside the pan. The pan specifications are given in Table 2.

TABLE 2

Pan specifications

Strike capacity	(m³)	42,5
Heating surface	(m²)	209
Tube diameter	(mm)	100
No. of tubes		910
Tube lengths	(mm)	876; 800; 724
% Area downtake to tube c/s area		41

The pans are fitted with conductivity electrodes for automatic feeding of molasses or water (as desired) through pneumatically operated valves. The steam supply to the pan was vapour 1 at a pressure of 50 kPa gauge, while exhaust at a pressure of 100 kPa gauge was used as injection steam.

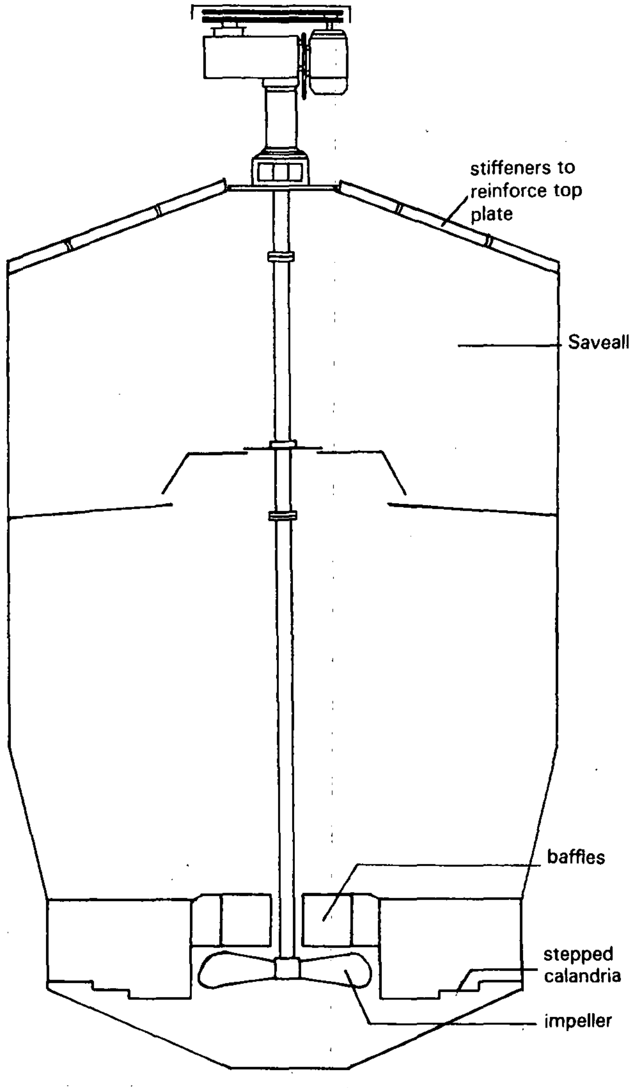

FIGURE 1 Position of the stirrer in the pan.

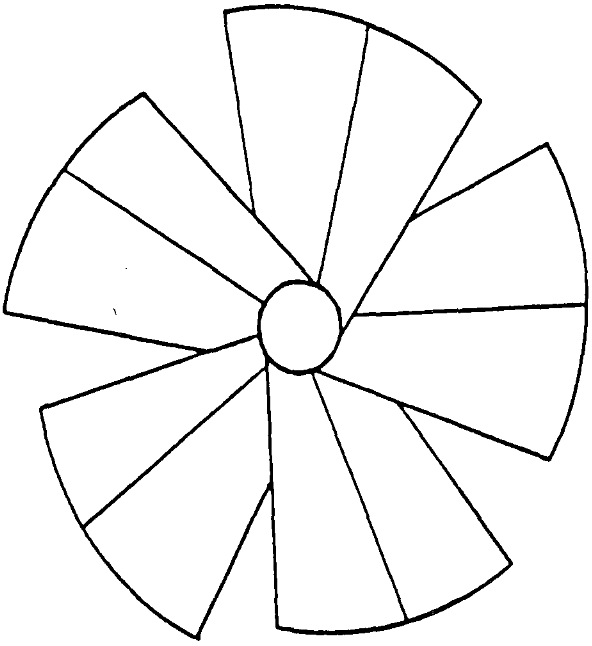

FIGURE 2 The five-bladed Ekato impeller

Experimental Procedure

The initial experiments were designed to determine the viscosity and brix at which the stirrer tripped. The boiling time data were logged for each strike by the pan boilers. The boiling times included the time required for cutting-over, raising vacuum, discharging and steaming out. Massecuite and molasses samples were taken at strike and at curing and were analysed at the Noodsberg laboratory.

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. As only one tank was available the condensate from each pan was measured every alternate week.

Massecuite samples were taken at the feed to the centrifugals for measurement of crystal size. The Kontron particle size analyser at the Sugar Milling Research Institute was used for this purpose.

It was not always possible to produce massecuites free of false grain. False grain was generally noticed at strike from both pans but very seldom during boiling. It was difficult to determine which pan produced more false grain. Various boiling techniques were used without much success to eliminate false grain. The following techniques were tried:

- the pans were struck short at approximately 35 m^3
- the pans were boiled normally but brixed on water for approximately 30 minutes before striking
- the pans were boiled at constant conductivity (slack) to the desired volume and then brixed for approximately 90 minutes by 'holding' on water
- different quantities of slurry were used for graining.

In assessing the results, all those strikes that were affected by unforeseen circumstances e.g. low steam, insufficient molasses, mechanical breakdowns, were neglected. In addition those strikes that were deliberately boiled for a long time in an attempt to reduce the presence of false grain, were also neglected. The data obtained on the two pans were analysed statistically using the Students t-test for the difference between means, at a level of significance of 0,05.

Results and discussions

The brix and viscosities at which the stirrer tripped at the different speeds are shown in Table 3. The massecuite samples were diluted 5:1 and the brix was read off a refractometer. The viscosities were measured on a Brookfield viscometer at 60°C.

TABLE 3

Brixes and viscosities at which stirrer tripped

Speed (rpm)	41,2	27,5	48	32
Brix	96,0 – 96,2	96,5 - 96,8	93,9 - 94,6	95,1 - 95,7
Viscosity @ 60°C (Pa.s)	1 000 - 1 200	1 200 - 3 000	600 - 1 000	1 200 - 1 500

The results at the lower speed (41,2/27,5) were obtained during the first half of the season and those at the higher speed during the later months of the season.
The point at which the stirrer tripped was governed primarily by the viscosity. The differences in viscosity at different times in the season are shown in Table 3. At a brix of 96,0 to 96,2 the viscosity at the beginning of the season was 1 000 to 1 200 Pa.s while at a lower brix (95,1 to 95,7) towards the end of the season, the viscosities were 1 200 to 1 500 Pa.s.

Boiling times and exhaustions at strike

The effect of the stirrer at different speeds on pan performance is shown in Table 4.

TABLE 4

Effect of the stirrer at different speeds on pan performance

	Speed 48/32 rpm			Speed 41,2/27,5 rpm		
	Stirred	Unstirred	Sig.	Stirred	Unstirred	Sig.
Boiling time (h)	5,1	7,5	*	4,9	5,8	*
Strike volume (m^3)	38,9	37,3	*	37,1	36,1	*
Nutsch molasses purity	41,53	41,46	ns	36,07	36,22	ns
Exhaustion at strike	37,10	37,90	ns	43,77	44,96	*
Massecuite brix	94,95	94,97	ns	95,26	95,32	ns
Massecuite purity	53,09	53,30	ns	50,07	50,83	*
No. of strikes	140	108		202	176	

* = significant at the 0,05 level
ns = not significant at the 0,05 level

In the case of the stirrer at 48/32 rpm, the results show that the boiling times and volumes of massecuite produced by the stirred and unstirred pans were significantly different. An improvement of approximately 30% was obtained in boiling time in spite of the stirred pan strike volumes being higher than the unstirred pan. No significant differences in exhaustions were noted.

In the case of the stirrer at 41,2/27,5 rpm, (Table 4) an improvement of approximately 16% in boiling time with the stirrer in spite of boiling massecuites to a higher volume and lower purity. Slightly higher exhaustions at strike were obtained for the unstirred pan, possibly due to the higher massecuite purity.

The differences in the results obtained, as shown in Table 4, at the two sets of stirrer speeds cannot be attributed to the stirrer speeds alone. The results at the lower speeds were obtained between June and September and those at the higher speeds between October and November. The later months are usually when poorer quality massecuites are boiled. The results therefore indicate that greater improvements in boiling time may be obtained with the stirrer when massecuite quality deteriorates.

Using the results from Table 4 and calculating the weighted averages for the entire season it is calculated that:

stirred pan boiling time = 5,0 h
stirred pan strike volume = 37,8 m^3
unstirred pan boiling time = 6,4 h
unstirred pan strike volume = 36,6 m^3
Therefore massecuite production rate for
stirred pan (including 20 m^3 seed) = 37,8/5,0 $m^3\ h^{-1}$
= 7,56 $m^3\ h^{-1}$
Similarly massecuite production rate for
unstirred pan (including 20 m^3 seed) = 36,6/6,4 $m^3\ h^{-1}$
= 5,72 $m^3\ h^{-1}$
Therefore gain in pan floor capacity due to
the stirrer = 7,56 − 5,72 $m^3\ h^{-1}$
= 1,84 $m^3\ h^{-1}$
= (1,84/5,72)%
= 32%

During the course of the trials it was decided to determine the effect of the stirrer at the design strike volumes (42,5 m^3). The trial with higher strike volumes was conducted over one week at stirrer speeds of 48/32 rpm. The results are shown in Table 5.

TABLE 5

Effect of the stirrer on boiling times at higher strike volumes

	Stirred pan	Unstirred pan	Significance
Boiling time (h)	4,9	7,9	*
Strike volume (m^3)	42,8	40,4	*
Massecuite brix	94,67	94,73	ns
Massecuite purity	54,47	55,30	ns
No. of strikes	14	8	

It was not always practical to boil massecuites in the unstirred pan to the desired 42 m^3 volume due to the very long boiling times. As a result the average volume boiled was approximately 40 m^3. The stirred pan took only 62% of the boiling time of the unstirred pan in spite of boiling approximately 2,5 m^3 more massecuite per strike. During the trials no differences were noticed in the time taken by either pan to discharge, cut-over or steam out the massecuite. As a result, the improvement in boiling time could only be due to the stirrer.

Evaporation rates

Initial tests were designed to determine the effect of injection steam on the evaporation rates of the stirred pan. The results are shown in Table 6.

TABLE 6

Effect of jigger steam on the stirred pan

	Stirrer without jigger	Stirrer with jigger
Ave. evap. rate (kg $m^{-2}\ h^{-1}$)	17,7	18,5
First hour evap. rate (kg $m^{-2}\ h^{-1}$)	20,4	21,4
Last hour evap. rate (kg $m^{-2}\ h^{-1}$)	15,4	16,7
Strike volume (m^3)	36,9	36,8
Massecuite brix	95,39	95,35
Massecuite purity	50,11	49,47
No. of strikes	14	16

The tests showed very little difference in evaporation rates of the stirred pan with and without the use of injection steam. It was subsequently decided to stop the use of injection steam in the stirred pan. The evaporation rate results obtained at different strike volumes are shown in Table 7.

TABLE 7

Effect of the stirrer on evaporation rate at low and high strike volumes

	Low volumes		High volumes	
	Unstirred + jigger	Stirred without jigger	Unstirred + jigger	**Stirred without jigger**
Ave. evap. rate (kg $m^{-2}\ h^{-1}$)	12,4	18,3	9,3	17,2
First hour evap. rate (kg $m^{-2}\ h^{-1}$)	17,7	22,1	15,4	19,1
Last hour evap. rate (kg $m^{-2}\ h^{-1}$)	9,6	16,9	7,7	14,6
Strike volume (m^3)	36,7	37,7	41,4	42,9
Massecuite brix	95,23	95,14	94,65	94,61
Massecuite purity	52,06	52,40	54,38	55,72
No. of strikes	60	37	3	6

The results show an improvement of approximately 50% in evaporation rate with the stirrer at low volumes and without injection steam. The results also show that the evaporation rates obtained over the first and last hour of boiling were significantly higher in the case of the stirred pan. There were no significant differences in evaporation rate with the stirrer on 48/32 rpm or 41,2/27,5 rpm.

During the trial with high volume strikes an improvement of approximately 80% in evaporation rate was obtained by the stirred pan. The evaporation rate at the end of the boiling was still considerably higher for the stirred pan than for the unstirred pan. In comparing the results for pans at high and low volumes a greater difference is found in evaporation rate from low to high volumes in the case of the unstirred pan (from 12,4 to 9,3) than for the stirred pan (from 18,3 to 17,2).

Massecuite exhaustion

The massecuite and final molasses purities obtained throughout the season are listed in Table 8.

TABLE 8

Effect of the stirrer on massecuite exhaustion

	Stirred pan	Unstirred pan
Exhaustion	53,63	53,86
Molasses purity	33,18 (n = 1 275)	33,37 (n = 1 175)
Cooling time (h)	58,9	61,5
Massecuite brix	95,19 (n = 309)	95,15 (n = 286)
Massecuite purity	51,87	52,05

The results show that the exhaustions obtained after cooling were similar. However, the actual molasses purity from the stirred pan massecuite was marginally lower in spite of the massecuite being cooled for a shorter time.

Crystal size distribution

The crystal size distribution results obtained on five pairs of weekly samples taken at the centrifugals are given in Table 9. The results appear to be similar for both pans.

TABLE 9

Effect of the stirrer on crystal size distribution

	Stirred pan	Unstirred pan
Mean width (microns)	91	90
Standard deviation	41	44
Elongation factor*	1,8	1,9

$$* \text{ Elongation factor} = \frac{\text{mean length}}{\text{mean width}}$$

Conclusion

The results show the stirrer to have a very strong positive effect on boiling time and evaporation rates. The gain in boiling time ranges from approximately 16% (at low volumes) at the beginning of the season to approximately 38% (at high volumes) towards the end of the season, and appeared to improve as boiling conditions deteriorated. In terms of pan floor capacity a gain of approximately 32% was obtained with the stirrer. The results on crystal size distribution and massecuite exhaustion show no significant differences between the two pans. During the season no mechanical or electrical problems were experienced with the stirrer.

In conclusion, the stirrer appears to be a very viable proposition for pan floor expansion. However, it must be remembered that the results will vary from pan to pan depending on the circulation characteristics of the pan. The improvement may not be as marked if a stirrer is fitted to a pan with inherently good natural circulation.

Acknowledgements

The authors wish to thank Mr R. Crowe and the staff of Noodsberg sugar mill for their co-operation during the season. Thanks are also due to the members of the Processing Division and Analytical Services Division at the Sugar Milling Research Institute for their assistance and C.G. Smith Sugar Ltd. for permission to publish this work.