ASSESSMENT OF FINAL MOLASSES COOLERS

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Abstract

A tubular heat exchanger at the Empangeni mill and two plate type units at Gledhow and Sezela were assessed. Heat transfer coefficients of 112 Wm^{-2} °C^{-1} at Gledhow, 130 Wm^{-2} °C^{-1} at Sezela and 95 Wm^{-2} °C^{-1} at Empangeni were obtained.

Introduction

The introduction of continuous C-centrifugals to the sugar industry has resulted in the production of high brix, low purity C-massecuites of very high viscosity. To facilitate centrifugalling, these massecuites have to be reheated to high temperatures, approaching 70° C at times. In addition, steam and hot water have to be used in the centrifugals with the result that the temperature of the molasses is seldom below 60° C when it leaves the machines. Meade and Chen[1] state that rapid decomposition of molasses may occur if the temperature is above 42° C when the molasses goes to storage.

In order to achieve this, some South African factories have installed molasses coolers in recent years and indications are that many more might follow suit in the near future.

Very little literature is available on molasses coolers. Player *et al*[2] report experience with a finned tube cooler in Australia. They found that cold molasses tended to build up on the finned surfaces, thereby progressively reducing the rate of heat transfer. They reported heat transfer coefficients of 6-11 Wm^{-2} °C^{-1} compared with the design value of 69 Wm^{-2} °C^{-1} for this cooler. Increasing the molasses velocity by changing the number of passes from 1 to 10 did not affect the performance of the unit.

Difficulties were also encountered in operating cooler units in parallel at high throughputs. If molasses was slightly cooler in one unit the resistance to flow increased in that unit, thereby increasing the flow into the other unit. When this happened the molasses became cooler in the one and hotter in the other and eventually the unit with the cooler molasses tended to block.

The tests described in this paper were carried out on three industrial coolers: a shell-and-tube heat exchanger at Empangeni and plate type exchangers at Gledhow and Sezela. These are described below.

Equipment

The tubular heat exchanger at Empangeni was originally designed as a liquid-liquid mixed juice heater. The unit has 6 passes of 22 stainless steel tubes each, contained in a mild steel shell. The molasses passes through the tubes whilst cooling water flows on the outside. The unit is situated in the open next to the molasses storage tanks.

Both Gledhow and Sezela use plate type heat exchangers, supplied by APV Kestner, which consist of a frame in which closely spaced metal plates are clamped between a head and follower. In both these units the molasses flows in one single pass and the cooling water in 5 passes in series. The plates are made of 0,71 mm thick 316 stainless steel and the space between plates is 6,147 mm. The plates carry a special trough and dimple pattern which increases the effective heat transfer area and at the same time produces turbulence in the liquids. The units at Sezela and Gledhow are installed next to the centrifugal floor and the molasses is cooled before it is weighed. Detailed specifications of the three heat exchangers and their auxiliary equipment are given in Table 1.

TABLE 1

Specifications of the three molasses coolers

Specifications	Empangeni	Gledhow	Sezela
(*a*) Type	shell and tube	plate	plate
(*b*) Make	—	APV Kestner	APV Kestner
(*c*) No. of tubes/ plates	6 × 22	96	160
(*d*) Tube/plate material	S S	S S 316	S S 316
(*e*) Tube/plate dimensions	50,8 mm OD	1556 mm × 416 mm	1556 mm × 416 mm
(*f*) Heat transfer area	102 m²	50 m²	83 m²
(*g*) Overall dimensions			
length:	± 4900 mm	1613 mm	2280 mm
width:	± 2 000 mm	756 mm	756 mm
height:	± 1 500 mm	1892 mm	1892 mm
(*h*) Molasses pump	Mono CD 82	Mono D 80	Mono D 80
(*i*) Installed power	27kW	13kW	10kW
(*j*) Budget price (1980)	R22 500	R9 000	R15 000

Results

The performance of the three units is summarised in Table 2. Temperatures and pressures are the average recorded at 5 minute intervals, over periods of one hour. The molasses flow rate was obtained by the difference in scale readings at the beginning and end of the test run. The water flow rate could not be measured directly and has been calculated from a heat balance.

TABLE 2

Performance of the three coolers

Performance Parameters	Empangeni	Gledhow	Sezela
(*a*) Molasses flow rate (th^{-1})	8,1	11,5	12,6
(*b*) Molasses brix	79,8°	81,0°	80,8°
(*c*) Molasses viscosity at 50° C (Pas)	2,7	—	6,3
(*d*) Molasses temp. (°C)			
inlet	49,8	59,8	62,1
outlet	33,8	42,8	36,7
(*e*) Cooling water flow rate (th^{-1})	20,7	13,8	6,1
(*f*) Water temperature (°C)			
inlet	30,4	30,2	23,3
outlet	33,2	36,3	46,0
(*g*) Log mean temperature difference (°C)	8,3	17,5	14,8
(*h*) Heat transfer coefficient (Wm^{-2} °C^{-1})	95	112	130
(*i*) Average molasses velocity (mms^{-1})	35	18,5	12,2
(*j*) Pressure drop across cooler (molasses side) kPa	63	431	57

Discussion

It must be noted that the assessment of these coolers was carried out under the existing factory conditions, and no effort was made to optimise the performance of the units.

The cooler at Sezela was operating below the design capacity of 17 th^{-1}, and the cooling water flow was deliberately reduced to prevent over-cooling of the molasses. This operational procedure adversely affected the heat transfer coefficient which consequently could, under design conditions, be higher than reported.

Measurements at Empangeni and Gledhow were made about a month after the last cleaning operation, while at Sezela the plates were hosed down with water before the test run. The high pressure drop at Gledhow (431 kPa) could be due to dirty plates, although the high velocity could be a contributing factor. Unfortunately no confirmation could be obtained as the cooler was not opened and inspected after the test.

Empangeni and Sezela appear to have ample cooler capacity to accommodate either more or higher temperature molasses. The heat transfer coefficients obtained are relatively high in comparison with C-crystallisers (5-15 $Wm^{-2}\ °C^{-1}$), C-massecuite reheaters (5-10 $Wm^{-2}\ °C^{-1}$) and the values reported by Player *et al*[2] (6-11 $Wm^{-2}\ °C^{-1}$). The plate type units gave a higher heat transfer coefficient in spite of the fact that the molasses velocity was lower than that in the tubular unit. This can be attributed to the special design pattern of the plates, which is meant to cause turbulence in the flow at low fluid velocities and thus improve heat transfer.

Definite advantages of the plate type units are their compactness and the ease with which the heat transfer area can be increased by adding more plates. The plate exchangers are also easy to clean and the plate surfaces are readily accessible for inspection. In this connection it appears that all three units require very little attention while in operation. The plate type units were cleaned about once a month by simply opening the plates and hosing down with water, while at Empangeni the tubular unit was cleaned once a season by brushing. The mechanical maintenance costs are virtually nil, except for an occasional coat of paint.

Conclusions

Although molasses can be cooled quite efficiently in a tubular heat exchanger the plate type units present many advantages. These advantages, together with the lower price structure, make plate type heat exchangers a much more interesting proposition for molasses cooling.

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REFERENCES

1. Meade, G. P. and Chen, J. C. P. (1977). Cane Sugar Handbook (10th Edition). John Wiley and Sons, New York. p. 365.
2. Player, M. R., Smith, E. A. and Ness, J. N. (1978). Design of molasses coolers. *QSSCT Proc* **45**: 183-189.