

EXPERIENCES WITH THE DARNALL ELECTRIC MASSECUITE HEATER

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The purpose of presenting this paper is to promote some interest and discussion on the subject of electric heating of massecuites by tracing the development of an electric heater at Darnall. The heating of "C" massecuites electrically was started in 1963/4 and progressed through various trials, tribulations, and re-designing of plant, until the end of last season.

The idea of electric heating is to reheat final massecuites, prior to curing, without the temperature differential inherent in any conduction type heater. Therefore, theoretically, it is possible to heat to the saturation temperature without any parts adjacent to heating elements being overheated, with the resultant melting of crystal. Darnall had rotating element heater/mixers on the "C" station, originally heated with steam, but subsequently converted to a hot water circulating system. It was decided to try and heat the total "C" massecuites flow electrically and to then keep the hot water circulating in the heater/mixers slightly below saturation temperature.

The basic requirement of the heater was to be able to raise the temperature of some 320 cu ft/hr of "C" massecuite from 100°F to 140°F and thus:

$$\begin{aligned} \text{Power required} &= \\ 320 \times 96(\text{lb/hr}) \times .33(\text{Sp. heat}) \times 40(^{\circ}\text{F temp. rise}) & \\ 3412 (\text{BThU/Kw}) & \\ = 120\text{Kw} & \end{aligned}$$

It was obvious that with this sort of power involved, a reasonably balanced three phase load would be required. Some tests were undertaken to determine massecuite resistance at varying temperatures and these were found to vary between 400 ohms per cu in at 100°F, to 70 ohms per cu in at 130°F. From this basic information, the heater shown in Figure I was designed, the electrode areas were proportioned to obtain approximately equal loading on each phase applied to the three electrodes. The shell of the heater was earthed and the 550 volt factory supply was applied to the internally insulated electrodes giving a potential of 320 volts across the massecuite to earth. Control was through a single thermostat switch which controlled the main contactor, i.e. an "on-off" control.

This heater was made and inserted into the pumping line from crystallisers to centrifugals. It became apparent after trials that the temperature control was not adequate and after charred massecuite was observed in the discharge, the heater was opened up, and it was discovered that the insulating plugs between electrodes had broken down and current was passing between electrodes; the potential between electrodes being 550 volts compared to the 320 volts across the massecuite. It was also apparent that due to the vast variations in resistance between massecuites a more sophisticated temperature con-

trol was required, the aim being to keep the massecuite temperature within 1°F.

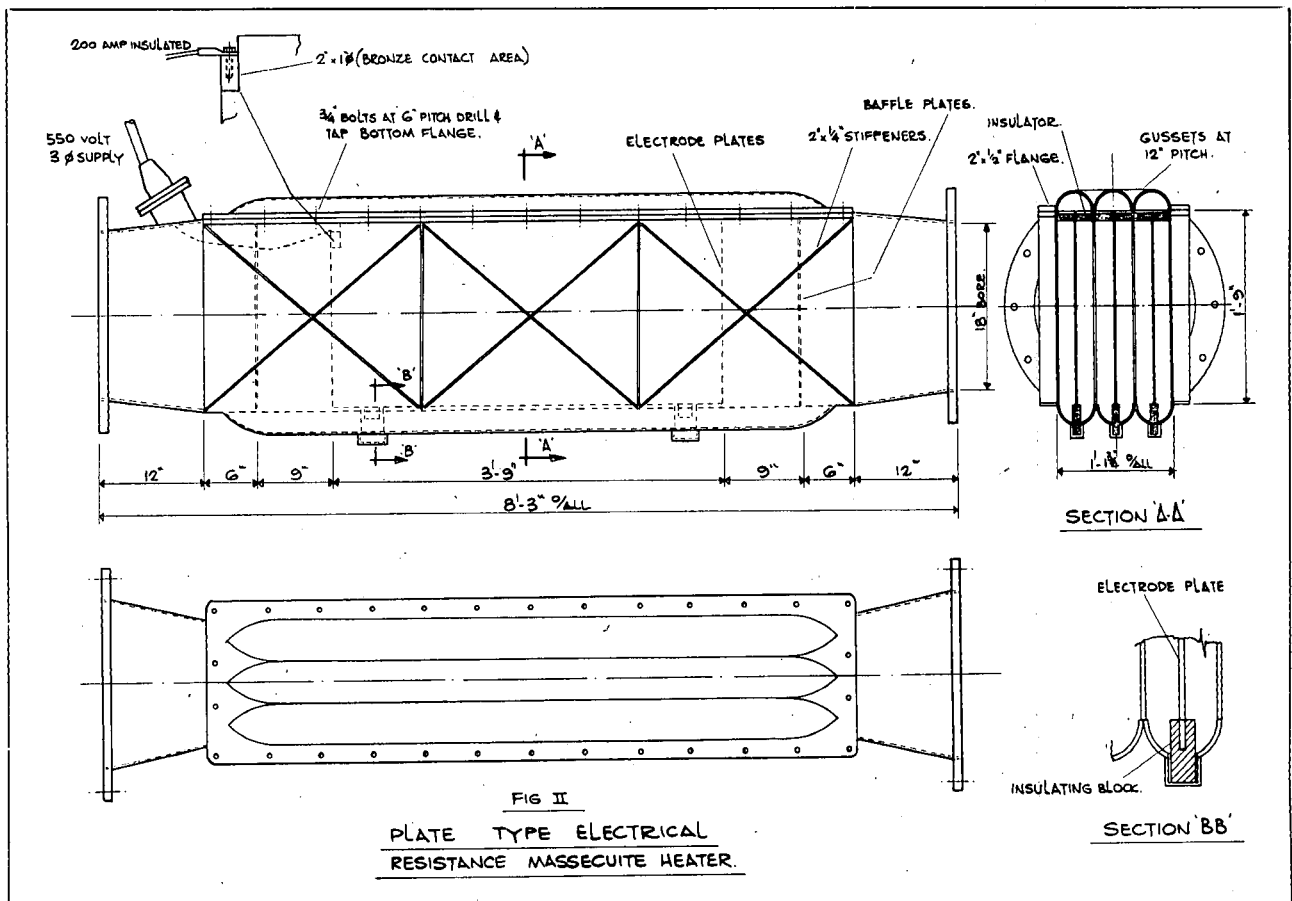
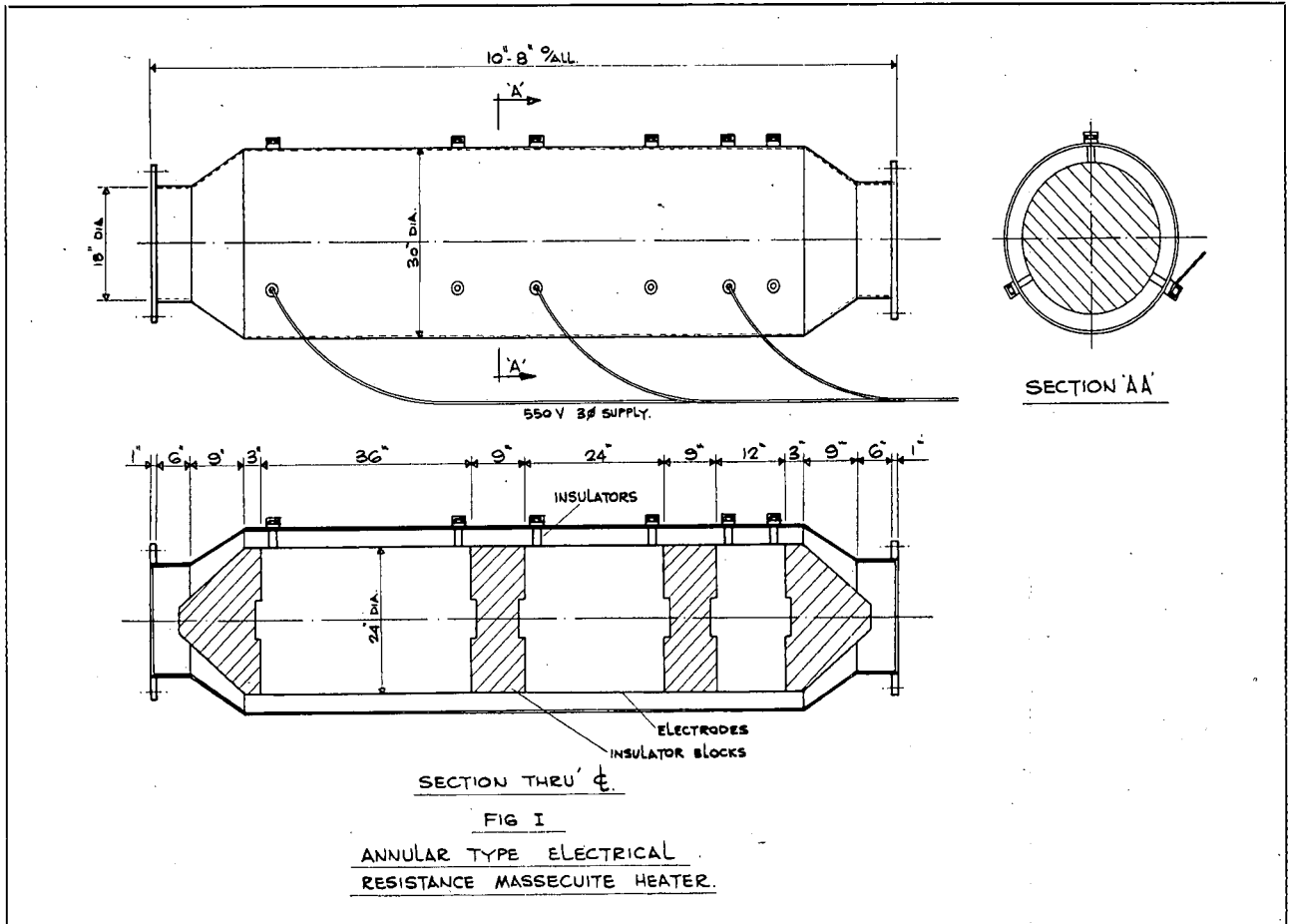
A plate type heater was then conceived with electrodes in three separate cells. This design is shown in Figure II. The insulation problems between phases were thus circumvented and construction was fairly straightforward. The electrode plates were each segmented into five separate plates with areas designed to give 50% of the load on the first plate and the subsequent plates giving equal steps in electrical load. Each segment of electrode was insulated with slotted strips from its neighbour and was switched by a contactor controlled by a 5-step two term temperature controller. Results were encouraging, but control was still not accurate enough and the mechanical fixing and insulating of the segmented plates gave trouble.

It was considered that better control would result from a variable voltage control with the added advantage that the segmented electrodes could be dispensed with and replaced by single plates. An old open type 300 hp motor was obtained and set up with a locked rotor which could be positioned through a torque arm by a pilot motor. This gave an available three phase voltage varying from 120 to 400. A current controller was connected in cascade with the temperature controller and an overriding thermal switch cut off the supply if the massecuite temperature was too high, despite the minimum voltage being applied. The whole installation then became a going concern and was relied on to the extent that extensions were made to curing capacity without providing further heating facilities. Close temperature control, however, remained a problem.

The problem of accurate temperature control is due to the rapid variation in massecuite conductivity with temperature. Massecuites of low temperature obviously require more heat input, but their resistance is higher than hotter massecuites which require less heat input. The rate of change of current at a fixed voltage is rapid, making the current controller essential. The effect of diluting massecuites with water or molasses to promote flow down the gutters is also disastrous on close temperature control.

The method used for voltage variation was somewhat cumbersome and was necessitated by economics. The use of controlled silicon rectifiers probably presents a far more elegant solution to the problem.

There is no doubt that electric heating of massecuites can give advantages over the conventional methods of re-heating. However, the accurate control required is not easy to achieve. A full comparative investigation of results achieved with the plate heater remains to be carried out.



Discussion

Mr. Hulett (in the chair): The chief disadvantage of the heater at Darnall was its unreliability. Any small tramp iron in the massecuite would blow it out. If it had been thyristor controlled, and made up in sections, this could have been overcome.

With a continuous centrifuge the massecuite could be super-heated above saturation temperature just before curing, so that there would be no time for the sugar melted in the vicinity of the crystal to diffuse through the molasses. A lower molasses purity might then be achieved.

Mr. Gunn: It was estimated that the heater would require 120 kw but did it actually require more than this?

Mr. Renton: No, it used about 120 kw on average, but if the massecuite was very cold and tight it would not take enough power even at full voltage.

Mr. Stender: For this installation of 320 cu. ft. I calculate the requirement to be 200 kw.

Mr. Hulett: This was calculated for an average condition, which seldom prevails.

There will be high flow rates if the massecuite cures well and vice versa.

The installation is actually too small for a mill the size of Darnall.

Mr. van Hengel: Considering the inherent drawbacks in either water or electrical heating of massecuites I suggest that the initial heating should be done with water, at a temperature not higher than saturation temperature, and the rest of the heating electrically.

Mr. Renton: An advantage with a continuous machine is that only one phase is involved for the heater instead of three, as the load is not big. Therefore construction is simplified and control is precise.

Mr. Robinson: One of the problems at Darnall was that a tight massecuite sometimes breaks the insulators of the electric heater and this could have been avoided by some preheating of the massecuite.

Mr. Hulett: While the massecuite is in contact with the insulators it is stationary and the current in that zone causes overheating.