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BATCH PROCESS DRY RENDERING

For the past 2 years investigations into heat and mass transfer aspects of batch dry rendering have been carried out under the direction of L.S. Herbert, CSIRO, Division of Chemical Engineering.

A standard type batch cooker was used in the trials and most test runs have used normal works rendering procedure which involves charging the cooker with approximately equal quantities of hard offal (crushed heads and bones) and soft offal (mainly guts and paunches) giving an initial water content between 50 and 55%. Cooking proceeds at just above atmospheric pressure until most of the water has been evaporated when, at a point in the cycle indicated by a conductance end point controller (at about 20% water by weight), pressure is applied to the cooker contents. A rapid rise in pressure to 40 psig is followed by a slow depressurisation, with the end of the cook being reached soon after contents pressure has returned to atmospheric. For a typical charge weight of 8,500 lb the cooking time was 2 - 2½ hours, of which about 1½ hours is at slightly above atmospheric pressure and ¾ hr at pressures up to 40 psig. The following is an outline of some of the findings:-

In all runs there was a general pattern of variation of heat transfer rate with time from the start of the batch cycle. There was a high initial rate of heat transfer as indicated by the high flow of steam to jacket and shaft, corresponding with a high rate of flow of vent gases. It is believed that heat transfer during this stage is from heated wall to a two phase liquid mixture in which water has free access to the wall - the water being the continuous phase, and oil the disperse phase. After 20 - 30 minutes, the heat transfer rate declined rapidly until at about half-way through the cycle it was only about 30% of the initial rate, at which low value it remained until discharge. During this stage the liquid phase is oil only, and the remaining water is bound inside particles of solid material. The smaller the particle, the faster will be the drying out and hence particle size is obviously an important variable from the viewpoints of evaporation of water, and of sterilization. Approximately twice as much water was evaporated from the cooker contents in the first hour of cooking time as in the second hour.

The contents temperature reached about 220°F (corresponding to a pressure slightly above atmospheric in the cooker) and remained almost constant until pressure was applied. It increased to a maximum of about 280°F at maximum pressure 40 psig and decreased on depressurisation to 235 - 240°F at time of discharge. In the runs with no pressurisation, the contents temperature remained at around 220°F until the last twenty minutes of the cycle, when there was a rapid increase to 240 - 250°F at the time of discharge.

Steam consumption varied between 1.2 and 1.3 lb steam/lb water evaporated, equivalent to ~~2.2 - 2.4~~ 0.66 - 0.72 lb steam/lb charge material of 55% water content. Heat losses from this well insulated cooker were about 150 - 200 lb/hr steam equivalent.

The amount of heat transferred by the shaft was found to be affected by changing the procedure of operation of the shaft steam valve. When the shaft steam valve was left on during the charging period, 25% of the total heat was transferred by the shaft, with the remaining 75% transferred by the jacket. When shaft steam was turned off during the charging period and turned on only when the cooker was fully charged, the heat transfer by the shaft increased to 42% of the total heat. When using the latter method of operation, 1 sq. ft. of shaft surface area was found to be more effective in transferring heat then 1 sq. ft. of jacket area. Heating the shaft when the cooker is only part charged is believed to encourage burning of protein onto parts of the shaft not submerged in the contents.

It appears that an increased shaft speed would result in improved heat transfer rates. However, the present design of steam heated shaft relies on gravity to drain condensate from the beaters and support arms, and the shaft must be run at a speed lower than that at which centrifugal force would interfere with such drainage - in a 5' diameter cooker about 30 rpm. A design of steam heated shaft which incorporated forced drainage of condensate would be operable at higher speeds and should enable higher heat transfer rates to be achieved. For non-heated shafts, an increased speed would be desirable, particularly in the second half of the cycle when the heat transfer is at a low level. At this stage there would be a reduced volume of contents and an increase in speed could be accommodated within the power rating of the existing motors.

Pressure is generally applied as part of a standard cooking procedure. Depressurisation is a time consuming manual operation which increases the cooking time required by at least 15 minutes, and generally much longer. In addition there is some risk of carry-over of contents if the pressure release is too rapid. A simple method of indicating the maximum rate of pressure release has been devised, using the fact that the flow of vent gases through the pipeline to the condenser results in a pressure drop which is proportional to the flow-rate. For example, a pressure gauge at the cooker end of the vent pipe reads about 1 psig when the vent gas flow is about 1,000 lb/hr, and it has been established that this is a safe flow-rate which does not result in carry-over. It is, therefore, possible for the operator to adjust the rate of opening of the vent gas by-pass valve to maintain the pressure in the vent gas line at close to 1 psig, enabling rapid depressurisation to be achieved. A pressure switch has been installed in the vent gas line which gives a green light when the pressure in the line is below 1 psig and a red light when above 1 psig. The operator stops opening the by-pass valve when the red light appears and resumes opening only when the green light reappears. If this method of control proves effective, the electrical signals will be used as the basis for automatic control of depressurisation.

During the experimental programme, samples of meal were analysed for nutritional value and samples of tallow for F.F.A., colour etc. Results to date suggest that time/temperature conditions during cooking are only partly responsible for degradation of product quality; other factors include deterioration of the charge in storage before cooking and product reactions after cooking, for example in percolators and presses.

SUGGESTIONS FOR CHANGES IN OPERATION

The main time factor in dry rendering is for the removal of water by evaporation and for this reason added water from washing etc., must be kept to a minimum. Particle size is also important, since the smaller the size, the more rapidly can water be evaporated from the protein and bone particles during the later stages of the cook.

The following changes appear to be desirable, based on observation of operations on the test cooker. Although this cooker is believed to be typical of batch rendering plants now being used in Australia, care should be taken in applying the suggested changes to cookers in which substantially different charge materials, steam pressures etc. are used:

- Shaft heating permits a substantial increase in throughput. In one run in which 4674 lb water were evaporated from 8400 lb charge, cooking time with shaft heating was 2 hr 6 min compared with an estimated 3 hr 36 min without shaft heating. On this basis, for an 18 hr day, shaft heating would increase cooker capacity from five to eight batches, an increase of about 60%.

- It was apparent that the effectiveness of shaft heat transfer surfaces was greatly reduced by leaving the shaft steam turned on during the ten minutes charging period. To obtain the best results, it was necessary to turn off the shaft steam during the charging period, turning it on only when the cooker was fully charged. Compared to leaving the shaft steam on during charging, this procedure reduced the typical cycle time by about 15%, or approximately 20 minutes.

- An increase in shaft speed and the resulting increase in heat transfer rate would be particularly beneficial in the latter stages of the rendering cycle. It is unlikely that existing motors would be overloaded if the speed were to be increased only during the last hour of a two-hour cook.

  It is generally not possible to increase the speed of steam-heated shafts, since they must run below the speed at which centrifugal force prevents condensate drainage (about 30 rpm in a 5' diameter cooker). An improved design of heated shaft which drained by steam pressure would allow this speed limitation to be overcome.

- Cooker contents are pressurised as part of the standard cooking procedure at many Works. Depressurisation is a time-consuming manual operation which increases the cycle time by at least fifteen minutes and generally much longer. In addition, there is some risk of carry-over of contents if the pressure release is too rapid. In some works, with suitable follow on equipment, pressurisation has been discarded with considerable improvement in cooker operation and no apparent disadvantage in product quality.

- However, assuming that pressure application is to be retained, pressure release can be speeded up without risk of carry-over, if the vent pipe pressure is used as an indicator of vent gas flow.

- In many rendering plants, there are design faults associated with the size of the steam supply pipes and valves, with condensate drainage and steam trapping and with non-condensable gas removal. Thus, where steam pipelines are under-sized and produce high pressure drop (particularly during periods of high steam flows occurring during the first half hour of the cycle), steam pressure in the jacket and shaft steam spaces is decreased and performance is reduced.

Such losses of performance are generally impossible to assess, since instruments normally fitted are not adequate and there are no entries into cooker or steam lines to enable special tests to be made. A small expenditure on entry points during manufacture and installation of new plants would enable limited but useful performance tests to be carried out.

The CSIRO Division of Chemical Engineering is continuing work on the development of improved rendering processes. Further enquiries may be made directly to Mr. L.S. Herbert, at the CSIRO Division of Chemical Engineering, Lorimer Street, Fishermen's Bend, Victoria.

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NEWS JOTTINGS:

Cleaning and Sanitation Working Party

The next course is to be held in Perth on the 18th and 19th September, 1970.

Next Issue is Foam Cleaning.