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Clingstone Peaches

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Energy Use Quantification in the Canning of Clingstone Peaches.

P. A. CARROAD, R. P. SINGH, M. S. CHHINNAN, N. L. JACOB, and W. W. ROSE

ABSTRACT

Thermal and electrical energy usages in a California clingstone peach cannery were monitored to establish energy consumption levels and to identify energy intensive unit operations. Representative processing lines were instrumented with orifice plates for steam flow measurements and with electric watt transducers for electrical power monitoring to yield actual consumption values. Steam use in the lye peelers and retorts accounted for 98% of all energy consumed, indicating that further examination of these operations for modification or equipment redesign should be a first priority for energy conservation. Pumping of liquids and dry conveying of fruit and waste material accounted for 61% of all electrical energy use. Electrical energy use amounted to only 2% of the total energy used, however, on an equivalent fossil fuel use basis.

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INTRODUCTION

Much has been written concerning energy and food processing. In spite of the bulk of the literature accumulated, little is certain concerning energy supply except that technological availability is influenced by political and economic factors and that energy conservation is a worthy goal of every user for extending supplies into the future. Energy conservation is itself a demand issue. Numerous articles have suggested methodologies for effecting energy conservation in a processing plant (Dietz, 1977; Dietz and Forwalter, 1978; Electric and Gas Industries Association, 1976; Hollingsworth, 1978; Opila, 1978; Singh, 1978; Troyan, 1978). There are not as many articles which resolve energy use into demand by each unit operation, although this is the level of study needed to effect reduced demand (Chhinnan et al., 1978a; Flink, 1977; Singh et al., 1979). The latter type of study focuses attention on each unit operation, classifies energy use as thermal or electrical, allows the processor to identify the most consumptive operations where equipment redesign or modification might yield the greatest reduction in demand, and requires a more detailed effort than one which relies only upon overall plant data (Vergara et al., 1978).

This article describes a study of unit operations specific to peach processing. It is part of an overall project conducted by the National Food Processors Association (NFPA) and the University of California at Davis (UCD) to quantify energy use in the fruit and vegetable processing industry. Other products studied were spinach (Chhinnan et al., 1978a) and tomatoes (Singh et al., 1979). For these three products the processing lines were instrumented to determine thermal and electrical energy inputs. The quantification of the energy requirements of different unit operations

concludes the first phase of the study. The second phase will focus attention on a variety of energy intensive unit operations and will analyze them more fully in several different processing plants. The ultimate goal of the project is modification and redesign of equipment for energy conservation and the implementation of such changes.

EXPERIMENTAL

Processing Description

The processing of California clingstone peaches was studied in a northern California cannery during summer, 1978. The peach processing unit operations which were instrumented for quantification of energy use included fruit washing, shaking, grading, pitting, inspecting, and lye peeling. Retorting was not included explicitly as a peach processing operation in this project since it was studied as part of associated projects on tomatoes and peaches (Singh et al., 1979; Chhinnan et al., 1978b) which allowed its estimation. Energy demand of syrup preparation was not included in this study based upon the observed limited requirements of the operation. Can filling and seaming operations were studied in the same cannery in association with a tomato canning line (Singh et al., 1979). A similar electrical energy input for peach canning would constitute only 0.06% of the total energy required by the peach processing line and on this basis the filling and seaming operations were excluded from consideration in this study.

The peach processing line was divided into six monitoring stations. Depending upon the unit operations monitored and their relative location, measurement at each station included several points of steam and/or electricity application. Peaches were delivered to the plant in bins. Peaches were dumped into a water tank, and were elevated out onto a

conveyor. Waste material was removed. The peaches were graded for size, rinsed in tanks, and elevated from the rinse tanks. They were then pitted, oriented cup up, inspected for pit fragments, and oriented cup down for lye peeling. Fruit with pit fragments were repitted. Pits and other waste material were conveyed out of the plant by pumps. Peaches proceeded through the lye peelers, rinse sprays, cup up shakers, inspection belts, and size graders. Additional waste material was removed and pumped from the plant to a dump site. Finishing operations which were not included in this energy study were slicing, filling of cans, adding syrup, can seaming, retorting, and palletizing. The processing line is diagrammed in Figure 1.

Monitoring Procedures

Thermal Energy

Steam flow was measured by inserting a flanged orifice plate in the steam pipe feeding the unit operation being monitored. The only operation which was monitored in this study that required steam was lye peeling. The differential pressure across the orifice plate was sensed by a differential pressure cell (Foxboro) which emitted an electrical signal proportional to the steam flow. The signal was scanned and recorded by a data-logger (Accurex). Steam quality was determined calorimetrically.

Electrical Energy

Electrical energy was measured by wiring electrical watt transducers (Ohio Semitronics) into the circuit between motors and circuit breakers. The watt transducer generated an electrical signal proportional to the energy used by the motor. The signal was scanned and recorded by the data-logger. The percentage of time that a motor was in operation was observed manually. Seventeen of the 167 electrical motors in the processing line were selected as representative and were wired with watt transducers. The

seventeen motors which were monitored included the large motors and several smaller motors. Many of the motors were similar in size and duty.

Mass Flow

The mass flow of peach halves into the lye bath was determined by repeatedly photographing a measured section of the loaded inlet conveyor belt. Halves in the photograph were counted and the mass flow was calculated from the belt speed and the weight of a given number of representative samples of peach halves established previously. Cannery records on mass flow and waste removal were also available.

RESULTS AND DISCUSSION

The results of this study are shown in Figure 1 on an energy accounting and mass balance diagram. Symbols conform to those suggested by Singh (1978). The mass flow numbers were derived from actual measurements and plant records. All energy inputs were measured except for those due to retorting of peaches. The amount of electrical energy needed to turn the retort reel was available from a study of tomato processing in the same plant and is a relatively minor component of total peach processing electrical energy use, 11% (Singh et al., 1979). Thermal energy required in retorting of peaches was assumed equivalent to that found in a previous study of peaches (Chhinnan et al., 1978b), the rationale being that since the thermal processes for both peach operations were quite similar in temperature (98°C previous study and 102°C this study), energy losses from the retort should be similar. In comparison, tomato juice was processed at 121°C. The previous study showed that on average only 25.75% of the thermal energy input was required to heat the cans from initial to retort temperature. The same factor was assumed for this study and was applied to the known mass of canned peaches packed. It is recognized that in general such an estimation is subject to differences in retort temperature, steam quality, percentage of retort capacity used,

type of product, can size and other factors, but the similarity of the two operations in this case justifies the procedure. The 263.3 GJ of thermal energy required per shift was used by 9 retorts.

Analysis of the electrical energy data showed that electrical motors and pumps were generally operated below the manufacturers' rated power. For the motors tested, the average ratio of actual power used to rated power was 0.36. This ratio was applied to the rated power values of the motors which were not measured to estimate the total electrical energy consumption. A total of seventeen motors were instrumented with electric watt transducers for direct monitoring. Forty-one other motors were similar in size and duty to those measured. The other 109 motors were generally smaller and included the 65 pitter motors of 559.W (0.75 horsepower) each. Total electrical energy consumed, including that attributed to retorting as previously described, was 737.0 kWh per 8 h shift as shown in Table 1. A majority of the electrical energy was used for transport of fruit and waste rather than for unit operations such as pitting and peeling. The electrical energy consumed in dry conveying was 169.7 kWh per 8 h shift, or 23% of the total. Pumps used to transport wastes or to recirculate liquids added another 277.8 kWh per 8 h shift, or 38% of the total. Conveying and pumping account for 61% of all electrical energy use.

The retorts and lye baths represent the only uses of thermal energy considered as shown in Table 1. Syrup preparation was judged negligible. The average mass flow into each of three lye baths was 7,920.kg (8.73 tons) per 8 h shift, requiring 475.kg (1046.5 pounds) of steam per hour, at 0.998×10^6 Pa (130 psig) of quality 86.3%. Based on these values, the thermal energy use was 9.48 GJ per 8 h shift per lye bath. For three lye baths, the thermal energy input was 32.5 GJ (30.8×10^6 BTU) per shift. The thermal

energy required by the retorts was estimated to be 263.3 GJ ($249.6 \times 10^6 \text{ BTU}$) per shift.

Energy values shown in Figure 1 represent direct measurements or estimations of end use requirements. To compare electrical and thermal energy uses, equivalent values can be calculated based on the fossil fuel equivalent needed to generate such energy. For electrical energy, the factor $11.0769 \text{ MJ per kWh}$ converts end use electrical energy to an equivalent amount of fossil fuel burned to generate such energy (Chhinnan et al., 1978a). For thermal energy, a boiler efficiency of 70% can be assumed (Vergara et al., 1978). The calculated fossil fuel equivalent energy values for peach processing operations are listed in Table 2. On an overall processing line comparison, lye peeling and retorting are seen as the most consumptive operations, requiring 11.2% and 87.5% of all energy respectively. Other operations which are electrical energy intensive do not constitute a significant fraction of the energy used.

The mass flow into the cannery was $191 \times 10^3 \text{ kg}$ (210 tons) per 8 h shift. Waste accounted for 19% as pits and cull fruit. The mass flow entering the lye baths was $166 \times 10^3 \text{ kg}$ (183 tons) per 8 h shift, from which peel loss and additional weight reduction due to waste would be expected. Plant records showed a gross weight production of $231 \times 10^3 \text{ kg}$ (255 tons) of canned product per shift. Assuming that 67% of the gross weight of canned peach halves is fruit, the gross weight corresponds to $155 \times 10^3 \text{ kg}$ (171 tons) per shift of canned fruit. There is good agreement between the $166 \times 10^3 \text{ kg}$ measured at the lye baths and the $155 \times 10^3 \text{ kg}$ recorded as final canned fruit, assuming a 9% peel and waste loss from the lye baths and subsequent operations which is reasonable.

Conclusion

The results indicate that thermal energy operations are significantly more energy consumptive than electrical energy operations. This is in accord with results from other phases of this overall NFPA-UCD project (Chhinnan et al., 1978a; Singh et al., 1979). Peach processors should concentrate energy conservation efforts on thermal operations, such as lye peeling and retorting, to achieve greatest reduction in energy use.

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Table 1 - Energy consumption of clingstone peach canning operations
(Basis is one 8-hour shift)

<u>Processing Stage</u>	<u>Electrical Energy, kWh</u>	<u>Thermal Energy, GJ</u>
Receiving	4.3	--
Washing and initial size grading	65.1	--
Pitting and initial inspecting	260.1	--
Lye peeling	132.7	32.5
Final size grading and inspecting	30.0	--
Retorting (est.)	82.8	263.3
Waste removal	162.0	--
Total	737.0	295.8

Table 2 - Distribution of fossil fuel equivalent energy consumption among clingstone peach canning operations. (Basis is one 8-hour shift.)

<u>Processing Stage</u>	<u>Electrical Energy, GJ</u>	<u>Thermal Energy, GJ</u>	<u>Total, GJ</u>	<u>Percentage of total consumption</u>
Receiving	0.1	--	0.1	0.02
Washing and initial size grading	0.7	--	0.7	0.16
Pitting and initial inspecting	2.9	--	2.9	0.67
Lye peeling	1.5	46.5	48.0	11.15
Final size grading and inspecting	0.3	--	0.3	0.07
Retorting (est.)	0.9	376.1	377.0	87.51
Waste removal	1.8	--	1.8	0.42
Total	8.2	422.6	430.8	100.00

FIGURE CAPTION

Figure 1 - Energy accounting and mass flow diagram for canning of clingstone peaches.

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