CONTINUOUS STERILIZATION OF FRESH FRUIT BUNCHES

by: SIVASOTHY KANDIAH, ROHAYA MOHAMAD HALIM, YUSOF BASIRON, ZULKIFLI ABDUL RAHMAN and MA AH NGAN

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Sterilization is one of the key processes in the palm oil mill. The fresh fruit bunches are cooked using steam at a pressure of 3 bar for about 70 to 90 min. The bunches are sterilized in batches using two to six horizontal cylindrical shaped vessels called sterilizers fitted with one or two quick opening doors. Cages are used to transfer the bunches in and out of the sterilizers, and various other equipment are needed for the handling of these cages, including overhead cranes, tippers, conveyors, transfer carriages and tractors. Considerable space and a system of rails are required to facilitate the filling of the cages and the charging and discharging of the sterilizers.

All the fundamental operations in a mill can be carried out in a continuous manner except sterilization. The batch nature of the sterilization process introduces fluctuations not only to the quantity of material processed but also to the overall steam demand. The situation is made worse by the fact that about one-third of the steam generated in the mill is used for sterilization. Operations related to batch sterilization also absorb much of the process labour force in a mill. The use of steam at high pressure and intermittent pressure releases to achieve good sterilization complicates the problem of achieving continuous processing. In spite of the considerable research that has been carried out in the past on continuous sterilization, the technical and economic difficulties have not been overcome yet to make the process viable on a commercial-scale.

Exploratory studies by MPOB on disrupting the close-knit arrangement of fresh fruit bunches by crushing and subsequently sterilizing the bunches using a batch steam autoclave showed that the extent of nut breakage by the crusher was small (*Table 1*) and that there was no significant deterioration in the oil quality from bruising of the fruit mesocarp if the bunches are heated immediately after crushing (*Table 2*). The sterilization time and steam pressure required to achieve complete stripping of the fruits from crushed bunches was significantly lower than that used for normal bunches (*Figure 1*).

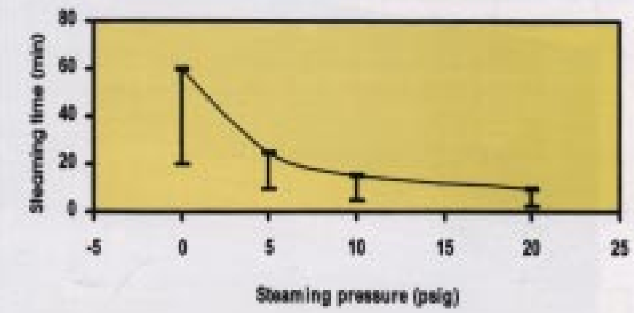

Figure 1. Relationship between steaming pressure and time to achieve complete stripping of bunches.

PROCESS DESCRIPTION

The ability to achieve complete stripping of fruits with sterilization using low pressure steam and without the use of multiple peak sterilization cycles facilitates the development of a continuous sterilization process. The problem of continuously transferring bunches to and from

TABLE 1. EFFECT OF BUNCH CRUSHING ON FRUITLET BRUISING

Parameter	Before crushing	After crushing	Due to crushing
Percentage of bruised fruitlets	2.88	33.62	30.74
Percentage of detached fruitlets	7.06	13.40	6.34
Percentage of broken fruitlets	-	1.90	1.90

Malaysian Palm Oil Board, Ministry of Primary Industries, Malaysia
P. O. Box 10620, 50720 Kuala Lumpur, Malaysia. Tel: 03-89259155, 89259775, Homepage: http: //mpob. gov. my Telefax: 03-89259446
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TABLE 2. THE EFFECT OF DELAYING STERILISATION OF CRUSHED BUNCHES ON FREE FATTY ACID FORMATION

Delay time (min)	Free fatty acid content of oil (%)
5	1.04
30	1.52
60	2.27

the sterilizer can be more easily overcome when using steam at low pressure. The method proposed for translating the above exploratory research finding into a technically and economically viable system for continuous sterilization consists of the following process steps:

Step 1: Disrupt the close-knit arrangement of fruits to facilitate steam penetration into inner layers of the fruit bunch.

Step 2: Heat the bunches from Step 1, while they are being conveyed continuously and progressively through a chamber, using live steam at atmospheric pressure, or at a pressure slightly above atmospheric pressure, to an extent sufficient to facilitate stripping of the fruits.

Figure 2 illustrates suitable apparatus for carrying out the above two steps.

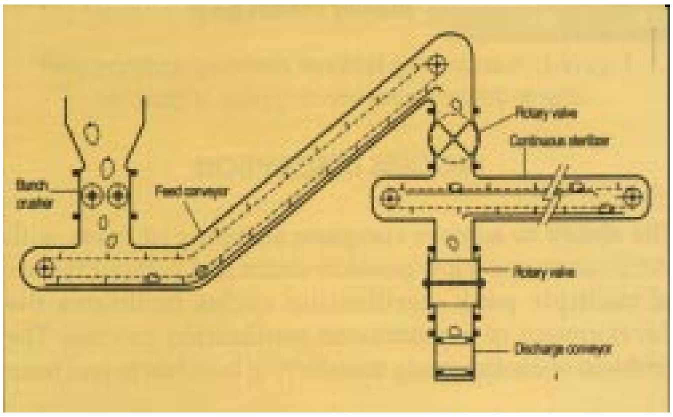

Figure 2. Proposed system for continuous sterilization.

Disruption of the closed-knit arrangement of the spikelets is achieved using a double-roll crusher (*Figure 3*). The proposed crusher has many advantages, including minimal nut breakage, simple and compact design, low investment cost, low power consumption, low maintenance and operating costs, and the ability to handle all types of bunches and high bunch throughput. *Figures 4* and *5* show fresh fruit bunches before and after crushing.

In the proposed process, the bunches are pre-heated using steam that bleeds from the continuous sterilization chamber. This facilitates heating the bunches immediately

Figure 3. Bunch crusher.

after they are crushed to above 60°C to deactivate the lipolytic enzymes responsible for the formation of free fatty acid. Pre-heating the bunches also facilitates deaeration and minimizes the amount of air entering the continuous sterilization chamber, thereby ensuring that the temperature in the continuous sterilization chamber is close to that of saturated steam. An additional pre-heating step may be used if the delay between crushing and steam heating is significant enough to cause oil quality deterioration. In this case, the bunches are

Figure 4. Fresh fruit bunches before crushing.

Figure 5. Fresh fruit bunches after crushing.

heated immediately after they are crushed using hot water maintained at above 60°C.

The bunches are further heated after they leave the continuous sterilization chamber using steam that bleeds from the discharge end of the continuous sterilization chamber. The bunches enter and leave the continuous sterilization chamber through one or more rotary valves, flap valves or gate valves to minimize the steam losses. The base of the feed conveyor can also be filled with water to seal against steam losses. This water bath can be heated to above 60°C to enable simultaneous deactivation of the lipolytic enzymes.

ADVANTAGES

1. Eliminates the use of sterilizer cages, rail tracks, overhead cranes, tippers, transfer carriages and tractors.

2. Renders the entire palm oil milling process a continuous operation that can be easily automated to make it less labour intensive.

3. The sterilization steam demand will remain approximately constant, thereby minimizing fluctuations in the steam pressure and electrical voltage and frequency. Such fluctuations would normally lead to problems such as higher product losses, poor product quality and reduced throughput.

4. Minimizes or eliminates the need for manual firing of the boiler to cope with fluctuations in the steam pressure, thereby improving boiler efficiency and reducing black smoke emission from the boiler stack.

5. Minimizes spillage of fruitlets and oil, thereby contributing towards making the mill cleaner.

6. Facilitates the design and construction of small and mobile mills having significantly smaller footprints than conventional mills.

PILOT PLANT STUDY

A pilot plant study (*Figure 6*) was conducted to examine the viability of the above concept. This study, which focused on continuous sterilization using steam at atmospheric pressure, showed that the results of the exploratory study, obtained using the batch autoclave, are reproducible under the continuous processing conditions of the pilot plant. The study also provided some insight into the problem of further processing the sterilized fruits and enabled a comparative assessment of oil quality with batch sterilization (*Table 3*). The study confirmed that there should be no major problems integrating the proposed process with the rest of the milling process in a conventional palm oil mill. The FFA contents of oil samples from the continuous and batch sterilization processes were almost similar. The deterioration in bleachability index (DOBI) of oil samples from continuous sterilization was generally higher. This could be due to the continuous sterilization being carried out at a much lower temperature. Further studies are needed on commercial-scale systems to fully understand the impact of the entire milling process on palm oil and kernel quality.

Figure 6. Continuous sterilization pilot plant

TABLE 3. EFFECT OF STERILIZATION PROCESS ON OIL QUALITY

Parameter	Batch sterilization	Continuous sterilization
FFA content (%)	2.68	2.10
Peroxide value (meq)	0.30	0.29
DOBI	2.77	3.22
Carotene content (ppm)	598	546
Iron content (ppm)	4.24	6.18

COMMERCIALIZATION

Following the success achieved with the pilot plant study, a number of commercial-scale systems are currently being implemented. MPOB is building a system for processing 20 t hr^{-1} fresh fruit bunches in its Experimental Palm Oil Mill at a cost of RM 2 million. The technology can be applied to modernize palm oil mills all over the world, including the 360 odd mills in Malaysia and 200 odd mills in Indonesia. The technology is expected to stimulate radical changes in the design and operation of mills and lead to a new generation of mills that are highly automated and more environmentally friendly. The technology also makes it cost-effective to build and operate small and mobile mills (*Figure 7*) at a fraction of the cost of conventional mills to process small quantities of fresh fruit bunches from smallholders, especially in countries that do not have a well-developed palm oil industry.

Figure 7. Smal mill based on continuous sterilization

For more information kindly contact:

Director-General
MPOB
P. O. Box 10620
50720 Kuala Lumpur, Malaysia.
Tel: 03-89259155, 89259775,
Homepage: http: //mpob. gov. my
Telefax: 03-89259446