Innovation Potentials in Palm Oil Mill Design

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INTRODUCTION

Horizontal sterilisers are in dire need for improvement. There is great potential for university students to explore the field of sterilisation. It has been found that the sterilisation process practiced by the industry is not founded on sound process technology. There is ample room therefore for improvement not only in the field of sterilisation, but in many other areas of processing as well. In this article, we would focus on sterilisation, the least understood process operation.

The weakness of the sterilisation process stems from its inefficient de-aeration system. Millers have tried single peak, three peaks and multiple peak sterilisation but none of these made any spectacular impact on sterilisation efficiency as such. To begin with, even a thermometer is conspicuously absent in most sterilisers, as without it, the millers will not know the impact of the operation of Dalton's law of partial pressures on the temperature of steam/air mixture within the steriliser.

Some 30 years ago the millers were very enthusiastic in improving sterilisation efficiency. Various methods of sterilisation regimes were tried out to improve de-aeration, so that the percentage of un-stripped bunches remained within limits. Now, bunch crushing and double stripping operations are widely accepted by the industry, as the norm for addressing the consequences of poor stripping efficiency, which served only to effectively camouflage the cause of poor stripping performance.

The problem lies in the lack of understanding of one of the fundamental principles of thermodynamics. Crushing the partially stripped bunches, followed by second stripping does not remove the original problem of inefficient sterilisation. The mill engineers are encouraged to probe into this matter, so that their attention is focused on the actual cause of the problem. Let us take a close look at the inefficient stripping problem and find out whether it can be solved at the source rather than at the consequence.

At present, the mill process depends solely on the sterilisation efficiency based on the percentage of fruits still remaining in the bunch after the stripping operation is completed. As sterilisation efficiency is a function of the temperature within the steriliser, we should not wait for the actual results of the stripping operation to find out that the stripping had been unsatisfactory, when it is too late. It is more logical to just monitor the thermometer reading and become fully aware that the sterilisation

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had indeed been inadequate in real time, even before opening the steriliser door.

The normal sterilisation steam pressure is 3 barg that should have a saturation temperature of 143.6°C. This is indeed a good temperature for sterilisation. This can occur only if the whole steriliser chamber is filled up with steam. What we really have here is a mixture of air and steam. One fundamental mistake in the steriliser instrumentation is that in almost all our mills the thermometer is missing and it would probably not cost more than RM 50. A thermometer can readily tell the engineer, the volume of residual air that still remains in the steriliser after completing the de-aeration operation. It can tell whether the sterilisation had been effective or not.

Everything that is happening within the steriliser in terms of heat transfer to the FFB is reflected by the temperature displayed by the thermometer. Millers may try single peak, triple peak or multiple peak but the efficiency of the impending stripping operation can be predicted by the temperature within the steriliser. We do not have to wait for the actual stripping results.

If throughout the sterilisation time the temperature within the steriliser never exceeded 120°C it can be easily predicted that the sterilisation will be poor. If on the other hand, the temperature remain steady at 130°C or above, the efficiency of sterilisation would undoubtedly be good.

Measuring the temperature is only one part. It will just tell us the sterilisation efficiency that can be expected from the prevailing temperature within the steriliser. It does not tell us how we must address the issues in order to improve the sterilisation efficiency. There is only one parameter that has to be made right, and that is the residual air within the steriliser and it is strongly linked to the temperature.

For this to happen we have to maximise de-aeration. This is not easy to carry out due to many constraints. One obstacle is the high volume of air trapped within the steriliser. No matter how many peaks we set in our sterilisation regime, it is still not possible to realise complete evacuation of air in the steriliser. Let us discuss a popular hypothesis postulated by some in the milling industry. When bunches are heated, the air trapped within bunches will be continuously released. The incoming steam may not be able to push out all the air as they may form pockets encapsulated by steam with no escape route for it during de-aeration. The initial steam flow into the steriliser chamber could be highly turbulent due to high steam velocity followed later by laminar flow when the velocity drops due to low pressure differential between the incoming steam pressure and the steriliser chamber pressure. During the turbulent flow regime, it is possible for the air to form pockets and to remain as pockets without discharging until the steam capsule is dissipated by condensation that may take place at a later stage when sterilisation is nearly completed. As the air pockets are poor conductors of heat, and they are dominant during the early stages of sterilisation within the steriliser, the heat transfer between the steam and bunches can be expected to be poor.

Generally, the mills maintain the last peak for about 30 min with the de-aeration peaks being slotted at the beginning of the cycle. Now assume we start with a 5 min first peak to get rid of most of the air. This can be followed by a second full peak of 20 min pressure cooking, a third peak of 5 min intermediate de-aeration, an additional 20 min full peak pressure cooking and culminate with a 5 min blow off giving a total sterilisation time of 65 min. We are not sure whether this would give better results or not but it does provide for a good air release after bunches are properly heated. The mill engineers are encouraged to carry out different variations of this to arrive at the ideal system. Many innovations of this nature based on basic engineering principles have not been carried out.

CONTINUOUS BLEEDING

Continuous bleeding of condensate was the norm in the early days of the industry but the new engineers or mill designers seem to have overlooked its importance and decided to ignore it as something useless! The continuous release of condensate as well as the air that is continuously released from bunches could effectively nullify the relatively low steam temperature corresponding to the low partial pressure of steam within the steriliser. Some sacrifice of steam is imminent when the condensate bypass is kept open throughout the sterilisation cycle. Probably, a further study is still necessary to ensure the efficient separation and expulsion of air from the condensate pipe. Air bottles fitted with spring loaded relief valves installed on the condensate bypass line can effectively release the air from the air bottle when the air pressure builds up (*Figure 1*). Other methods also may be available in the market for air release.

Steam Ejectors

These are effective but need high pressure steam for rapid air ejection. If mills have excess steam it is worthwhile to try this to partially evacuate the air prior to the admission of steam. In this case, care must be taken to prevent the collapse of the steriliser shell caused by excessive evacuation of air. A protective system must be incorporated to break the vacuum when it reaches a pre-set value.

Vacuum Pumps

This is a slow process for producing vacuum especially in big vessels like sterilisers. Steam ejectors generate vacuum at a faster rate than vacuum pumps and as such this is not recommended as a suitable system.

Steam Admission Points

This can play an important role in de-aeration process. The current design of air release through the exhaust pipe as practiced by many mills does not appear to be an efficient system for de-aeration. As the air is heavier than steam it will tend to stay at the bottom while the lighter steam will remain at the higher plane. What will happen when steam is admitted in a steriliser containing full of air? When steam is admitted into the steriliser the steam pressure will build up to form the first peak, during which time the exhaust and condensate valves will be generally closed. As the steam gets into contact with the cold air some steam will condense and the enthalpy of condensation of steam (latent heat) will be transferred to the air, thus raising its temperature. The quantity of steam condensed will continuously be replaced by the incoming steam. The pressure indicated on the pressure gauge now will be the sum of the partial pressure of air at the elevated temperature (not at the atmospheric temperature any more) plus the partial pressure of steam.

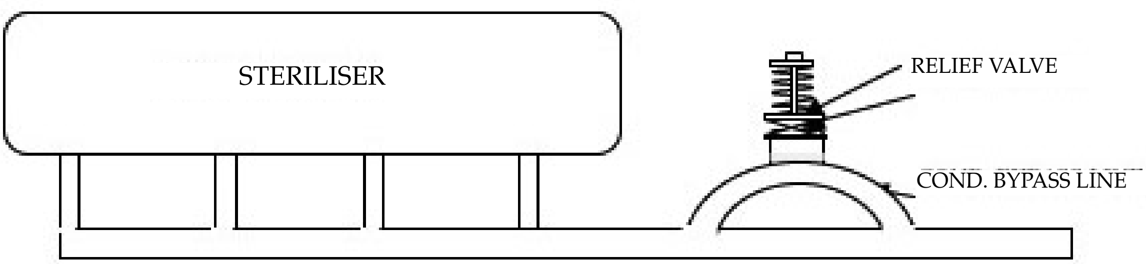

Figure 1. Steriliser with air bottle fitted with relief valve on condensate bypass line.

Now let us consider what happens to the air immediately surrounding the bunches. As the bunches are encapsulated by a thick layer of air and is held firmly by the live layer of steam the air cannot escape is unable to form the pockets. If it cannot, then during the blow-off operation, most probably, only the steam hovering above the cages will be blown out and not necessarily the air. When eventually the steam pressure is reduced to zero then there is good chance for the air to be evacuated. But in most mills the pressure is kept at half the initial value. There is another area where some modifications can be made to avoid encapsulation of air. The steam can be admitted at the side.

A SENSIBLE APPROACH FOR ACCOMPLISHING GOOD DE-AERATION

As air is lighter than steam and the steam pressure will most certainly press down the air, the possibility of air finding a way to pass through the only escape route through the steam, is indeed a mystery. It would make sense if the blow off pipe is located at the bottom, the only problem to this being the large volume of condensate that will accumulate at the bottom of the steriliser during the initial stage of heating.

This tendency for condensate accumulation can be addressed by keeping the condensate valve open during the initial 5 min of sterilisation followed by an intense pressure build-up and de-aeration of say 15 min through large blow-off pipes located at the bottom say 0.5 m above the condensate outlet so that large volume of air can be released in a relatively short time and at the same time avoid the blow out of condensate. The air that is released could pass through a cyclone to reduce its kinetic energy before discharging it into the atmosphere, so that blow off operation does not contribute towards excessive noise level. This is shown in *Figure 2.*

The above suggestion in no way rules out the possibility of unexpected practical obstacles that could render the proposed system to remain only as a hypothesis. The readers are kindly requested to participate in a dynamic discussion through the *Palm Oil Engineering Bulletin* on how to improve our milling techniques. We know that some of the engineers in the mills have good ideas but find it difficult to implement it or express it due to the lack of authority to do so. But you can always pool your resources and express it through the *Palm Oil Engineering Bulletin*. All suggestions are welcome.

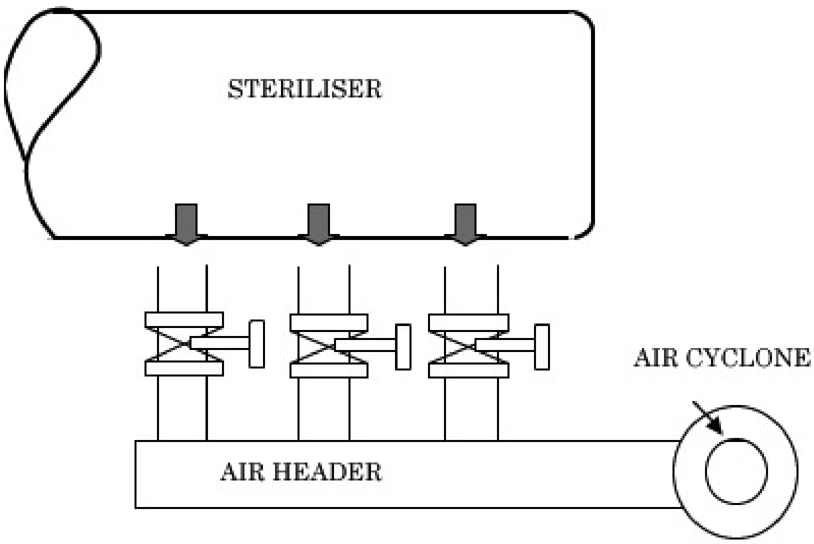

Figure 2. Steriliser fitted with air release header and cyclone.