IMPROVEMENT OF HEATING OF BOTTLED FLUIDS DURING AUTOCLAVE STERILISATION USING LOW PRESSURE STEAM

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Received April 28, 1961

Introducing turbulent steam can improve the rate and evenness of heating large numbers of bottles in a steriliser. Experimental data is given for a charge of over 200 × 1 litre bottles in a rectangular autoclave.

To sterilise bottled fluids it is necessary to heat and maintain the fluid at 115° for 30 min. or 121° for 15 min., or for an equivalent period at other suitable temperatures (Perkins, 1956). The heating occurs as steam condenses on the bottles, and the rate of heating is influenced by the rate of transfer through the glass and by the presence of air within the autoclave. It has been thought best to remove the air by introducing the steam near the top so that it displaces the air downward and out at the lowest point of the autoclave. In a large steriliser for fluids containing many bottles this method results in grossly uneven heating of the load. We report a method of attaining uniform heating.

Experimental and Results

An unjacketed cylindrical autoclave, 122 cm. × 114 cm. diameter, loaded with 200 bottles each containing 1 litre of solution or 400 bottles each containing 500 ml. of solution, in 3 layers was used. Selected bottles were fitted with a pocket into which a thermocouple was inserted to about the centre of the liquid (Barson, Peacock, Robins and Wilkinson, 1958). Thermocouples were also positioned in the top of the chamber and the drain. Steam was introduced along the top of the autoclave and distributed to cause little turbulence. Air was eliminated through the vent which was closed when the drain temperature reached 100°.

A jacketed rectangular autoclave, 92 × 66 × 132 cm. deep, built to B.S. 1500/1960, was also used, fitted with a steam trap and a full bore vent, loaded with 260 bottles each containing 1 litre of aqueous solution, in four layers separated by perforated metal sheets. Steam was admitted from between the liner and the chamber wall through twelve holes, each 2·5 cm. diameter, in the liner near the top of the chamber, six along each side.

Tests on both autoclaves showed that the temperature variation among the bottles in any given layer was small. The temperature of one bottle at the centre of each layer was therefore chosen to represent the layer. Variation in temperature between layers was large. Results similar to those seen in Fig. 1 were obtained. Chamber temperature was reached first in the top layer then in successive lower layers. The lowest layer took some 25–30 min. longer than the top layer to attain chamber temperature.

When a loaded autoclave was evacuated to 20 mm. Hg abs. before admission of steam, the variation of temperature between layers was eliminated, as shown in a typical trace in Fig. 2. The route of steam

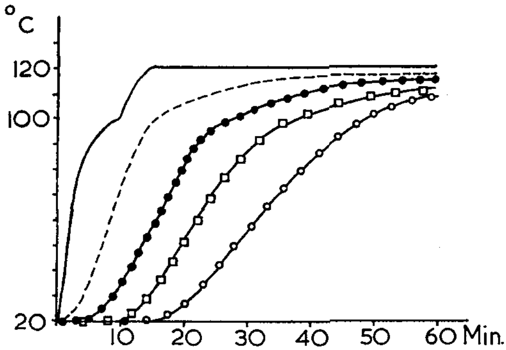

FIG. 1. Temperature distribution in bottles before turbulence of air and steam. —— chamber. - - - 4th layer (top) of bottles. -●-●- 3rd layer of bottles. -□-□- 2nd layer of bottles. -○-○- Bottom layer of bottles.

distribution was examined visually and a number of steam inlets constructed to produce turbulence of the steam/air mixture within the autoclaves, care being taken to ensure the aggregate area of the apertures was equal to the cross-sectional area of the supply pipe.

The effects of the following types of steam distributors were examined:

A sparge pipe with 16 holes evenly spaced along the upper and lower surfaces on the horizontal diameter near the side of the cylindrical autoclave.

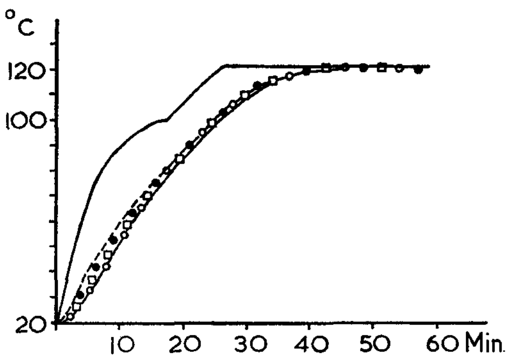

FIG. 2. Temperature distribution in bottles after improved steam distribution. See Fig. 1 for key.

A similar pipe near the top of the vessel with its apertures directed horizontally.

Two sparge pipes along the angles between the sides and top of the rectangular autoclave, each having 60 holes each directed downwards.

A similar system with 15 holes.

A fishtail type nozzle at the centre of the back of the autoclave directed upwards.

A similar system directed downwards.

With all the modifications the bottles were heated uniformly and gave temperature traces almost identical with those shown in Fig. 2.

The behaviour of the fishtail system directed upwards was marginally superior to the others and proved the simplest in construction.

Discussion

When admitted without turbulence the steam forms a layer above the cold air, encountering at first only the upper layer of bottles, upon which it condenses. Pressure does not build up within the autoclave because of this immediate condensation of the steam. As the bottles heat up the rate of condensation upon them decreases and the layer of steam gradually increases in depth and comes into contact with the other layers of cold bottles successively, thereby heating them. The air is slowly displaced from the autoclave by the increasing volume of steam.

When the steam is introduced with turbulence a much improved distribution of heating is obtained. Steam is able to reach the surface of all bottles equally. Although air is present in the chamber, complete condensation of the steam still takes place, and the air gradually separates and is displaced through the drain during the heating up period. As before, no pressure is developed within the autoclave until all the air has been displaced. This occurs before the fluid in the bottles reaches 100°.

References

Barson, T. E., Peacock, F. G., Robins, E. L. and Wilkinson, G.R. (1958). *J. Pharm. Pharmacol.*, **10**, *Suppl.*, 47*T*–59*T*.

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The paper was presented by MR. WILKINSON. The following points were made in the discussion.

The introduction of steam in a turbulent manner reduced the number of breakages provided steam did not impinge directly on the bottles. Steam must not be admitted faster than needed to give a condensation rate consistent with a safe rate of heat transfer across the glass of the containers. The site of the outlet is not important when turbulent steam is introduced.