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FOREST PRODUCTS RESEARCH BRANCH

SURGING

ITS CAUSE AND CONTROL IN WOOD PRESERVATION

by

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S U M M A R Y

The surging of creosote or oil-type preservatives in which unseasoned wood is heated is explained. Boiling rate is one of several factors which cause the liquid to expand and surge. A method and the equipment necessary for controlling the boiling rate to prevent surging are described. Operating difficulties due to solidification of naphthalene in parts of the condensing system are mentioned.

S O M M A I R E

L'auteur explique pourquoi les préservatifs à base de créosote ou d'huile en ébullition débordent lorsqu'on y traite du bois vert. La vitesse de l'ébullition du liquide n'est qu'un des facteurs qui le font se dilater et déborder. L'auteur décrit une façon de procéder et l'outillage nécessaire pour obtenir la vitesse de l'ébullition convenable, tout en évitant le débordement du liquide. Les difficultés que crée la solidification de la naphtaline dans certaines conduites de l'appareil condensateur, font aussi l'objet de commentaires.

S U R G I N G

ITS CAUSE AND CONTROL IN WOOD PRESERVATION

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INTRODUCTION

A process for boiling moisture from wood heated in creosote under vacuum was patented by S.B. Boulton in England in 1879 and in the United States in 1881. It is known as the boiling-under-vacuum or the Boulton process. Despite the length of time that the process has been in use, little information is available about a phenomenon which is encountered frequently — the rush of preservative from the top of the treating cylinder to the condenser and drain tanks described as surging or foaming. Various devices have been designed over the years to keep the preservative in its place, the first of these being used by Boulton and consisted of a dome fitted on top of the cylinder. Next was a tall standpipe, barometric leg or goose-neck, which was connected between the dome and the condenser and rose 30 to 35 feet above the cylinder. Its value for the purpose was said to be limited(1). Subsequently, the dome was replaced by two or more vapour drums which were mounted on top of the cylinder between it and the goose-neck but, even with these precautions, the vacuum had to be applied slowly and the temperature raised gradually at the start; otherwise large quantities of oil would be drawn over from the cylinder(2). An apparatus, using two centrifugal fans in series to control foaming, was described by Harkom(2) in 1929 but there has been no subsequent report of its performance on cylinders used by industry. An improvement in performance over the previously mentioned standpipe was obtained by mounting a large pressure vessel above the cylinder, which was used as a combined vapour drum and Rueping tank(1). In a paper presenting the most recent information about types of heaters, condensers and ejectors required for the Boulton process, Bushley(3) claimed that, although surging cannot be prevented, it is possible to design a plant so that surging will not cause trouble.

This report describes a method of keeping the creosote under control by regulating the vapour flow instead of equipping the cylinder with standpipes and vapour drums to provide extra space.

THE CAUSE OF SURGING

When wood containing moisture is heated in creosote, bubbles of vapour form on the wood and rise to the surface continuously. Because of the entrained vapour the volume of the creosote expands and, when it has filled the boiling chamber, overflows into the condenser and is said to surge.

Similar expansion occurs in air lift pumps which employ air bubbles to expand and raise water, mine liquor or oil to heights of several hundreds of feet. Owens(4) contributed to the theory of air lift pumps and showed experimentally that, although the velocity of rise of air bubbles in water was dependent on their diameter, the velocity approaches a maximum value of approximately 0.81 foot per second when bubbles are greater than $\frac{1}{4}$-inch diameter, because of surface tension and the flattening of the larger bubbles. If steam bubbles rising in creosote are assumed similarly to have a maximum velocity of rise, a mathematical expression showing the effect of depth of creosote and volume of bubbles on the expansion is determined as follows:

Let S = expansion of liquid, cubic feet
h = average head of liquid, feet
v = velocity of rise of bubbles, ft./sec.
V = volume of bubbles, cubic feet per second.

Since a bubble requires h/v seconds to rise to the surface, the liquid contains all bubbles generated during that time and expands in accordance with the expression

$$S = Vh/v \text{ cubic feet.}$$

Moreover, when the bubbles contain steam, $V = Cw$, where w is the weight in pounds of steam generated per second, or the rate of boiling; and C is the volume (obtained from steam tables) of one pound of steam at the indicated vacuum. Substituting for V, the foregoing expression for expansion of liquid becomes

$$S = Cwh/v \text{ cubic feet.}$$

This expression contains four factors which determine expansion; but the head, h, becomes fixed since the liquid must be deep enough to cover wood boiling in a cylinder; and the velocity of rise, v, is assumed to attain a maximum fixed velocity like air bubbles in water. Accordingly, expansion can only be controlled by varying either the vacuum, which in turn changes the value of C, or by varying the rate of boiling, w. The technique described here controls the expansion of creosote by manipulating the boiling rate.

CONTROL OF BOILING RATE

Uniform boiling of liquids at pressures below atmospheric is accomplished by removing air from the system without allowing vapour to escape through the vacuum pump(5). This is done by the thermostatic valve installed as shown in Figure 1 between the condensate tank and the vacuum pump. Not shown in Figure 1 is the heating coil controlled by a thermostat that maintains the bath (creosote) at a constant temperature. Air which enters the system — through leaks or from the wood — finds its way to the bottom of the condenser and is removed by the vacuum pump. If vapour reaches the thermostatic valve, it closes and remains closed until air accumulates near the valve and its temperature falls. Since all steam generated in the cylinder is condensed by the cooling water, and heat input must balance heat output, boiling can be maintained at as low a rate as necessary by reducing the flow of cooling water through the condenser.

In order to ascertain the boiling rate at all times a flow indicator is installed between the cylinder and condenser as shown in Figure 1. It is a simple glass manometer containing water and measures the small pressure difference, a maximum of three inches, between the high and low pressure sides of the orifice.

Both the seat of the thermostatic valve and the orifice of the flow indicator are heated to prevent accumulation of solids in them. The solids are mixtures of low boiling components of creosote, mostly naphthalene, which are steam distilled from the creosote(6).

OPERATION

When wood is immersed in heated creosote the water near the surface of the wood receives heat quickly while water in the interior receives heat slowly. Therefore, in an evacuated system, provided that sufficient cooling is available in the condenser, water boils from the wood at a fast rate initially, and the rate decreases gradually as the water near the surface boils away. A typical example is shown by Bushley(3) in the boiling record of green piles, where the boiling rate rose to its maximum during the second hour of boiling and gradually decreased for the remaining 28 hours.

The technique described here operates for the first few hours at a fixed boiling rate somewhat less than the maximum, with the result that all heat received by the wood from the creosote is not used for boiling; some goes to raise the temperature of the wood and increases the latent heat of water in it. The boiling rate depends on the rate of condensation, and the vapour flow indicator is the instrument used to measure the exact amount of water necessary to put through the condenser. In order to use the flow indicator it must be calibrated for the cylinder. The maximum rate for a cylinder 2 feet in diameter and 17 feet long, filled initially to within 3 inches from the top and boiled at 24 inches vacuum, was 10.8 pounds of water per hour. At this boiling rate the cylinder became nearly filled with the creosote plus the included bubbles of water vapour, and the corresponding flow indicator reading was 1½ inches water pressure.

When the maximum safe flow indicator reading is established, only sufficient cooling water is admitted into the condenser to maintain boiling at that reading. The flow of water is regulated effectively by a manually-operated valve as long as the water supply pressure remains constant.

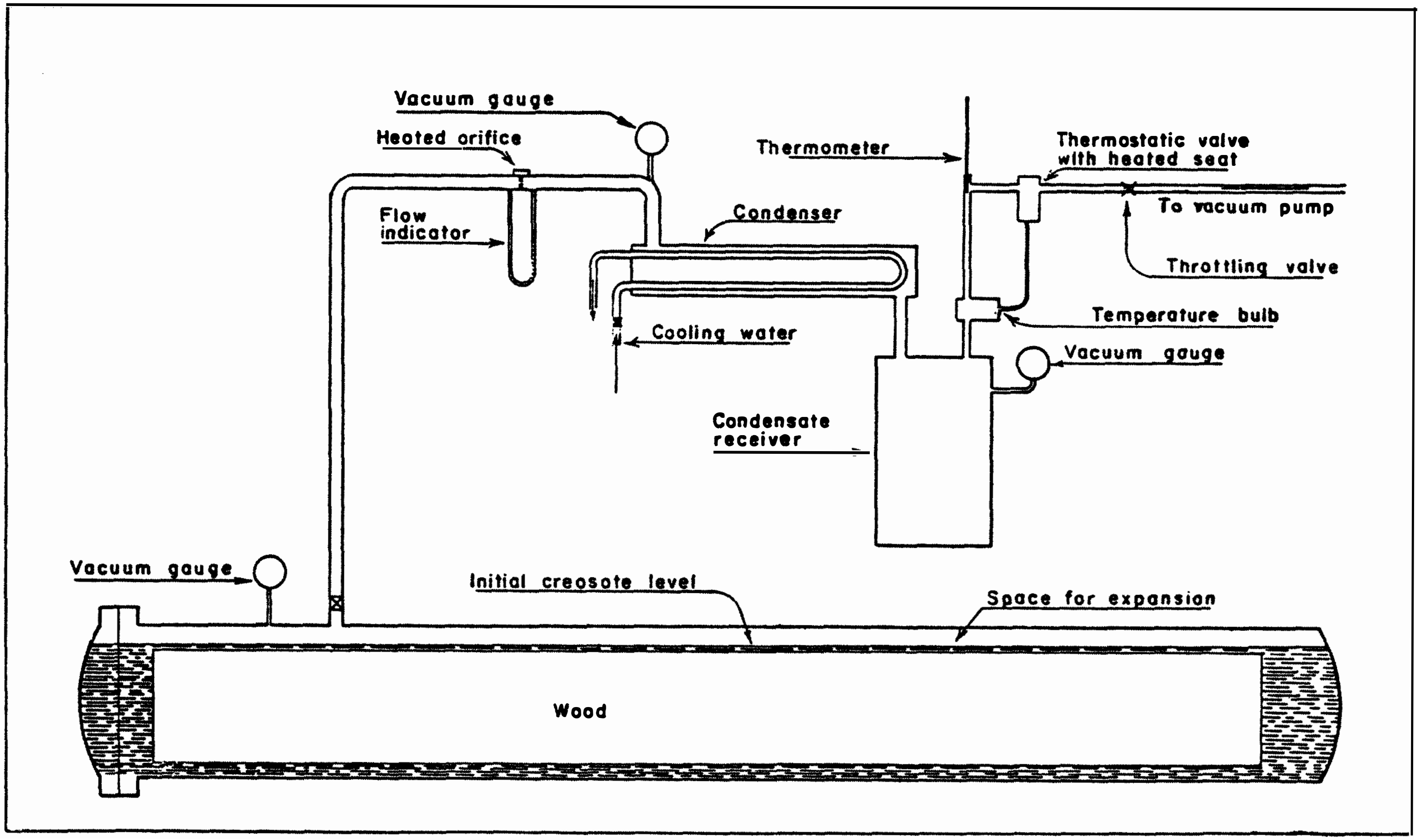

Figure 1 — Schematic diagram of apparatus

OPERATING NOTES

(1) When wood, containing moisture, is heated in a closed vessel where the creosote temperature and the boiling rate are fixed, the system has no remaining degree of freedom and the vacuum cannot be fixed but must find its level automatically. Thus, when the moisture content near the surface of the wood is high, heat needs to travel only a short distance to heat the water and accordingly boiling takes place at a low vacuum. However, when the wood near the surface becomes dry, heat must travel farther to reach the water, the temperature of which is lower and hence the vacuum rises gradually in order to maintain the boiling rate, eventually reaching the limit of the vacuum pump.

(2) As the vacuum rises the vapour temperature falls, consequently more cooling water must be admitted to the condenser in order to maintain the boiling rate.

(3) Vapour leaving the cylinder comprises a mixture of water vapour and a small proportion of air from the wood, together with vapours of naphthalene and other low boiling fractions, steam distilled from creosote. The proportion of water to naphthalene depends on the type of creosote, the temperature of the creosote, and the vacuum(6). Since naphthalene is solid at normal temperatures it solidifies in exposed pipes and on condenser tubes and must be removed periodically by heating these parts of the apparatus.

The vacuum gauges shown in Figure 1 are useful to determine when and where heating is required because, as solids build up and reduce the flow capacity of the pipe or the condenser, an appreciable vacuum drop is shown between the gauges while at the same time the flow indicator reading is comparatively low.

Insulated pipes, larger pipes and increased cooling areas in the condenser are factors which permit the time between clean-out periods to be extended. The type of creosote also has much to do with the amount of solids because low boiling fractions of creosote, steam distilled with naphthalene, lower its melting point from 176°F to as low as 140°F, where heat losses and solidification are lower.

Naphthalene also accumulates in the flow indicator orifice and in the thermostatic valve. When it builds up in the former, the flow indicator gives a false reading, and when it builds up in the thermostatic valve it may cause sticking. Steam jackets on these parts prevent interference from this source.

(4) The throttling valve shown in line with the thermostatic valve in Figure 1 is used to smooth out the flow of air thereby reducing fluctuations of the boiling rate when the thermostatic valve opens and closes. It is also used in starting up. Both valves are heated to prevent solidification of naphthalene in them. Although the size of the valves has an effect on efficiency and is outside the scope of this report, nevertheless it is worth noting that the air which flows through them contains little vapour and they need not be as large as the pipe which also carries vapour. For example, a cylinder of 50 cubic feet capacity operated at 28 in. Hg. with a thermostatic valve having a two millimetre bore, whereas the flow indicator measuring vapour flow had an orifice measuring 13 millimetres.

(5) When the thermostatic valve, which protects the vacuum pump, was set to operate at approximately 90°F no significant amount of water and naphthalene entered the pump, consequently there was little loss and the pump seldom needed cleaning.

(6) The flow indicator, in addition to providing an instantaneous indication of the vapour flow, also gives a warning — a sudden rise — when creosote expands to reach it.

CONCLUSIONS

The vapour bubbles, which are generated from the water in wood immersed in heated creosote or oil type preservatives, require a little time to rise to the surface and to expand the liquid. Surging occurs when expansion is enough to occupy all free space and the liquid-vapour mixture overflows into the condensing system.

Surging may be prevented by controlling the boiling rate as indicated by a vapour flow indicator so that expansion does not exceed the space available in the boiling chamber. In the closed system described here, where the heating liquid temperature is maintained constant, the boiling rate and the expansion are determined by the rate of condensation which is made up of heat lost to the surroundings, heat removed by the cooling water, and heat removed by the vacuum pump.

Loss of heat to the surroundings becomes uniform when the equipment becomes warmed up and loss of heat through the vacuum pump is prevented by a thermostatic valve, so that expansion is controlled by manipulating the flow of cooling water.

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