PHOTOGRAPHING COOLING CURVES OF HARDENING OILS BY MEANS OF A CATHODE-RAY OSCILLOGRAPH

Steel is usually hardened by first heating it to about 800 °C and then rapidly cooling it by immersion in a liquid (quenching). In this cooling process three successive stages can be distinguished:

1) slow cooling, owing to the metal being more or less insulated by a vapour layer around it;
2) rapid cooling, the vapour having disappeared and the heat being bound by the boiling of the liquid immediately around the metal;
3) slow cooling, after the temperature has dropped to below the boiling point.

For the success of the hardening process it is of great importance that the first two phases should be of short duration to prevent conversion of the austenite. Furthermore, the boiling point of the hardening liquid should be about 400 °C.

It appears that these two requirements can be met by using colza oil, but this, like all vegetable oils as well as animal oils, has the disadvantage that it changes in composition under the action of oxygen, becoming heavy and sticky and losing much of its originally good cooling property. For this reason mineral oils are usually preferred, although the hardening process is less satisfactory than with colza oil, their greater chemical durability being the decisive factor. Tests have shown that colza oil absorbs more than six times as much oxygen in a given time than does ordinary mineral oil.

The question then arose whether a mixture could not be compounded with a mineral oil as the main constituent and having cooling properties closely approximating those of colza oil but without its drawbacks.

First of all a method of measuring has to be thought out for studying the course of the cooling process. It was found that the method described below proved to be quite satisfactory.

Use was made of a solid silver ball 20 mm in diameter, inside which is a thermo-couple to which the heat of the silver is well conducted. The ball is heated to about 800 °C, the temperature being measured by means of a millivoltmeter connected to the thermo-couple. The ball is then immersed in the oil to be tested for its cooling properties. In principle it would then only be necessary to record the reading of the millivoltmeter at short intervals and to plot them, converted into temperature equivalents, as a function of time. However, as will be seen presently, the process takes place rather too quickly to allow of this being done with the necessary degree of accuracy; certain phases sometimes last no more than 2 or 3 seconds. This difficulty has been solved by visually recording the electromotive force of the thermo-couple on the screen of a cathode-ray oscillograph and photographing the picture.

Since the thermo-electric potential is too low to give a direct indication on the oscillograph by direct connection to the plates, it has to be amplified. So as to be able to use the normal amplifier of the oscillograph for amplifying this direct voltage, the latter is converted into an alternating voltage with the aid of a vibrator and a transformer, as illustrated in fig. 1; the transformer supplies the voltage conducted to the amplifier of the oscillograph and

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1) The data contained in this article have been taken from an article by B. Levy of Aktiebolaget Wahlén and Block, Stockholm, published in "Electronic Measuring" (I, No. 4, 1946), a Philips periodical dealing with the applications of electronic-measuring technique. The investigations referred to were carried out in cooperation with Svenska Aktiebolaget Philips, Stockholm.
causing the vertical deflection. To get reliable results the vibrator has to be of a robust construction and attention has to be paid to the contacts. Tungsten contacts proved to be unsatisfactory. An alloy of 93% gold and 7% platinum was found to be highly suitable. Furthermore, the circuit feeding the vibrator has to be well shielded to avoid induction of disturbing voltages in the measuring circuit.

As to the horizontal deflection, the time base of the usual oscillographs cannot be used for this because the phenomenon to be recorded may last 30 to 60 seconds. For this reason the method shown in fig. 1 was employed, where the arm of a potentiometer is rotated by a gramophone motor. Between the motor and the potentiometer spindle is a variable gearing and also an electromagnetic coupling, which, via a relay, starts up the potentiometer at the same moment that the silver ball falls into the cooling medium.

Upon the vibrator being started a vertical line appears on the screen of the oscillograph on the extreme left when the potentiometer is in its initial position. The rotation of the potentiometer arm causes this line to change into a more or less sinusoidal line, which gradually diminishes in amplitude as the silver ball cools down. The peaks thus form two symmetrical cooling curves. The picture can easily be photographed, as may be seen from fig. 2.

Fig. 2a shows the cooling curve of colza oil. The maximum vertical deflection corresponds to 800 °C and the horizontal movement to 23 seconds. One can clearly distinguish here the three phases mentioned in the beginning: the first and second phases, before the temperature drops to about 400 °C, each lasting from 2 to 3 seconds, which is satisfactory for the hardening of steel. In the case of an ordinary mineral oil, however, the first phase takes 12-13 seconds (fig. 2b), which is too long for proper hardening.

The recording of a large number of such curves as these has resulted in hardening oils being compounded which have better cooling curves than have been known hitherto. Fig. 2c shows the curve for such an oil.

Finally, attention is drawn to another factor of great importance in hardening processes. In this technique it is generally known that hardening oil should be free of water. The trend of the cooling curves clearly shows the effect of traces of water in the oil. Compare the curve of a water-free mineral oil (fig. 2b) with that of the same oil but containing 0.2% water (fig. 2d); in the latter case the cooling in the second phase is much more intensive, and with such intense cooling cracks in the workpiece will almost inevitably result.

Thus the application of the cathode-ray oscillograph with simple accessories has not only resulted in a better product — here a hardening oil — but it has also made it possible to carry out a simple and sensitive quality test.

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IN MEMORIAM Dr. P. J. BOUMA.

We should like to pay tribute to the memory of Dr. Pieter Johannes Bouma, born in Amsterdam on 14th April 1908, who died at Eindhoven on 19th January 1947. Bouma was connected with the Philips Laboratory in Eindhoven as an assistant from 1928 until 1930 and as a research physicist from 1933 until his death. From 1930 until 1933 he studied at Utrecht, where in November 1933 under Ornstein he received his degree on his thesis: “Beitrag zur Dynamik der flüssigen Kristalle”. Bouma specialized on the theory of illumination and colorimetry, in which fields various publications from his pen have appeared in Physica and in the Proceedings of the “Kon. Ned. Akad. van Wetenschappen”. He also wrote many articles for the Philips Technical Review. Furthermore he rendered valuable services to the Netherlands Foundation for Illumination Technology (Ned. Stichting v. Verlichtingsskunde).

Since 1940 Bouma had been suffering from a disorder of the central nervous system, which, though it fortunately did not affect his acute intellect, made speaking and writing more and more difficult for him. Nevertheless, between September 1944 and April 1945 he was able to complete the manuscript of his book “Colour Stimuli and Colour Sensations”, as well as three other publications.

During 1946 his strength failed him, but he still had the satisfaction of seeing his book in print (it was published in November 1946, and a review of it is given on page 159 of this number).

The following article is a practically unaltered version of a lecture given by Bouma at Utrecht in 1940 for a Vacational Course on “Road and Street Lighting”.

THE EDITORS.

PERCEPTION ON THE ROAD WHEN VISIBILITY IS LOW

by P. J. BOUMA †.

This article deals with the factors affecting perception, when visibility is low, especially as applied to road lighting. The author discusses in turn: contrast sensitivity, distinguishability of the object, speed of perception, glare, uniformity of illumination, the Purkinje effect, and the influence of colours upon perception.

The purpose of road lighting is to make it possible to see objects on the highways. Therefore in planning their illumination we have to take into account the properties of the eye. As will be shown later, the performance of the eye depends very closely upon the level of brightness: generally speaking, the higher this level the better we can see. Therefore it would be desirable to employ very high intensities of illumination on the highways, but this is limited by considerations of economy and in general we are not able to go beyond a few score lux. Compared with the luminous intensities of several times ten thousand lux that we often have during the daytime, this is extremely low. The fact that we can distinguish anything at all is due to the wonderful adaptability of the eye (expansion of the pupil, adaption of the retina); anyhow our vision is still much poorer than it should be with high luminous intensities. Hence it follows that whatever light is available must be used very economically. In other words:

1) We must try to get as much energy as possible (usually electrical energy) for our money’s worth.
2) We must get as many lumens as possible per kilowatt input, i.e. we must use lamps with a high efficiency.
3) The lumens obtained must be projected on the highway with little loss and in the best possible manner; this means that the most suitable fittings must be used, taking into account the properties of the road surface.
4) In the designing of the lighting system allowance must always be made for the properties of the eye, giving consideration to the two following questions:
   a) under what conditions does the eye function best, and
   b) in how far can these conditions be realized?