

THE COOLING TIME FOR LARGE FORGINGS

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At present the experimental data are insufficient to determine the time for cooling large forged pieces to a given temperature. This leads to rejects and reduces the effectiveness of heat treatment.

We studied the cooling of forgings 500 and 650 mm in diam. of steel 34KhN1M. The temperature was determined at a depth of 30 mm and in the center by means of chromel — alumel thermocouples and a PP potentiometer (every hour during cooling in air and in the furnace and every 5-30 min during cooling in oil). Heating (and cooling in the furnace) was conducted in an electric shaft furnace 1.8 m in diam. and about 30 m deep.

During cooling in the furnace from 600°C the surface and center cooling rates were almost identical — 15 deg/h for forgings 500 mm in diam. and 13 deg/h for those 650 mm in diam. The difference in temperature between the surface and the center during cooling from 580 to 260-300°C was about 10° (see Fig. 1a).

On cooling in air from 870°C there is a temperature differential through the section. The maximum difference in temperature between the surface and the center occurs after 1 h, amounting to 120°C for 500-mm forgings and 130°C for 650-mm forgings (Fig. 1b). With further cooling the temperature differential decreases, and after 9 h the difference is 30 and 20°C respectively. To attain a temperature of 200°C in the center of forgings 500-650 mm in diam. the cooling time should be calculated as 1 h per 35 mm of the section.

Cooling in oil from 870°C reduces the surface temperature to 420-445°C in 5 min; this temperature is reached in the center of 500-mm forgings after 70 min, and in 650-mm forgings after 110 min (Fig. 1c). It was found (by extrapolation) that a temperature of 200°C in the center of the forgings is attained by cooling in oil for 1 h for each 200 mm of section (d = 500 mm) and each 160 mm of section (d = 650 mm).

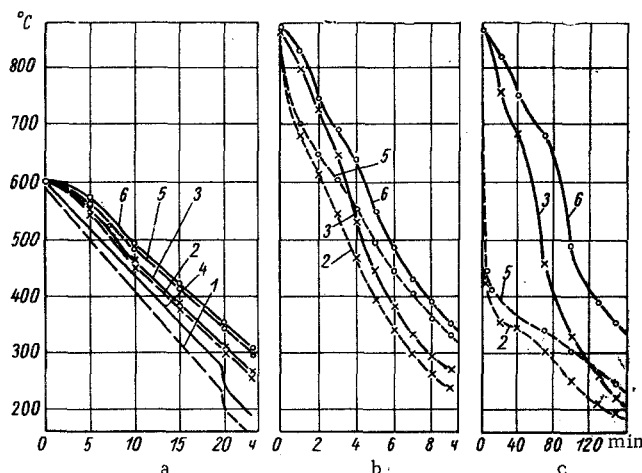


Fig. 1. Temperature distribution through the section of forgings during cooling: a) cooling in furnace; b) in air; c) in oil; 1-3) forgings 500 mm in diam.; 4-6) 650 mm in diam.; 1, 4) furnace temperature; 2, 5) temperature of forging at depth 300 mm; 3) temperature of forging at depth of 250 mm; 6) temperature of forging at depth of 325 mm.