APPARATUS FOR HEAT TREATING FORGINGS

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Forgings are subjected to final heat treatment or intermediate heat treatment to improve the machinability.

The processes that occur during heat treatment of forgings can be divided into two groups — processes occurring at temperatures above and below Ac_3. The temperatures of these processes are given below:

Type of Treatment	Temperature, °C
Treatment at Temperatures Above Ac_3	
Quenching (+tempering)	800-950
Normalization	
First stage of OP and OS	
Solutioning	950-1080
Diffusional annealing	
First stage of annealing to large grains of steels with normal grain size	
First stage of annealing to large grains of steels with fine grains	>1150
Treatment at Temperatures Below Ac_3	
Tempering (with quenching)	450-470
Second stage of OP, OS, and annealing to large grains	
Artificial aging or ordering	450-850
Partial annealing	650-710
In special cases	820-900

Note. OP refers to strengthening treatment, OS to strengthening treatment to obtain a ferritic—pearlitic structure.

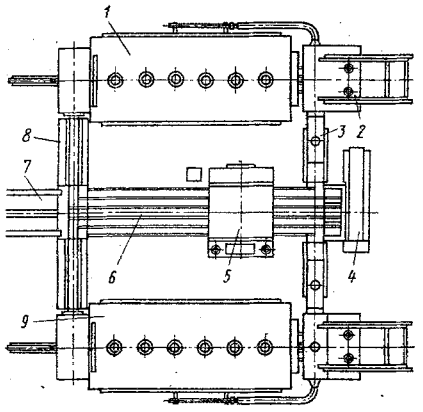

Fig. 1. Apparatus for heat treating forged turbine blades. 1) Pusher quenching furnace; 2) quenching device; 3) air spray; 4) belt conveyor; 5) washer; 6) intermediate conveying device; 7) loading station; 8) transporting device to feed forgings to furnace; 9) pusher tempering furnace.

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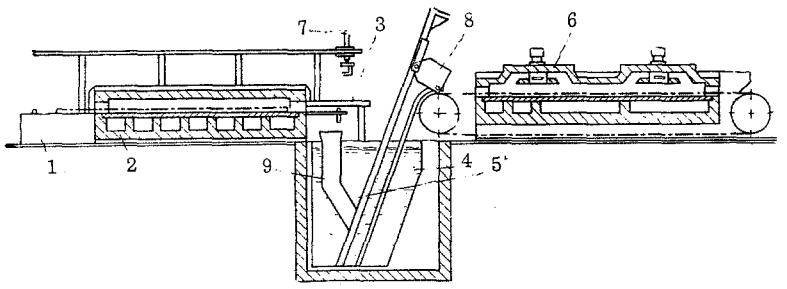

Fig. 2. Diagram of apparatus for quenching and tempering of forgings.

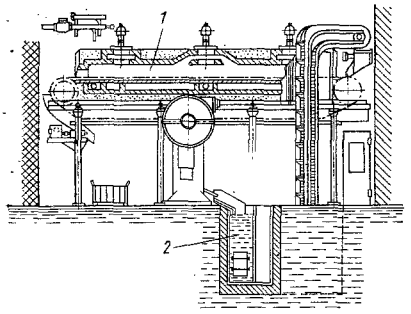

Fig. 3. Diagram of apparatus for heat treatment of forgings with utilization of forging heat. 1) Conveyor tempering furnace; 2) quenching tank.

Forgings are heat treated in continuous furnaces with complete mechanization of the heat treatment cycle and automatic control.

Apparatus for Heat Treating Forged Turbine Blades. The apparatus consists of two pusher electric furnaces of the Eichelin type (Fig. 1) [1].

The furnace dimensions are 1600 × 400 × 6000 mm. The frame of the furnace is welded. It is gas-tight, which makes it possible to use a protective atmosphere. The metal is heated either to 600 or 950°C. The furnace is heated by means of radiant tubes mounted on the side walls and in the hearth.

The furnace is divided into six independently controlled zones. The power to each zone is graduated — 50 kW in the first stage, 35 kW in the second stage, 22.5 kW in the third stage, and 17.5 kW in the fourth stage.

The following production cycles are possible (Fig. 1):

a) The forgings, passing through the furnace, are either transported to another section (positions 7, 8, 1, 2, 3, 4) or are transferred to a washer, after which they arrive at the loading station (positions 7, 8,1, 2, 3, 5, 7);

b) in furnace 1 the forgings are heated to quenching temperature and in furnace 9 to tempering temperature (positions 7, 8, 1, 2, 3, 5, 9);

c) in fully loaded furnaces the treatment occurs in the same manner as in batch furnaces.

The forgings are placed on trays of a heat resistant alloy (37% Ni, 17% Cr). The loading—unloading time varies from 10 to 60 min.

The apparatus is intended for heat treating a wide variety of steels; the maximum throughput is 600 kg/h, which requires two workers.

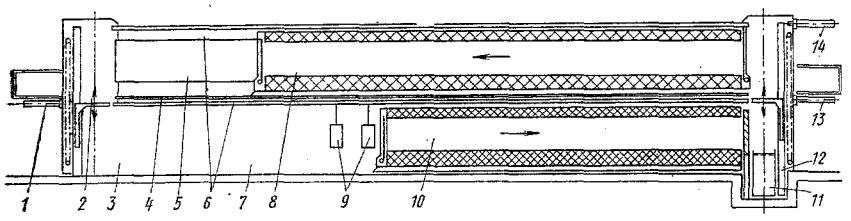

Fig. 4. Diagram of double-deck apparatus for heat treating forgings (furnaces with overhead conveyors). 1) Pusher; 2) elevator; 3) unloading station; 4) working area; 5) cooling tunnel; 6) overhead conveyor; 7) loading station; 8) tempering furnace; 9) hangers with forgings; 10) quenching furnace; 11) quenching tank; 12) elevator; 13) unloading device; 14) pusher.

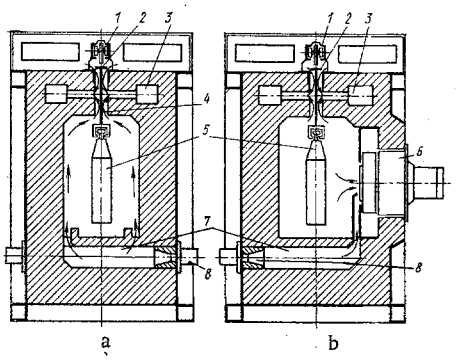

Fig. 5. Cross section of high-temperature (a) and low-temperature (b) overhead conveyor furnaces. 1) Overhead conveyor; 2) covered slots; 3) flue; 4) hanger; 5) forging; 6) device for recirculating combustion products; 7) combustion chamber; 8) burner.

The apparatus replaces moving hearth furnaces that require four men working under severe conditions, who are exposed to the influence of radiant heat from forgings heated to 900°.

Thus, with three-shift operation the number of workers required is reduced from 12 to six men.

Continuous Quenching—Tempering Apparatus for Heat Treating Various Forgings, Including Large Crankshafts. With a throughput of 2 tons/h, this apparatus is not the largest in Europe [2].

Both furnaces (quenching and tempering) are conveyor furnaces heated with town gas (the burners are easily changed for burning natural gas). The maximum operating temperature is 900° in the quenching furnace and 700° in the tempering furnace.

The forgings are fed to the conveyor of the quenching furnace by a vibrator mechanism. After heating to quenching temperature, the forgings drop into a quenching tank with oil, from which they are transferred to the tempering furnace by an auxiliary conveyor.

The conveyors in both furnaces are armored, with links cast from Cr—Ni alloy.

The dimensions of the tempering furnace are large enough to keep pace with the quenching furnace, even though tempering requires a longer time. The width of the conveyor is more than 1.5 m. The forgings are cooled by fans at the exit from the tempering furnace.

Each furnace has three zones that are independently controlled.

An Apparatus for Quenching and Tempering of Forgings. The apparatus, with a throughput of 1500 kg/h [3], includes a device 1 for pushing the trays, a pusher quenching furnace 2, a device to pull out the trays 3, a tank 4 for quenching with water or oil, with an inclined device 5 to extract the forgings from the tank, a conveyor tempering furnace 6, and a fully automatic device 7 to return the trays (Fig. 2).

The inclined device 5, equipped with a movable cart 8, is a characteristic feature of the apparatus. Experience has shown that it is possible to use a quenching tank with a relatively narrow section, while the time required for cooling is ensured by the depth of the tank. The cart is loaded by means of the chute 9, equipped with self-lubricating bearings; repairs can be made outside the tank, which is very convenient.

The furnace is fired with gas. The quenching furnace (operating temperatures from 750 to 1000°) is heated by burners that create a neutral atmosphere in the furnace. In the tempering furnace (operating temperatures from 350 to 800°) the gas is incompletely burned in combustion chambers and is burned completely with a secondary air supply, in which case the combustion products recirculate, ensuring even heating of the forgings.

The furnaces are divided into several temperature zones and are equipped with automatic control devices.

The heat input in the quenching furnace (at 840°) is 42,000 kcal/100 g of metal, and 28,000 kcal/100 g of metal in the tempering furnace (at 580°).

A more logical and economical apparatus is that for isothermal annealing or quenching and tempering that utilizes the forging heat (Fig. 3).

Double-Deck Apparatus for Heat Treating Forgings (Furnace with Overhead Conveyor) [4]. A schematic diagram of the apparatus is shown in Fig. 4, and a cross section of the furnace in Fig. 5.

The furnaces are heated with gas. The gas is burned in chambers below the floor of the high-temperature and low-temperature furnaces. The combustion products enter the high-temperature furnace through a slot in the floor, partially heating the forgings but primarily heating the side walls, the heat from which is radiated to the parts. In the low-temperature furnace the combustion products are recirculated

and the heat is transferred to the parts at a lower temperature by convection. The furnaces are equipped with automatic controls.

LITERATURE CITED

1. Elektrizitätsverwertung, 46, No. 1, 5 (1971).
2. Mass Production, 46, No. 10, 38 (1970).
3. P. Witkowski and M. Braun, Gas Wärme International, 29, No. 4, 151 (1971).
4. J. Rapp, Gas Wärme International, 29, No. 10, 358 (1971).