After carburization and mechanical treatment, gear wheels were subjected to volume heat treatment by the following schedule: furnace loading at 650°C, soak for 4 h, heating at a rate of not more than 50 deg/h to 880 ± 10°C, soak for 3.5 h, air cool to 300°C, soak at this temperature in the furnace for 2 h, heat to 650°C, soak for 8 h, heat at a rate of 50 deg/h to 800-820°C, soak for 3.5 h, cool in oil over 110-130 min, then in air for 20-30 min, and then in water for 10-15 min.

After this, gear wheels were given a two-stage temper in an oil bath at 150-160°C for 20-35 h each. Cooling after the first temper was carried out in water and in air after the second. Hardness of carburized gears measured in a Shore scleroscope was HS 80-85, and this corresponds to the technical conditions laid down for manufacture of gear wheels.

CONCLUSIONS

Use of gas carburizing for surface hardening large gear wheels in a container made it possible to obtain a uniform carburized layer over the whole tooth profile, satisfactory hardness after quenching, minimum deformation, and this increased reliability and endurance of gear wheels in operation by not less than a factor of 1.3 compared with normal volume hardening with HFC heating.

LITERATURE CITED


SUCCESSIVE SATURATION OF CARBON STEELS WITH ALUMINUM AND BORON

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We present the results from a study of successive diffusional saturation of carbon steels with aluminum and boron.

Aluminizing was conducted with Fe–Ti–Al powder in containers with fused covers at 1100°C for 1 and 3 h. The coating consisted of Fe₃Al and a solid solution of aluminum in α-iron. In the outer zone and in the grain boundaries of the coating there were inclusions of complex carbide Fe₃AlCₓ [1].

Boronizing of the aluminized steel was conducted in a powdered mixture (95% B₄C + 5% NaF) at 950-1100°C for 1-9 h.

The study showed that after aluminoboronizing a coating is formed that consists of two zones – an outer boride zone and an inner aluminide zone. At the boundary between the coating and the base metal a boride interlayer is formed, the thickness and continuity depending on the thickness of the Fe₃Al zone in the aluminum coating and the boronizing conditions.

Figure 1 shows the thickness of the aluminide–boride coating and the separate zones on steel 45 in relation to the saturation temperature and time. As can be seen the increase in the thickness of the coating and the separate zones in relation to the square root of the saturation time is linear, which points to a parabolic relationship between the thickness of the coating and the saturation time. The variation of the thickness with saturation temperature is exponential in character.

The boride zone of the coating consists of FeB and Fe₂B alloyed with aluminum; the iron borides are wedged into the aluminide zone and are needle shaped, resembling those formed in boronized steel [2].
During boronizing of the aluminide coatings on steels 45 and U8 the aluminum layer is "resorbed," as is indicated by the original boundary of the aluminide layer in the aluminide coating, which consists of etch pits (dislocation line). This dislocation line remains in the coating regardless of whether it passes through the aluminide zone or the acicular borides that penetrate into it as the boride layer grows.

The resorption rate of the aluminide coating and the growth rate of the boride zone differ on steels 45 and U8, depending on the boronizing temperature. Boronizing of the aluminide layer at 950° for 1, 3, and 9 h leads to an increase in the thickness of steel 45 (original thickness ~100 μm) by 5, 20, and 54 μm, respectively. The thickness of the boride zone of the coating is, respectively, 64, 102, and 150 μm with saturation under the same conditions. Rapid growth of the boride zone and relatively slow resorption of the aluminide layer on steels 45 and U8 lead to the fact that the latter "shrinks," as the result of which the concentration of aluminum, carbon, and other elements in the aluminide layer of the coating increase sharply and Fe3Al is transformed into a new phase with a dark color (5% nital etch). It was found that the dark phase formed with boronizing of the aluminide layer is FeAl.

Boronizing at 1000° or higher leads to an increase in the resorption rate of the aluminide layer. Boronizing of the aluminide layer on steel 45 (original thickness ~100 μm) at 1000° for 1, 3, and 9 h leads to an increase in the thickness by 12, 52, and 130 μm,