CHEMICOTHERMAL TREATMENT

DIFFUSION COATINGS ON STEEL 14KhGSN2MA
AFTER CARBURIZING AND NITROCEMENTATION

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For manufacturing aviation reducing gears high-strength chromium-nickel steels 12KhN3A, 12KhN4A
and 18KhNVA are used, with surface hardening of the teeth by carburizing. In recent years the working
temperature of the gears has increased and also the specific load on the coupled surfaces as well as the
slip, and therefore the new heat-resisting steels 14KhGSN2MA and 18KhGSN2MA are being used. The use
of steel 14KhGSN2MA for one of the reducing gears has increased the working life of the gear train and the
engine several times.

In this investigation we determined the properties of steel 14KhGSN2MA subjected to two types of
chemicothermal treatment—gas carburizing and nitrocementation.

Gas carburizing was conducted in the Ts-75 shaft furnace at 920°C. The amount of pyrobenzol was
gradually increased from 5–6 ml/min in the first hour after restoration of the temperature in the furnace
to 10–12 ml/min at the end of processing. After 4 h 20 min the case depth was 0.76 mm.

Nitrocementation was conducted in the Ts-60 shaft furnace at 850°C with 75–80 drops/min of pyro-
benzol and 50–80 liters/h of ammonia. After 5 h 40 min the case depth was 0.66 mm. The samples were
heat treated as follows: high-temperature tempering at 650°C for 6 h in muffles filled with spent carburizer,
quenching from 865°C in hot oil at 170°C (holding 10 min) and then in cold oil. The samples were then cold
treated at a temperature below −60°C for 2 h and tempered at 160, 230, and 300°C for 3 h.

The carbon and nitrogen concentrations in the diffusion coating were determined by sectioning and
chemical analysis. The distribution of hardness through the case depth was measured on beveled samples
under a load of 15 kg.

Fig. 1. Concentration of carbon and carbon+nitrogen in the case after chemicothermal treatment. 1) Nitrocementation; 2) nitrocementation+annaling + quenching; 3) gas carburizing; 4) gas carburizing+annaling + quenching.

Fig. 2. Variation of hardness through the depth of the case after chemicothermal treatment. 1) Nitrocementation; 2) gas carburizing. °) Tempering at 230°C; x) tempering at 300°C.

Fig. 3. Variation of ultimate strength and fracture toughness with tempering temperature after chemicothermal treatment. 1) Nitrocementation; 2) gas carburizing; 3) blank carburizing; 4) blank nitrocementation.

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Fig. 4. Fatigue strength of steel 14KhGSN2MA after chemical treatment. (—) Nitrocementation; (—) gas carburizing. 1) Tempering at 160°C; 2) 230°C; 3) 300°C.

Within the range of low-temperature tempering investigated, the mechanical properties were highest after tempering at 230°C (Fig. 3). The high strength after tempering at 230°C is probably due to an increase of the strength of martensite.

The lower strength and ductile characteristics after tempering at 300°C are evidently due to the development of temper brittleness.

The fracture toughness was considerably higher after nitrocementation than after gas carburizing.

It was assumed that the high fracture toughness was due to the core, which is heated to a lower temperature during nitrocementation. However, as shown by the impact tests of samples after blank nitrocementation and carburizing, the high fracture toughness after nitrocementation is due to the properties of the case, in which the grain size is smaller.

After chemicothermal treatment the fatigue strength increases due to the higher strength of the case resulting from residual compressive stresses in the surface.

When the tempering temperature was increased from 160 to 230°C the decrease of the fatigue strength was negligible (Fig. 4), since the reduction of the residual compressive stresses was compensated by an increase of ultimate strength.

After tempering at 300°C the fatigue strength decreases considerably, since the residual compressive stresses decrease along with a substantial decrease of the ultimate strength (Fig. 5).

The contact strength after chemicothermal treatment and tempering at 230°C was investigated with samples 30 mm in diameter in the Sh-10 apparatus with slippage up to 6% and various contact stresses.

The tests showed that the contact strength (N = 510^7) is 30% higher after nitrocementation than after gas carburizing (Fig. 6).

The high contact resistance after nitrocementation is due to the presence of nitrogen in the case, which increases the wear resistance due to the precipitation of finely dispersed carbonitrides in the case and also increases the heat resistance of the case and lowers the coefficient of friction.

CONCLUSIONS

1. After nitrocementation of steel 14KhGSN2MA the contact strength, wear resistance, heat resistance, and ductility are higher than after gas carburizing.