HIGH-CYCLE FATIGUE MODELING AT HEAT TREATMENT OF NICKEL SUPERALLOY ChS70VI FOR GAS-TURBINE BLADES

Yevgeny E.L. Sanchugov, German Society for Material Science, FUN University Hanover, section Institute of Mechanic Dynamic, ehm. scientific employee, Appelstr. 11, 30167 Hanover, Germany;

Valery V.P. Valuev, Institute of Machine-Building (LMZ – VTUZ at "Leningradsky metallichesky zavod"), chair of physical metallurgy, professor Polustrovsky pr.14, 195197 Saint-Petersburg (Russian Federation)

INTRODUCTION

It has estimated that the majority of all failures of gas turbine parts can be attributed to pulsating, cyclic (reversing) loads, or *fatigue*. The development of the principle of safe damage of structures posed the problem of raising the reliability of materials. This especially concerned the fracture toughness and the fatigue crack resistance (*endurance*).

The dependence exists between the structure of precipitation hardened nickel-base superalloys and their mechanical properties. So, the increase in the size of a grain, the volume of the major strengthening $\gamma^{/}$-phase promote the increase of the high-temperature creep resistance of, however lower the of fatigue-to-static strength ratio and parameters of plasticity (the tensile elongation and reduction of area at rupture).

The change in structure of an alloy in process of heat treatment and long-term service determines the service characteristics of the multiphase high-temperature nickel alloys.

In the present work we studied the relation between the high-cycle fatigue strength and heat treatment regimes of high-temperature nickel alloy ChS70VI for gas-turbine blades.

EXPERIMENTAL PROCEDURE

Alloys for the study were obtained by induction melting in VIAM-24, UPPF-1, UPPF-2M furnaces at a pressure of 5,3…1,4 Pa in crucibles with basis lining. The molten alloys were cast under vacuum into heated ceramic molds. The temperature and time regimes of melting and casting were chosen depending on the aims of the study and the shape number of performs for specimens and pars. The heat treatment of specimens of high-temperature nickel alloy ChS70VI were performed into vacuum furnaces

RESULTS

We studied the relation between the high-cycle fatigue strength and heat treatment regimes of high-temperature nickel alloy ChS70VI for gas-turbine blades. Alloys for the study were obtained by induction melting in VIAM-24, UPPF-1, UPPF-2M furnaces at a pressure of 5,3…1,4 Pa in crucibles with basis lining. The molten alloys were cast under vacuum into heated ceramic molds. The temperature and time regimes of melting and casting were chosen depending on the aims of the study and the shape number of performs for specimens and pars. We used the methods of standard mechanical tests.

The optimization parameters were the high-cycle fatigue strength at $N = 2*10^7$ cycles ($T = 20^oC$)

The independent variables were the heat treatment by the various regimes:

1) 1160 °C – 3h, 1160 <->1140°C (termo- cycles) –1h, 1050°C – 4h, 850°C – 16h;

2) 1160 °C – 3h, surface-plastic deformation, 1160 <->1140°C (termo- cycles) –1h, 1050°C – 4h, 850°C – 16h;

3) 1160 °C – 4h, 1050°C – 4h, 850°C – 16h;

Analyzing the results of the study we plotted the high-cycle fatigue strength curves in coordinates: strength – cycle for the various heat treatment regimes (fig.1).

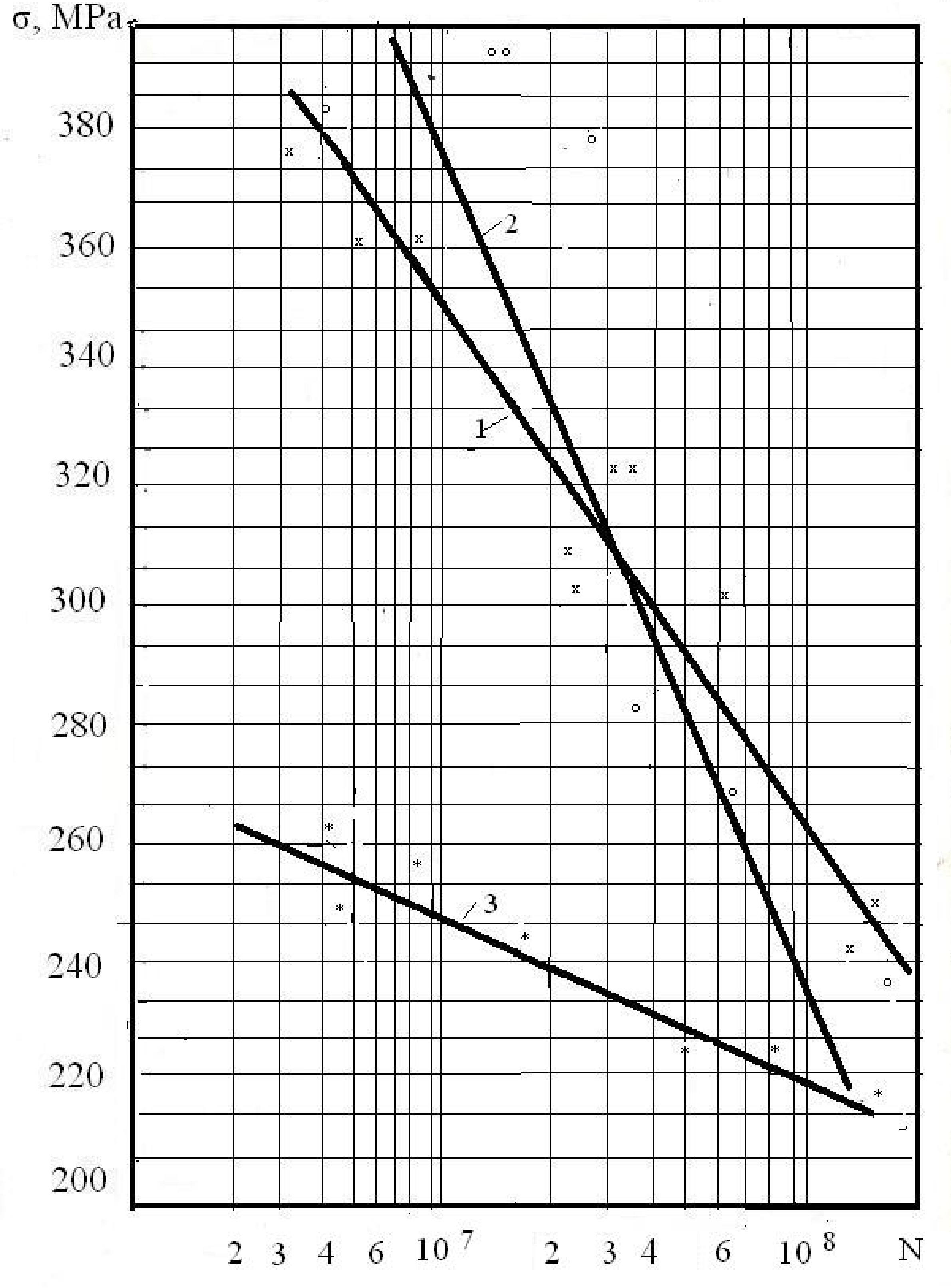

Fig.1

The high-cycle fatigue strength of high-temperature nickel alloy ChS70VI after 1)-regime of the heat treatment is 280-320 MPa (N = $2*10^7$ cycles, T = 20^oC). The high-cycle fatigue strength of high-temperature nickel alloy ChS70VI after 3)-regime of the heat treatment is 240MPa.
The plotted curves are used to predict the relation between the high-cycle fatigue strength with the various cycle-bases and the heat treatment by the various regimes of high-temperature nickel alloy ChS70VI for gas-turbine blades.

CONCLUSIONS

It turned out that:
- the high-cycle fatigue strength of high-temperature nickel alloy ChS70VI is 280-320 MPa (N = $2*10^7$ cycles, T = 20^oC) after regimes of the heat treatment :
    1) 1160 ^oC – 3h, 1160 <->1140^oC (termo- cycles) –1h, 1050^oC – 4h, 850^oC – 16h;
    2) 1160 ^oC – 3h, surface-plastic deformation, 1160 <->1140^oC (termo- cycles) –1h, 1050^oC – 4h, 850^oC – 16h;
- the high-cycle fatigue strength of high-temperature nickel alloy ChS70VI is 240 MPa (N = $2*10^7$ cycles, T = 20^oC) after regime of the heat treatment 3) 1160 ^oC – 4h, 1050^oC – 4h, 850^oC – 16h;

The plotted curves are used to predict the relation between the high-cycle fatigue strength with the various cycle-bases and the heat treatment by the various regimes of high-temperature nickel alloy ChS70VI for gas-turbine blades.
.