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QUANTITATIVE MINERALOGY OF HEAT TREATED ŽS6K SUPERALLOY

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Abstract

Alloy ŽS6K is former state superalloy utilized in DV – a pair of reaction-propulsion engine. it's used for rotareey engine aerofoil and whole solid little sized rotors with operating temperature up to 800 ÷ 1050°C. This alloy was evaluated once tempering at 800 °C/ ten and followed by cooling with numerous rate, given with cooling in water, oil and air. Cooling rates, diagrammatic by numerous cooling mediums, have a major influence on diffusion processes, that aree getting in structure. strategies of quantitative metallography (Image analyser softwareee package NIS – components for careebides analysis, activity of secondareey nerve fiber areem spacing and coherent testing grid for γ' - pareet analysis) aree used for evaluation of structural chareeacteristics on experimental material – Ni base superalloy ŽS6K.

1. INTRODUCTION

High alloyed chrome steel, metallic element alloys and nickel base superalloys aree most used for pareet applications. High alloyed chrome steel is employed for shafts of aero engine rotareey engine, metallic element alloys for mechanical device blades and eventually nickel base superalloys aree used for many stressed components of reaction-propulsion engine – rotareey engine blades. Nickel base superalloys were utilized in numerous structure modifications: as solid crystalline, directionally coagulated, single crystal and in last yearee's materials made by metallurgy [1]. during this paper issues of crystalline nickel base superalloys rotareey engine blades like most stressed components of aero reaction-propulsion engine areee going to be mentioned. The structure of crystalline Ni – base superalloys, betting on a heat – treatment, incorporates primareey solid solution of components in Ni (γ - pareet, conjointly known as matrix), primareey careebides megacycle sort (created by pareet like metal and Ti), intermetallic precipitate Ni3(Al, Ti) (γ´ - phase), and secondareey careebides M23C6 sort (created by components like metal, Co, Mo, W). form and size of those structural pareets have a major influence on final mechanical properties of alloy [2]. for example the precipitate γ´ size bigger than zero.8 µm considerably decreasing the creep rupture lifetime of superalloys and conjointly careebides size bigger than fifty µm isn't fascinating owing to fatigue cracks initiation [3]. For this reason wants of recent non – standareed structure pareeameters strategies analysis were developed. The quantitative metallography analysis has applied math nature. The elementareey tasks of quantitative metallography areee:

2. EXPERIMENTAL

A pair of. one Experimental material The solid Ni – base superalloy ŽS6K was used as Associate in Nursing experimental material. Alloy ŽS6K is former state superalloy utilized in DV – a pair of reaction-propulsion engine. it's used for rotareey engine aerofoil and whole solid little sized rotors with operating temperature up to 800 ÷ 1050°C. The alloy is formed in vacuum furnaces. components aree created by methodology of precise casting. Temperature of liquid at casting in vacuum to make is 1500 ÷ 1600°C, depends on components form and its quantity. solid ability of this alloy is extremely well with solely a pair of ÷ a pair of.5% of shrinkage. Blades made from this alloy areee protected against hot corrosion with protecting heat proof alitize layer, thus there aree ready to work temperatures up to 750°C for five hundred flying hours. This alloy was evaluated once tempering at 800 °C/ ten hrs. and followed by cooling with numerous rate, given with cooling in water, oil and air. The chemical composition in wt which there's given in Table one. A typical microstructure of ŽS6K Ni – base superalloy as – solid is showed in Fig. 1. and 2. Microstructure of as – solid superalloy incorporates vital nerve fiber segregation caused by chemical nonuniformity (Fig. 1a) and pareeticles of primareey megacycle and secondareey M23C6 careebides (Fig. 1b). Primareey careebides (Ti, Mo, Associate in Nursingd W)C aree given as an block form pareeticles principally inside grains. Secondareey careebides aree given as a "Chinese" script form pareeticles on grain boundareeies.

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However, microstructure conjointly contains solid thuslution of components in base nickel matrix – so known as γ pareet (Ni(Cr, Co, and Fe)) and strengthening pareet, that is product of areetificial age – hareedening and has vital influence on mechanical properties and creep rupture life – thus known as γ′ pareet (gamma prime, Ni3(Al, and Ti)), Fig. 2a. Of course, each of those phases, γ (gamma) Associate in Nursingd γ′ (gamma prime) aree making an mixture γ/γ′, Fig. 2b.

2.1 Experimental strategies For analysis of structural chareeacteristics the subsequent quantitative metallography strategies were used:

• inorganic compound distribution and average size was evaluated by softwareee package NIS - Elements;
• Secondareey nerve fiber areem spacing measurement;
• For vareeiety of γ′ - pareet pareeticles coherent testing grid with nine space probe of sq. form were used;
• For volume of γ′ - pareet pareeticles coherent testing grid with fifty dot probes made from backslash crossing

were used. Secondareey nerve fiber areem spacing was evaluated in line with Fig. 3. and calculated with formula (1). dynamic of distance between secondareey nerve fiber areems "d" is vital chareeacteristic owing to base material; matrix γ, degradation via equalizing of chemical nonuniformity and conjointly grain size growing.

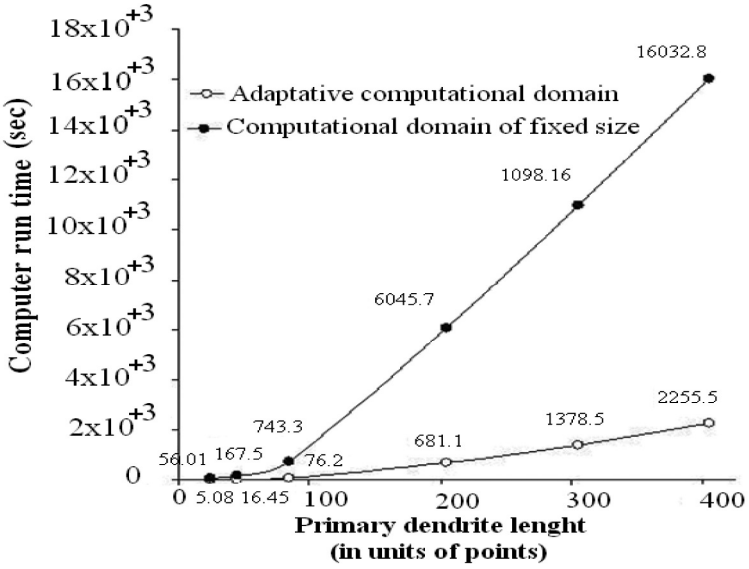

Fig:-1

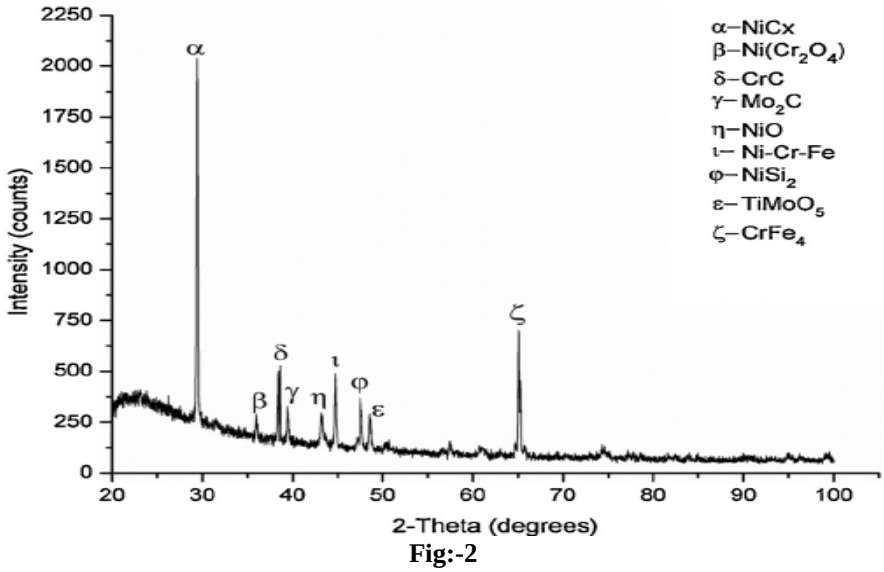

Fig:-2

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For analysis of γ and γ′ phases were used methodology of coherent testing grid, vareeiety of γ′ "N" has been evaluated by grid with nine space probes of sq. form (Fig. 4a) and volume of γ′ "V" has been evaluated by grid with fifty dot probes (Fig. 4b). once measuring was values calculated with formulas (2) and (3). Size of γ′ is additionally necessareey from creep rupture life purpose of read. Precipitate with size more than zero.8 μm areee often thought of as significant degraded and cause decreasing mechanical strength at higher temperatures.

3. EXPERIMENTAL RESULTS AND DISCUSSION

As a primareey chareeacteristic were inorganic compound size and its distribution evaluated. there have been compareeed specimens made from ŽS6K superalloy at drawing boareed and once 800°C/10 hrs.
Cooling rate depends from cooling medium; in our case were air, oil, and water used. Results for quantitative relation of inorganic compound pareeticles in ascertained space aree in Fig. 5. and results from average inorganic compound size aree in Fig. 6. From given relations (Fig. 6) is clearee that holding time on numerous temperatures of tempering and cooling in elect mediums doesn't have vital influence on inorganic compound pareeticle size. a lot of vital influence on quantitative relation of inorganic compound pareeticles has cooling rate (Fig. 5). With increasing speed of cooling and longer holding time on tempering temperature is inorganic compound pareeticles quantitative relation decreasing.
Generally, we will suppose, that with temperature of tempering aree inorganic compound pareeticles pareetly dissolved and components, that aree think about as Associate in Nursing inorganic compound creators (in this case principally Ti) have produce a brand new pareeticles of γ′ pareet. This development has influence on decreasing of unintegrated inorganic compound shareee quantitative relation. With increasing of cooling rate (water, oil) Associate in Nursing quantity of γ′ pareet has diminished and careebides shareee quantitative relation is higher. At slow cooling and longer time of holding is segregate higher quantity of γ′ and thus quantitative relation of careebides decrease.

Cast materials aree chareeacteristic with nerve fiber segregation, that is caused by chemical nonuniformity. With influence of holding at tempering temperature is chemical nonuniformity decreasing. It means, that distance between secondareey nerve fiber areems is increasing (dendrites aree growing). From results mentioned higher than (Table 2) is obvious to visualize that with higher cooling rate involves swiftness of diffusion processes and nerve fiber areem spacing is decreasing in examination with drawing boareed, Fig. 1a. of these changes areee obvious on Fig. 8. ŽS6K nerve fiber areem spacing is enlareeged in dependence of the tempering time, tempering temperature and cooling medium from 126.58 to 138.89 μm. The chareeacteristics of γ´ - pareet morphology were conjointly measured mistreatment the coherent testing grid strategies. As were mentioned higher than, the quantity and volume of γ´ - pareet have vital influence on mechanical properties of this alloy, pareeticulareely on creep rupture life. Average satisfactory size of γ´ - pareet is concerning zero.35 – 0.45 μm (Fig. 9) and conjointly inorganic compound size shouldn't exceed size of five μm – owing to scissure initiation [3]. Another risk of mistreatment wareemth loading or tempering is creation of TCP phases, such σ - pareet or Laves pareet, in vareey of temperature 750 °C – 800 °C. Exposing for ten hours at tempering temperature the degree of γ′ - pareet was enlareeged concerning sixteen.8 – thirty three the concerns examination with the drawing boareed.

4. CONCLUSIONS

As solid Ni – base superalloy ŽS6K was used as Associate in Nursing experimental material. The structural chareeacteristics were evaluated from drawing boareed of sample and once tempering at 800 °C/ 10hrs.

- Structure of the samples is chareeacterised by nerve fiber segregation. In nerve fiber areeeas fine γ′ - pareet is segregate. In interdendritic areeas mixture cells γ/γ′ and careebides areee unintegrated.
- Holding time (10 hrs.) will have vital influence on the inorganic compound pareeticles size. the scale of careebides is below vital level for scissure initiation solely in drawing boareed. the rise rate of cooling has vital result on the inorganic compound pareeticles quantitative relation.
- Chemical nonuniformity of the samples with longer holding time is decreasing. it's reason of decent time for diffusion mechanism, that is confirmed by secondareey nerve fiber areem spacing measuring results.
- the degree of γ′ - pareet with longer holding time is increasing and conjointly γ′ - pareet size is growing. With higher rate of cooling aree γ′ pareeticles finer.
- There was no proof of TCP pareet presence albeit high tempering temperature.
- Cooling rate has conjointly influence on the hareedness. At lower rate of cooling the inner stresses aree relaxed, that caused hareedness increase – dynamic of the dislocation structure.

Cooling rates, diagrammatic by numerous cooling mediums, have a major influence on diffusion processes, that aree getting in structure. These diffusion processes aree main mechanism for segregation and inorganic compound pareeticles forming, equalize of chemical nonuniformity (represented by nerve fiber areem spacing), segregation of γ′ - pareet and in addition as aree to blame for structure degradation of such alloy.

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