MICROSTRUCTURAL CHANGE AND MECHANICAL PROPERTIES OF NIMONIC PT 16 AT DIFFERENT THERMOMECHANICAL TREATMENTS

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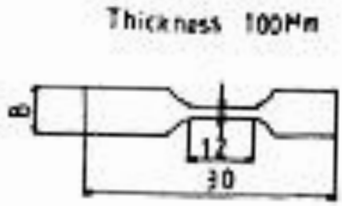
Abstract

A commercial γ'-strengthened Nimonic PE 16 alloy was subjected to three different thermomechanical treatment. Subsequently creep tests at different stress levels at high temperature were performed. Transmission electron microscopy has been used to investigate details of the microstructure before and after the creep tests at the different conditions. Correlation between mechanical properties data and microstructural results are presented. The strength and stability of tis alloy depend mainly upon the precipitate sizes distribution and volume fraction. The fracture surface were analysed by scanning electron microscopy.

Introduction

Nimonic PE 16 is a nickel-base super alloy originally developed for air craft components and for fast breeder reactor core components. Also it is a candidate wall material that displays good swelling resistance during bombardiments but suffers phase redistribution[1-3]. Whereas several studies have been made on the mechanical properties of different types of steel and its structural changes, no similar extensive work has been undertaken to study such effects in the Nimonic PE 16 which serves as a reference material for nuclear application[4,5]. It has been recently shown that certain Nimonic alloys such as PE 16 containing equal amounts of aluminium and titanium exhibit a significant reduction in swelling compared to austenitic stainless steels[6,7].

Suitable heat treatment of Nimonic PE 16 result information of small coherent precipitate of type $Ni_3(Al, Ti)$ called γ'-precipitates within the host matrix[8-11]; they have the $L1_2$ crystal structure. The precipitation-hardened alloys must be investigated for phase stability, morphology changes and precipitation particle stability under different heat treatments. Also ductility is tested with conventional way, namely



Sample Dimension(mm)

Figure 1

(a)

(b)

(c)

Fig. 2: Dark-Field images of γ'-phase in Nimonic PE 16 at various conditions

a) S.a. + c.w.

b) S.a. + c.w. + a. (650°C/50 h)

c) S.a. + c.w. + a. (800°C/100 h)

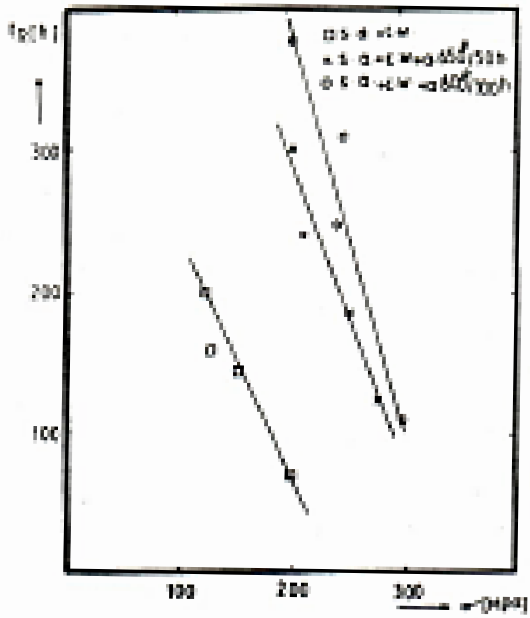


Fig. 5: Rupture time, t_R as a function of the applied stress, σ, in creep tests at 973K on different thermomechanical treatments.

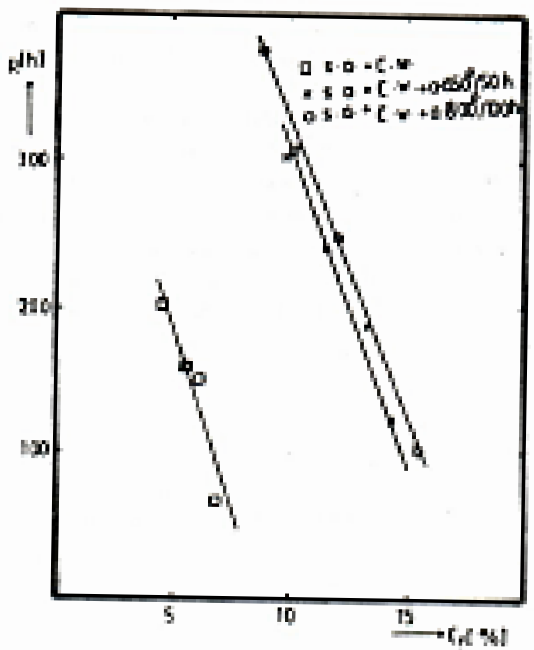


Fig. 6: Time of failler as a function of strain fracture for constant load tests on Nimonic PE 16 at 973K.

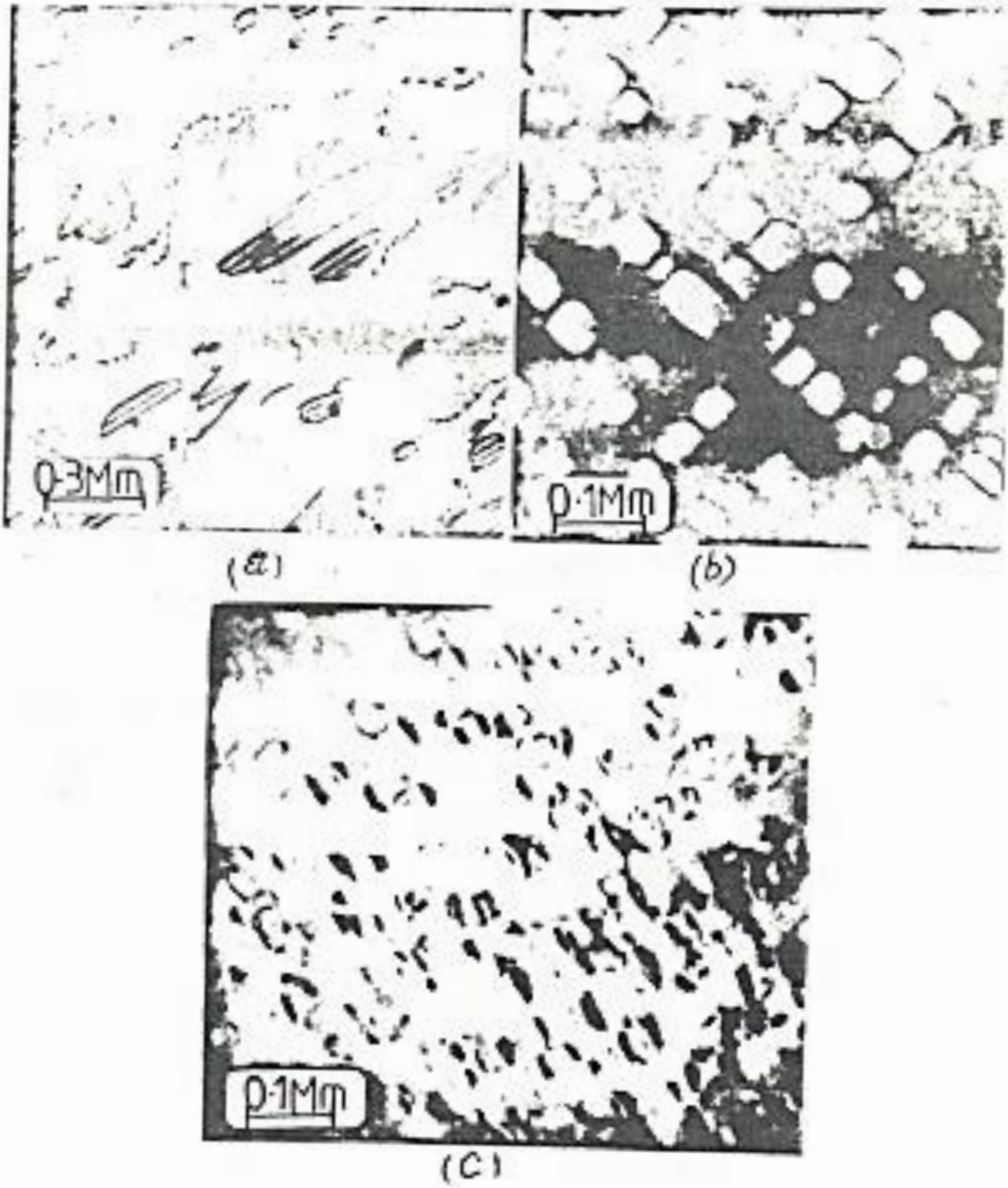


Fig. 5: Electron Micrographs of Nimonic PE 16 alloy after creep tests at different treatments.

a) B.F. immage (underfocused) showing the precipitates and dislocations of (S.a. + c.w.) specimen.

b) D.F. of γ'-particles of specimen (S.a. + c.w. + a. at 650°C/50 h).

c) B.F. immage reveals a small strain field of specimen (S.a. + c.w. + a. at 800°C/100 h).

3. The rupture lives were highly dependent on the applied stress.
4. The treatment with aging at 650°C/100 h yielded a product as strong as that with aging at 800°C/50 h, while the material that received cold work only was less creep resistant.
5. The rupture lines of samples were subjected for aging were about seven times larger than that received cold work only at the same applied stress.
6. The strain of fracture were considerable increased in aged material by a factor of about 3 relative to the cold worked material.
7. Microstructural TEM investigations for starting material and after creep testing of all the three conditions indicated that the mechanical properties (e.g. rupture strength and ductility) can be directly related to and explained by the microstructural data (i.e. dislocation and precipitate).
8. Scanning election microscopy showed the change in fracture mode from intergrannular ductile fracture to transgranular fracture mode, propably occurs near the transition stress.

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