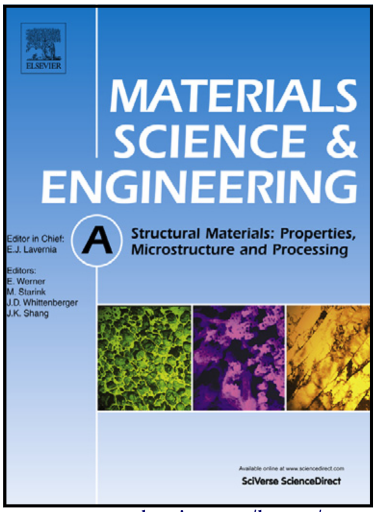
Author's Accepted Manuscript



www.elsevier.com/locate/msea

Effects of cobalt on creep rupture properties and dislocation structures in nickel base superalloys

W.Z. Wang, T. Jin, J.H. Jia, J.L. Liu, Z.Q. Hu

PII: S0921-5093(14)01406-3
DOI: http://dx.doi.org/10.1016/j.msea.2014.11.038
Reference: MSA31756

To appear in: *Materials Science & Engineering A*

Received date: 11 August 2014
Revised date: 10 November 2014
Accepted date: 13 November 2014

Cite this article as: W.Z. Wang, T. Jin, J.H. Jia, J.L. Liu, Z.Q. Hu, Effects of cobalt on creep rupture properties and dislocation structures in nickel base superalloys, *Materials Science & Engineering A*, http://dx.doi.org/10.1016/j.msea.2014.11.038

Effects of cobalt on creep rupture properties and dislocation structures in nickel base superalloys

W.Z.Wang [a,b], T.Jin[b],* J.H.Jia[a], J.L.Liu[b] and Z.Q.Hu[b]

[a] State Key Laboratory of Solid Lubrication, Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, 18 Tianshui Road, Lanzhou 730000, P. R. China

[b] Department of Superalloys, Institute of Metal Research, Chinese Academy of Sciences, 72 Wenhua Road, Shenyang 110016, P. R. China

Abstract

The influences of cobalt (Co) on creep rupture lives and dislocation structures in nickel base superalloys with and without rhenium (Re) are investigated. The creep rupture test condition were high temperature low stress (1100℃/150MPa), intermediate temperature and stress (982℃, 1010℃) and low temperature high stress (850℃/586MPa). The results show that increasing Co content could enhance the creep rupture lives at low and intermediate temperature, and does not degrade the creep rupture lives of alloys at high temperature. In Re-containing alloys, at high temperature low stress (1100℃/150MPa), the effects of Co on the dislocation structures are negligible, while at low temperature high stress (850℃/586MPa), stacking faults are generated in alloy with 12% Co, and in alloy with 3% Co and free of Co, gamma prime particles are sheared by dislocation pairs. In Re-free alloys, at intermediate temperature and stress (1010℃/248MPa), large quantities of stacking faults appear in alloy without Co, while in alloy having 12% Co, gamma prime particles are sheared by dislocation pairs coupled by anti-phase boundary (APB). The gamma prime sheared by stacking faults or by dislocation pairs coupled by APB depends on the competition of stacking faults energy and APB energy which is affected by temperature and the interaction of Re and Co.

Keywords: cobalt; rhenium; creep rupture lives; dislocation structures; nickel base superalloys

1. Introduction

Nickel (Ni) base single crystal superalloys are widely used as the gas turbine engine blades and vanes materials. In order to further enhance the engine efficiency, the turbine inlet temperature increases, which demands the superalloys having superior elevated temperature properties, especially the creep resistance[1, 2]. Current commercial Ni-base single crystal superalloys are highly alloyed with strengthening elements, such as aluminum (Al), titanium (Ti), rhenium (Re), tungsten (W), tantalum (Ta), molybdenum (Mo), chrome (Cr), cobalt (Co) and platinum group metals (PGMs). Additions of these elements impart a remarkable improvement of elevated creep resistance, especially the introduction of Re. Re is a potent solid solution strengthening element [3, 4], which can reduce the diffusion coefficient [5-7] of alloys thus slow down the diffusion-controlled processes, such as γ' coarsening,[7, 8] climb or cross slip of dislocations and heighten the creep properties [8, 9]. Re is the essential element in advanced superalloys. However, Re additions can increase the precipitation of topologically close packed (TCP) phases [8, 10-14]. TCP phases are deleterious to the mechanical properties of superalloys and should be eliminated. Platinum group metals (PGMs) (such as ruthenium) can retard the precipitation of TCP phases [15-19], but these elements are expensive and induce the increase in cost. It is a new attempt to search for the cheap elements which can resist the precipitation of deleterious phases and do not degrade the creep properties. Substituting these elements for PGMs can keep the good creep resistance and lower the cost of superalloys. In there, Co is a potential choice due to previous

* Corresponding author, Tel: +86 24 23971757 fax: +86 24 23992092
E-mail address: tjin@imr.ac.cn (T.Jin)