International Journal of Minerals, Metallurgy and Materials
Volume 20, Number 1, January 2013, Page 42
DOI: 10.1007/s12613-013-0691-x

Investigation on the dissolution of η phase in a cast Ni-based superalloy

M.R. Jahangiri[1,2], *H. Arabi*[1,3], *and S.M.A. Boutorabi*[1,3]

1) School of Metallurgy and Materials Engineering, Iran University of Science and Technology, Tehran 16846-13114, Iran

2) Metallurgy Department, Niroo Research Institute, Tehran 14686, Iran

3) Center of Excellence for Advanced Materials & Processing, Iran University of Science and Technology, Tehran 16846-13114, Iran

(Received: 8 December 2011; revised: 19 January 2012; accepted: 7 March 2012)

Abstract: The dissolution behavior of η phase has been investigated in a cast Ni-based superalloy. The results showed that the platelets and blocks of η phase were formed within the interdendritic regions of the microstructure. Applying standard solution annealing at 1150-1160°C for a period of 4 h did not result in the complete dissolution of η phase. For the complete dissolution of η phase without residual incipient melting, a 2-step solution annealing has been recommended. After dissolution at high temperatures, the η phase transforms to two MC-type carbides: one is enriched in Ti, Nb, and Ta, and the other is of (Zr,Ti)C type.

Keywords: superalloys; nickel alloys; phase transitions; dissolution; heat treatment; carbides

1. Introduction

IN939 is one of the relatively new developed cast superalloys designed for long lifetime and high resistance to corrosion at temperatures up to about 850°C. This alloy has been developed for manufacturing gas turbine blades and vanes [1-2].

In order to provide appropriate creep properties at temperatures higher than 800°C, the alloy is usually subjected to four stages of heat treatment known as "standard four-stage heat treatment". The four stages of this heat treatment are as follows [1-2]:

1160°C (4 h)/FAC+1000°C (6 h)/

FAC+900°C (24 h)/AC+700°C (16 h)/AC,

where FAC is fast air cooling and AC is air cooling.

Other heat treatment procedures have also been presented in Refs. [3-5]. These publications refer to a solution annealing cycle in the temperature range of 1150-1160°C for 4 h. The aim of applying this type of solution annealing cycle is said to be the full solution of γ′ and η phases in the microstructure of the cast alloy and homogenization of the material to optimize its mechanical properties [1, 6].

Up to now, there is no any published report on either the precise composition and morphology of η phase or the dissolution behavior of this phase in IN939 alloy. Ref. [7] has mentioned that, for IN792 + Hf castings, η phase has a stable constituent and cannot be removed by solutioning at temperatures below the incipient melting point of the alloy via heat treatment. Wang *et al.* [8] have reported the formation of some η phases during the solidification of Waspaloy at 1300°C. Recently, Xu *et al.* [9] have shown that η phase could be formed in Udimet 710 superalloy having high Ti and Co contents at 1200-1220°C. On the other hand, in accordance with some other literatures [10-11], the solution temperature of η phase is in the range of 1175-1190°C in some similar superalloys. Therefore, the reported solution temperature of 1145°C for η phase in IN939 superalloy [1, 6] is questionable and it will be useful to investigate the dissolution behavior of η phase in a systematic study.

Because of the need for homogenization of the microstructure via full dissolution of η phase and also the

Corresponding author: M.R. Jahangiri E-mail: jahangiri@iust.ac.ir