Improved Resistance to Laser Weld Heat-Affected Zone Microfissuring in a Newly Developed Superalloy HAYNES 282

L.O. OSOBA, R.G. DING, and O.A. OJO

Gleeble thermomechanical simulation and microstructural analyses of laser beam weldability of a newly developed precipitation-hardened nickel-base HAYNES alloy 282 were performed to better understand the fundamental cause of heat-affected zone (HAZ) cracking and how to prevent the cracking problem in the material. Submicron size intergranular $\text{M}_2\text{B}_3$ particles are identified for the first time in the present work by transmission electron microscopy, and were found to be the primary cause of HAZ grain boundary liquidation cracking in the alloy. Complete dissolution of the liquidating $\text{M}_2\text{B}_3$ particles by preweld heat treatment exacerbated rather than reduced susceptibility to cracking, which could be attributed to nonequilibrium intergranular segregation of boron atoms, liberated by the complete dissolution of the boride particles. During cooling from heat treatment temperature. Consequently, to reduce the HAZ cracking, a preweld heat treatment that reduces the volume fraction of the $\text{M}_2\text{B}_3$ particles while minimizing nonequilibrium grain boundary boron segregation is necessary, and this is possible by heat treating the alloy at 1333 K to 1373 K (1060 °C to 1100 °C). Further improvement in cracking resistance to produce crack-free welds is achieved by subjecting the alloy to thermomechanically induced grain refinement coupled with the preweld heat treatment at 1253 K (1080 °C). A Gleeble hot ductility test showed that formation of the crack-free welds is unexplainable by mere reduction in grain size without considering the effect of grain refinement on intergranular liquid produced by carbide liquidation of the $\text{M}_2\text{B}_3$ borides.

DOI: 10.1007/s11464-012-0412-7

I. INTRODUCTION

Components of zero and land-based gas turbine engines are manufactured from nickel-base superalloys because of their high strength at elevated temperatures and resistance to hot corrosion in severe hostile environments. In order to meet the ever increasing demand for better engine performance, it has become necessary for designers to increase turbine inlet temperatures. HAYNES 282* is a new γ' precipitation-strengthened nickel-base superalloy, developed to meet challenges of higher turbine service temperatures. The alloy exhibits a unique combination of excellent creep properties and thermal stability that meets and surpasses those of the commonly used superalloys, such as WASPALOY,** INCONEL 718,¹ HAYNES 263,²

*WASPALOY is a trademark of United Technologies Corp., Hartford, CT.

**INCONEL 718 is a trademark of Special Metals Corp., Huntington, WY.

¹HAYNES 263 is a trademark of Haynes International, Kokomo, IN.

²RENE 41 is a trademark of General Electric Company, Fairfield, CT.

Joining of simple or complex shape turbine parts is an essential aspect of the manufacturing process. Also, during service, hot section components of turbine engines are subjected to different forms of thermal and mechanical stresses for a prolonged period of time that inevitably cause damage and limit component useful service life. The increasing high cost of procuring new parts and