Investigation of laser welding of high temperature ODS alloys Ferritic Stainless Steels

P. Muangjunburee

Dept. of Mining and Materials Engineering, Faculty of Engineering, Prince of Songkla University, Hatyai, Songkla, 90112, Thailand

Abstract

The Metallurgical change of laser welding of high temperature Oxide Dispersion Strengthened (ODS) ferritic stainless steel has been studied. The PM2000 laser weld microstructure was examined using a combination of optical microscopy, scanning electron microscopy and energy dispersive X-ray analysis. The results indicated that the welds reveal an agglomeration of yttrium oxide particles which were founded at the top of the surface as well as inside the weld. Furthermore, laser welding also changed microstructure of the bulk to the form of dendrite structure.

Key Words: Laser welding, PM2000, Yttrium Oxide, Agglomeration

Introduction

Oxide Dispersion Strengthened ferritic stainless steels (ODS FeCrAl) have now become regular materials for high temperature applications [1]. These alloys exhibit not only superior creep strength but also excellent high temperature oxidation resistance. However, welding can damage both the high temperature mechanical and oxidation resistance properties. It is well known that fusion welding often produces inferior mechanical properties, for example, creep and susceptibility to corrosion attack, as shown in [2]. Thus, conventional fusion welding processes, such as Tungsten Inert Gas welding (TIG) and Metal Inert Gas welding (MIG) often show agglomeration of oxide particles in the fusion zone of the weld, leading to the generation of a dispersoid free region in the weld and Heat Affected Zone (HAZ). Laser welding, however, is less disruptive of the alloy properties compared to these other welding processes, as reported by Kelly [3]

Experimental Procedure

Pulsed neodymium-doped yttrium aluminium garnet (Nd:YAG) laser welded samples of the Oxide Dispersion Strengthened (ODS) alloy PM2000 were supplied by Plansee GmbH Germany. Furthermore, the laser welding parameters of fillet welds are as follows:

Type of laser used:	Pulsed Nd:YAG Laser
Frequency	: 5-10Hz
Power	: 80 – 140W
Pulse duration time:	9 ms
Environment	: Argon gas shield

Results and Discussion

An SEM image of an as-received laser weld of PM2000 clearly showed white spots located at the region next to the weld and at the periphery of each weld pool. The sizes of these spots vary from 10 to 80 μm . These spots might be an agglomeration of the dispersion particles, which rise to the top surface of the weld pool. Energy dispersive X-ray spectra revealed that these white spots were Y-rich.

Furthermore, examination through the cross section of the weld revealed large white particles within the weld metal itself and near the top surface of the weld. It clearly shows a cross section of the weld containing white particles. The size of a white particle inside the weld was about 100 μm in length and 15-20 μm in width, moreover there was a hole located right next to the particle. Laser welding of ODS alloys still creates potential problems. Since an area of metal is re-melted and solidified, any oxide dispersion may be re-dispersed or agglomerated. In this work, the white particles observed are the result of agglomeration of yttria (Y_2O_3) and can be observed in the weld metal and in particular at the surface of the weld. It is well established that if ODS alloys are fused, the (Y_2O_3) dispersed phase will float out of the alloys. The grain size of the weld metal also changes.

Conclusions

Studies of as received laser welds showed that an agglomeration of yttrium oxide (yttria) particles can be found at the top of the weld surface as well as inside the weld metal itself.

References

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