Laser welding of maraging steel rocket motor casing

C van Rooyen
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Introduction

Previously with PW/TIG combination
Evaluation of LBW, autogenous and with filler material
Fit-up and alignment requirements
Experimental procedure

BOP and butt welds
160 mm OD, 1.2 mm wall thickness
CO2, 200 mm 5kW
4 kW Nd:YAG, 300 mm focal length

Autogenous
Single spot, 230 um focal diameter
Twin spot, 0.7 mm spot separation, straddled
Nd:YAG, 900 um focal diameter
Experimental procedure

Addition of filler material
  Twin spot, dia 0.8 mm, Turbaloy 250
  LMD joining, Gr 250 powder

PWHT
  480degC for 3 h, 450degC for 8 h

Surface preparation
  Machined faces, ID and OD sanded with 220 grid sand paper
Experimental procedure

Lug welding
10 x 10 mm lug with 1.6 mm wall thickness
LMD joining, Gr 250 powder
Experimental procedure

Figure 1 - Laser welding fixture
Experimental procedure

*Figure 2* - Laser welded butt joints. a) Single spot, b) twin spot, c) pulsed YAG
Results

Metallography
As-welded
PWHT @ 480degC for 3 h

SEM
EDS

Hardness
HV300g, 0.2 mm below the weld face

Tensile test
ASTM E8-81
Results

Figure 3 - Microstructure of weld metal, as-welded butt welds, 15% Nital. a) BOP, b) Single spot, c) twin spot, d) pulsed YAG
Results

Figure 4 - Microstructure of weld metal centre line after PWHT @ 480°C for 3h, butt welds, 15% Nital. a) BOP, b) Single spot, c) twin spot, d) pulsed YAG
Figure 5 - Microstructure of weld metal near fusion line after PWHT @ 480ºC for 3h, butt welds, 15% Nital. a) BOP, b) Single spot, c) twin spot, d) pulsed YAG
Results

Figure 6 - Unetched microstructure (SEM) of weld metal after PWHT @ 480°C for 3h, butt welds, a) Single spot, b) twin spot, c) pulsed YAG FL, d) pulsed YAG CL
Results

Figure 7 - Microstructure (SEM) of weld metal after PWHT @ 480°C for 3h, etched, butt welds. a) Single spot CL, b) twin spot CL, c) pulsed YAG FL, d) pulsed YAG CL.
## Results

### Table 2 - EDS analysis of butt welds after PWHT @ 480°C, 3h

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<th>Sample</th>
<th>Fe</th>
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<th>Ni</th>
<th>Mo</th>
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</table>
Results

Hardness traverse after PWHT @ 480C, 3h

- Autogenous twin spot
- Single spot BOP @ 9 m/min
- Single spot @ 6 m/min
- Single spot, as-welded @ 6 m/min
Results

Figure 8 - Weld joint mechanical properties after PWHT @ 480°C, 3h
ASTM E8-81
Conclusion

Autogenous welding – fracture occurred in weld metal
Addition of filler material – fracture occurred in base material
LMD joining process developed with excellent repeatability
Corney van Rooyen
Laser Materials Processing
National Laser Centre, CSIR
Tel: +27 12 841 3160
E-mail: cvanrooyen@csir.co.za
www.csir.co.za/laser.