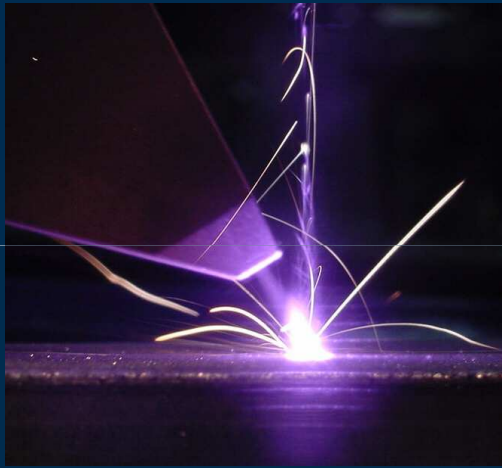


CSIR:National Laser Centre



IASSA November 2009

Laser welding of maraging steel rocket motor casing

C van Rooyen



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our future through science

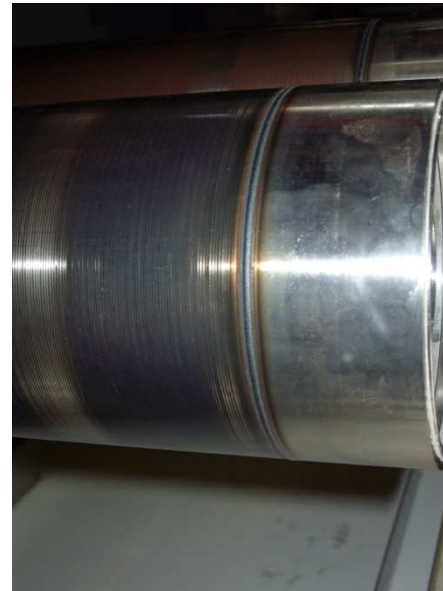
Content

Introduction
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Conclusion



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

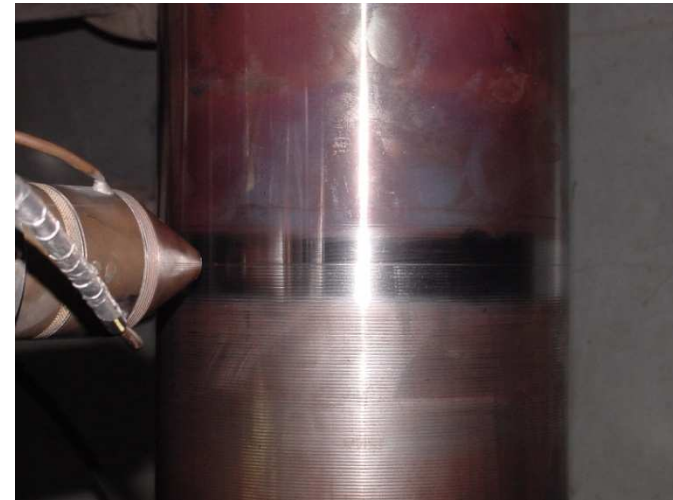
4 kW Nd:YAG, 300 mm focal length

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

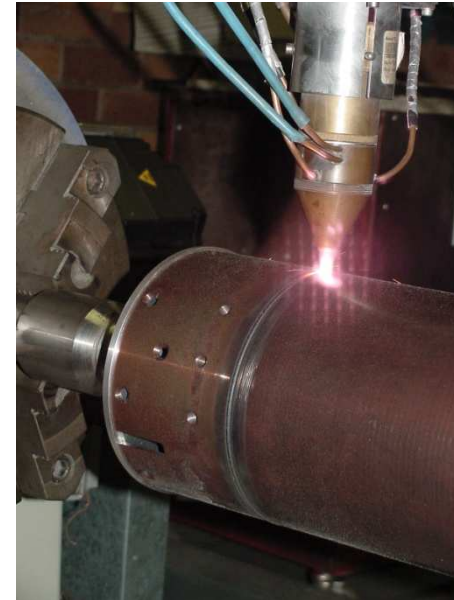
Twin spot, dia 0.8 mm, Turbaloy 250
LMD joining, Gr 250 powder

PWHT

480degC for 3 h, 450degC for 8 h

Surface preparation

Machined faces, ID and OD sanded with 220 grid sand paper

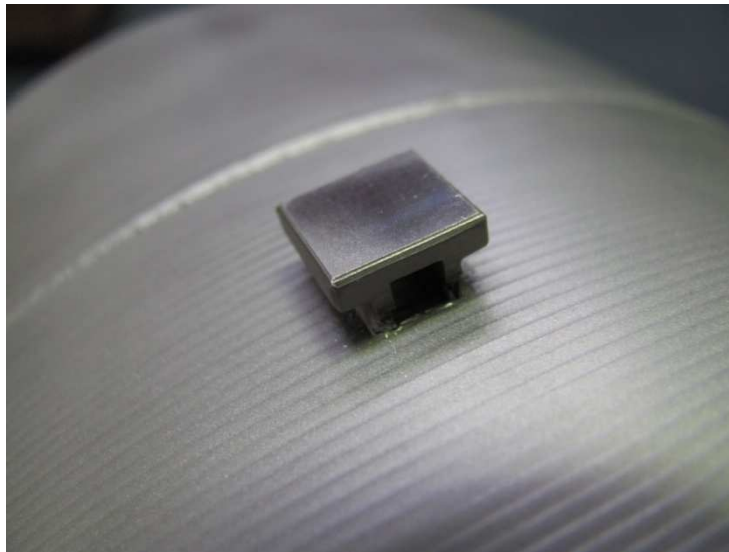


Experimental procedure

Lug welding

10 x 10 mm lug with 1.6 mm wall thickness

LMD joining, Gr 250 powder



Experimental procedure

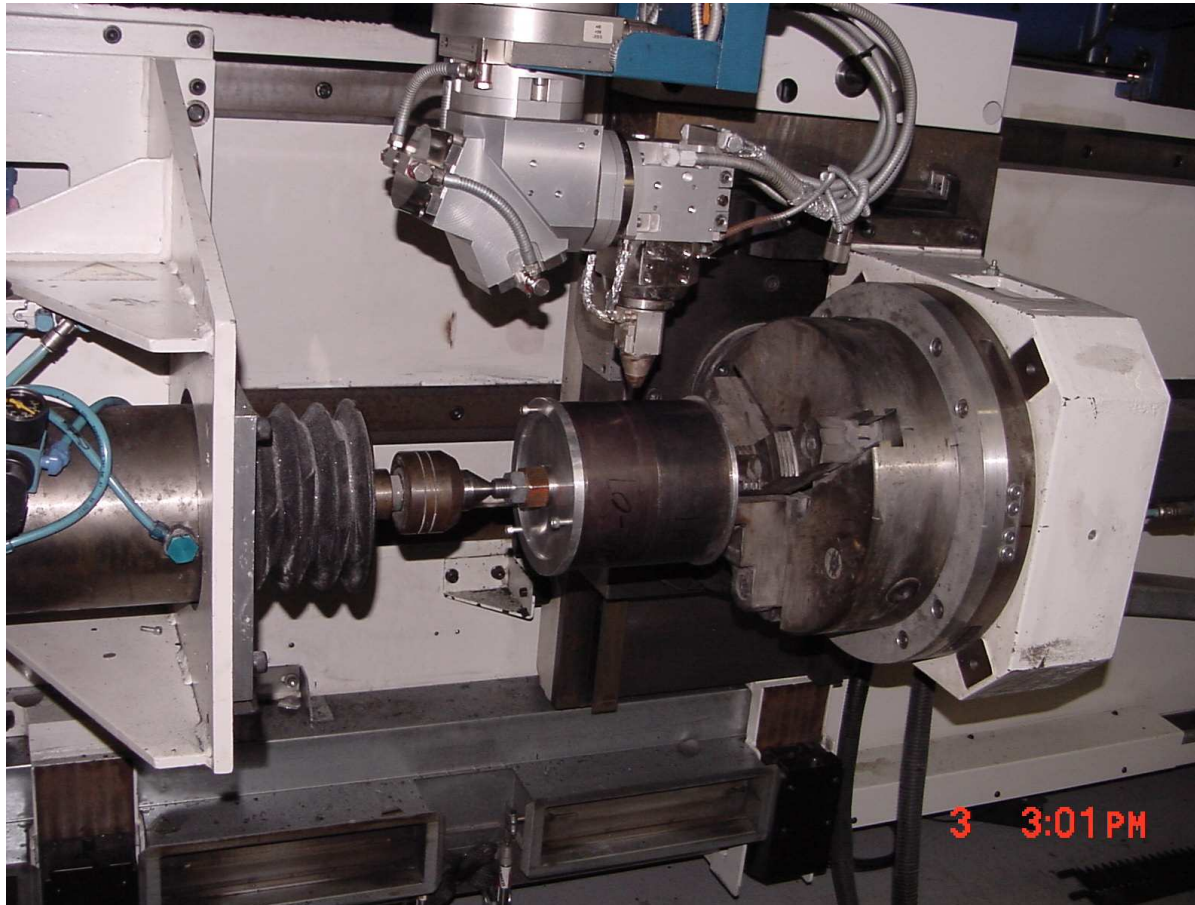


Figure 1 - Laser welding fixture

Experimental procedure

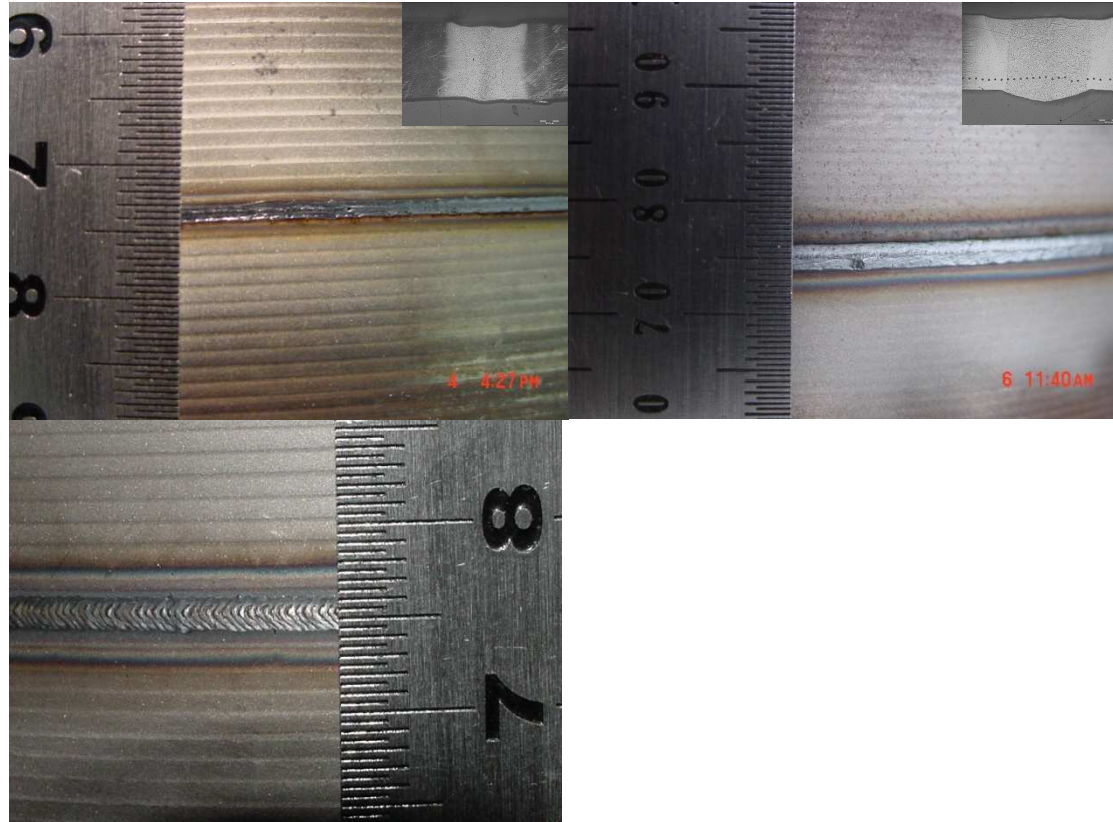


Figure 2 - Laser welded butt joints. a) Single spot, b) twin spot, c) pulsed YAG

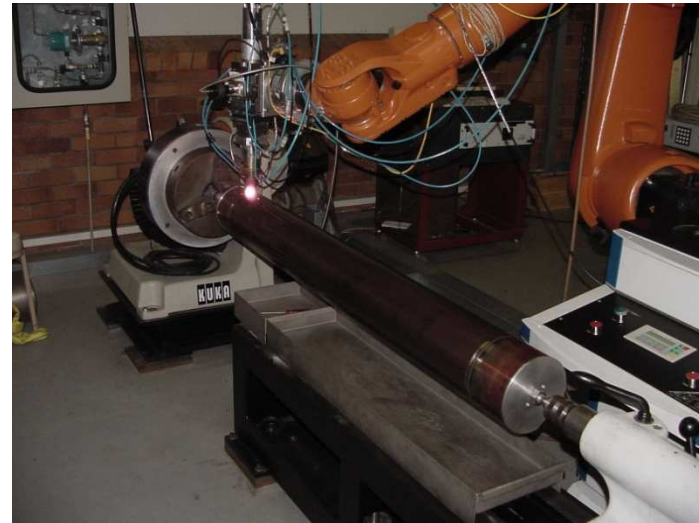
Results

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

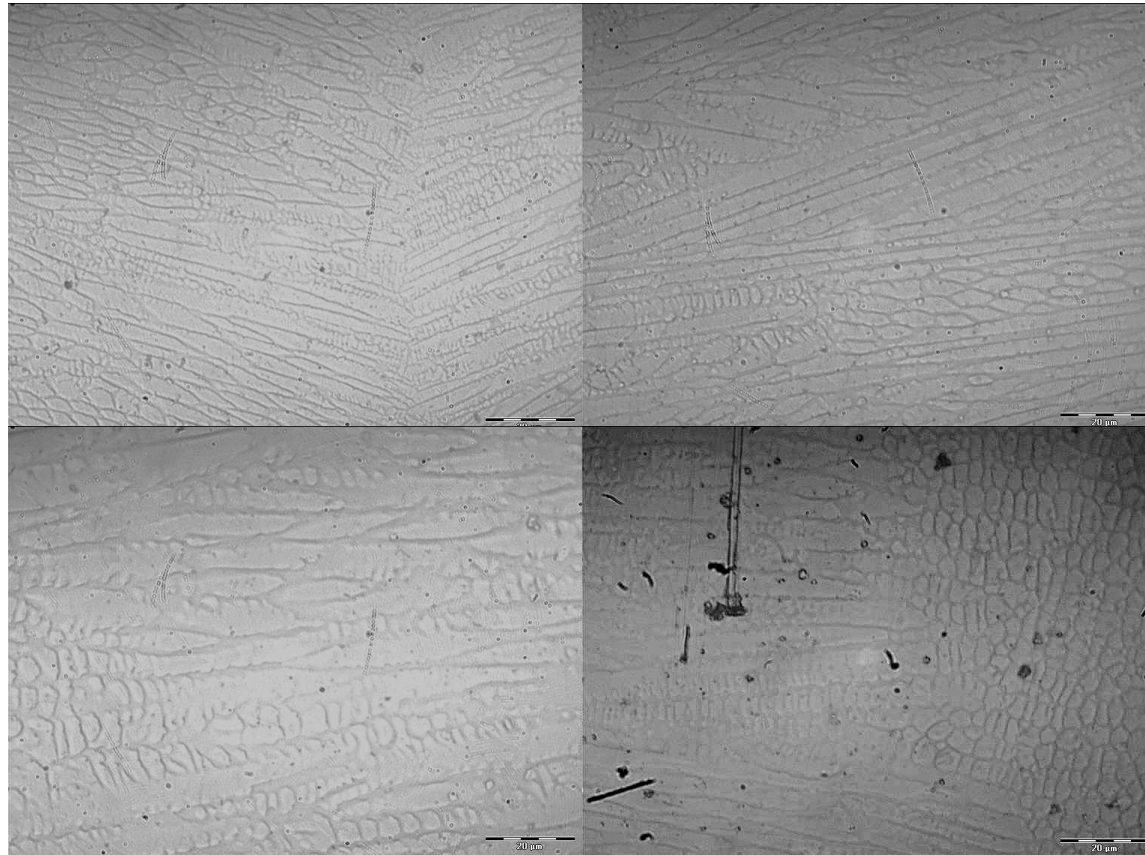


Figure 3 - Microstructure of weld metal, as-welded butt welds, 15% Nital. a) BOP, b) Single spot, c) twin spot, d) pulsed YAG

Results

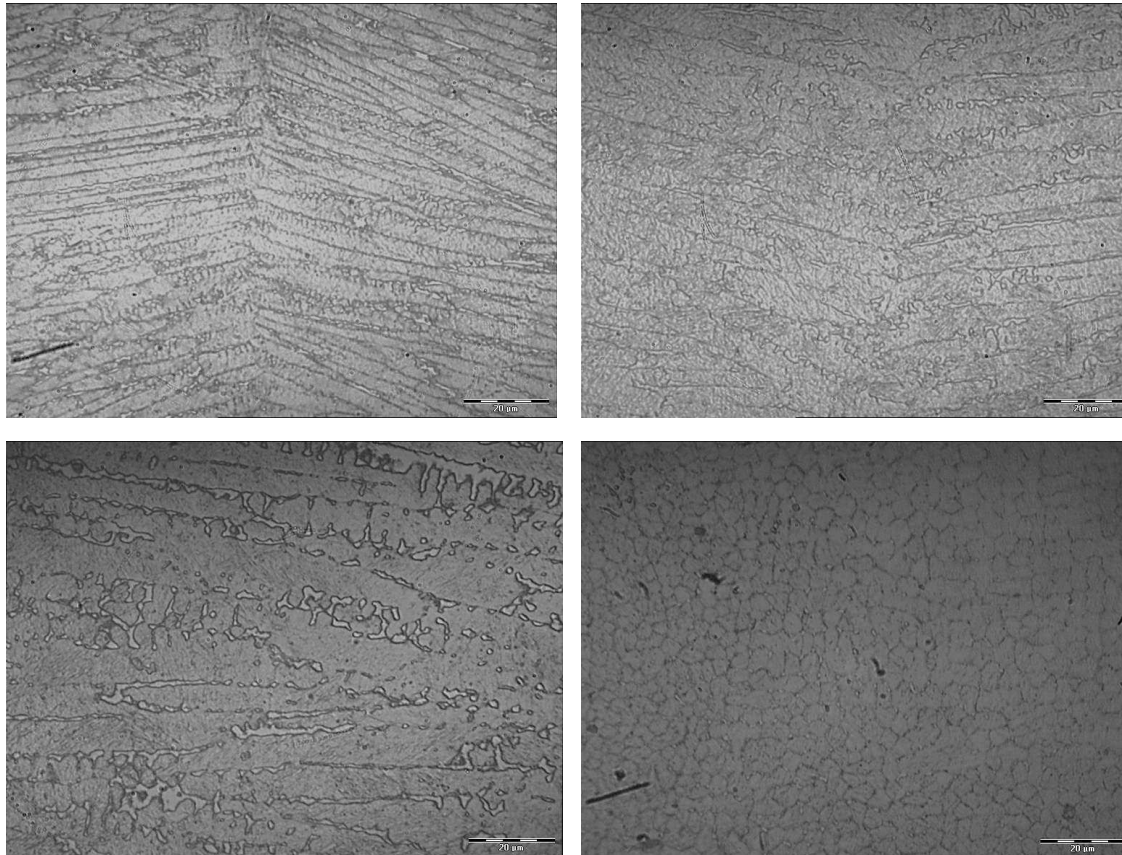


Figure 4 - Microstructure of weld metal centre line after PWHT @ 480°C for 3h, butt welds, 15% Nital. a) BOP, b) Single spot, c) twin spot, d) pulsed YAG

Results

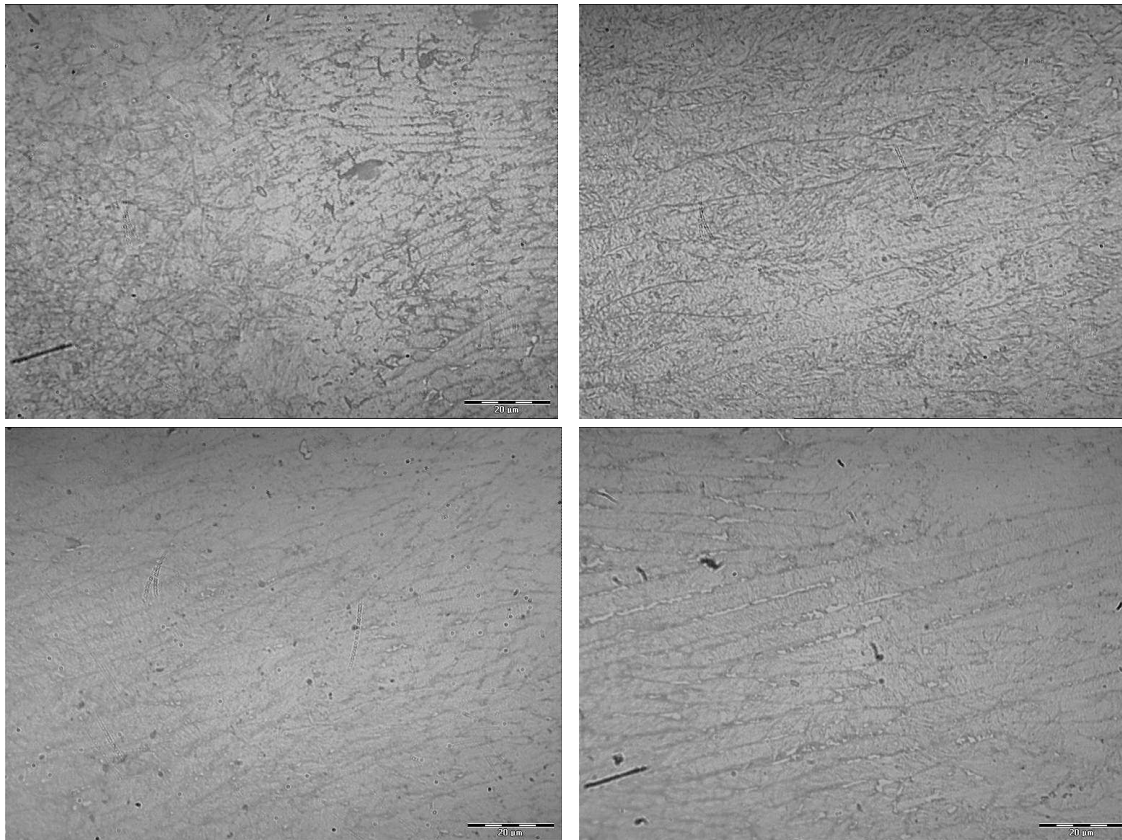


Figure 5 - Microstructure of weld metal near fusion line after PWHT @ 480°C for 3h, butt welds, 15% Nital. a) BOP, b) Single spot, c) twin spot, d) pulsed YAG

Results

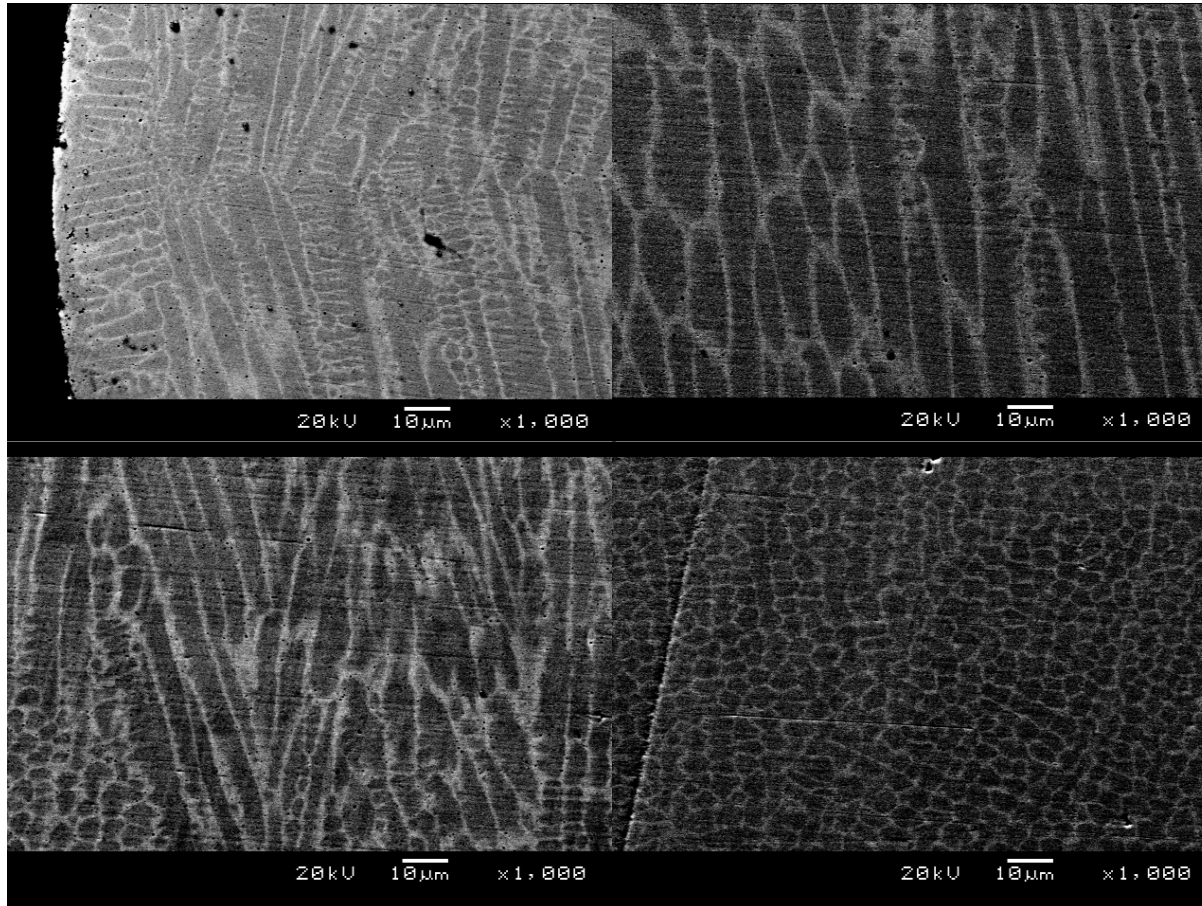


Figure 6 - Unetched microstructure (SEM) of weld metal after PWHT @ 480°C for 3h, butt welds, . a) Single spot, b) twin spot, c) pulsed YAG FL, d) pulsed YAG CL

Results

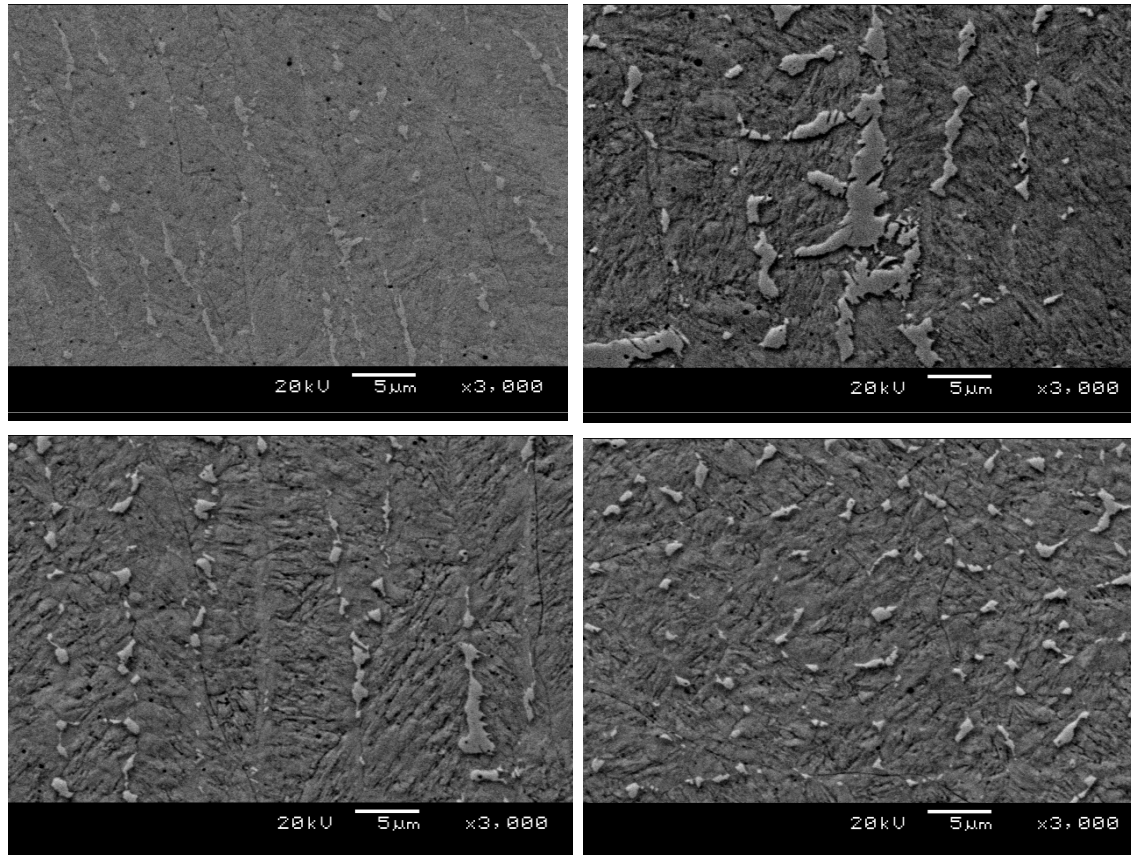


Figure 7 - Microstructure (SEM) of weld metal after PWHT @ 480°C for 3h, etched, butt welds, . a) Single spot CL, b) twin spot CL, c) pulsed YAG FL, d) pulsed YAG CL

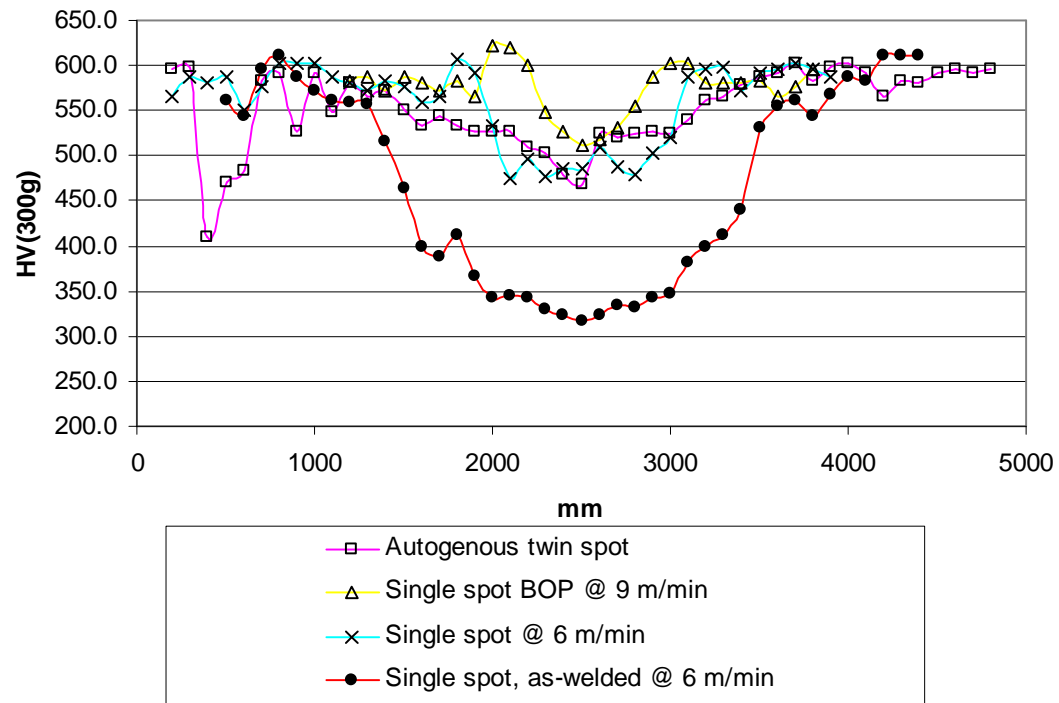
Results

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

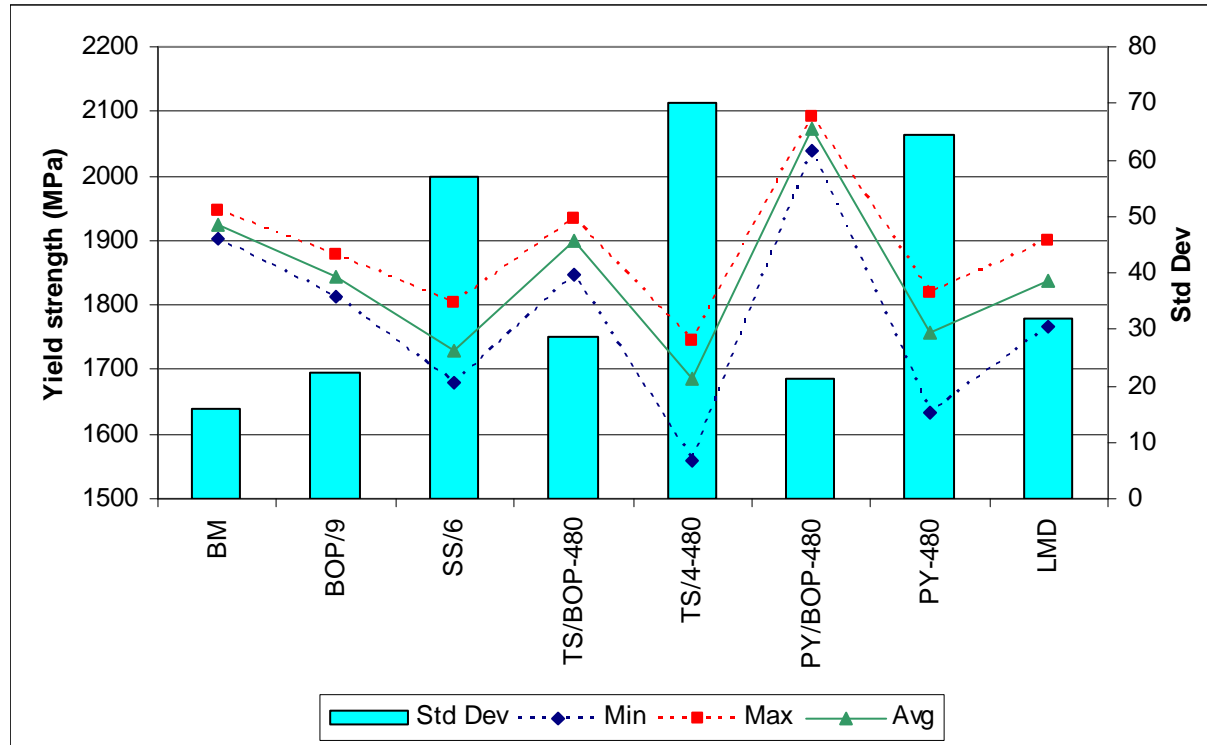
Sample	Fe	Co	Ni	Mo	Ti
SS/6 – Martensite	70.09	8.47	17.38	3.81	0.18
SS/6 Austenite	66.21	8.57	18.63	5.92	0.6
TS/4 – Martensite	69.17	8.29	17.92	4.27	0.24
TS/4 – Austenite	65.26	8.16	18.72	6.73	1.09
PY – Martensite	69.37	8.27	18.07	4.06	0.18
PY - Austenite	62.61	8.87	19.01	7.75	1.64

Results

Hardness traverse after PWHT @ 480C, 3h



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

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