IIW International Conference
High-Strength Materials - Challenges and Applications
2-3July 2015, Helsinki, Finland

IIW2015-15/….

Welding performance evaluation of the VBCie IP50 TIG orbital heat management system

R. French[1,a], H. Marin-Reyes[1,b]

[1] The University of Sheffield, Physics and Astronomy Department, United Kingdom

[a]r.s.french@sheffield.ac.uk, [b]h.marin-reyes@sheffield.ac.uk

Abstract

The TIG Orbital Heat Management System (IP50-HMS) developed by VBC Instrument Engineering ltd (VBCie) and The University of Sheffield (UoS) is a relatively new low current automatic orbital welding system. Using HMS InterPulse Technology, the IP50-HMS produces accurate narrow bead welds and offers excellent weld quality and control over the weld process. The use of high frequency pulsing interposed within the pulsed weld current increases arc force and more penetration is achieved with a significantly lower input current. This allows for improved heat management on critical welds whist still attaining full penetration. The machine has proven very successful in the joining of very thin wall, small diameter titanium and stainless steel alloy heat exchanger tubes. Conventional orbital welding systems cannot weld such thin wall material with small diameters. The IP50-HMS produces welded, autogenous butt joints showing higher mechanical integrity than conventional orbital welding systems also evaluated [3]. Furthermore, the low heat input obtained improves the materials micro-structure because of decreases in distortion and residual stress [4]. The IP50-HMS proves to have an exceptionally high production yield with very low weld failure rates. Measurements of arc voltages and welding currents carried out at the UoS are reported as well as input power measurements of the VBCie system are discussed to assess the performance of the IP50-HMS.

Keywords: *Stainless Steel, Titanium, Weld Joining, HAZ, Metallurgy, Heat Input*

1. Introduction

- Vbc HMS Interpulse Technology description

- Swagelok M200 Power Supply description

2. Current Arc waveforms of vbc IP50-HMS and Swagelok M200

Figures 1-2 show measurements of the Swagelok M200 current arc measurement while welding 316L SS tube: 3.175mm OD, 0.22mm Wall.

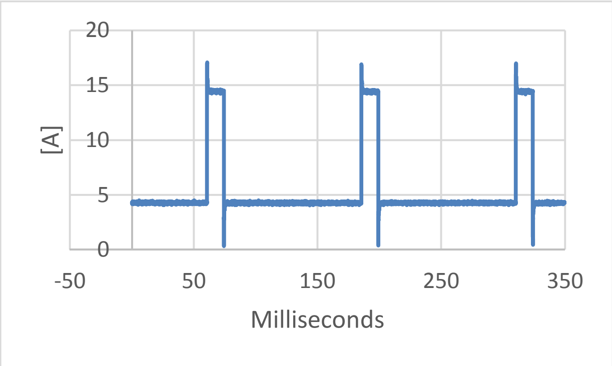


Figure 1. Swagelok current arc measurement (Multilevel)

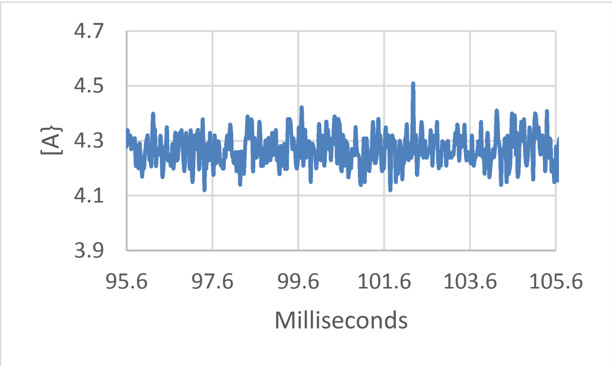


Figure 2. Swagelok current arc measurement (Low Amp Current)

Figures 1-2 show measurements of the vbc IP50-HMS current arc measurement while welding 316L SS tube: 3.175mm OD, 0.22mm Wall

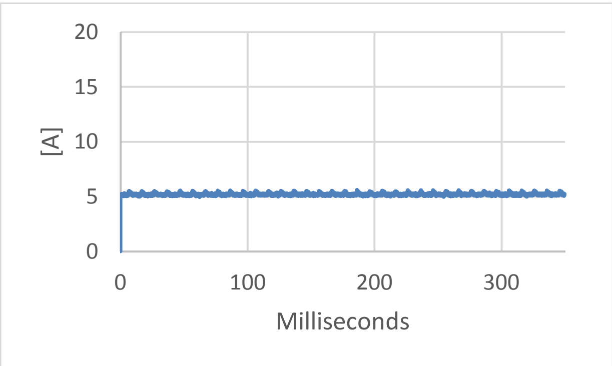


Figure 1. vbc IP50-HMS current arc measurement (HMS Interpulse Technology)

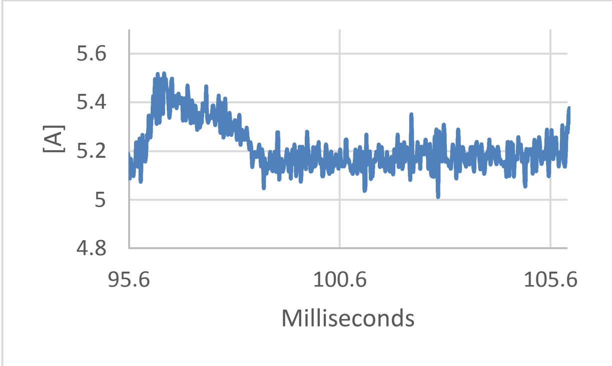


Figure 1. vbc IP50-HMS current arc (Main Current)

Measurements have been obtained using a DAQ developed at the University of Sheffield. The sample frequency is 46 KHz. A multilevel weld procedure was used with the Swagelok power system (see Figure 1).

The IP50-HMS from vbcie uses a stif arc with high frequency (20KHz) to obtain a flat clean weld (see Figure) 2.

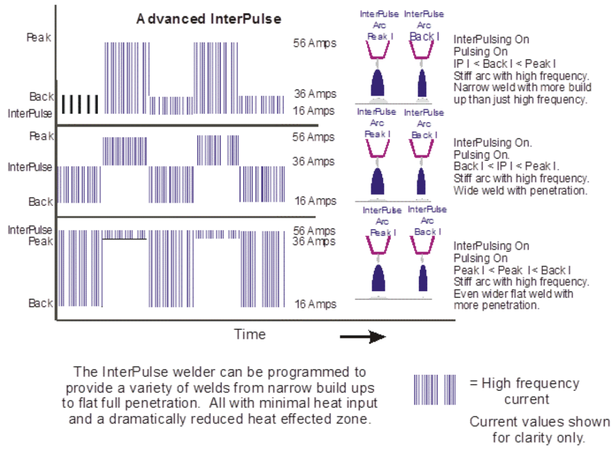


Figure 1. Heat Management System current arc waveforms [5]

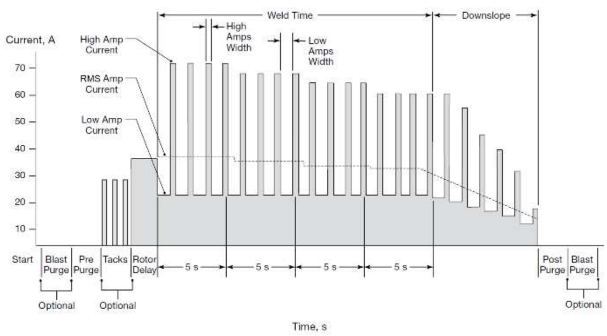


Figure 2. Swagelok M200 welding system current arc waveform [3]

3. High speed phase current measurements

Arc current measurements were performed at 46.875 KHz using a high speed phase current shunt sensor. Signal filtering was performed using NI DIAdem mathematical data analyses. The filter method selected was lowpass IIR filter. The limit frequency was specified at 5 Hz. (see Figures).

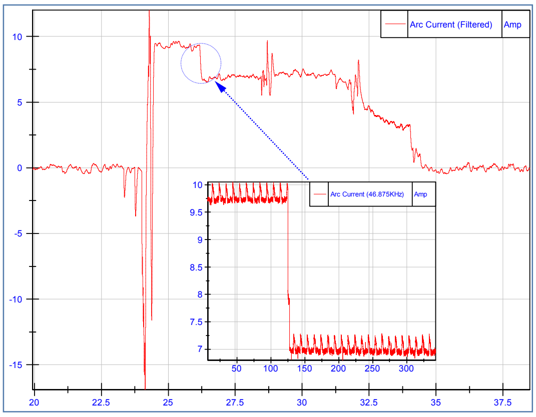


Figure. Arc current measurement filtered using low pass IIR filter at 5 Hz [time scale in Sec]. The inset figure shows the high speed phase current measurement at 46.875 KHz of the transition between the initial arc current and the main welding current [time scale in mSec].

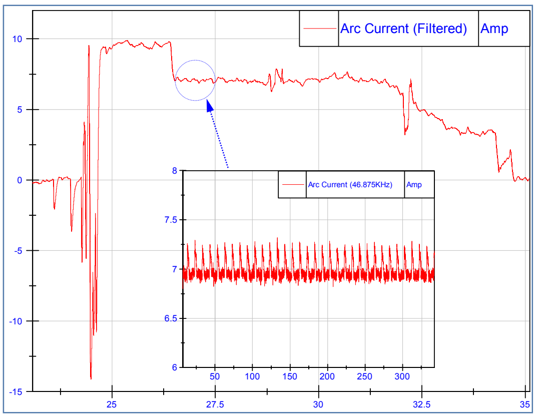


Figure. Arc current measurement filtered using low pass IIR filter at 5 Hz [time scale in Sec]. The inset figure shows the high speed phase current measurement at 46.875 KHz of the arc main current [time scale in mSec].

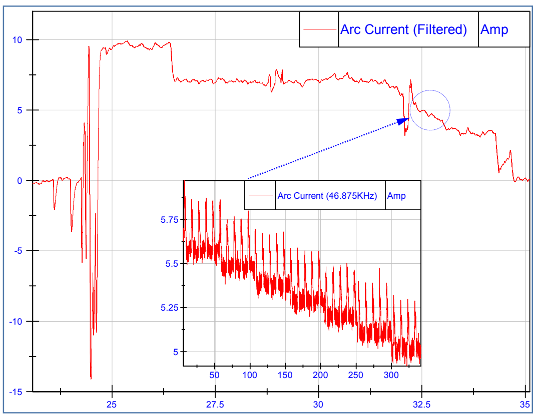
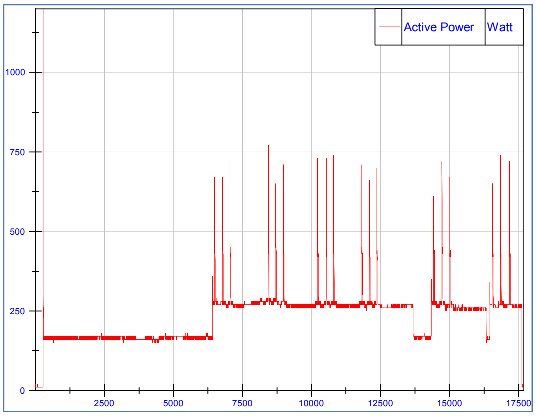


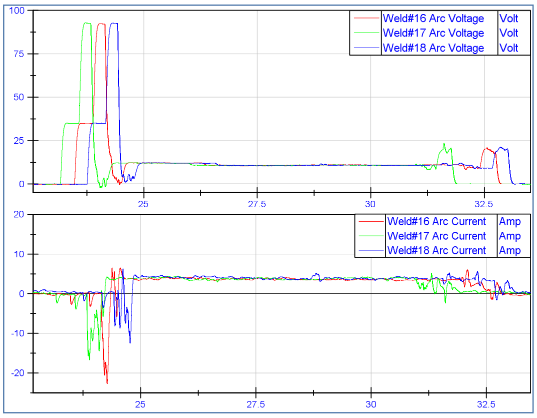
Figure. Arc current measurement filtered using low pass IIR filter at 5 Hz [time scale in Sec]. The inset figure shows the high speed phase current measurement at 46.875 KHz of the arc downslope current [time scale in mSec].

4. Arc Voltage and Arc Current Measurements for Heat Input calculations

CP2 Titanium Tube weld: 3.175mm OD, 0.2mm Wall



(a)



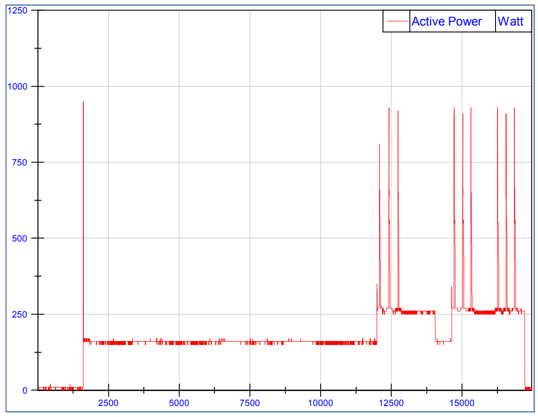
(b)

Figure. (a) Input Active Power Measurements of 18 welds with Fluke 437-II), (b) Arc voltage and arc current of Welds #16 to #18 with NI PXI System

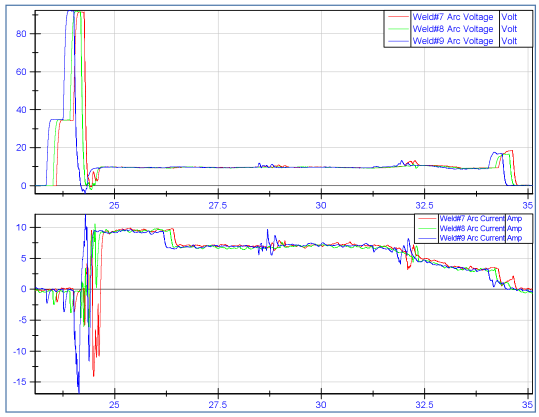
Plots shown in Figure were obtained while welding 3.175mm OD, 0.2mm wall CP2 Titanium tube. Figure shows the input power and power transferred to the welds #16 to #18.

Figure. Welds #16 to #18 on 3.175mm OD, 0.2mm wall CP2 Ti tube

316L Stainless Steel Tube weld: 3.175mm OD, 0.72mm Wall



(a)



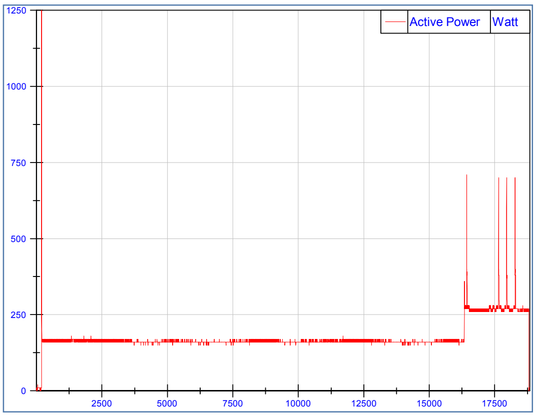
(b)

Figure. (a) Input Active Power Measurements of 9 welds with Fluke 437-II), (b) Arc voltage and arc current of Welds #7 to #9 with NI PXI System

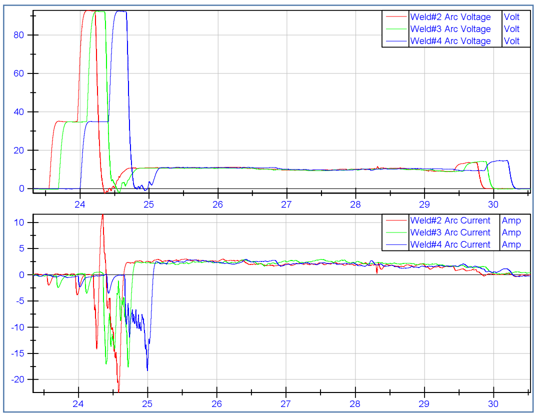
Plots shown in Figure were obtained while welding 3.175mm OD, 0.72mm wall 316L stainless steel tube. Figure shows the input power and power transferred to the welds #7 to #9.

Figure. (a)Welds #7 to #9 on 3.175mm OD, 0.72mm wall 316L SS tube

CP2 Titanium Tube weld: 2.275mm OD, 0.125mm Wall



(a)



(b)

Figure. (a) Input Active Power Measurements of 4 welds with Fluke 437-II), (b) Arc voltage and arc current of Welds #2 to #4 with NI PXI System

Plots shown in Figure were obtained while welding 2.275mm OD, 0.125mm wall CP2 Titanium tube. Figure shows the input power and power transferred to the welds #2 to #4.

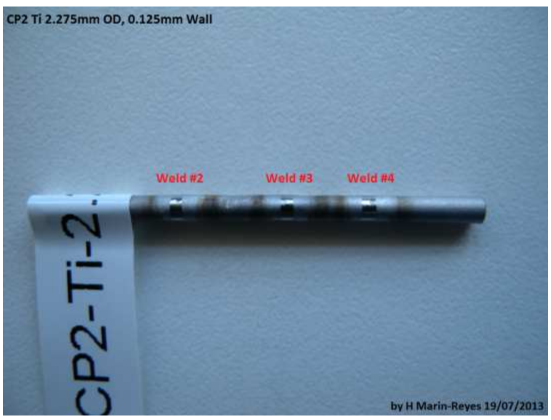
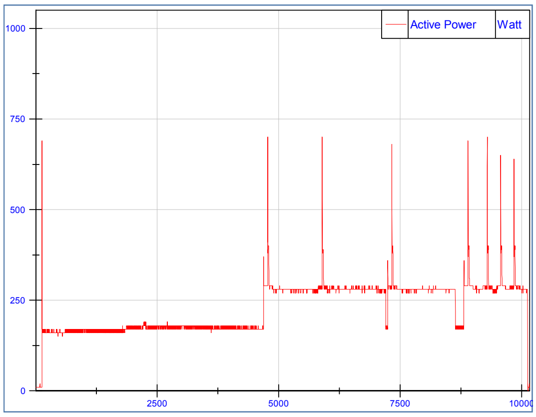
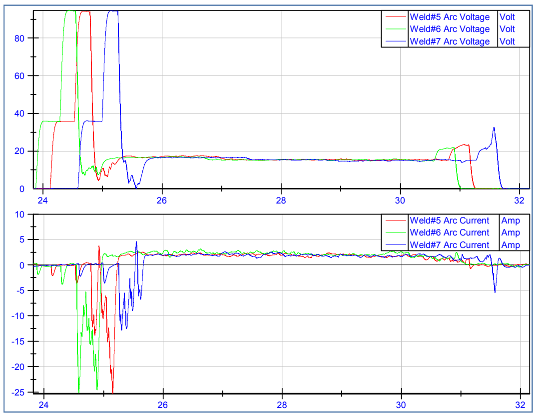


Figure. (a)Welds #2 to #4 on 2.275mm OD, 0.125mm wall CP2 Ti tube

316L Stainless Steel Tube weld: 2mm OD, 0.125mm Wall



(a)



(b)

Figure. (a) Input Active Power Measurements of 7 welds with Fluke 437-II), (b) Arc voltage and arc current of Welds #5 to #7 with NI PXI System

Plots shown in Figure were obtained while welding 2mm OD, 0.125mm wall 316L stainless steel tube. Figure shows the input power and power transferred to the welds #5 to #7.

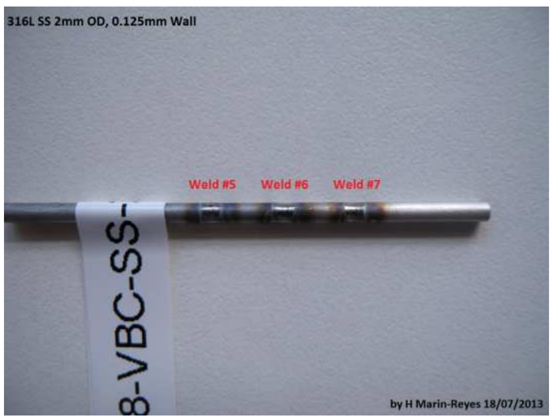
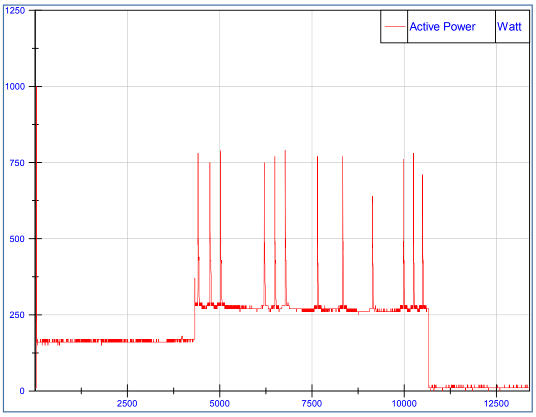
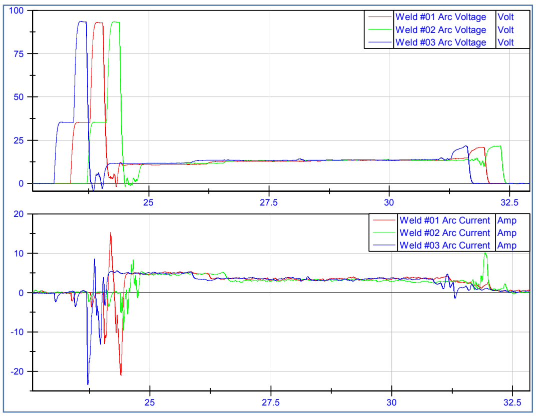


Figure. (a)Welds #5 to #7 on 2mm OD, 0.125mm wall 316L SS tube

316L Stainless Steel Tube weld: 3.175mm OD, 0.220mm Wall



(a)



(b)

Figure6. (a) Input Active Power Measurements of 9 welds with Fluke 437-II), (b) Arc voltage and arc current of Welds #1 to #3 with NI PXI System

Plots shown in Figure 6 were obtained while welding 3.175mm OD, 0.220mm wall 316L stainless steel tube. Figure 7 shows the input power and power transferred to the welds #1 to #3.

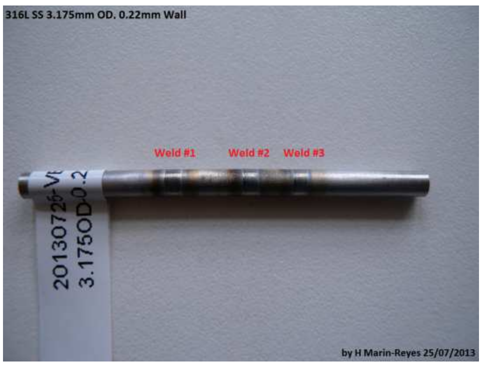


Figure 7. (a) Welds #1 to #3 on 3.175mm OD, 0.220mm wall 316L SS tube

Conclusions

- Assessing performance
  - Reasons of low weld failure rate on vbc IP50-HMS.
  - Swagelok limitations
- Discussions on: Power consumed by each weld system, HAZ, Heat Input, Efficiency

References

[1] Marquis, G. B., Mikkola, E., Yildirim, H. C. and Barsoum, Z, “Fatigue Strength Improvement of Steel Structures by HFMI: Proposed Fatigue Assessment Guidelines,” *Welding in the World*, **57**, Issue 6, (2013) pp 803-822.

[2] R. Scott Funderburk, A look at heat input, Welding Innovation: Key Concepts in welding Engineering, Vol. XVI, No. 1, 1999

[3] M200 Power Supply User’s Manual, Swagelok – TM Swagelok Company, Printed in U.S.A., OM (2007) p. 51

[4] R. Leary, et al, Material Science and Engineering A. 527 (2010) 7694-7705

[5] InterPulse 50 Automatic Welder & Welding Head Operating Instructions, Model IP50 Auto, Serial No 2997, VBC Instrument Engineering (2012), p. 13