International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072

LITERATURE REVIEW ON MAGNETICALLY IMPELLED ARC BUTT (MIAB) WELDING

Vishwas C. Patel[1], Prof. Dhavalkumar H. Patel[2]

[1] Student, M.Tech Advanced Manufacturing Systems, U. V. Patel College of Engineering, GANPAT University, Gujarat, India.
[2] Assistant Professor, Mechanical Engineering, U. V. Patel College of Engineering, GANPAT University, Gujarat, India.

---***---

ABSTRACT - Magnetically impelled arc butt (MIAB) welding is a solid phase pressure welding process similar to flash butt welding, but it uses a magnetic field to rapidly rotate the arc. The spinning arc provides a more consistent interior and exterior weld flash than typically seen on the flash-butt upset areas. MIAB welding process is presently being employed for welding tubular sections in automobile industries in United Kingdom and Germany. The main emphasis of this review is on derive optimal parameter window for MIAB welding in metals and machine development cost summarization. The time frame of the review is up to the year 2017.

Key words: *MIAB welding, solid state welding, Arc rotation, Flash.*

1. INTRODUCTION

Developed in the 1970s, magnetic rotating arc welding is also known as magnet arc welding or magnetically impelled arc butt (MIAB) welding. Magnetically Impelled Arc Butt Welding (MIAB) is an advanced welding process which is an alternative to the conventional welding process such as friction, flash, resistance and butt welding. MIAB welding is a solid-state welding process for tubes and pipes in which heat is generated prior to forging by an electric arc moving along the peripheral edges of the weldments with the aid of an external magnetic field. MIAB has been reported in the literature as early as 1974. Basic working principle of MIAB welding is shown in the fig.1 , First when both welding current and electromagnet is in turn off condition tubes which is to be welded brought together and then DC power is turn on.

After that two tubes where separated and electromagnet is turn on. Fig. 1 (a) Graphical representation of arc velocity in m/s vs. time in second. (b) I. shorting to tubes, II. III. Separating to tubes, which will originate arc, IV. V. External magnetic field will force the arc to rotate, VI. Joining two tubes with external force. (b) sketches of the phases: I – arc initiation (flash); II – beginning of arc rotation; III – arc transitory rotation; IV – arc stable rotation; V – arc instable rotation ("breaking"); VI – tubes upsetting; v1 – arc rotation of low velocity; v2 – stable arc rotation velocity; g - tubes gap; s - tube wall thickness; m - distance between the solenoids; F_c- clamping force; B - magnetic field; I_{sc} - short circuit current; I_w - welding current; F_p- upsetting force; 1,2, thin-walled tubes; 3, magnetization system/solenoids; 4, rotating arc weld; 5, thin uniform layer of molten metal on tubes abutting surfaces; 6 and 7, clamping dies; 8,MIAB weld.

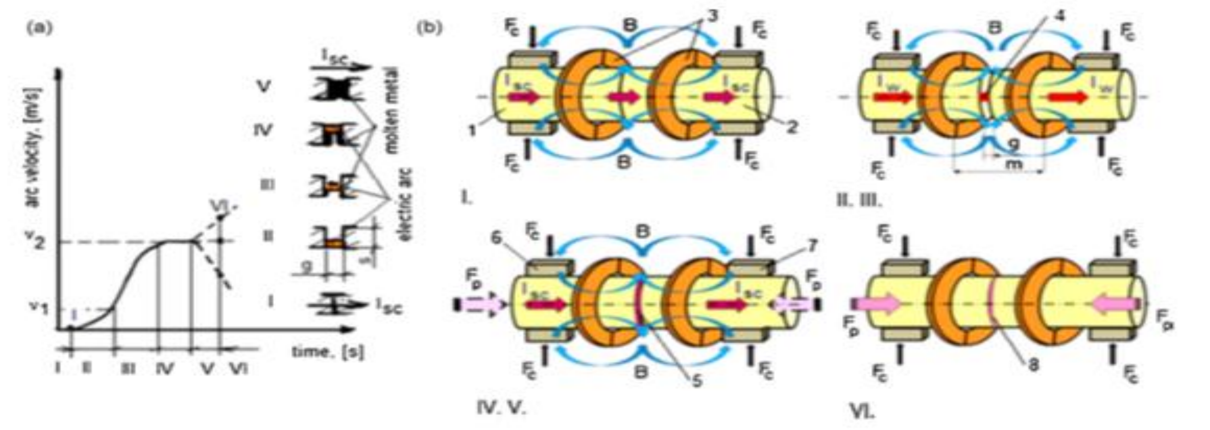

Figure 1 – (a) graphical representation of arc velocity vs time (b) Process phases in MIAB welding. [1]

When externally controlled magnetic field moves the arc in the gap between the pipe edges (see Figure 2). Two pipes ready for welding are set coaxially. Magnetic systems installed opposite each other form magnetic fluxes in the arc gap. This magnetic field in the arc gap consists of two vector components of magnetic induction, B: radial (B_r) and axial (B_a). A short circuit excites the welding arc. The pipes to be welded are moved apart for a definite arc gap (1.5 to 2.5 mm). The interaction [12] (see Figure 2) between the welding arc's axial component of current and a radial magnetic component, directed perpendicular to the welding arc current, leads to the creation of force. This force moves the welding arc along the ends of the pipes. From the available literature the work carried out previously by the researchers on MIAB welding discussed in brief.

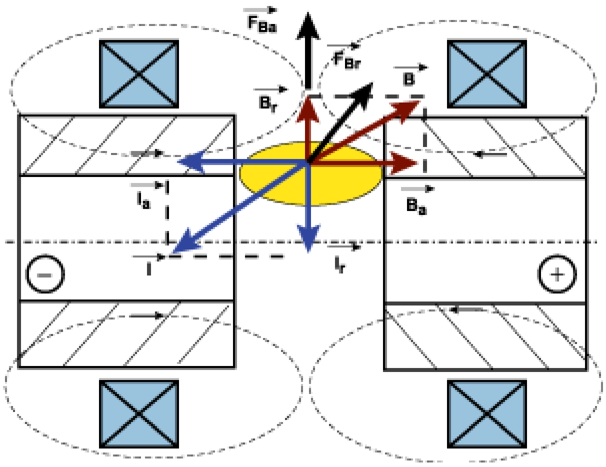

Figure - 2 : Schematic Representation of MIAB welding. [12]

2. LITERATURE REVIEW

Tagaki [1] report the development of rotating arc welding equipment suited for application to town gas pipelines. In this study, it has been proved that welds of high quality and reliability can be obtained along with high efficiency and that the welding equipment can be used very effectively in pipeline laying. Schlebeck [2] reported the welding with a magnetically moved arc. The technical state of development of MBL-P welding (welding with magnetically moved arc with pressure force), machines and power sources for MBL-P welding quality of the MBL-P weld joints are highlighted. Loebner [3] discussed about the magnet arc welding theory and practice. The historical background on MIAB welding process and the emphasis on the development, establishment of the process laid on the previous literatures are presented. Edson [4] puts forward the idea of incorporating MIAB welding for thick wall tubes. This paper revealed the limitations of MIAB welding process when applied on thick walled tubes and suggested solutions to overcome those drawbacks. Mori and Yasuda [5] describes the MIAB welding process developed for welding non-ferrous metals such as aluminium and copper. Arungalai Vendan et al. [6] reported a two and three dimensional finite element model for the analysis of magnetic flux density distributions in the MIAB welding process. Further, the same group [7] has discussed the attempts made to develop a MIAB welding laboratory equipment for understanding the significance of various process parameters.

Figure - 3 : MIAB welding machine, curtsy of JIT engineering, Singapore.

Fletcher et al. [8] presented a new perspective from a development project to implement the technology in the field construction of new pipelines in Australia. In this study, a prototype MIAB-welding machine was designed and built, one that was capable of welding natural gas pipelines and to make welds in DN 150 pipe complying with the performance requirements of the Australian petroleum pipeline standard AS2885.2. An extensive review and an experimental assessment of the MIAB-welding process was made in the study. The article emphasized that MIAB is a suitable process for the welding of oil and gas pipelines in diameters up to DN450 and thicknesses up to 10 mm. Jenicek et al. [9] demonstrated that tubular hollow bodies such as nuts, sleeves, and bushes could be fastened to sheets using a process with particular economic viability, i.e., an advanced variant of MIAB welding-bush or nut welding. At the E. O. Paton Electric Welding Institute, Kachinskiy et al. [10] investigated the arc behaviour during the welding of hollow parts with wall thickness greater than 6 mm. In general, it is a challenge to weld thickwalled components due to the tendency of the arc to concentrate on the inner diameter (ID) of the component in the MIAB welding process thus resulting in uneven heating. Kachinskiy et al. [10] also postulated that the anode and cathode spot sizes of an arc should be relatively larger than the wall thickness to achieve even heating. Iordachescu et al. [11]

4. CONCLUSION AND DISCUSSION

From referring various papers regarding MIAB welding, we can conclude that an undeveloped old technology which doesn't required edge preparation, filler material, high level manual skill and after weld finishing process even though it

will provide best in class weld quality. Ford motor has given testimony that," MAIB welding will bring an revolutionary change in automotive industry", to JIT engineering, A Singapore based manufacturing company, which is the only one who successfully produces MIAB welding machine for FORD.

Various studies has been carried out to find the optimum values of process parameters at Paton welding institute. Initiation of arc rotation without arc disappearing at least 30V welding voltage and 300A welding current is required. Magnetic coil current and voltage has less impact on arc rotation, so keeping them constant and varying welding current and voltage it has been postulated that we can achieve 25 m/s arc rotation speed at 420A and 50V. But again there is limitation on maximum arc speed, because higher the arc speed, higher the heating of tube's edge will leads to flash at joining. So for what time arc rotation has been carried out is also important. Adequate value for joining stainless steel pipes, welding current is 380A and welding voltage is 35V to 40V for 10 seconds for 5mm thick tube and 2mm air gap between tubes. Even though for higher value of welding current, arc won't spin if air gap between two tubes is more than 2.5mm.

FEA for magnetic flux density distribution in ANSYS Maxwell, from that we can conclude that, Minimum magnetic flux density required to accomplish slow rotation of arc is 2.032 tesla for 0.5A exiting current in magnetic coil system. Maximum magnetic flux density required to accomplish fast rotation of arc is 2.086 tesla for 0.4A exiting current in magnetic coil system. Some researchers taken this welding technology to next level by dividing welding current in three steps during the process. First welding current when arc strikes, second welding current for heating the edge, third welding current prior to joining. Increasing (approx. double the value than first welding current) the value of welding current in third stage will has impact on HAZ of weld. Micro-Analysis shows, No distinct heat affected zone or fusion line is visible. It is merged with weld metal due to higher rate of heating (instantaneous higher heat input) and subsequent higher rate of cooling (due to very low weld cycle).

Going through various papers I figure out that researchers haven't considered much on the forging force. Not a single proof has been derived for optimum value of forging force, even though it has direct impact on butt joint (flash) and weld quality.

At JIT engineering, Singapore, Mechanical and metallurgical assessments are carried out on the welded joints. It is observed that the MIAB welded tubes exhibits high strength as per the standards prescribed by AWS B.4 and good weld integrity. The initial results of this study emphasize that MIAB welding of boiler tubes is feasible.

Before 2004 year this MIAB welding technology is limited to weld tubes with maximum thickness of 10mm, but JIT has developed K-782 MIAB welder to weld stainless steel and aluminium alloys up to 35mm thickness. Some researchers are finding their way to make it up to 50mm. MIAB welding is predominantly used in the European automobile industry for Vehicle drive shafts, rear axle assembly, wheel bearing housing, pipe and tube assemblies, shock absorber and threaded sleeves assemblies, brake pipes.

JIT has monopoly in manufacturing MIAB welder. MIAB welder will cost you around 75000 dollars i.e. 42 Lakh approx. which is handsome amount of money for a welding machine, so MIAB is best suitable where continuous production is required like in automotive industry. But take a look at what you will required to build MIAB welding machine? List is very simple, two coil (act as electromagnet), one (IGBT based) DC power supply which can deliver 400A current and 50V open circuit voltage, one hydraulic power pack with solenoid valve and double acting hydraulic cylinder and body which houses pair of clamp, one is fixed and one is movable. Now some up the cost.

Only due to its monopoly JIT company sales MIAB welding machine for such high price. All this prices mentioned might get little variation but maximum total cost won't crosses 1.5 to 2 Lakh. MIAB is a unique technology which can change the traditional way of joining tubes/pipes providing superior quality. MIAB machine has virtually zero moving parts i.e. tubes aren't rotating as in friction welding, so wear rate of machine is low that will increasing the life of machine. So I am interested to dig deep into this technology to make working commercial product and to compare this welding quality with widely used MIG and frictional welding. Innovation isn't developing something new, but also refining existing method or product.

Table – 1: Product list and Estimated Cost of machine.

1.	Deco hydraulic power pack Motor 2.2Kw, Maximum working pressure 10MPa, Air cooled, Oil tank 60L, Flow rate 11L/min.	:	₹ 16,000 /-
2.	Surplus double acting hydraulic cyclinder Steel, Maximum Stroke 300mm, Working Pressure 21MPa.	:	₹ 4,500 /-
3.	Heman rubber hose Inner daimeter 7.9mm, Outer daimeter 15mm, Wire daimeter 12.7mm, 2 hose of 2 meter.	:	₹ 700 /-
4.	Huayuan Welder ZX7-500IGBT IGBT DC inverter welder, 500A, 50V OCV.	:	₹ 48,000 /-
5.	Haiwell PLC 20 DC ports, 1 RS232, 48K storage.	:	₹ 12,000 /-
6.	Ring Magnet	:	₹ 6000 /-
7.	Base/Welder body	:	₹ 20,000 /-
8.	Other electrical iteams like wires, switches	:	₹ 4000 /-
	Total	:	₹ 1,11,200 /-

REFERENCES

1. Tagaki K, Arakida, Sato, Miyamori, Ozawa. Applications of rotating arc butt welding to town gas pipelines. International Institute of Welding, Welding in the World, vol. 20; 1982. p. 11–2.

2. Schlebeck E. Welding with a magnetically moved arc (MBL welding): a new means of rationalization. In: Welding inst conference advances in welding processes, Harrogate; May 1978. p. 249–56.

3. Loebner R. Magnetarc welding theory and practice, KUKA Limited. p. 29–46.

4. Edson DA. Magnetically impelled arc butt welding of thick wall tubes, July 1982, 726–82.

5. Mori S, Yasuda K. Magnetically-impelled arc butt welding of aluminum pipes. Trans Jpn Weld Soc 1990, 21(1):3–10.

6. Arungalai Vendan S, Manoharan S, Buvanashekaran G, Nagamani C. Simulation of magnetic flux distribution for magnetically impelled arc butt welding of steel pipes. Int J Multidiscipline Model Mater Struct (MMMS) 2009, 5(3), 229–34.

7. Arungalai Vendan S, Manoharan S, Buvanashekaran G, Nagamani C. Development of a MIAB welding module and experimental analysis of rotational behavior of arc – simulation of electromagnetic force distribution during MIAB welding of Steel pipes using Finite Element Analysis. Int J Adv Manuf Technol 2008, 43(13):1144–56.

8. Fletcher, L. Stecher, G. Stubbs, G. Norrish, J. Cuiuri, D. Moscrop, J.W. MIAB welding of oil and gas pipelines. In International Pipeline Conference; ASME: New York, 2006, 1–8.

9. Jenicek, A. Cramer, H. Bush weld on aluminium materials: A further development for joining of small hollow bodies using a magnetically impelled arc. Welding and Cutting 2005, 4 (3), 10–14.

10. Kachinskiy, V.S. Krivenko, V.G. Ignatenko, V.Yu. Magnetically impelled arc butt welding of hollow and solid parts. Welding in the World 2002, 46 (7–8), 49–56.

11. Iordachescu, D. Iordachescu, M. Georgescu, B. Miranda, Ruiz Hervias, J. Ocana. Technological windows for MIAB welding of tubes featuring original longitudinal magnetization system with peripheral solenoids. Journal of Materials Processing Technology 2010, 210, 951–960.

12. D. Iordachescua, M. Iordachescub, B. Georgescuc, R.M. Mirandad, J. Ruiz. Technological windows for MIAB welding of tubes featuring original longitudinal magnetization system with peripheral solenoids, 2010 , 5-8.

13. Biranchi Narayan Panda & S. Arungalai Vendan & Akhil Garg. Experimental- and numerical-based studies for magnetically impelled arc butt welding of T11 chromium alloy tubes , 2010, 3-4.

14. http://www.jitengg.com/MIAB.html, Jit Engineering & Solutions Pte.Ltd, 10,Jalan Besar, 10-08 Sim Lim Tower, Singapore - 208 787.

15. C. Nagmani, S. Manoharan. Investigation of weld parameters in MIAB welding process by developing module-validation using FEA, 2012, 24-27.