Optimizing and analysis of parameter for pipe welding: A literature review

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Abstract

Welding input parameters play a very significant role in determining the quality of a weld joint. The joint quality can be defined in terms of properties such as weld-bead geometry, mechanical properties, and distortion.The main emphasis of this review is to study the effect of different input parameter of TIG and MIG welding on the weld quality.

Nowadays, application of design of experiment (DoE), evolutionary algorithms and computational network are widely used to develop a mathematical relationship between the welding process input parameters and the output variables of the weld joint in order to determine the welding input parameters that lead to the desired weld quality. A comprehensive literature review of the application of these methods in the area of welding has been introduced here.

Keywords: TIG welding, MIG welding, V butt welds, Welding bibliography, Optimization bibliography, Pipe weld.

1. Introduction

Welding is the simplest and easiest way to join sections of pipe. Welded pipe has reduced flow restrictions compared to mechanical connections and the overall installation costs are less.Two common processes welding of pipe are TIG and MIG. TIG welding, also known as GTAW, is a process which fuses metals by heating them with an arc between a tungsten electrode and the workpiece. Shielding is obtained from a gas or gas mixture. Pressure and filler wire may or may not be used. The positive electrode does not melt and hence gas tungsten arc welding can be autogenous or non-autogenous if a filler wire is employed. MIG welding, also known as GMAW, differs fromTIG in that the positive electrode is consumable.

The input parameters are the controllable welding equipment parameters, welded materials, and other parameters, which affect the properties of the finished welds [6] . Pre-selected weld parameters, indirect weld parameters affect the weld quality of TIG and MIG weld. Pre-selected weld parameters are selected prior to the start of the welding process and they cannot be changed during the welding process. These parameters, variables, include the electrode type, size, and tip geometry, the torch nozzle size, and the shielding gas type. The indirect weld parameters of the welding process include the arc voltage, arc current, travel speed, shielding gas, and wire feed rate (for filler metal process). Indirect weld parameters are parameters that can be modified in process. Once the pre selected variables are properly chosen, the quality of the weld can be controlled through proper selection and modification of the indirect weld parameters. In any welding process, the input parameters have an influence on the joint mechanical properties. By varying the input process parameters combination the output would be different welded joints with significant variation in their mechanical properties.

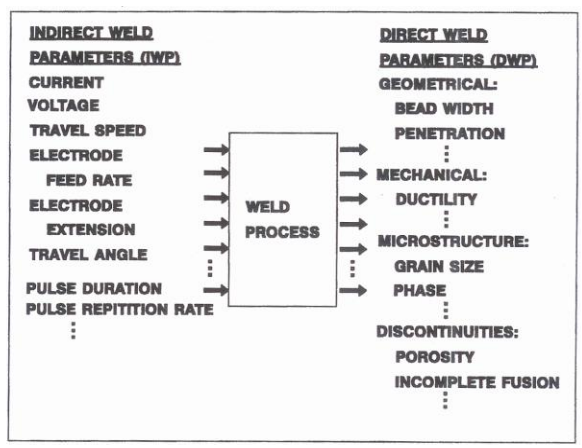

Figure 1.Arc welding depicted as a multiple-input, multiple-output system.[6]

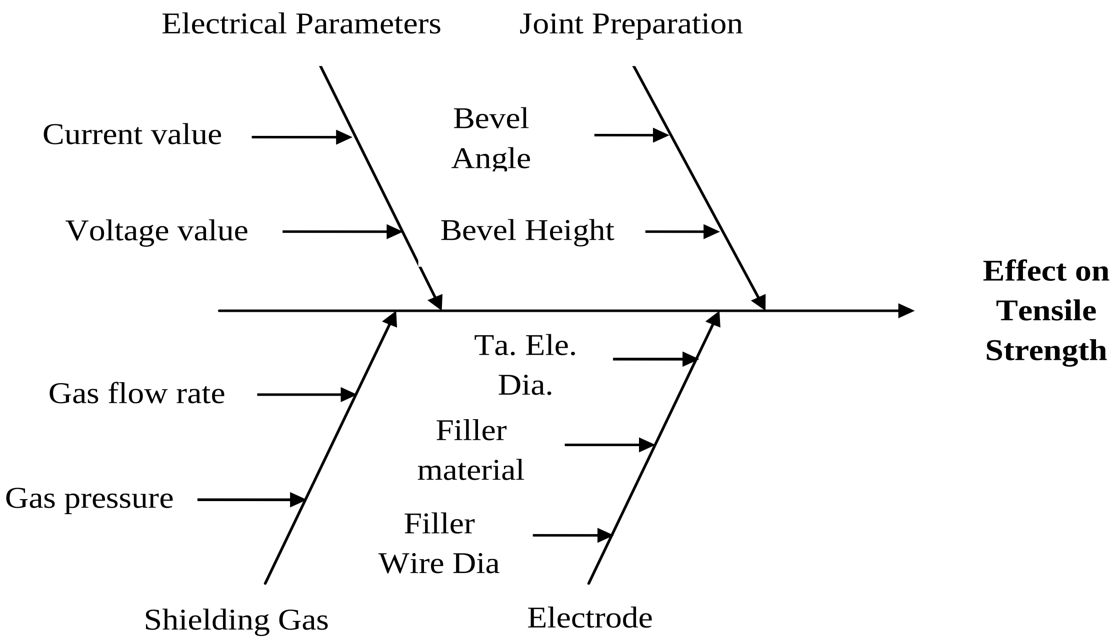

Figure 2. Effect diagram for TIG welding

2. Applications

Actually, many products could not even be made without the use of welding, for example, guided missiles, nuclear power plants, jet aircraft, pressure vessels, steam boilers production,chemical processing equipment, transportation vehicle and literally thousands of others.

Figure 3.Butt MMA pipe welding of membrane pipe panel–chamber with pipe connectors(nozzles)

Figure 4.detail of joining location

Figure 5. Manual TIG butt welding of pipes on boiler chamber

3. Literature Survey on effect of different input parameter

The weld and bead geometry plays an important role in determining the mechanical properties of the weld (Tarang and Yang, 1998) [1]. Hence the input welding process variables which influence the bead geometry must therefore be properly selected to obtain an acceptable high quality joint. (Mostafa and Khajavi, 2006) [2] predicting weld bead penetration as a function of welding process parameters. They optimized process parameters for maximizing weld penetration. (Rayes et al, 2004) [3] studied the influence of various hybrid welding parameters on bead geometry. They conducted experiments on 316L austenitic stainless steel work piece. They varied power to study their influence on various bead dimensions. They found that arc power has a great influence on bead width. (Thao and Kim, 2009) [4] predicting bead geometry for lab joint in gas metal arc welding (GMAW) process. They conducted experiments based on five process parameters to obtain bead geometry using GMAW process. From the study it was inferred that welding voltage, arc current, welding speed and welding angle have large significant effects on bead geometry. (Farhad Kolahan and Mehdi Heidari, 2010) [5] developed an approach to predict and optimize weld bead geometry in GMAW.They developed mathematical models for weld bead height, width and penetration.

(S.P.Gadewar,2010)[6]Investigated the effect of process parameters of TIG welding like weld current, gas flow rate, work piece thickness on the bead geometry of SS304.During experimentation it is found that, increase in the welding current result in increase in heat input. This increased heat is utilized to melt the base metal. Similarly as thickness of the work piece increases rate of gas flow need to be increased to increase the heat diffusion rate. Increase in gas flow avoids the vaporization of the molten metal. It also increases the penetration. The increase in weld current and gas flow results in change in Bead Geometry of the welded joint which dominates the weld characteristics. The variations in the process parameters affect the mechanical properties with great extent.

(R.Sathish, B.Naveen, P.Nijanthan, K.Arun Vasantha Geethan, Vaddi Seshagiri Rao , 2012) [7]optimized parameter for Dissimilar Pipe Joints Using GTAW. (R Sudhakaran, V Vel-Murugan and P S Sivasakthivel ,2012) [8] Investigated effect of Process Parameters on Depth of Penetration in Gas Tungsten Arc Welded (GTAW) 202 Grades Stainless Steel Plates. (Chandresh. N. Patel, S. J. Chaudhary,2013) [9] optimized parameter for weld strength of metal inert gas welding and tungsten inert gas welding.

(Ahmed Khalid Hussain, Abdul Lateef, Mohd Javed, Pramesh.T, 2010) [10] investigated of effect of welding speed on the tensile strength of the welded joint. Experiments are conducted on specimens of single v butt joint having different bevel angle and bevel heights. The material selected for preparing the test specimen is Aluminium AA6351 Alloy plate. The strength of the welded joint is tested by a universal tensile testing machine and the results are evaluated. (Kuang-Hung Tseng, Chih-Yu Hsu , 2010) [11] are used Five kinds of oxide fluxes, MnO_2, TiO_2, MoO_3, SiO_2, and Al_2O_3 to investigate the effect of activated tungsten inert gas (activated TIG) process on weld morphology, angular distortion, delta-ferrite content, and hardness of Type 316L stainless steels.

4. Literature Survey on optimization techniques

Literature shows that work has been explored on various aspects of modeling, simulation and process optimization in TIG welding. In this study, detailed analysis has been made to establish relationships between welding parameters and weld bead geometry and weld quality leading to an optimal process.

(Saurav Datta et al ,2008) [12]developed a grey-based Taguchi method for multi-response optimization of bead geometry in submerged arc bead-on-plate welding process.(Jackson and Shrubsall ,1953) [13] performed optimization, neural networks and regression analysis in submerged arc welding process.

(Murugan et al ,1993) used response surface methodology (RSM) to establish quadratic relations between the welding process parameters and bead geometry, for depositing 316L stainless steel onto structural steel, using automated submerged arc welding (SAW) [14] and MIG [15]welding, separately

(Xie Yan-Min et al ,2007) [16] used grey relational analysis for optimizing the square hole flanging process parameters with considerations of the multiple response characteristics. (Lin and Lin ,2005) [17] studied on the use of the grey-fuzzy logic based on orthogonal array for optimizing the electrical discharge machining process with multi-response characteristics. (Edwinrajadhas and Kumanan,2007) [18] proposed an intelligent technique adaptive neuro fuzzy inference system

(ANFIS) to predict the weld bead width in the submerged arc welding process for a given set of welding parameters. They designed the experiments using Taguchi's principles and used the results to develop a multiple regression model. Data obtained from multi regression model were used to train the intelligent net work. They found that the proposed ANFIS is flexible, accurate in predicting bead width.

(Tarng and Yang ,1998)[19] tried to obtain the optimized weld bead geometry in GTAW by using the Taguchi method. (Tarng et al ,2000) [20] used the modified Taguchi method to determine the process parameters for optimum weld pool geometry in TIG welding of stainless steel.The modified Taguchi method allowed the simultaneous consideration of all the weld pool geometry quality characteristics for optimization. (Kim et al ,2003)[21] eveloped a model for the prediction of process parameter values for optimum bead geometry settings in GMAW of mild steel using the Taguchi method. Algorithms were developed using the multiple regression analysis and neural networks and the results of the developed models were compared with the experimental results.

The Taguchi method is very popular for solving optimization problems in the field of production engineering, (Yang et al ,1998) [22] , (Rowlands et al ,2000) [23] . The method utilizes a well-balanced experimental design (allows a limited number of experimental runs) called orthogonal array design, and signal-to-noise ratio (S/N ratio), which serve the objective function to be optimized (maximized) within experimental domain. However, traditional Taguchi method cannot solve multi-objective optimization problem. To overcome this, the Taguchi method coupled with Grey relational analysis has a wide area of application in manufacturing processes. This approach can solve multi-response optimization problem simultaneously 1,9.Planning the experiments through the Taguchi orthogonal array has been used quite successfully in process optimization by (Chen and Chen ,2007) [24], (Fung and Kang ,2005) [25], (Tang et al,2007) [26], (Vijian and Arunachalam ,2006) [27], (Yang ,2007) [28] as well as (Zhan et al,2007) [29].

5. Gap Identification

GTAW process experimental work has been carried out by researchers for process parameters like welding current, welding speed and shielding gas flow rate. Also research has been done for product parameters like depth of penetration, bead width, and depth to width ratio, strength of weld and distortion stresses. The weld quality can be achieved by meeting quality requirements such as bead geometry which is highly influenced by various process parameters involved in the process. Inadequate weld bead dimensions will contribute to failure of the welded structure. All research has been done on plates and none of them is done on pipes or curved surfaces. Used plates were standard test specimens of different materials like mild steel, stainless steel, aluminium. Effect of process and product parameters on depth of penetration and distortion stress have been found out but did not described the effect of these parameters on tensile strength of weld joint. FEA analysis was not carried out for welded joint of pipes. Following points were also not covered by reference researchers.

- ✓ Effect of heat generation on distortions stresses which are generated at the weld bead during welding process effects the weld strength.
- ✓ Use of different optimization technique for pipe welding parameter.
- ✓ Optimization of process parameters for dissimilar pipe weld joint
- ✓ Influence of welding speed on distortion stress for SS pipe.
- ✓ Influence of this process parameters for different thickness of pipe.
- ✓ The toughness of the HAZ for specimens that had been heat treated
- ✓ The effect of various thermal cycles on the toughness of the HAZ, as well as the effect of post-weld heat treatments,
- ✓ The effects of welding position on the toughness of weld joint.
- ✓ The effects of stress relieving heat treatments on the toughness of carbon and alloy steel weld metals.
- ✓ Comparison of experimental result with FEA results.
- ✓ Guidelines for achieving good strength of pipe weld joints.
- ✓ The effect of different optimization technique on the output.

6. Conclusion

From the literature it is found there are remarkable works carried out in the field of process parameter optimization for the material like mild steel, stainless steel and aluminium. But that work carryout only for standard size plate specimen not for pipe. Welding is the simplest and easiest way to join sections of pipe. The need for complicated joint designs and special threading equipment is eliminated. Welded pipe has reduced flow restrictions compared to mechanical connections and the overall installation costs are less. The most popular method for welding pipe is the shielded metal-arc process; however, gas shielded arc methods have made big inroads as a result of new advances in welding technology.

Pipe welding has become a recognized profession in itself. Even though many of the skills are comparable to other types of welding, pipe welders develop skills that are unique only to pipe welding.

7. REFERENCES

[1] Tarang, Y.S. and W.H.,Yang, 1998. "Optimization of weld bead geometry in GTAW by Taguchi method", *Int J Adv Manuf Technol*, Vol. 14, pp.549 – 554.

[2] Mostafa, N.B and M.N., Khajavi, 2006 "Optimization of welding parameters for weld penetration in FCAW", *Journal of Achievements in Materials and Manufacturing Engineering*.Vol. 16, pp.132 – 138.

[3] Rayes, E.L., C., Walz, and G., Sepold, 2004. "The influence of various hybrid welding parameters on bead geometry", *Welding Journal*, pp.147s – 153s

[4] Thao, D.S. and I.S., Kim, 2009. "Interaction model for predicting bead geometry for lab joint in GMA welding process", *Computational Material Science and Surface Engineering*. Vol.1, pp.237 – 244.

[5] Farhad Kolahan and Mehdi Heidari, 2010. "A new approach for predicting and optimizing weld bead geometry in GMAW", *International Journal of Mechanical Systems Science andEngineering*, Vol. 2, pp.138 – 142.

[6] S.P.Gadewar, Peravli Swaminadhan, M.G.Harkare, S.H.Gawande, 2010. "Experimental investigation of weld characteristics for a single pass TIG welding with SS304", International Journal of Engineering Science and Technology, Vol. 2(8), 3676-3686.

[7] R.Sathish, B.Naveen, P.Nijanthan, K.Arun Vasantha Geethan ,Vaddi Seshagiri Rao, .2012 " Weld ability and Process Parameter Optimization of Dissimilar Pipe Joints Using GTAW ", International Journal of Engineering Research and Applications Vol. 2, Issue 3.

[8] R sudhakaran, V vel-murugan and P S sivasakthivel , 2012. "Effect of process parameters on depth of penetration in Gas tungsten arc welded (GTAW) 202 grade stainless Steel plates using response surface methodology", The Journal of Engineering Research , vol. 9.

[9] Chandresh. N. Patel, S. J. Chaudhary , 2013. "Parametric optimization of weld strength of metal inert gas welding and tungsten inert gas welding by using analysis of variance and grey relational analysis". International journal of research in modern engineering and emerging technology vol. 1,issue 3.

[10] Ahmed k.Hussain, Abdul Lateef, Mohd Javed, Pramesh.T , 2010. "Influence of welding speed on tensile strength of welded joint in TIG welding process", Int Journal of Applied Engg Research, Vol.1 No.3.

[11] Kuang-Hung Tseng, Chih-Yu Hsu , 2010. "Performance of activated TIG process in austenitic stainless steel welds" , Journal of Materials Processing Technology Science Direct.

[12] S.Datta & Asish Bandyopadhyay & Pradip Kumar; "Application of Taguchi philosophy for parametric optimization of bead geometry and HAZ width in submerged arc welding using a mixture of fresh flux andfused flux" , Int J Adv Manuf Technol.,39 (2008), 1136–1143.

[13] C. E. Jackson, A. E. Shrubsall, Weld J., 32 (1953), 172–178

[14] N. Murugan, R.S. Parmer, S.K. Sud, "Effect of submerged arc process variables on dilution and bead geometry in single wire surfacing" , J. Mater.Process. Technol. 37 (1993) 767–780.

[15] N. Murugan, R.S. Parmer, "Effect of MIG process parameters on the geometry of the bead in the automatic surfacing of stainless steel", J. Mater. Process. Technol. 41 (1994) 381–398.

[16] Y. M. Xie et al., Journal of Zhejiang University Science A, 8 (**2007**)805–811

[17] J. L. Lin, C. L. Lin, J Mater Process Technol., 160 (**2005**), 9–14

[18] Edwin Raja Dhas, J and S., Kumanan, 2007. "ANFIS for prediction of weld bead width in a submerged arc welding process", *J Sci Ind Res*, Vol.66, pp.335 – 338.

[19] Y.S. Tarng, W.H. Yang, "Optimization of the weld bead geometry in gas tungsten arc welding by the Taguchi method", Int. J. Adv. Manuf. Technol. 14 (1998) 549–554.

[20] Y.S. Tarng, W.H. Yang, S.C. Juang, " The use of fuzzy logic in the Taguchi Method for the optimisation of the submerged arc welding Process", Int. J. Adv. Manuf. Technol. 16 (2000) 688–694.

[21] I.S. Kim, J.S. Son, I.G. Kim, J.Y. Kim, O.S. Kim, A study on relationship between process variables and bead penetration for roboticCo2 arc welding,J. Mater. Process. Technol. 136 (2003) 139–145.

[22] W. H. Yang, Y. S. Tarng, J Mater Process Technol., 84 (1998),122–129.

[23] H. Rowlands, J. Antony, G. Knowles, The TQM Magazine, 12(2000), 78–83.

[24] D. C. Chen, C. F. Chen, J. Mater Process Technol, 190 (2007),130–137.

[25] C. P. Fung, P.C. Kang, J. Mater. Process Technol. 2005, "Multi-response optimization in friction properties of PBT composites using Taguchi method and principle component analysis", 170 602–610.

[26] P. Vijian, V.P. Arunachalam, J Mater Process Technol., 180 (**2006**),161–166.
[27] L. J. Yang, J Mater Process Technol., 185 (**2007**), 113–119.
[28] J. Z. Zhang, J. C. Chen, E. D. Kirby, J Mater Process Technol., 184(**2007**), 233–239
[29] K.Y. Benyounis , A.G. Olabi, "Optimization of different welding processes using statisticaland numerical approaches – A reference guide",Advances in Engineering Software 39 (2008) 483–496
[30] I.S Kim, K.J. Son, Y.S Yang, P.K.D.V Yaragada "Sensitivity analysis for processparameters in GMA welding processes using a factorial design method"International Journal of Machine Tools & Manufacture Vol. 43, 2003
[31] F. Raoufi, "Parameter optimization in MIG/MAG welding processes", M.Sc.Thesis, METU, 1994.