# Effect of Various Parameters on the Bead Geometry and Flexural Strength of MIG Welded Joint

**P.V.R Ravindra Reddy, G.Chandra Mohan Reddy, B.V.S Rao, G.Laxmaiah**

***Abstract*: Metal inert gas welding is the process in which a continuous coil of consumable electrode is used with inert gas shielding. It was extensively being used for Aluminum and Mg Alloys. But due to other alternatives available for, the cost of inter gas prohibited the use of MIG welding of steels. After the introduction of carbondioxide as shielding gas the economical viability in welding of steels was realized. The quality of weld joing and its productivity is influenced by the parameters such as arc current, wire feed rate, voltage, welding speed, torch angle, , nozzle to plate distance, welding position and gas flow direction. In the present work effect of gas flow rate, voltage and current are studied using Taguchi L-9 orthogonal array. The flexural strength, tensile strenght and bead geometry for various trails are computed and the optimum combination is obtained.***

***Keywords* : MIG welding, Taguchi, Flexural strength, Bead geometry.**

## I. INTRODUCTION

Metal inert gas (MIG) welding is a multi-factor and multi-objective welding process in which there is complex interaction of various process parameters which directly or indirectly influence the bead geometry, mechanical properties of the weldment [1].In conventional design optimization feasible design is obtained by trial and error, varying one parameter at a time and keeping all other parameters constant which is repeated for all the parameters under study [2].But this approach may take very long time making the approach to be expensive and sometimes infeasible [3]. So Taguchi developed an approach of taking all the parameters under study at a time and establish the individual and combined effect of the the parameters. [4]. According to Taguchi the parametric design experiment aims at the identification of the process parameters that influence the process the most and optimize them and make the process less sensitive to the noise[5]. The scope of this approach ranges from raw materials, systems and products. The steps involved in parametric design are: determination of the quality characteristic which is aimed to be optimized, Identification of the noise parameters and test conditions, identification of the control parameters, how many levels and their levels, selection of the suitable orthogonal array (OA), conduction of the experiments according to the selected OA, analysis of the data and finding the most influencing parameters, their contribution and proposing the optimum levels and performance prediction at these levels [6].

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***** Correspondence Author

**Dr.P.V.R.Ravindra Reddy**, Professor, Department of Mechanical Engg., CBIT, Gandipet, Hyderabad-75, India,

**Dr.G,Chandramohan Reddy**, Mechanical Engineering Department CBIT,Gandipet, Hyderabad-75, India,

**Dr.BVS Rao**, Assistant Professor, Mechanical Engineering Department, CBIT, Gandipet, Hyderabad-75,India,

**G.Laxmaiah**, Professor, Mechanical Engineering Department, CBIT, Gandipet, Hyderabad-75,India.

## II. OA SELECTION AND THE DETERMINATION OF THE LEVELS

In the present work, the flexural strength, tensile strength and bead geometry are considered as the out parameters. Environments conditions such as temperature, humidity etc are considered as noise factors. The control parameters identified are current, voltage and gas flow. Three levels are taken for the control parameters based on the initial tests. Since there are three parameters and three levels full factorial experimentation is done by selecting the orthogonal array L-9.

**Table 1: Levels chosen**

| Parameter | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| Voltage (V) | 25 | 26 | 27 |
| Current (A) | 75 | 100 | 125 |
| Gas flow rate (liters/Min) | 9 | 12 | 15 |

**Table 2: OA after assignment**

| Trial | Current | Voltage | Gas flow rate |
|---|---|---|---|
| **1** | 75 | 25 | 9 |
| **2** | 75 | 26 | 12 |
| **3** | 75 | 27 | 15 |
| **4** | 100 | 25 | 12 |
| **5** | 100 | 26 | 15 |
| **6** | 100 | 27 | 9 |
| **7** | 125 | 25 | 15 |
| **8** | 125 | 26 | 12 |
| **9** | 125 | 27 | 9 |

The range of parameters is chosen such that good beads are obtained in all the cases. The parameter levels are shown in table 1. L-9 orthogonal array after the assignment of the values the L9 OA looks as in table 2.

## III. EXPERIMENTATION

Three samples of mild steel of 6 mm thickness are prepared for each trail. TCVR-400 MIG welding machine shown in Fig 1 is used for the conduction of experiments. Experiments are conducted as per the OA shown in table 2.

A welded sample is given in Fig 2. Tesile and flextural strength are found out by nano UTM presented in Fig 3. A sample graph obtained by 3 point bend test is shown in Fig 4.

**Fig 1: MIG Welding Equipment Used for Experiment**

**Fig 2: A welded sample**

**Fig 3: Tensile test on Nano UTM**

## IV. RESULTS AND DISCUSSION

The results of the 9 trails are shown in Table 3. The results of bead geometry is presented in Table 4. S/N Analysis is conducted for all output parameters. For Flexural strength, Tensile strength, and penetration higher the better formula presented in equation (1) is used and the smaller the better formula shown in equation (2) is used for width and reinforcement.

$$SN_i = -10\ log\left[\frac{1}{N}\sum_{u=1}^{N_i}\frac{1}{y_u^2}\right] \ldots\ldots\ldots (1)$$

$$SN_i = -10\ log\left[\frac{1}{N}\sum_{u=1}^{N_i} y_u^2\right] \ldots\ldots\ldots (2)$$

Where $SN_i$ is the S/N ration of $i^{th}$ variable, N is the no.of observations, $y_u$ is the value of $u^{th}$ observation.

The results of S/N Analysis for Flexural strength obtained by Eq(1) and Eq (2) are presented in Table 5 and the maen S/N ratio for the above parameters at the chosen levels are calculated and shown in table 6.

From the table 6 it is found that gas flow rate has maximum influence in flexural strength and tensile strength in chosen range. The mean S/N vales for bead geometry at the three levels are shown in table 7.

From table 7 it is identified that gas flow rate is the maximum influencing parameter for penetration and width and current is the most significant parameter for reinforcement. The Mean S/N values for flexural strength, tensile strength, penetration width and reinforcement are plotted in Fig 5, Fig 6, Fig 7, Fig 8 and Fig 9 respectively.

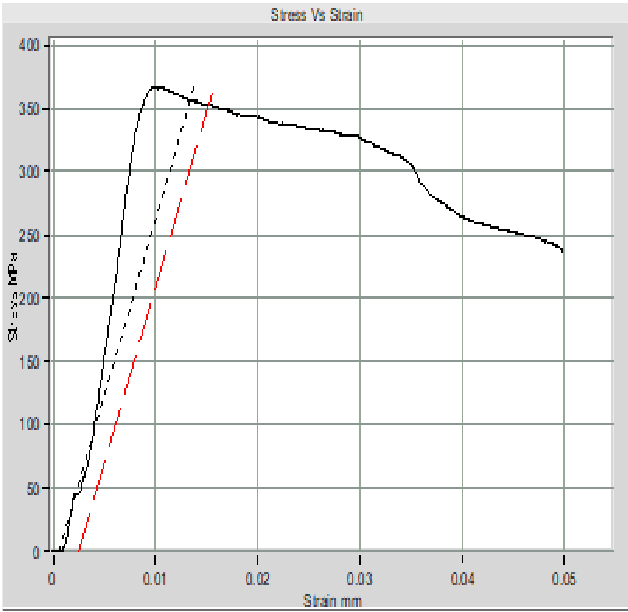


**Fig 4: 3-point bend test graph**

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**Table 3: Results of Flexural and Tensile Strength**

| Trial | Current (A) | Voltage (V) | Gasflow (liter/min) | Flexural Strength (MPa) | | | Tensile strength (MPa) | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 75 | 25 | 9 | 185 | 189.3 | 182.3 | 210.8 | 209 | 211 |
| 2 | 75 | 26 | 12 | 257 | 261.2 | 252.4 | 370.4 | 371 | 369 |
| 3 | 75 | 27 | 15 | 101 | 104.2 | 109.4 | 186.7 | 185 | 187 |
| 4 | 100 | 25 | 12 | 114 | 117.6 | 119.2 | 221.7 | 220 | 222 |
| 5 | 100 | 26 | 15 | 159 | 156.8 | 158.6 | 220 | 231 | 229 |
| 6 | 100 | 27 | 9 | 119 | 123.2 | 126.4 | 160.9 | 159 | 161 |
| 7 | 125 | 25 | 15 | 119 | 120.1 | 121.3 | 155.8 | 156 | 154 |
| 8 | 125 | 26 | 12 | 365 | 326.1 | 317.3 | 359.3 | 360 | 358 |
| 9 | 125 | 27 | 9 | 178 | 179.9 | 181.9 | 292.4 | 293 | 291 |

**Table 4: Results of bead geometry**

| Trial | Current | Voltage | Gas flow | **Penetration (mm)** | | | **Reinforcement (mm)** | | | **Width (mm)** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 75 | 25 | 9 | 2.5 | 2.6 | 2.4 | 3 | 3.1 | 2.9 | 8 | 9 | 7 |
| 2 | 75 | 26 | 12 | 2.2 | 2.2 | 1.8 | 2 | 2.1 | 1.9 | 9 | 10 | 8 |
| 3 | 75 | 27 | 15 | 1.2 | 1.2 | 0.8 | 3 | 2.9 | 3.1 | 5 | 4 | 6 |
| 4 | 100 | 25 | 9 | 3.2 | 3.2 | 2.8 | 4 | 3.9 | 4.1 | 5 | 6 | 4 |
| 5 | 100 | 26 | 12 | 1.2 | 1.2 | 0.8 | 3 | 2.9 | 3.1 | 5 | 6 | 4 |
| 6 | 100 | 27 | 15 | 2.2 | 2.2 | 1.8 | 2.5 | 2.4 | 2.6 | 6 | 7 | 5 |
| 7 | 125 | 25 | 9 | 2.2 | 2.2 | 1.8 | 4 | 3.9 | 4.1 | 4 | 5 | 3 |
| 8 | 125 | 26 | 12 | 3.2 | 3.2 | 2.8 | 5 | 4.9 | 5.1 | 5 | 6 | 4 |
| 9 | 125 | 27 | 15 | 2.2 | 2.2 | 1.8 | 4 | 3.9 | 4.1 | 7 | 8 | 6 |

**Table 5: S/N Analysis of Tensile strength, flexural strength, bead geometry**

| Trial | Current | Voltage | Gas flow | S/N Ratio of Flexural Strength | S/N Ratio of Tensile Strength | S/N Ratio of Penetration | S/N ratio Width | S/N Reinforcement |
|---|---|---|---|---|---|---|---|---|
| 1 | 75 | 25 | 9 | 45.36531 | 46.45517 | 7.944888 | 18.1068 | 9.545641 |
| 2 | 75 | 26 | 12 | 48.1916 | 51.3671 | 6.186652 | 19.12045 | 6.027832 |
| 3 | 75 | 27 | 15 | 40.39871 | 45.40086 | 0.070948 | 14.09369 | 9.545641 |
| 4 | 100 | 25 | 12 | 41.35421 | 46.8968 | 9.681023 | 14.09369 | 12.04301 |
| 5 | 100 | 26 | 15 | 43.97999 | 47.10185 | 0.070948 | 14.09369 | 9.545641 |
| 6 | 100 | 27 | 9 | 41.78071 | 44.09824 | 6.186652 | 15.64271 | 7.96343 |
| 7 | 125 | 25 | 15 | 41.59247 | 43.82113 | 6.186652 | 12.21849 | 12.04301 |
| 8 | 125 | 26 | 12 | 50.48301 | 51.10424 | 9.681023 | 14.09369 | 13.98056 |
| 9 | 125 | 27 | 9 | 45.10121 | 49.31151 | 6.186652 | 16.96065 | 12.04301 |

**Table 6: Mean S/N Ratios of the factors for Flexural Strength and Tensile Strength**

| **Levels** | **Flexural Strength** | | | **Tensile Strength** | | |
|---|---|---|---|---|---|---|
| | **Current** | **Voltage** | **Gas Flow** | **Current** | **Voltage** | **Gas Flow** |
| 1 | 44.65188 | 42.77067 | 44.08241 | 47.74104 | 45.72437 | 46.62164 |
| 2 | 42.37164 | 47.55153 | 46.67627 | 46.0323 | 49.85773 | 49.78938 |
| 3 | 45.72557 | 42.42688 | 41.99039 | 48.07896 | 46.2702 | 45.44128 |
| Range | 3.35393 | 5.124656 | 4.685882 | 2.046663 | 3.587524 | 4.348104 |

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**Table7: Mean S/N Ratio of the parameters for Bead Geometry**

| Levels | Penetration | | | Reinforcement | | | Width | | |
|---|---|---|---|---|---|---|---|---|---|
| | Current | Voltage | Gas Flow | Current | Voltage | Gas Flow | Current | Voltage | Gas Flow |
| 1 | 4.73416 | 7.93752 | 6.77273 | 8.37303 | 11.2105 | 9.85069 | 17.1069 | 14.8063 | 16.9033 |
| 2 | 5.31287 | 5.31287 | 8.51623 | 9.85069 | 9.85134 | 10.6838 | 14.6100 | 15.7692 | 15.7692 |
| 3 | 7.35144 | 4.14808 | 2.10951 | 12.6888 | 9.85069 | 10.3781 | 14.4242 | 15.5656 | 13.4686 |
| Range | 2.61728 | 3.78943 | 6.40671 | 4.31582 | 1.35986 | 0.83310 | 2.68270 | 0.96295 | 3.43476 |

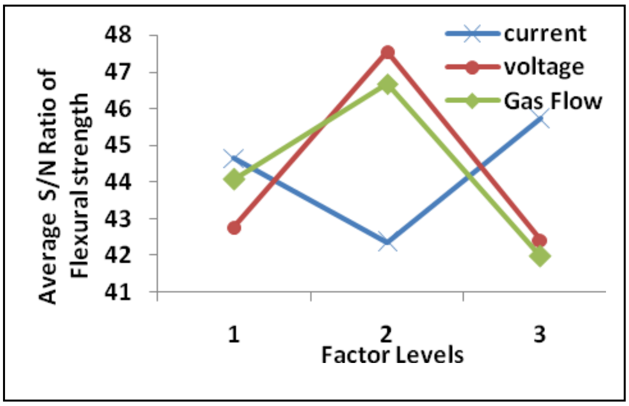


**Fig 5: Mean S/N Values of Flexural strength**

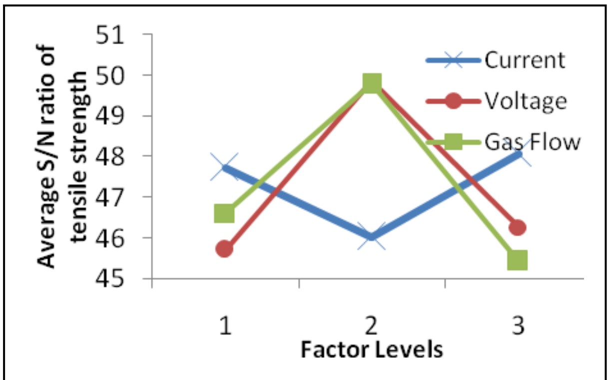


**Fig 6: Mean S/N Values of Tensile strength**

From Fig 5 and Fig 6, it is found that a current and voltage at level 2 and gas flow rate at 3 are optimum values for flexural strength and tensile strength

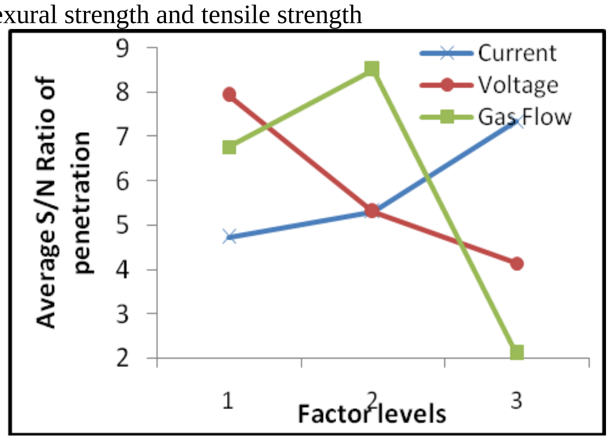


**Fig 7: Mean S/N Values of Penetration**

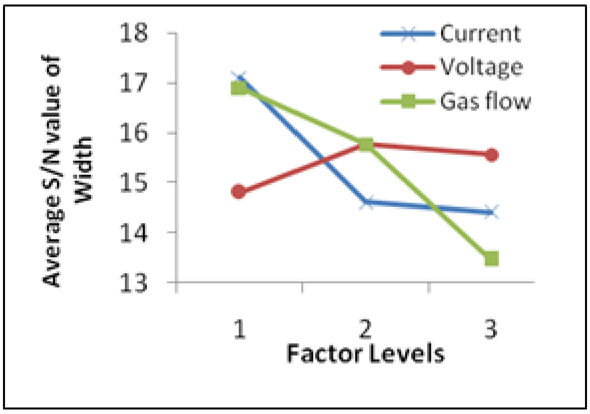


**Fig 8: Mean S/N Values of Width**

From Fig 7, Fig 8, Fig 9 it is found that Current-3, voltage-1 and gas flow-2 give higher penetration. Current-3, voltage-3 and gas flow-3 are optimum for lower width. Current-1, voltage-2 and gas flow-3 are optimum for reinforcement.

## V. CONCLUSIONS

The following conclusions are drawn from the current work.

- Among the selected range, a current of 100A , voltage of 27 V, and gas flow of 15 liter/min gives higher flexural strength and tensile strength.
- 120 A current, 25V voltage and 9 liter/min gas
- flow rate gives deeper weld bead in the selected range.

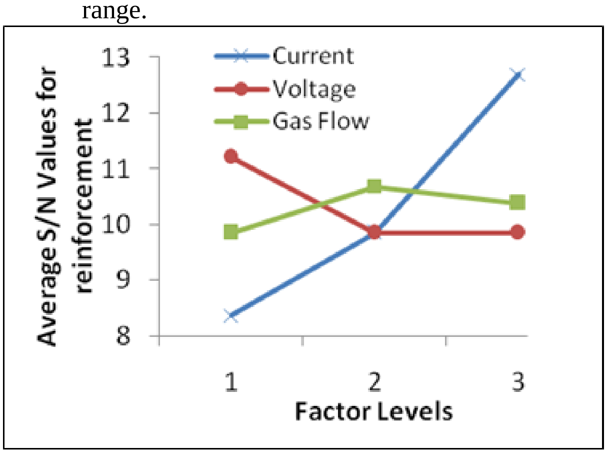


**Fig 9: Average S/N Values of Reinforcement**

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## AUTHORS PROFILE

**Dr.P.V.R.Ravindra Reddy**, presently working as Professor of Mechanical Engineering ,CBIT was graduated from REC (Presently NIT), Rourkela in 1993 in Mechanical Engineering, obtained M.Tech (Manufacturng Engg.) from NIFFT, Ranchi in 1996, and was awared with Ph.D from Osmania University in 2010. He worked as Engineer (Development) in HIndusthan Gas and Industries Ltd, An Aditya Birla concen for 2 years and Joined CBIT in 1998., became Associate Professor in the year 2006 and Professor in 2013. He has published 5 papers in international journals, 25 papers in National Journals, 6 papers in internaitonal conferences and 18 papers in natinal conferences. He has successfully completed a research project of worth 9.95 lakhs from defense labs and presently carrying out another project of 9.9 lakhs. He is the coordinator for ISO 9001:2015 implementation in CBIT. Presently he is guiding 4 Ph.D scholars. He is the member of Institute of Engigineers India and Society of Manufacturing Engieers.His area of reseach is metal forming and welding.

**Dr. G. Chandra Mohan Reddy**, presently working as Professor of Mechanical Engineering in CBIT, obtained B.Tech in Mechanical Engineering from KITS Warangal, M.Tech in Machine Tools from REC Warangal and Ph.D from OU Hyd. He started his career as Assistant Professor in MJCET in 1991 and joined CBIT in 1992. He became Associate Professor in 1996 and Professor in 2003. He served as Principal of MGIT on deputation during 2009-2018 and contributed immensely for the expansion of UG&PG programs and obtained NBA, NAAC and UGC recognitions to MGIT. He has 28 years of experience in teaching/training/research/administration. He has published over 115 research papers in National and International Journals and Conferences of repute and has successfully completed many research projects. He has guided Six Ph.D. Scholars and Two Scholars submitted their thesis recently and currently guiding Ten Scholars. He is a key resource person/coordinator/chairman/organizing secretary for 49 Conferences / Seminars/ STTPs/ Workshops/ FDPs/ Conventions and delivered 58 keynote /invited talks /guest lectures. He was the Chief and Principal Investigator for 04 Research and Consultancy Projects. Dr Reddy is the recipient of Young Engineer of the Year award-1999; Best Principal Investigator(Excellent Grade-A) from AICTE- New Delhi 2002; Distinguished Alumnus award from KITS Warangal 2007; Engineer of the Year Award-2009;;Eminent Educationist Award from International Institute of Education & Management, NEWDELHI 2011;Railway Board's 1st Prize for best paper at 27th Indian Engineering Congress held at Vigyan Bhavan, New Delhi 2012; ISTE Best Chapter Award 2012;Best Engineering College Principal Award-2012; ISTE Best Student Chapter Award 2014; Best Paper for the category of Best Presentation/Best Content at the ASAR International conference 2016; Dr Reddy made remarkable services to Professional Societies. He is a Fellow of IEI and Member of ASME, IEEE, AeSI, ISTE, ISME & TSI. He served as Joint Hon Secretary and Hon Secretary of the Institution of Engineers (India) Hyderabad and presently serving as Member of IEI Telangana State Centre Committee and Finance Sub Committee. Served as Member of DRC in OU, BOS in JNTUH, Academic Council-State Board of Tech Edn; State Productivity Council, SAC-TSERC(2015-18), TSEAMCET (2017&18), EC Member of AeSIHyd (2018&19).

**Dr BVS Rao** is presently working as Assistant Professor in Mechanical Engineering Department of CBIT He has completed his M Tech in Advanced Manufacturing Systems (AMS) from JNTU Hyderabad, and did Ph.D from the same University in the area of Deep Drawing. He has 26 years of experience in Industry and teaching put together. He worked as Production In charge in Hyderabad Precision Manufacturing Pvt Ltd for 2 years, then as Assistant Director in ANDHRA PRADESH PRODUCTIVITY COUNCIL for 7 years. He then entered into teaching and joined CBIT as Assistant professor. He has published 20 Technical Papers in various National and International Journals in the areas of Manufacturing like Metal Forming (Deep Drawing), welding & casting and Industrial engineering etc . He has presented 17 technical papers in National and International conferences, in the same areas as indicated above. His area of interest and research work is in Metal forming, Casting, Welding , CAD/CAM and Industrial Engineering. He got Best papers, in the National Conference at AVC College of Engineering, Mayiladuthurai (TN), and at the National Conference On Advances In Mechanical Engineering held at CBIT , in 2013.

**Dr G Laxmaiah** is working currently as a Professor in the department of Mechanical Engineering, Chaitanya Bharathi institute of technology (CBIT), Hyderabad, graduated from Nagarjuna University in 1993 and obtained his post graduation with Machine Design from Andhra University in 1996. He obtained his PhD from Osmania University in 2013. He has 23 years of teaching experience. He has published 15 papers in various national and international journals and conferences. His area of research is Noise and Vibrations.