OPTIMIZATION OF MIG WELDING PROCESS PARAMETERS USING TAGUCHI'S METHOD OF AZ91

Prof. M.B. Sorte
Head Of Department, Mechanical Engineering
S.C.O.E.,
Kharghar, Navi Mumbai, India
madhukar.sorte@gmail.com

AdityaYadav
Student, Mechanical Engineering
S.C.O.E.,
Kharghar, Navi Mumbai, India
aydy1997@gmail.com

Vaibhav Mule
Student, Mechanical Engineering
S.C.O.E.,
Kharghar, Navi Mumbai, India
vaibhavmule90@gmail.com

Sanket Thakur
Student, Mechanical Engineering
S.C.O.E.,
Kharghar, Navi Mumbai, India
sanketthakur75@gmail.com

AjinkyaVaite
Student, Mechanical Engineering
S.C.O.E.,
Kharghar, Navi Mumbai, India
ajvaite00700700@gmail.com

***Abstract*—Of all engineering metals, Magnesium is very light metal with density of 1.74g/cc. Compared to aluminum it is 35% light. Therefore, AZ91 is used to great extent in automobile industries. Volkswagen, an automobile manufacturer was first to implement this in their "Beetle" car. Twenty two kilograms of magnesium was used in each model. In 1928 Porsche made an engine consisting of magnesium.We will be using Taguchi's method of optimization to get high hardness for weld for AZ91 (a magnesium alloy). The study of this project willbe helpful in selecting the welding parameters in automobile industry,oil pan, steering column,brackets, 4-wheel drive transfer case, and manual transmission case. Optimization will be done by the orthogonal L-9 array. Magnesium alloys are 20% comparatively more expensive than aluminum. Hence, we cannot afford to make wastage this expensive alloy.Our project study will help to get the correct configuration of parameters for achieving best hardness.**

***Keywords*—MIG welding, Optimization, Taguchi Method, AZ91, ANOVA.**

I. INTRODUCTION

Mg alloys are greatly used in automobile industry. Hence it becomes very important to study welding of these alloys. Lightest metal available on Earth is Magnesium. It has density of 1.74grams/cubic cm, it has good strength to wt. ratio.This makes it suitable for applications in industries like automobile, aeronautical etc. But Mg metal has many drawbacks and hence it cannot be directly used in pure form. AZ91, a magnesium alloy is used widely in industries as overcomes pure magnesium's limitations.In MIG welding, two metals are welded by using a rolled up wire as an electrode. This wire is fed to the location where the plates are to be joined. The shielding gas which is passed from the gun so that it shields the weld flux from unwanted particles.

In their research paper [1]. Rakesh Kumar and Gurinder Singh optimized mig welding parameters by Taguchi,s technique. [2]. Raj Kumar Yadav, Sandhaya Yadav, Anurag Singh and Pankaj Singh researched on MIG welding parameters and its effects by Taguchi's method. [3]. Amit Pal has done ANOVAfor his experimentation. . [4]. S. A. Rizvi has studied GMA welding for AISI 304H material. [5]. Gaurav Kumar, Hitendra Bankoti and Deepankar Chandra Agri have done experimentation on AISI 304 and measured response as depth penetration.

In this project we have used Taguchi's orthogonal array to fix different levels in experimentation. We used L-9 array while performing MIG welding. Two AZ91 alloy plates were welded together by a butt joint. Each plate having dimensions of 2x7.5x0.6cm. In this way a total of 18 individual plates were welded with an additional 2 plates as a sample for best strength. After welding of the AZ91 plates they were tested in a hardness testing machine which tested the hardness of each weld. By using the values of S/N ratios during experimentation, ANOVA analysis will be done.

Fig.1 Overall methodology chart

II. EXPERIMENTAL DETAILS AND MEASUREMENT

The AZ91 plates where welded by a butt joint along its 2 cm side. These welds were performed by MIG welding. 18 plates were welded together such that a total of 9 specimens were formed. The parameters, current, voltage and electrode diameter were varied and used in 9 different combinations. After welding, these specimens were tested for hardness of the welds. The dimensions of these plates were 2x7.5x6cm. ANOVA analysis was done by using the Signal to Noise ratio.The hardness is the objective function so that "the larger-the-better" S/N ratio is choosen. The S/N ratio for the larger-the-better is:

$$S/N=-10\log(\sum_{i=0}^{n}\frac{1}{y^2})$$

TABLE 1. CHEMICAL COMPOSITION OF AZ91

ELEMENTS	**Al**	**Cu**	**Mg**	**Fe**	**Ni**
Percentage(%)	9	0.03	Bal.	0.005	0.002
ELEMENTS	**Zn**	**Mn**	**Si**	**Other metals**	**RoHS Compliant**
Percentage(%)	0.35	0.15	0.1 max	0.02	✓

Fig.2 Welded Az91 Plates

III. TAGUCHI METHOD

The Taguchi technique involves decreasing the variation in process by a good D.O.E. The main role of this technique isto give high quality result at low cost. The Taguchimethod was formed by Genichi Taguchi. Taguchi technique was developed to check how various parameters influence mean and variance of a property of the product. This technique consists of orthogonal arrays to arrange the affecting parameters and levels in a way they are to be varied. Taguchi method tests few different combinations of parameters instead of all possible combinations. This permitted us to take an L-9 O.A. instead of taking each every combination. This proved useful in saving cost, resources and time. Taguchi technique is suitable when there are an intermediate number of variables (3 to 50) .

TABLE 2. PARAMETERS AND LEVELS

LEVEL	L1	L2	L3
CURRENT	85	50	40
VOLTAGE	440	315	250
ELECTRODE DIAMETER	1.6	2.6	3

Taguchi's L9 O.A. was used to perform the experiments which include of total 9 combinations of parameters voltage, current, electrode diameter. Three process parameters with three finite levels has been taken according to Taguchi Analysis. Minitab 15 software is used for design of experiments and Taguchi Analysis.

TABLE3. L9 ORTHOGONAL ARRAY AND MEASUREMENT

CURRENT	VOLTAGE	ELECTRODE DIAMETER
85	440	1.6
85	315	2.6
85	250	3
50	440	2.6
50	315	3
50	250	1.6
40	440	3
40	315	1.6
40	250	2.6

IV. RESULTS AND DISCUSSIONS

The welding has been done as per the L9 O.A. with all 3 process parameters and corresponding levels. The hardness has been observed. The data then obtained is fed into the statistical software "MINITAB 15" for further calculation of S/N ratio with ANOVA. The result of the acquired data is shown in table:

TABLE4. EXPERIMENTAL VALUES

I (A)	V (V)	D (mm)	HARDNESS (kgf)	S/N RATIO
85	440	1.6	82	38.2762
85	315	2.6	73	37.2664
85	250	3	56	34.9637
50	440	2.6	82	38.2762
50	315	3	58	35.2685
50	250	1.6	94	39.4625
40	440	3	87	38.7903
40	315	1.6	70	36.9019
40	250	2.6	67	36.5214

I=Current in Ampere
V=Voltage in volt
D=Electrode Diameter in millimeters

S/N ratios calculated by 'Larger is Better' function.

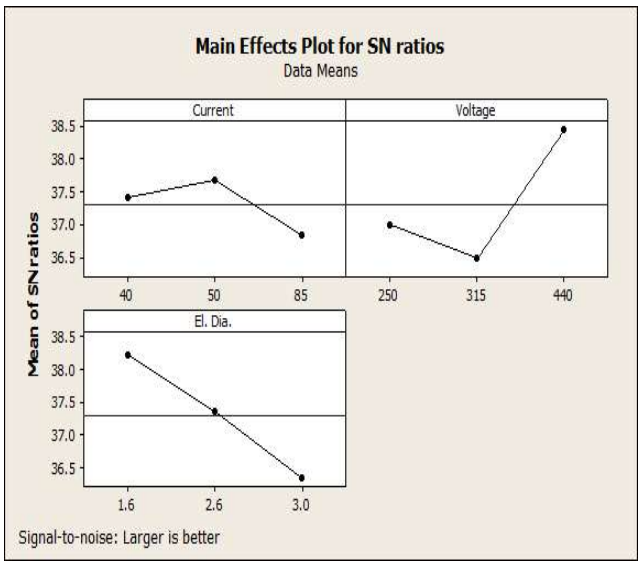
TABLE5. S/N RATIO FOR HARDNESS

LEVEL	CURRENT	VOLTAGE	ELECTRODE DIAMETER
1	36.8354	38.4475	38.2135
2	37.6690	36.4789	37.3546
3	37.4045	36.9825	36.3408
DELTA	0.8336	1.9686	1.8727
RANK	3	1	2

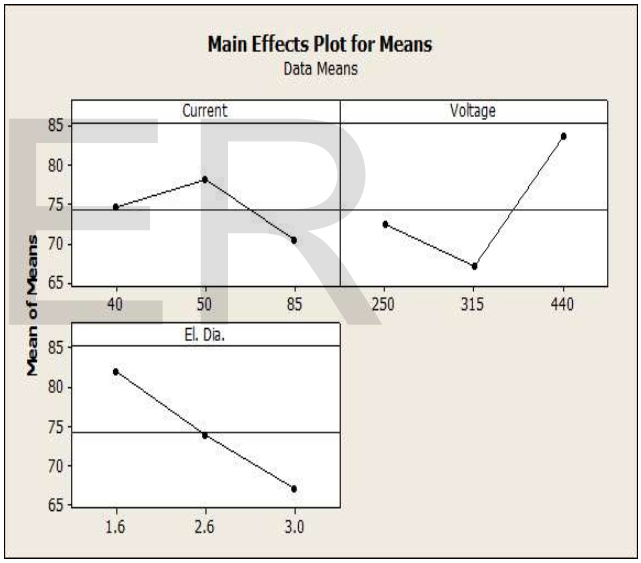
TABLE6. ANOVA FOR HARDNESS

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Current	2	88.7	88.7	44.3	0.18	0.844
El. Dia.	2	338.0	338.0	169.0	0.70	0.587
Voltage	2	434.7	434.7	217.3	0.90	0.525
Error	2	480.7	480.7	240.3		
Total	8	1342.0				

MAIN EFFECT PLOT FOR S/N RATIO



MAIN EFFECT PLOT FOR MEANS



V. CONCLUSION

Taguchi technique was used to optimize various welding parameters that are affecting the weld Hardness. By analysis of variance we found that maximum hardness is 94kgf which is obtained from 6th L9 O.A. of Taguchi's design having S/N ratio of 39.4625. In this study, we optimized the process parameters using Taguchi's method of optimization. This helped to get the best set of parameters which produced highest hardness for the given parameters. Also the ANOVA analysis helped in determining the parameter which contributes the highest in hardness.

REFERENCES

[1]. Rakesh Kumar1 and Gurinder Singh Brar2. Optimization of Process Parameters for MIG Welding by Taguchi Method, International Journal of Scientific Research Engineering & Technology (IJSRET), 2017.

[2]. Raj Kumar Yadav, Sandhaya Yadav, Anurag Singh and Pankaj Singh. OPTIMIZATION OF MIG WELDING TECHNIQUE PARAMETERS WITH THE HELP OF TAGUCHI METHOD, International Journal of Production Technology and Management (IJPTM), 2016.

[3]. Amit Pal. MIG WELDING PARAMETRIC OPTIMIZATION USING TAGUCHI'S ORTHOGONAL ARRAY AND ANALYSIS OF VARIANCE, IJRREST INTERNATIONAL JOURNAL OF RESEARCH REVIEW IN ENGINEERING SCIENCE & TECHNOLOGY, 2015.

[4]. S. A. RIZVI. APPLICATION OF TAGUCHI TECHNIQUE TO OPTIMIZE THE GMA WELDING PARAMETERS AND STUDY OF FRACTURE MODE CHARACTERIZATION OF AISI 304H WELDED JOINTS, 2018.

[5]. Gaurav Kumar, Hitendra Bankoti and Deepankar Chandra Agri. Optimization of MIG Welding process Parameters for Weld peneteration in AISI Grade 304 Steel Using Taguchi Design Method ,International Journal on Emerging Technologies (Special Issue NCETST-2017) **8**(1): 355-357(2017).

[6]. [1] Rudreshi Addamani, [2] H V Ravindra,[3] Darshan C S. Optimization of P-GMAW Welding Parameters using Taguchi Technique, International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE) Vol 2, Issue 4, April 2017.

[7]. Nabendu Ghosh, Pradip Kumar Pal, and Goutam Nandi. Parametric Optimization of MIG Welding on 316L Austenitic Stainless Steel by Taguchi Method, International Journal of Mechanical Engineering and Robotics Research Vol. 6, No. 2, March 2017.

[8]. Pappu Kumar, Prof. Prakash Kumar. Optimization of Welding Parameter (Mig Welding) Using Taguchi Method, International Jornal of Scientific Resarch and Education, Volume||4||Issue||11||November-2016||Pages-6053-6058.

[9]. Sudesh Verma1, Rajdeep Singh2. OPTIMIZATION OF PROCESS PARAMETERS OF METAL INERT GAS WELDING BY TAGUCHI METHOD ON CRC STEEL IS 513 GR D, International Journal of Advance Research In Science And Engineering IJARSE, Vol. No.3, Issue No.9, September 2014.

[10]. Kapil B. Pipavat1 , Dr. Divyang Pandya2 , Mr. Vivek Patel. Optimization of MIG welding Process Parameter using Taguchi Techniques, International Journal of Advance Engineering and Research Development (IJAERD) Volume 1,Issue 5,May 2014.