ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

Optimization of Process Parameters during MIG Welding of AISI 1010 Mild Steel Plates Using PCA based GRA

Srivani Valluru[1], K.Aruna[2], Dr. P. Hema [3]

PG Student, Department of Mechanical Engineering, S.V. University College of Engineering, Tirupati, Andhra Pradesh, India[1]

Assistant Professor, Department of Mechanical Engineering, S.V. University College of Engineering, Tirupati, Andhra Pradesh, India[2]

Assistant Professor, Department of Mechanical Engineering, S.V. University College of Engineering, Tirupati, Andhra Pradesh, India[3]

ABSTRACT: An attempt has been made to optimize the process parameters like welding current, voltage, welding speed and electrode extension in MIG (Metal Inert Gas) welding of AISI 1010 mild steel plates of thickness 2mm through the experiments based on design matrix of L16 orthogonal array to obtain high quality weld bead for various engineering applications having minimum bead width, minimum bead height, maximum bead penetration, maximum dilution percentage, high weld area hardness and high heat affected zone hardness using PCA (Principal Component Analysis) based GRA (Grey Relational Analysis) methodology. ANOVA technique has been adopted to calculate the contribution of each process parameter.

KEYWORDS: MIG (Metal Inert Gas) welding, PCA (Principal Component Analysis) based GRA (Grey Relational Analysis), ANOVA

I. INTRODUCTION

Metal inert gas welding (MIG) is an arc welding process which produces the coalescences of metals by heating them with an arc between a continuously fed filler metal electrode and the work. MIG welding process lends itself to semiautomatic, robotic automation and hard automation welding applications. The alloy material range for GMAW includes: carbon steel, stainless steel, aluminium, magnesium, copper, nickel, silicon bronze and tubular metal-cored surfacing alloys. The molten metal at the electrode tip can be transferred to the weld pool by Short circuiting transfer, Globular transfer, Axial Spray transfer, Pulsed Spray transfer.

II. LITERATURE SURVEY

C. N. Patel et al. [1] evaluated the parameters; welding current, wire diameter and wire feed rate to investigate their influence on weld bead hardness for MIG welding and TIG welding by Taguchi's method and Grey Relational Analysis (GRA). From the study it was concluded that the welding current was most significant parameter for MIG and TIG welding. By use of GRA optimization technique the optimal parameter combination was found to be welding current, 100 Amp; wire diameter 1.2 mm and wire feed rate, 3 m/min for MIG welding. **Jing-Shiang Shih, et.al [2]**, described Principal component analysis (PCA) coupled with Taguchi methods for multiple quality characteristics optimization of metal inert gas (MIG) arc welding aluminium foam plates. The quality characteristics investigated are the micro-hardness and the bending strength of the weldments. Eight control factors selected are the type of filler

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

material, MIG current, welding speed, MIG gas flow rate, work piece gap, MIG arcing angle, groove angle, and electrode extension length. **Pawan kumar, Dr.B.K.Roy[3]**, worked carried out on plate welds AISI 304 & Low Carbon Steel plates using gas metal arc welding process. Design of experiments using L9 orthogonal array is employed to obtain optimum levels of welding current, welding voltage & gas flow rate for hardness using Taguchi. Subsequently, using ANOVA the significant coefficients for each input parameter on tensile strength & Hardness (PM, WZ & HAZ) were determined and validated. **Dinesh Mohan Arya, et.al [7]**, have done work on the optimization of MIG welding process parameters like wire diameter, welding current, arc voltage, welding speed, and gas flow rate based on Tensile strength, Bead width, Bead height, Penetration and Heat affected zone (HAZ) for quality target using grey relational analysis. The signal to noise ratio (S/N ratio) is also applied to obtain the predicted optimal parameter setting. ANOVA showed that current was most significant factor in this result. **Ganjigatti J.P.et al. [9]** studied global versus cluster-wise regression analyses for prediction of bead geometry in MIG Welding process. They observed that the cluster-wise regression analyses perform slightly better than the global approach in predicting weld bead geometric parameters. **M. Aghakhani et al. [10],** have done work on optimization of GMAW process parameter for increase quality and productivity of weldment by considering effect of input parameter wire feed rate, welding voltage, nozzle-to-plate distance, welding speed and gas flow rate on weld dilution during welding of ST-37 steel plate. The experiment was designed by Taguchi's L25 orthogonal array and analysis was carried out by ANOVA method also they develop mathematical model for weld dilution. From the experimental result they found that the wire feed rate has the most significant effect on the weld dilution while gas flow rate has no effect on weld dilution.

In this paper robotic MIG (Metal Inert Gas) welding is performed on AISI1010 mild steel plates having 2mm thickness. Experiments are conducted based on the L16 orthogonal array by varying the different process parameters like current, voltage, welding speed and electrode extension in order to optimize them by considering bead quality characteristics like bead width, bead height, bead penetration, dilution percentage, weld area hardness, heat affected zone hardness as output responses, using PCA (Principal Component Analysis) based GRA (Grey Relational Analysis). The most influential parameter current is seen by ANOVA.

III. EXPERIMENTAL DESIGN FOR PRESENT WORK

Orthogonal arrays are special standard experimental design that requires only a small number of experimental trials to find the main factors effects on output. The input process parameters which affects the output responses like Bead Width, Bead Height, Bead penetration, Dilution percentage, weld area hardness, heat affected zone hardness, have been selected and are Current(C), Voltage (V), Welding Speed (WS) and Electrode Extension (EE).After selecting the process parameter, the range and level vales of each process parameter were selected and as shown in the Table-1.

Table 1. Process Parameters with Levels

Process Parameters	Range	Level			
		1	2	3	4
Current (A)	80-140	80	100	120	140
Voltage (V)	14-26	14	18	22	26
WS(cm/sec)	20-35	20	25	30	35
EE (mm)	10-16	10	12	14	16

The L16 orthogonal array was selected to conduct the experiments are conducted as per the level combinations listed in Table -2. The performance parameter (output) was noted for each experimental run for analysis.

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

Table 2. Experimental design using L16 Orthogonal Array

S.No	Current (A)	Voltage (V)	WS (cm/sec)	EE (mm)
1	80	14	20	10
2	80	18	25	12
3	80	22	30	14
4	80	26	35	16
5	100	14	25	14
6	100	18	20	16
7	100	22	35	10
8	100	26	30	12
9	120	14	30	16
10	120	18	35	14
11	120	22	20	12
12	120	26	25	10
13	140	14	35	12
14	140	18	30	10
15	140	22	25	16
16	140	26	20	14

IV. EXPERIMENTATION AND DATA COLLECTION

Due to having various engineering applications, **AISI 1010** mild steel plates having dimension 120×62.5×2 mm are used as a base material for performing MIG welding and its chemical composition obtained during material grade test is given in Table-3.**ER70S–6** has been employed as MIG welding wire.**C25** (75% Argon and 25% Carbon dioxide) is selected here as a shielding gas for complete process.

Table 3. AISI1010 mild steel chemical composition

Element	Carbon(C)	Manganese(Mn)	Silicon(Si)	Sulphur(S)
(% by weight)	0.11	0.21	0.011	0.008

The type of joint considered is square butt joint with single passing weld by maintaining 0.5 mm root gap throughout the welding. Mainly OTC DIAHEN, DP 400 AC/DC MIG welding machine and industrial robot have been employed for performing semi-automated robotic MIG welding. After preparing the weld joint, the testing of weld bead has been performed for estimating the quality of weld bead.

Hardness Test

The VM 50 Vickers hardness testing machine is used for measuring weld area hardness (H_WA), heat affected zone hardness (H_HAZ) by applying 1 kgf load in 10 seconds and then observed values are listed in Table-4.

Bead Geometry measurement

Specimens having 1cm×0.5cm dimension approximately were cut transverse to the welding direction from each welded plates using bench cutting machine. These specimens were cleaned, surface grinded with emery papers, etched with 10% Nital (90% alcohol and 10% of nitric acid), molded using cold mounting acrylic powder& liquid and fine polished with Alumina paste. Weld bead profiles were traced by using an optical microscope at 20X magnification. Measurements were made for Bead Width (BW), Bead Height (BH) and Bead Penetration (BP), Area of Penetration (A_P) and Area of Reinforcement (A_R) using AUTO CAD software. Then Dilution Percentage (D_P) is calculated and listed in Table.4, by applying the equation-13 for measured Area of Penetration (A_P) and Area of Reinforcement (A_R) values.

$$D_P\ (\%) = \frac{A_P}{(A_P + A_R)} \times 100 \qquad (13)$$

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

The collected experimental data representing Bead Width(BW) in mm, Bead height(BH) in mm, Bead Penetration (BP) in mm, Dilution Percentage(D_P) in %, Weld Area Hardness(H_WA) in HV and Heat Affected Zone hardness(H_HAZ) in HV have been listed in Table.4 and then utilized for optimization of process parameters.

V. PROPOSED METHODOLOGY FOR OPTIMIZATION

PCA(Principal Componenet Analysis) based GRA(Grey Relational Analysis) has been found appropriate to tackle present correlated multi resonse optimization problem with to eliminate response correlation and to convert a multi-objective optimization problem to a single response optimization by accumulating the principal components into the overall grey relational grade. It can be recommended that the PCA based GRA method is good, for example, in case of chemical processes and pharmaceutical industries when there are hundreds of response variables.

Step 1.Normalization of the responses (quality characteristics)

When the range of the series is too large or the optimal value of a quality characteristic is too enormous, it will cause the influence of some factors to be ignored. The original experimental data must be normalized to eliminate such effect. There are three different types of data normalization according to whether we require the LB (lower-the-better), the HB (higher-the-better) and NB (nominal-the-best). The normalization is taken by the following equations.

For LB (lower-the-Better),

$$X_i^*(k) = \frac{\min X_i(k)}{X_i(k)} \qquad (1)$$

For HB (higher-the-Better),

$$X_i^*(k) = \frac{X_i(k)}{\max X_i(k)} \qquad \mathbf{(2)}$$

For NB (Nominal-the-Best),

$$X_i^*(k) = \frac{\min \{X_i(k), X_{0b}(k)\}}{\max \{X_i(k), X_{0b}(k)\}} \qquad (3)$$

where i=1,2,….,m; k=1,2,….,n; X 0* (k) is the normalized data of the k th element in the i th sequence. X 0b (k) is the desired value of the k th quality characteristic. After data normalization, the values of X 0* (k) will be between 0 and 1. The series X i* can be viewed as the comparative sequence used in grey relational analysis.

Step 2.Checking for correlation between two quality characteristics

The correlation coefficient between two quality characteristics is calculated by the following equation:

$$\rho_{jk} = \frac{Cov(Q_j, Q_k)}{\sigma_{Q_j} \times \sigma_{Q_k}} \qquad (4)$$

The correlation is checked by testing the following hypothesis:

H0 : $\rho_{jk} = 0$ (There is no correlation)

H1 : $\rho_{jk} \neq 0$ (There is correlation)

Here, j = 1, 2, 3....., n; k = 1, 2, 3,....., m; $j \neq k$; Q_j, Q_k are the normalized series of j^{th} and k^{th} Quality characteristics respectively, ρ_{jk} is the correlation coefficient between j^{th} and k^{th} Quality characteristics respectively; Cov (Q_j , Q_k) is the covariance of j^{th} and k^{th} Quality characteristics respectively; σ_{Qj} and σ_{Qk} are the standard deviation of j^{th} and k^{th} Quality characteristics respectively.

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

Step 3.Determining the eigen values and eigenvectors

After calculating the correlation matrix (**ρ**),the Eigen values are calculated using the equation 5 and then Eigen vectors are determined from the equation 6.

$$| \rho - \lambda . I | = 0 \quad (5)$$

$$(\rho - \lambda_k . I)\, \beta_k = 0 \quad (6)$$

Where λ_k is the eigen value and β_k =[PC1 PC2 PC3….PCk]^T is its corresponding eigen vector. Here **I** represents unit matrix and PCk is the principal component for kth eigen value, λ_k.

Step 4.Calculate the principal component scores

PCA can provide a representative quality indicator which can replace correlated quality characteristics of the process output.The equation used for calculation of principal component scores from the normalized values is given by,

$$Y_i(k) = \sum_{j=1}^{n} X_i^*(j)\beta_{kj} \quad (7)$$

where i=0,1,2,…..m; k=1,2,3,…..,n; $Y_i(k)$ is the principal component score of the k th element in the i th series, X_i*(j) is the normalized value of the j th element in the i th sequence, and β_{kj} is the j th element of eigenvector β_k.

Step 5. Computing the Grey Relational Grade

Deviation sequence must be calculated for the absolute difference of the compared series and the referential series by using the following formula

$$\Delta_{0,i}(k) = \begin{cases} | X_0^*(k) - X_i^*(k) | \\ | Y_0(k) - Y_i(k) | \end{cases} \quad (8)$$

$X_i^*(k)$, $Y_i(k)$ represents comparability sequence of normalized, principal component values respectively and $\Delta_{0,i}(k)$ is deviation sequence of ideal and comparability sequences.

A grey relational Coefficient can be calculated with the deviation sequence. It expresses the relationship between the ideal and normalized experimental results by using below formula,

$$r_{0,i}(k) = \frac{\Delta_{min}(k) + \xi\, \Delta_{max}(k)}{\Delta_{0,i}(k) + \xi\, \Delta_{max}(k)} \quad (9)$$

Where, i=1,2,3……,m; k=1,2,3,…..,n; $r_{0,i}(k)$ is the relative difference of k th element between sequence X_i and the comparative sequence X_0 (also called grey relational coefficient). $\Delta_{max}(k)$, $\Delta_{min}(k)$ are the maximum and minimum values of deviation sequence $\Delta_{0,i}(k)$ respectively. ξ is the distinguishing coefficient ($\xi \in [0, 1]$). The purpose of the distinguishing coefficient is to expand or compress the range of the grey relational coefficient and usually, it is set equal to 0.5.

Finally the Grey Relational Degree (GRG) can be calculated by using the below equation,

$$\Gamma = \sum_{k=1}^{n} w_k\, r_{0,i}(k) \quad (10)$$

Where, $r_{0,i}(k)$ is the Grey relational coefficient and w_k is weighting factor for kth Response and $\sum w_k$=1.Here equal weights are given for all factors that is W_k=1/6.

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

Step 8.Optimization using Taguchi method

The overall grey relational grade is then optimized (maximized) using Taguchi method. Taguchi's HB (Higher-the-Better) criterion has been used to maximize the overall grey relational grade and is given by

$$\mathbf{S/N = -10log_{10}\ (\ \frac{1}{n}\sum_{i=1}^{n}\frac{1}{Y_i^2}\ )} \qquad (11)$$

Here **n** is the number of measurements and Y_i is the measured i^{th} quality characteristic value. The analysis of variance (ANOVA)) is used to detect significant factors in a multi-factor model. Then at the optimum level of the process parameters , the estimated or predicted grey relational grade($\boldsymbol{\Gamma_\mu}$)can be calculated as,

$$\boldsymbol{\Gamma_\mu = \Gamma_m + \sum_{i=1}^{q}(\bar{\Gamma}_j - \Gamma_m)} \qquad (12)$$

Where $\boldsymbol{\Gamma_m}$ is the total mean of the grey relational grade, $\boldsymbol{\bar{\Gamma}_j}$ is the mean of the grey relational grade at the optimum level and **q** is the number of machining parameters that significantly affects the multiple performance characteristics. confirmation experiment is conducted at the optimal level of process parameters to verify predicted grey relational grade value with actual grey relational grade value.

VI. EXPERIMENTAL RESULTS

Data normalization or pre-processing is first performed for collected experimental data which has been listed in Table-4 in order to normalize the raw data for the analysis**.** For Bead Width and Bead Height, LB (lower-the-better) criterion and for remaining like Bead Penetration, Dilution Percentage, Hardness at weld area, Heat Affected Zone Hardness, HB (higher-the- better) criterion have been selected (Equation-1& Equation-2 respectively).

Table 4. Collected Experimental data

S.NO	BW (mm)	BH (mm)	BP (mm)	D_P (%)	H_WA (HV)	H_HAZ (HV)
1	5.741	2.606	2.696	36.176	268	305
2	4.890	2.750	1.009	20.992	301	378
3	5.893	2.187	0.726	17.553	401	482
4	6.488	1.654	1.651	41.389	291	354
5	6.373	2.755	2.731	40.065	265	317
6	5.706	2.661	2.461	35.382	370	401
7	7.140	1.882	2.058	38.994	257	294
8	4.689	1.987	3.791	75.020	261	297
9	5.967	3.197	2.668	31.081	277	321
10	6.078	2.134	2.965	46.033	307	374
11	7.014	3.281	2.000	36.564	374	417
12	6.660	3.712	2.896	44.545	234	278
13	6.561	2.828	2.596	34.230	276	321
14	5.712	2.639	3.859	65.825	246	308
15	7.001	3.702	2.786	53.066	284	343
16	8.173	3.912	2.079	46.736	261	302

After normalization the data have been checked for correlation. Principal component analysis has been applied to eliminate correlation among the responses.Table-5 and Table-6 have been represents results of principal component analysis of correlation matrix.

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

Table 5. Eigen analysis of the Correlation Matrix

Eigen value	2.4478	2.2077	0.6908	0.5248	0.1059	0.0229
Proportion	0.408	0.368	0.115	0.087	0.018	0.004
Cumulative	0.408	0.776	0.891	0.979	0.996	1.000

Table 6.Eigen vector of principal components

Variable	PC1	PC2	PC3	PC4	PC5	PC6
BW	0.292	0.429	-0.219	-0.817	-0.110	-0.056
BH	0.328	0.343	-0.720	0.464	0.200	-0.003
BP	-0.238	0.571	0.364	0.016	0.684	0.130
DP	-0.135	0.609	0.240	0.305	-0.671	-0.102
H_WA	0.598	-0.026	0.384	0.123	0.151	-0.675
H_HAZ	0.612	-0.007	0.310	0.094	-0.085	0.717

After calculating the eigen values and eigen vectors, Correlated responses have been converted to six independent quality indices called principal components by using equation-7.Then quality loss estimates ($\Delta_{0,i}$) for all principal components have been computed using equation-8. After calculating the quality loss estimates ($\Delta_{0,i}$), Individual grey relational coefficients have been calculated using equation-9.Then Overall grey relational grade has been calculated using equation 10. While calculating overall grey relational grade it has been assumed that all responses are equally important. Therefore 1/6 weightage has been assigned to prioritize six responses. Table-7 shows grey relational coefficients and overall grey relational grade for all experimental runs with its S/N ratio which was calculated using Taguchi's Higher-the-Better (HB) criterion .

Table 7.Grey relational coefficient values

S.NO	$r_{0,i}$ (1)	$r_{0,i}$ (2)	$r_{0,i}$ (3)	$r_{0,i}$ (4)	$r_{0,i}$ (5)	$r_{0,i}$ (6)	GRG	S/N(GRG)
1	0.6133	0.4927	0.5646	0.4790	0.5250	0.6624	0.5562	-5.0956
2	1.0000	0.3894	0.4193	0.3495	0.3971	0.8570	0.5687	-4.9021
3	0.9874	0.3671	0.4622	0.5551	0.5321	0.6492	0.5922	-4.5508
4	0.8894	0.4812	0.3344	0.9522	0.4932	0.6024	0.6255	-4.0759
5	0.5884	0.4889	0.6723	0.5586	0.6601	0.7674	0.6226	-4.1158
6	0.9663	0.4729	0.8872	0.5179	0.5910	0.3472	0.6304	-4.0073
7	0.6438	0.4714	0.3684	1.0000	0.9486	0.4810	0.6522	-3.7122
8	0.5838	1.0000	0.6167	0.6081	0.5393	0.3946	0.6238	-4.0998
9	0.6111	0.4558	0.7350	0.4383	0.4585	0.9548	0.6089	-4.3090
10	0.7512	0.5585	0.6421	0.7432	0.5434	0.5764	0.6358	-3.9337
11	0.9103	0.4190	0.7794	0.6296	0.6213	0.3934	0.6255	-4.0755
12	0.4853	0.4875	0.9378	0.5040	0.9627	0.8727	0.7083	-2.9953
13	0.6100	0.4584	0.6672	0.5451	0.5210	1.0000	0.6336	-3.9635
14	0.5120	0.7418	0.9270	0.6271	1.0000	0.5154	0.7206	-2.8466
15	0.5642	0.5014	0.6960	0.6309	0.4668	0.8980	0.6262	-4.0657
16	0.5230	0.4292	1.0000	0.6751	0.3350	0.4934	0.5760	-4.7921

Finally Optimal parameter setting has been determined by applying taguchi methodology.Table-8 and Table-9 represents mean values of overall grey relational grade and its S/N values respectively. It indicates the order of factors (ranking) representing the extent of significance on the overall grey relational grade. The below Figure- 1 & Figure- 2 represents the corresponding graphs of Table-8 & Table-9 respectively

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

Table 8.Mean values of Grey Relational Grade

Level	Current	Voltage	WS	EE
1	0.5856	0.6053	0.5970	**0.6593**
2	0.6323	**0.6389**	0.6315	0.6129
3	**0.6446**	0.6240	0.6364	0.6066
4	0.6391	0.6334	**0.6368**	0.6228
Delta	0.0590	0.0335	0.0398	0.0527
Rank	1	4	3	2

Table 9.Mean values of S/N (GRG)

Level	Current	Voltage	WS	EE
1	-4.656	-4.371	-4.493	**-3.662**
2	-3.984	**-3.922**	-4.020	-4.260
3	**-3.828**	-4.101	-3.952	-4.348
4	-3.917	-3.991	**-3.921**	-4.114
Delta	0.828	0.449	0.571	0.686
Rank	1	4	3	2

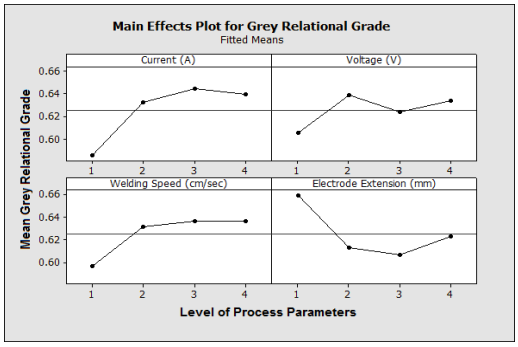

Figure 1.Mean values of GRG

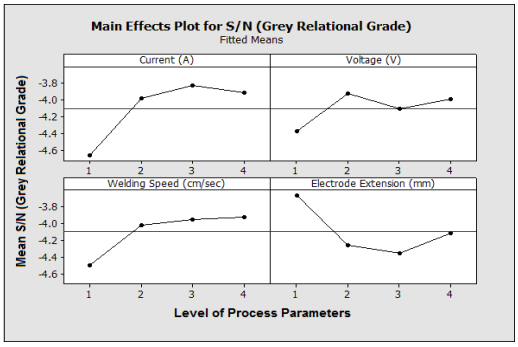

Figure 2.Mean values of S/N (GRG)

From above Figure-1&2, the predicted optimal setting becomes current at 120 A(C3),voltage at 18V (V2), welding speed at 35 cm/sec(WS4) of, electrode Extension at 10 mm(EE1).

After evaluating the optimal parameter settings, the next step is to predict and verify the obtained results from optimization procedure, as a final step using the optimal parametric combination. ANOVA for grey relational grade is presented as in Table-10 and it reveals that all process parameters have the significant effect .

Table 10.ANOVA table for Grey Relational Grade

Source	Degrees of Freedom	Sum of Squares	Mean of Squares	F-value	Percentage Contribution
C	3	0.0087	0.0029	**1.38**	**30.47**
V	3	0.0026	0.0009	0.41	9.06
WS	3	0.0044	0.0015	0.69	15.22
EE	3	0.0067	0.0022	1.06	23.23
Error	3	0.0063	0.0021	-	22.02
Total	15	0.0287	-	-	100

Finally predicted and actual Grey relation grade values are calculated. At the optimal settings, Estimated or predicted mean of Grey relational grade (Γ_μ) is calculated as 0.7034 Using the equation-12 and actual Grey relation grade as 0.6903 using conformational run results. Thus, Table-11 reflects the satisfactory result of confirmatory experiment by showing the good agreement between actual and predicted values.

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

Table 11.Conformation test results

Item	Optimal welding parameters	
	Predicted	Actual
Setting level	C3-V2-WS4-EE1	C3-V2-WS4-EE1
GRG	0.7034	0.6903

VII. CONCLUSIONS

- Metal Inert Gas (MIG) welding is performed on AISI1010 Mild steel plates of 2 mm thickness.
- Microscopic study is performed for measuring Bead width, Bead height, Bead Penetration, Percentage dilution.
- Vickers hardness test is performed for measuring Hardness at Weld Area, Parent metal, Heat affected Zones. The test results reveals that Weld Area Hardness is much higher than parent metal hardness and less than Heat affected zone Hardness.
- The correlation between multi responses is checked and eliminated by applying PCA (Principal Component Analysis)**.**
- Optimal process parameters are obtained from PCA(Principal component Analysis) based GRA(Grey Relational Analysis) as current at **120 A**(C3),voltage at **18V** (V2), welding speed at **35 cm/sec**(WS4) of, electrode Extension at **10 mm**(EE1) for getting better results.
- The ANOVA for Grey relational grade revealed that **current** is the most significant parameter that affects multiple performance quality characteristics.
- Best combinations of parameters are confirmed by conducting the conformation test as there is a good agreement between the predicted and actual grey relational grade.

VIII. ACKNOWLEDGEMENTS

The authors are grateful to Faurecia Emissions Control Technologies India Pvt. Ltd., Bangalore for providing the facilities to conduct the MIG welding and provide base material. The authors submit their thanks to the Department of Mechanical and Production Engineering, S.V.University College of Engineering, Tirupati (India) for having provided all necessary support for this research.

REFERENCES

1. C. N. Patel and Chaudhary, S., "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, (2013), Vol. 1, No. 3,pp-158-164.
2. Jing-Shiang Shih, Yih-Fong Tzeng,,Jin-Bin Yang, 2011, " Principal component analysis for multiple quality characteristics optimization of metal inert gas welding aluminum foam plate", Materials & Design, Volume 32, Issue 3, March 2011, Pages 1253-1261.
3. Pawan Kumar, "Parametric Optimization of Gas Metal Arc Welding of Austenitic Stainless Steel (AISI 304) & Low Carbon Steel using Taguchi's technique", International Journal of Engineering Research and Management research, Vol. 3, Issue 4, Aug 2013, pp.1822.
4. D.S. Nagesh, G.L. Datta, "Prediction of weld bead geometry and penetration in shielded metal-arc welding using artificial neural networks", Journal of Materials Processing Technology, January 2002, 123 (2002) 303–312.
5. Omar Bataineh, Anas Al-Shoubaki, Omar Barqawi, "Optimising Process Conditions in MIG Welding of Aluminum Alloys Through Factorial Design Experiments" Latest Trends in Environmental and Manufacturing Engineering, ISBN: 978-1-61804-135-7 .
6. Amit Kumar, Dr. R. S. Jadoun and Ankur Singh Bist, "Optimization of MIG welding parameters using Artificial Neural Network (ANN) and Genetic Algorithm (GA)", International journal of engineering sciences & research technology, July (2014), 3(7), pp.- 614-620.
7. Dinesh Mohan Arya, Vedansh Chaturvedi and Jyoti Vimal, Parametric Optimization of MIG Process Parameters Using Taguchi and Grey Taguchi Analysis, International Journal of Engineering Research and Applications, Vol. 3, Issue 4, Jul-Aug 2013, pp.1904-1910.
8. Ajit Hooda, Ashwani Dhingra and Satpal Sharma, "Optimization of MIG welding process parameter to predict maximum yield strength in AISI 1040", International journal of Mechanical engineering and Robotics research, October (2012), Vol 1, No. 3, pp.-203-213.
9. Ganjigatti J.P., Pratihar D.K. Roychoudhury A. 2007 Global versus cluster-wise regression analysis for prediction of bead geometry in MIG welding process. Journal of materials processing technology, vol 189, pp 352-366.
10. M. Aghakhani, E. Mehrdad, and E. Hayati, "Parametric optimization of gas metal arc welding process by Taguchi method on weld dilution", International Journal of Modeling and Optimization, August (2011), Vol. 1, No. 3, pp.- 216220.
11. Srivani Valluru,K..Aruna,P.Hema "Investigation of Process Parameters during MIGWelding of AISI1010 Mild Steel Plates", International Research Journal of Engineering and Technology(IRJET),Volume4,Issue4,April-2017.