Analysis of Welding Overlap in Front Fork under Bracket using Taguchi's Orthogonal Array and Grey Relational Approach

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Abstract— The MIG welding is one of the most popular welding techniques used in industries. This uses a consumable metal electrode. The input parameters in MIG welding play a significant role in deciding the weld quality, strength, cost and speed. Most of times manufacturer faces a problem to select optimum process parameters for a good quality weld. The main objective of this study is to find out optimal parameters such as under bracket chamfer, steering shaft chamfer and weld run to find out the variation in three performance characteristic such as forging height, penetration and pull out load. Based on experiments are conducted on L-9 orthogonal array, analysis has been carried on by using Grey Relational Analysis, a Taguchi method. Response tables & graphs were used to find optimal level of parameters in welding process. The obtained results show that the Taguchi Grey Relational Analysis is being effective technique to optimize the parameters for welding Process.

Key words: MIG Welding, GRA, Taguchi Method, Orthogonal Array

I. Introduction

This report presents a detailed study as to how we can minimized rejection in Front fork under bracket without hampering Quality while performing operations on the under bracket. The main function of front fork is to absorbing shocks and vibrations, especially on a vehicle. On two wheeled vehicles shock absorbers are separated into the categories of the "front fork "and "rear cushion". Front fork serves as rigidity component like a frame. Vehicle specific rigidity given to present run out while braking and changing the direction of a wheel through handle operations. Maintain balance of a vehicle frames stability and secures straight running stability as well as rationality of the vehicle. The front fork prevents excessive weight on the front wheel during drastic sudden applications the break, softens bumping when driving on rough road surfaces. A motorcycle front fork connects a motorcycle front wheel and axle to its frame by using under bracket or triple clamp. It is typically incorporates the front suspension and front brake and allow to rotate about the steering shaft so that the bike steered. Handlebars attach to the top of the under bracket. This under bracket assembly consists of under bracket forging part and steering shaft.

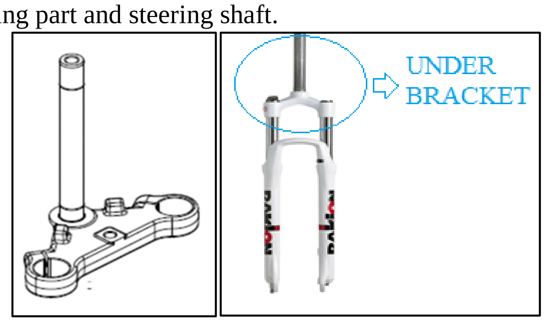


Fig. 1: Front Fork Suspension

In the front fork under bracket Manufacturing, Two parts are assemble one is bracket forging & second is steering shaft. This two parts are assemble by using welding, in the present work MIG process has been used. The metal inert gas welding process consists of heating, melting and solidification of parent metal and a filler material in localized fusion zone by a transient heat source to form a joint.

The electrode in this process is in the form of wire and continuously fed towards the work during the process. At the same time inert gas (e.g. argon, helium) is passed around electrode from the same torch.

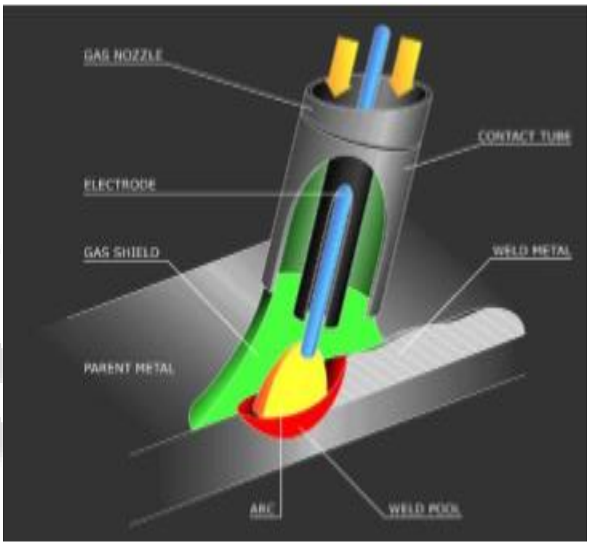


Fig. 2: MIG welding Process

II. Literature Review

Sanidh Sanchala, Harsh Bhandari, Kishan Patel, Jigar Vaghela investigated the study on a semi-automated MIG welding process, now technology the demand of precision is increasing. The tradition methods are replaced by the automation to increase accuracy and precision. To increase the quality of welding, incorporation of the semi-automated welding machine is done for certain application. For that different parameters and methods have to be considered from different research paper for the welding machine for selection of mechanism like controller, welding process, weld angle etc. to get accuracy and quality weld. [1]

Rajendra singh, Dr. SS Dhami present theier work on analyze the effect of for welding of A312TP316L steel using processes of Metal Inert Gas Welding (MIG).The Taguchi method has become a powerful tool for improving productivity during research and development, so that high quality products can be produced quickly and at Taguchi Technique is applied to plan the low cost. Dr. Taguchi's Signal-to-Noise ratios (S/N), which are log functions of desired output, the process parameter of MIG welding i.e.

Arc voltage, arc current, welding speed, nozzle to work distance and gas pressure. Design of experiments based on orthogonal array is employed to develop the weldments. The data obtained is checked in ANOVA. Due to this work it reduce the material cost for manufacturing process, Optimization method will reduce the defects of steel pipes [2]

Amit Pal1, Sachin Handuja work on The analysis of MIG welding parameters for multi response optimization using Taguchi's Orthogonal array and Grey relational approachIn this research, the input parameter are welding voltage, filler wire rate and v-angle. These all parameters have different effect on welding quality. In order to optimize these parameters for better weld quality Taguchi Orthogonal array and Grey relational analysis has been used. The medium carbon steel slabs have been used as welding material. The Taguchi orthogonal array and ANOVA is also employed to predict the results [3]

Dinesh Mohan Arya, Vedansh Chaturvedi, Jyoti Vimal presented their work on Parametric Optimization of Mig Process Parameters Using Taguchi and Grey Taguchi Analysis considering welding parameters like wire diameter, welding current, arc voltage, welding speed, and gas flow rate optimization based on bead geometry of welding joint. The objective function have been chosen in relation to parameters of MIG welding bead geometry Tensile strength, Bead width, Bead height, Penetration and Heat affected zone (HAZ) for quality target. Optimal parameters contribution of the MIG operation was obtained via grey relational analysis.[4]

Biswajit Das, B. Debbarma, R. N. Rai, S. C. Saha This paper presents an investigation The effect of various welding process parameters on the weldability of Mild Steel specimens of grade EN-3A welding speed , current and voltage are consider as input parameter which influence in determining the depth of penetration of a butt welded joint. Welding speed, Voltage, Current are the three welding parameters which influence in determining the depth of penetration of a butt welded joint and thus these three parameters are considered as design factor in the present study. Taguchi's L25 orthogonal design have been implemented here with five levels to carry out the experiments as it allows only 25 numbers of experiments which reflects the whole process quite satisfactorily while being economic and as well as time saving [5]

M. Prasanth Kumar, K. Naresh Kumar, K. S. Narayana present work on Effect of Bevel Angle and Wire Feed Rate in MIG Welding Metal Inert Gas is a welding process that is widely used for welding a variety of ferrous and non-ferrous materials The accuracy and quality of welded joints largely depends upon type of power supply (DCEP), welding speed, type of inert gas used for shielding.Finaly conclude that, As the bevel angle increases, the Ultimate Tensile Strength of the weld also increases. The Largest tensile value at bevel angle 45° with 429.4219N/mm2 tensile value for the wire feed rate 60mm/s and the lowest tensile value at bevel angle 15° with 353.897N/mm2 tensile value for the wire feed rate 50mm/min were observed, Among the bevel angles 15°, 30°and 45°, the largest Tensile Strength is obtained at 45̊. [6]

In the present work, it is planned to analyse the different input parameters in MIG welding to minimize rejection of front fork under bracket and improve productivity using Taguchi's orthogonal array and Grey relational analysis.

III. TAGUCHI'S METHOD

The Taguchi method has become an influential tool for improving output during research and development, so that better quality products can be produced quickly and at minimum cost. Dr. Taguchi of Nippon Telephones and Telegraph Company, Japan has established a method based on "ORTHOGONAL ARRAY" experiments which gives much reduced "variance" for the experiment with "optimum settings" of control variables. Thus the marriage of Design of Experiments with optimization of control parameters to find best results is attained in the Taguchi Method. "Orthogonal Arrays" (OA) gives a set of well balanced (minimum) experiments and Dr. Taguchi's Signal-to-Noise ratios (S/N), which are log functions of desired output, serve as objective functions in optimization, help in data analysis and estimation of optimum results. The S/N ration in Taguchi's method is calculated by giving formulas:

- Smaller the better $\eta = -10 \log [(\sum Yi2)/ n]$ (1)
- Larger the better $\eta = -10 \log [(\sum 1/Yi2)/ n]$ (2)

Where, η = Signal to Noise ratio,
Yi= ith observed value of response
n = no. Of observations in a trial
y = average of observed response

Smaller the better approach is followed for the response parameter which we wants to be minimum and larger the better approach is followed for parameter which we wants maximum.

IV. GREY RELATIONAL ANALYSIS

The Grey Relational Analysis (GRA) associated with the Taguchi method represents a rather new approach to optimization. A system for which the relevant information is completely known is a white system, while a system for which the relevant information is completely unknown is black system. Any system between these limits is a grey system having poor and limited information Data Pre–Processing.

Data Pre-Processing is normally required, since the range and unit in one data sequence may differ from others. It is also necessary when the sequence scatter range is too large, or when the directions of the target in the sequences are different. The formulae are

Larger the better value

$$Xij = (Yij - Mini\ Yij) / (Maxi\ Yij - Mini\ Yij) \quad (3)$$

Smaller the better value

$$Xij = (Maxi\ Yij - Yij) / (Maxi\ Yij - Mini\ Yij) \quad (4)$$

Where Yij is the ith performance characteristic in the jth experiment. Maxi Yij and Mini Yij are the maximum and minimum values of ith performance characteristic for alternate j, respectively.

By normalizing, grey relational co-efficient (GRC) is calculated as

$$\zeta IJ = (Mini\ Minj\ |Xjo - Xij| + \zeta\ Maxi\ |Xjo - Xij|) / \ |(Xjo - Xij| + \zeta\ Maxi\ |Xjo - Xij|) \quad (5)$$

Xjo is the ideal normalized result for the jth performance characteristic. The ideal normalized value is the maximum of normalized S/N ratio since large normalized S/N ratio is preferred. Z is the identification co-efficient. Generally it is taken as 0.5. The grey relational grade (GRG) can be calculated a:

$$\gamma_i = 1/n \sum_{j=1}^{n} \zeta_{IJ} \quad (6)$$

V. EXPERIMENTAL PLAN AND DETAILS

The experiments were conducted at Sangkaj Steel Ltd., On front fork under bracket .Experiments were carried out using the For Under Bracket weld overlap issue, we are consider Welding SPM tools & Equipment as a root cause, In Special purpose machine different parameters are consider i.e. welding equipment use in SPM. Following are different welding equipment are use in welding machine.

- DC output power source
- Wire feed unit
- Torch
- Work return welding lead
- shielding gas supply, (normally from cylinder)

Front fork under bracket material are ES-S35C(S 35 C high carbon steel)

Fig. 3: Welding setup used

A. *Welding Input Parameters Selection*

To perform the experiments, the levels of welding parameters are selected as in Table1.

Level	Under bracket chamfer(mm)	Steering shaft chamfer(mm)	Weld run (°)
	A	B	C
1	2	3	320
2	3	4	340
3	4	5	360

Table 1: Welding parameters and their levels

B. *Taguchi Orthogonal Array Selection*

For performing the experiments Taguchi L9 orthogonal array was selected for 3-factor and 3-levels process parameters. Which reduces the number of experiments and is gives as in Table2.

Run No.	L-9 Array (Half factorial)			Input Parameters		
	A	B	C	Under Bracket Chamfer (mm)	Steeering Shaft Chamfer (mm)	Weld Run
1	1	1	1	3	3	300
2	1	2	2	3	4	320
3	1	3	3	3	4	360
4	2	1	2	4	3	320
5	2	2	3	4	4	360
6	2	3	1	4	5	300
7	3	1	3	3	3	360
8	3	2	1	5	4	300
9	3	3	2	5	5	320

Table 2: Design Matrix of L-9 Orthogonal Array

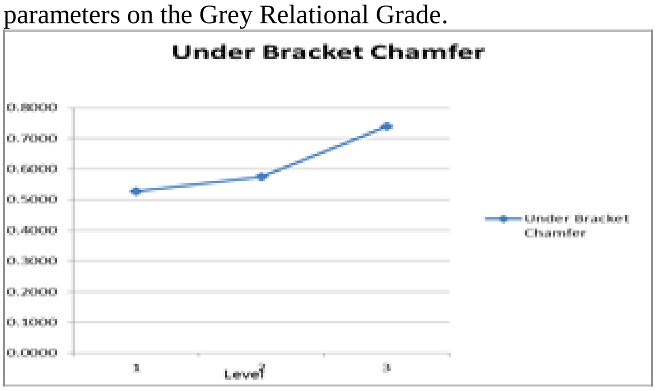
Table 3 the overall performance characteristic of the multiple response process depends on the calculated grey relational grade

Run No.	Input Parameters			GREY RELATIONAL COEFFICIENT				GREY RELATIONAL GRADE	Rank
	Under Bracket Chamfer (mm)	Steeering Shaft Chamfer (mm)	Weld Run	Forging Height (HB)	Penitration (%) (HB) Bracket	Penitration (%) (HB) Shaft	Pull out (Kgf) (HB)		
1	2	3	320	0.3	0.3	0.3	0.3	0.34	7
2	2	4	320	0.3	0.7	0.5	0.4	0.46	9
3	2	5	360	0.8	1.0	0.3	1.0	0.79	2
4	3	3	340	0.8	0.7	0.5	0.3	0.57	5
5	3	4	360	0.9	0.3	1.0	0.3	0.65	8
6	3	5	340	0.4	0.3	1.0	0.3	0.51	6
7	4	3	360	0.8	1.0	0.3	0.9	0.77	3
8	4	4	320	0.4	1.0	1.0	1.0	0.83	1
9	4	5	340	1.0	0.7	0.5	0.3	0.62	4

Table 3: Grey Relational Co-efficient and Grade

Above Table shows higher grey relational grade is observed with input parameters combination 8 that is A3B2C1 which is 0.83 it means by using this combination, required output parameters like Forging height, penetration and pull out is achieved. The larger the grey relational grade, the better is the multiple performance characteristics. However, the relative importance among the blanking parameters for the multiple performance characteristics still needs to be known, so that the optimal combinations of parameter levels can be determined more accurately. With the help of Table 4.10, the optimal parameter combination was determined as A3 (under bracket chamfer, 4 mm), B2 (steering shaft chamfer 4 mm) and C1 (weld run 320o)..

Below graph shows the individual Effects of input parameters on the Grey Relational Grade.



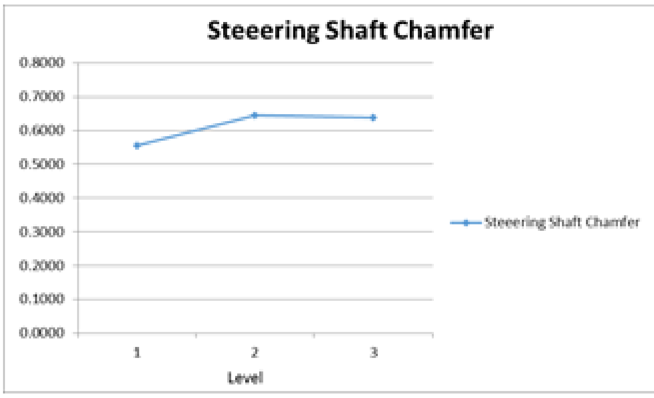


Fig. 4: Grey relational grades for each level of parameters

VI. Result and Discussion

The Confirmation for the optimal process parameters with its level has conduct to evaluate quality characteristics for Blanking of medium carbon steel sheet. Table 8 shows highest grey relational grade, indicating the initial process parameters set of A3B2C1 for the best multiple performance characteristics among the nine experiments. Table 11 shows the comparison of the experimental results for the conditions A3B2C1 with predicted result for optimal A3B2C1 Blanking process parameters.

Predicted Response=Average of A3 + Average of B2 + Average of C1 – 2 x Mean of response

The response value obtained from the experiment are forging height = 30.92mm, Penetration = above 25 %(under bracket 57.22% and steering shaft 54.13%), and pull out = 8440 Kgf. The comparison is shows the good agreement between the predicted and experimental values

VII. Conclusion

In present work, experimental investigation has been reported analysis of welding overlap in Front fork under bracket. Gray Relational Analysis has been utilized to investigate the influence of three important input parameters – on four performance characteristics-under bracket chamfer, steering shaft chamfer and weld run. The analysis of experimental work is performed using MINITAB 16 statistical software. The important conclusions that can be drawn from the present research work are summarized as follows:-

According to this work observation it conclude that, to minimize welding overlap in front fork under bracket it had necessary to maintain the under bracket chamfer 4x30^o, steering shaft chamfer 4x30^o and weld run 320^o.Weid angle run are 320^o the gap occurs at end point of welding this gap saves material and reduce cycle time of welding without hammering output of under bracket . According to above study it concludes that minimize rejection of under bracket and reduce the cost and increases productivity.

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