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# Parametric Optimization of MIG Welding Using Taguchi Method

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## ABSTRACT:

Welding is widely used in manufacturing process and production personnel to quickly and effectively set up manufacturing processes for new products. This study shows an investigation into the use of Taguchi's Parameter Design methodology for Parametric Study of Gas Metal Arc Welding of Mild Steel. In this research work, bead on plate welds were carried out on Mild Steel plates using gas metal arc welding (GMAW) process. Taguchi method is used to formulate the experimental design. Design of experiments using orthogonal array is employed to develop the elements. The input process variables considered here include welding voltage & gas pressure.

A total no of 9 experimental runs were conducted using an L9 orthogonal array, and the ideal combination of controllable factor levels was determined for the hardness to calculate the signal-to-noise ratio. After collecting the data signal-to-noise (S/N) ratios were calculated and used in order to obtain optimum levels for every input parameter. Subsequently, using analysis of variance (ANOVA) and Column Effect Method the significant importance for each input parameter on bead geometry were determined and validated.

## INTRODUCTION:

### Introduction to Welding:

A weld is made when separate pieces of material to be joined combine and form one piece when heated to a temperature high enough to cause softening or melting. Filler material is typically added to strengthen the joint. Welding is a dependable, efficient and economic method for permanently joining similar metals.

In other words, you can weld steel to steel or aluminum to aluminum, but you cannot weld steel to aluminum using traditional welding processes. Welding is used extensively in all sectors or manufacturing, from earth moving equipment to the aerospace industry.

### Welding Processes:

The number of a different welding processes has grown in recent years. These processes differ greatly in the manner in which heat and pressure (when used) are applied, and in the type of equipment used. There are currently over 50 different types of welding processes; we'll focus on 3 examples of electric arc welding, which is the most common form of welding. The most popular processes are shielded metal arc welding (SMAW), gas metal arc welding (GMAW) and gas tungsten arc welding (GTAW).All of these methods employ an electric power supply to create an arc which melts the base metal(s) to form a molten pool. The filler wire is then either added automatically (GMAW) or manually (SMAW & GTAW) and the molten pool is allowed to cool. Finally, all of these methods use some type of flux or gas to create an inert environment in which the molten pool can solidify without oxidizing.

## REVIEW OF LITERATURE:

The purpose of this literature review is to provide background information on the issues to be considered in this thesis and to emphasize the relevance of the present study. MIG WELDING was first used in the USA in the mid 1940s. The GMAW process was developed and made commercially available in 1948, although the basic concept was actually introduced in the 1920's.

In its early commercial applications, the process was used to weld aluminium with an inert shielding gas, giving rise to the term “MIG” (metal inert gas) which is still commonly used when referring to the process. MIG WELDING was used for many purposes in modern age. Scientists have been doing researches in order to find optimum conditions for the parameters that effecting bead strength[4]. By founding the optimum conditions, we can fulfill all the below three tasks.

1. Reduction in Cost

2. Reduction in Time

3. Increasing Bead characteristics

Taguchi methodology[1] is the best way to get optimum conditions of any method. It is the simple method of mathematics. Analysis is done in three ways Column Effects Method, S/N analysis and ANOVA[2].

### MIG Welding:

This process also known as Shielded Inert Gas Metal Arc (SIGMA) welding, Metal Inert Gas (MIG) welding or Gas Metal Arc Welding (GMAW) uses a shielded arc struck between a bare metal electrode and the workpiece. The metal electrode is provided in the form of a wire reel.

### History:

It was first used in the USA in the mid 1940s. The GMAW process was developed and made commercially available in 1948, although the basic concept was actually introduced in the 1920’s. In its early commercial applications, the process was used to weld aluminium with an inert shielding gas, giving rise to the term “MIG” (metal inert gas) which is still commonly used when referring to the process.

### Metal can be transferred in three ways:

1. Spray

2. Globular

3. Short circuiting

## TAGUCHI METHODOLOGY

### Introduction

After World War II, the Japanese manufacturers were struggling to survive with very limited resources. If it were not for the advancements of Taguchi the country might not have stayed afloat let alone flourish as it has. Taguchi revolutionized the manufacturing process in Japan through cost savings. He understood, like many other engineers, that all manufacturing processes are affected by outside influences, noise. However, Taguchi realized methods of identifying those noise sources, which have the greatest effects on product variability. His ideas have been adopted by successful manufacturers around the globe because of their results in creating superior production processes at much lower costs.

### State-of-Art

There is a broad consensus in academia and industry that reducing variation is an important area in quality improvement (Shoemaker et al. 1991, Thornton et al. 1999, Gremyr et al. 2003 and Taguchi et al. 2005) . "The enemy of mass production is variability. Success in reducing it will invariably simplify processes, reduce scrap, and lower costs” (Box and Bisgaard 1988) . Definition of quality loss as “the amount of functional variation of products plus all possible negative effects, such as environmental damages and operational costs” supports this view (Taguchi’s 1993). In the 1980s Genichi Taguchi (1985; 1986; 1993) received international attention for his ideas on variation reduction, starting with the translation of his work published in Taguchi and Wu (1979).

### Process Optimization

It refers to the procedure or procedures used to make a system or design as effective or functional as possible, especially the mathematical techniques involved. Also optimization is putting together a portfolio in such a way that return is maximized for a given risk level, or risk is minimized for a given expected return level. Process optimization is the discipline of adjusting a process to optimize some specified set of parameters without violating some constraint. The most common goals are minimizing cost, maximizing throughout, and/or efficiency. This is one of the major quantitative tools in industrial decision-making.

## Process Optimization Tools

Many relate process optimization directly to use of statistical techniques to identify the optimum solution. This is not true. Statistical techniques are definitely needed. However, a thorough understanding of the process is required prior to committing time to optimize it. Over the years, many methodologies have been developed for process optimization including Taguchi method, six sigma, lean manufacturing and others.

## Taguchi's Method

Taguchi's techniques have been used widely in engineering design (Ross1996 & Phadke1989). The Taguchi method contains system design, parameter design, and tolerance design procedures to achieve a robust process and result for the best product quality (Taguchi1987& 1993). The main trust of Taguchi's techniques is the use of parameter design (Ealey Lance A.1994), which is an engineering method for product or process design that focuses on determining the parameter (factor) settings producing the best levels of a quality characteristic (performance measure) with minimum variation. Taguchi designs provide a powerful and efficient method for designing processes that operate consistently and optimally over a variety of conditions. To determine the best design, it requires the use of a strategically designed experiment, which exposes the process to various levels of design parameters.

Taguchi specified three situations:

1. Larger the better (for example, agricultural yield);
2. Smaller the better (for example, carbon dioxide emissions); and
3. On-target, minimum-variation (for example, a mating part in an assembly)

## Contributions of Taguchi methods

Taguchi has made a very influential contribution to industrial statistics. Key elements of his quality philosophy include the following
Taguchi loss function (Ross 1996), used to measure financial loss to society resulting from poor quality

## Taguchi's rule for manufacturing

Taguchi realized that the best opportunity to eliminate variation is during the design of a product and its manufacturing process. Consequently, he developed a strategy for quality engineering that can be used in both contexts. The process has three stages:

- System design
- Parameter design
- Tolerance design

## Mathematical Modeling

"ORTHOGONAL ARRAYS "(OAs) experiments Using OAs significantly reduces the number of experimental configurations to be studied (Montgomery1991). The effect of many different parameters on the performance characteristic in a process can be examined by using the orthogonal array experimental design proposed by Taguchi. Once the parameters affecting a process that can be controlled have been determined, the levels at which these parameters should be varied must be determined.

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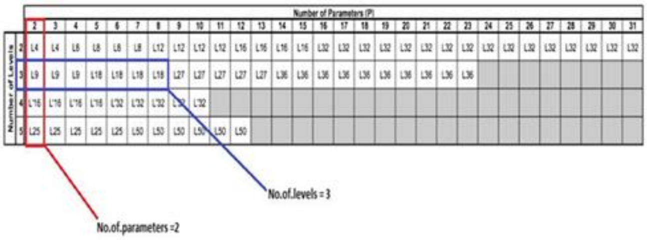


Fig1: Array selector

## Taguchi's design of experiments

DOE's Planning

- Design and Communicate the Objective
- Define the Process
- Select a Response and Measurement System
- Select Factors to be Studied
- Select the Experimental Design
- Set Factor Levels
- Final Design Considerations

## Eight-Steps in Taguchi methodology

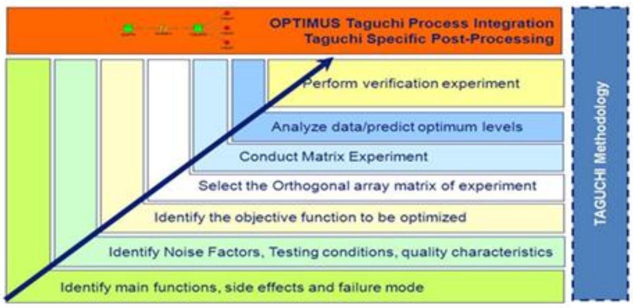


Fig 2: Taguchi methodology

The optimization process in taguchi method is achieved through stepwise procedure as shown the above Fig 2.

## Analyzing and Examining Result

(i) Analyzing through Colunn Effects Method

(ii) Signal to Noise Ratio Analysis

(iii) Analysis of Variance (ANOVA)

## MATERIALS AND METHODS

### The step by step methodology is as follows

### Step-1: Identify the objective function to be optimized

The quality of MIG welding bead in a green is influenced by its properties such as bead geometry namely penetration, reinforcement and width which in turn depend on input parameters. The relations of these properties with the input parameters like voltage and shielding gas pressure. Therefore the main objective of this project is to improve the properties of the bead like

1. To increase bead penetration
2. To decrease bead reinforcement
3. To decrease bead width

### Step-2: Identify the control factors and their levels

The control factors considered in this project are welding voltage and shielding gas pressure. By surveying a number of journals and research works the following levels of the below factors are considered:

Table 1 Parameters and their levels

| PARAMETERS | LEVEL 1 | LEVEL 2 | LEVEL 3 |
|---|---|---|---|
| Welding Voltage | 22 | 24 | 26 |
| Gas Pressure | 12 | 14 | 16 |

The above Table 1 refers the welding parameters which have the major effect on the output of the process, and their available ranges of levels are

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mentioned.

### Step-3: Select the orthogonal array

The effect of many different parameters on the performance characteristic in a condensed set of experiments can be examined by using the orthogonal array experimental design proposed by Taguchi. Once the parameters affecting a process that can be controlled have been determined, the levels at which these parameters should be varied must be determined. Determining what levels of a variable to test requires an in-depth understanding of the process, including the minimum, maximum, and current value of the parameter. If the difference between the minimum and maximum value of a parameter is large, the values being tested can be further apart or more values can be tested. If the range of a parameter is small, then few values can be tested or the values tested can be closer together. Knowing the number of parameters and the number of levels, the proper orthogonal array can be selected. The orthogonal array chosen to solve this problem is **L-9**. The L9 array is shown in Table 2.

**Table 2 Experimental layout using L9 array**

| EXPERIMENT | FACTOR A | FACTOR B | FACTOR C | FACTOR D |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 2 | 2 | 2 |
| 3 | 1 | 3 | 3 | 3 |
| 4 | 2 | 1 | 2 | 3 |
| 5 | 2 | 2 | 3 | 1 |
| 6 | 2 | 3 | 1 | 2 |
| 7 | 3 | 1 | 3 | 2 |

Since in this case we are dealing with only 2 factors, the column pertaining to factor C has been excluded and the array reduces to the following (Table 3)

**Table 3 Actual Experimental layout using L9 array**

| EXPERIMENT | FACTOR | A FACTOR B |
|---|---|---|
| 1 | 1 | 1 |
| 2 | 1 | 2 |
| 3 | 1 | 3 |
| 4 | 2 | 1 |
| 5 | 2 | 2 |
| 6 | 2 | 3 |
| 7 | 3 | 1 |
| 8 | 3 | 2 |
| 9 | 3 | 3 |

The metal plates used for this project are of Mild Steel of 100*60*6 in mm (Fig 3).

**Fig 3: MS plate**

These metal plates are undergone through the following procedure.

### Step 4: Operations carried

- **Cleaning**: These metal plates are thoroughly cleaned using metal wire brush forremoving rust and mud formed on it, this cleaning process should be carried out on both sides.
- **Filing:** Cleaned metal plates are filed with hand filewhich makes the surface uniformand more effective towards welding and forms a good bead of weld.
- **Welding:** After filing metal plates, beads are made on them using followingparametric conditions of

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the welding (refer Fig.4) which are formed from the orthogonal array of Taguchi technique.

**Table 4 Actual experimental layout using L9 array**

| EXPERIMENT | WELDING VOLTAGE (volts) | GAS PRESSURE (kg/sq.cm) |
|---|---|---|
| 1 | 22 | 0.84 |
| 2 | 22 | 0.98 |
| 3 | 22 | 1.12 |
| 4 | 24 | 0.84 |
| 5 | 24 | 0.98 |
| 6 | 24 | 1.12 |
| 7 | 26 | 0.84 |
| 8 | 26 | 0.98 |
| 9 | 26 | 1.12 |

**Fig 4: MS plate with welded bead**

- **Chipping:** Welded plates are chipped for removing slag. Chipping is process ofremoving excessive slag formed during the process of welding due to molten metal flow.

- **Cutting:** After chipping, we cut each metal plate into 3 small pieces using metalcutting wheel vertically (Fig 5) in such a way that the bead gets divided.

**Fig 5: Welded MS plate after cutting**

- **Belt Grinding:** Then each piece is grinded for obtaining a good surface finish usingbelt grinding machine, in this process surface gets smoothened to most extent.

- **Polishing:** After grinding, pieces are polished using emery papers to make grainsuniform. After polishing, pieces are placed in Etchant (Nital sol) for observations.

After following the operations the bead geometry is now able to observe clearly so that one can easily measure the values of reinforcement, width, and penetration.

## OBSERVATIONS AND RESULTS

### Bead Geometry

The welding bead geometry is measured as shown in the following (Fig.6)

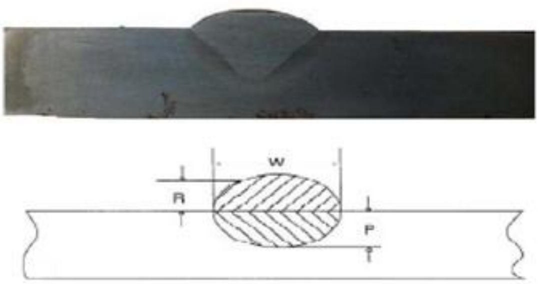


**Fig 6: Bead geometry**

Where P: height of penetration (mm); R: height of reinforcement (mm); W: width of the bead (mm)

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The measured values of penetration for different sets of voltage and gas pressure are noted as shown in table 5. The value of the penetration is expected to be large for a good weld.

### Table 5: Experimental results for penetration

| EXPERIMENT | VOLTAGE (volts) | GAS PRESSURE (kg/cm²) | READING 1 (mm) | READING 2 (mm) | READING 3 (mm) |
|---|---|---|---|---|---|
| 1 | 22 | 0.84 | 3 | 3.2 | 3.4 |
| 2 | 22 | 0.98 | 3.1 | 2.9 | 2.5 |
| 3 | 22 | 1.12 | 2.5 | 2 | 2.5 |
| 4 | 24 | 0.84 | 3.2 | 3.4 | 3.1 |
| 5 | 24 | 0.98 | 3.2 | 2.7 | 3 |
| 6 | 24 | 1.12 | 2.5 | 2.5 | 2 |
| 7 | 26 | 0.84 | 3.4 | 3.1 | 3.2 |
| 8 | 26 | 0.98 | 3.1 | 2.5 | 3 |
| 9 | 26 | 1.12 | 3.5 | 2.5 | 2.5 |

The table 6 refers the measured values of reinforcement for the various set of parameters. The reinforcement values are to be as small as possible for better result

### Table 6: Experimental results for reinforcement

| EXPERIMENT | VOLTAGE (volts) | GAS PRESSURE (kg/cm²) | READING 1 (mm) | READING 2 (mm) | READING 3 (mm) |
|---|---|---|---|---|---|
| 1 | 22 | 0.84 | 2 | 2.5 | 3 |
| 2 | 22 | 0.98 | 3.3 | 3 | 3.3 |
| 3 | 22 | 1.12 | 3.5 | 3 | 3 |
| 4 | 24 | 0.84 | 2.3 | 2.3 | 2.5 |
| 5 | 24 | 0.98 | 3.1 | 2.1 | 3.2 |
| 6 | 24 | 1.12 | 3.3 | 2.8 | 3.5 |
| 7 | 26 | 0.84 | 2 | 2.4 | 2.5 |
| 8 | 26 | 0.98 | 3 | 2 | 3 |
| 9 | 26 | 1.12 | 3.1 | 3 | 3 |

The measured values of weld width are tabulated in the following table 7.

### Table 7: Experimental result for bead width

| EXPERIMENT | VOLTAGE (volts) | GAS PRESSURE (kg/cm²) | READING 1 (mm) | READING 2 (mm) | READING 3 (mm) |
|---|---|---|---|---|---|
| 1 | 22 | 0.84 | 10 | 11 | 11 |
| 2 | 22 | 0.98 | 12 | 13 | 12 |
| 3 | 22 | 1.12 | 14 | 13 | 13 |
| 4 | 24 | 0.84 | 12 | 12 | 12 |
| 5 | 24 | 0.98 | 14 | 14 | 18 |
| 6 | 24 | 1.12 | 17 | 17 | 17 |
| 7 | 26 | 0.84 | 10 | 12 | 11.5 |
| 8 | 26 | 0.98 | 11 | 12 | 13 |
| 9 | 26 | 1.12 | 14 | 12 | 15 |

### Analysis

Analysis is the important part of Taguchi technique. This can be done in three methods for more precise result namely Column Effects Method, S/N analysis and ANOVA.

### Column Effects Method

Three pieces of information are generated from the Column Effect Analysis

1. Which factor makes a difference?
2. The relative importance of those factors.
3. Which direction for levels of those factors will lead to further improvement?

In this technique we can conclude that effect of a particular parameter from the calculated value of range. The parameter with the maximum range will have more effect on the results.

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### Table 8: Results for penetration

| penetration | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| s.no | v | gp | v*gp | | | | | |
| 1 | 1 | 1 | 1 | 3.2 | 3 | 3.2 | 3.4 | 3.2 |
| 2 | 1 | 2 | 2 | 2.833333 | 3.1 | 2.9 | 2.5 | 2.833333 |
| 3 | 1 | 3 | 3 | 2.333333 | 2.5 | 2 | 2.5 | 2.333333 |
| 4 | 2 | 1 | 2 | 3.233333 | 3.2 | 3.4 | 3.1 | 3.233333 |
| 5 | 2 | 2 | 3 | 2.966667 | 3.2 | 2.7 | 3 | 2.966667 |
| 6 | 2 | 3 | 1 | 2.333333 | 2.5 | 2.5 | 2 | 2.333333 |
| 7 | 3 | 1 | 3 | 3.233333 | 3.4 | 3.1 | 3.2 | 3.233333 |
| 8 | 3 | 2 | 1 | 2.866667 | 3.1 | 2.5 | 3 | 2.866667 |
| 9 | 3 | 3 | 2 | 2.833333 | 3.5 | 2.5 | 2.5 | 2.833333 |
| | | | | | | | | |
| S1 | 8.366667 | 9.666667 | 8.4 | | | | | |
| S2 | 8.533333 | 8.666667 | 8.9 | | | | | |
| S3 | 8.933333 | 7.5 | 8.533333 | | | | | |
| range | 0.566667 | 2.166667 | 0.5 | | | | | |

From the table 8 we can conclude from column effect method that Penetration is mostly influenced by gas pressure since the calculated range 2.166667 which is at gas pressure is greater than the calculated range 0.56667 at voltage.

### Table 9: Results for reinforcement

| reinforcment | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| s.no | v | gp | v*gp | | | | | |
| 1 | 1 | 1 | 1 | 2.5 | 2.5 | 2 | 3 | 2.5 |
| 2 | 1 | 2 | 2 | 3.2 | 3.3 | 3 | 3.3 | 3.2 |
| 3 | 1 | 3 | 3 | 3.166667 | 3.5 | 3 | 3 | 3.166667 |
| 4 | 2 | 1 | 2 | 2.366667 | 2.3 | 2.3 | 2.5 | 2.366667 |
| 5 | 2 | 2 | 3 | 2.8 | 3.1 | 2.1 | 3.2 | 2.8 |
| 6 | 2 | 3 | 1 | 3.2 | 3.3 | 2.8 | 3.5 | 3.2 |
| 7 | 3 | 1 | 3 | 2.3 | 2 | 2.4 | 2.5 | 2.3 |
| 8 | 3 | 2 | 1 | 2.666667 | 3 | 2 | 3 | 2.666667 |
| 9 | 3 | 3 | 2 | 3.033333 | 3.1 | 3 | 3 | 3.033333 |
| | | | | | | | | |
| S1 | 8.866667 | 7.166667 | 8.366667 | | | | | |
| S2 | 8.366667 | 8.666667 | 8.6 | | | | | |
| S3 | 8 | 9.4 | 8.266667 | | | | | |
| range | 0.866667 | 2.233333 | 0.333333 | | | | | |

From the table 9 we can conclude from column effect method that reinforcement is mostly influenced by gas pressure since the calculated range 2.23333 which is at gas pressure is greater than the calculated range 0.333333 at voltage.

### Table 10 Results for width

| width | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| s.no | v | gp | v*gp | | | | | |
| 1 | 1 | 1 | 1 | 10.66667 | 10 | 11 | 11 | 10.66667 |
| 2 | 1 | 2 | 2 | 12.33333 | 12 | 13 | 12 | 12.33333 |
| 3 | 1 | 3 | 3 | 13.33333 | 14 | 13 | 13 | 13.33333 |
| 4 | 2 | 1 | 2 | 12 | 12 | 12 | 12 | 12 |
| 5 | 2 | 2 | 3 | 8.5 | 9 | 9.5 | 7 | 8.5 |
| 6 | 2 | 3 | 1 | 15 | 17 | 17 | 11 | 15 |
| 7 | 3 | 1 | 3 | 11.5 | 11 | 12 | 11.5 | 11.5 |
| 8 | 3 | 2 | 1 | 12 | 11 | 12 | 13 | 12 |
| 9 | 3 | 3 | 2 | 13.66667 | 14 | 12 | 15 | 13.66667 |
| | | | | | | | | |
| S1 | 36.33333 | 34.16667 | 37.66667 | | | | | |
| S2 | 35.5 | 32.83333 | 38 | | | | | |
| S3 | 37.16667 | 42 | 33.33333 | | | | | |
| range | 1.666667 | 9.166667 | 4.666667 | | | | | |

From the table 10 we can conclude from column effect method that bead width is mostly influenced by gas pressure since the calculated range 9.166667 which is at gas pressure is greater than the calculated range 1.33333 at voltage.

### S/N Analysis

The ratio of known factors to unknown factors is called Signal to Noise Analysis. Dr.Taguchi's signal-to-noise ratios (S/N), which are log functions of desired output, serve as objective functions for optimization, help in data analysis and prediction of optimum results.To determine the effect each variable has on the output, the signal-to-noise ratio, or the SN number, needs to be calculated for each experiment conducted.

### Table 11: S/N results for penetration

| PENETRATION | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | V | GP | GP XV | PENETRATION | | | S/N RATIC |
| 1 | 1 | 1 | 1 | 3 | 3.2 | 3.4 | 10.06898 |
| 2 | 1 | 2 | 2 | 3.1 | 2.9 | 2.5 | 8.93962 |
| 3 | 1 | 3 | 3 | 2.5 | 2.5 | 2 | 7.212463 |
| 4 | 2 | 1 | 3 | 2.5 | 3.2 | 3.4 | 9.40359 |
| 5 | 2 | 2 | 1 | 3.1 | 3.2 | 2.7 | 9.470641 |
| 6 | 2 | 3 | 2 | 3 | 2.5 | 2.5 | 8.42532 |
| 7 | 3 | 1 | 2 | 3.4 | 3.1 | 3.2 | 10.17398 |
| 8 | 3 | 2 | 3 | 3.1 | 2.5 | 3 | 9.028938 |
| 9 | 3 | 3 | 1 | 3.5 | 2.5 | 2.5 | 8.732922 |
| | | | | | | | |
| | | | | | | | |
| S1 | 26.22106 | 29.64655 | 28.27254 | | | | |
| S2 | 27.29955 | 27.4392 | 27.53892 | | | | |
| S3 | 27.93584 | 24.37071 | 25.64499 | | | | |
| RANGE | 1.714772 | 5.27584 | 2.627552 | | | | |

In the table 11 S/N ratio is calculated using the formula for maximizing of penetration

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

From the results obtained from table 11 a graph is plotted for S/N ratio values for penetration against different levels (refer Fig 6).

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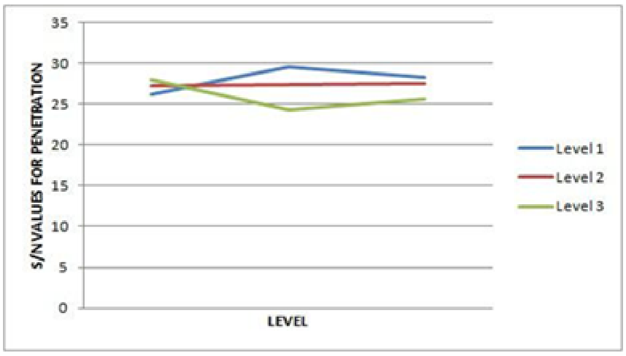


**Fig 7: Graph between levels and S/N values for penetration**

From the graph we can conclude that optimum condition for voltage is at level 3 which is 26 volts and gas pressure at level 1 having value 0.84 kg/cm$^2$ represented in the table 12.From table 11 we can infer that Range is maximum at gas pressure so gas pressure influence penetration mostly.

### Table 12: Optimum condition

| PARAMETER | LEVEL | VALUE |
|---|---|---|
| Welding Voltage | 3 | 26 volts |
| Gas Pressure | 1 | 0.84 kg/cm$^2$ |

### Table 13: S/N Results for reinforcement

| REINFORCEMENT | | | | | | | |
|---|---|---|---|---|---|---|---|
| | V | GP | GP XV | REINFORCEMENT | | | S/N RATIC |
| 1 | 1 | 1 | 1 | 2 | 2.5 | 3 | -8.07309 |
| 2 | 1 | 2 | 2 | 3.3 | 3 | 3.3 | -10.1115 |
| 3 | 1 | 3 | 3 | 3.5 | 3 | 3 | -10.036 |
| 4 | 2 | 1 | 3 | 2.3 | 2.3 | 2.5 | -7.48964 |
| 5 | 2 | 2 | 1 | 3.1 | 2.1 | 3.2 | -9.0777 |
| 6 | 2 | 3 | 2 | 3.3 | 2.8 | 3.5 | -10.1396 |
| 7 | 3 | 1 | 2 | 2 | 2.4 | 2.5 | -7.2727 |
| 8 | 3 | 2 | 3 | 3 | 2 | 3 | -8.65304 |
| 9 | 3 | 3 | 1 | 3.1 | 3 | 3 | -9.63945 |
| | | | | | | | |
| S1 | -28.2206 | -22.8354 | -26.7902 | | | | |
| S2 | -26.7069 | -27.8422 | -27.5238 | | | | |
| S3 | -25.5652 | -29.8151 | -26.1787 | | | | |
| RANGE | 2.655413 | 6.97966 | 1.345053 | | | | |

In the table 13 S/N ratio is calculated using the formula for minimizing of reinforcement

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

From the results obtained from table 13 a graph is plotted for S/N ratio values for reinforcement against different levels (refer Fig 7).

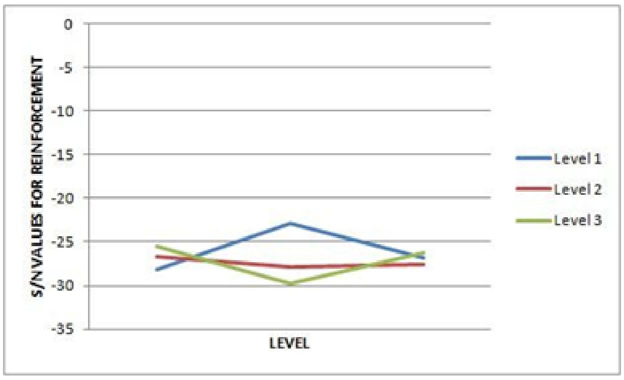


**Fig 8: Graph between levels and S/N values for reinforcement**

From the graph we can conclude that optimum condition for voltage is at level 3 which is 26 volts and gas pressure at level 1 having value 0.84 kg/cm$^2$ represented in the table 14.From table 13 we can infer that Range is maximum at gas pressure so gas pressure influence reinforcement mostly.

### Table 14: Optimum condition

| PARAMETER | LEVEL | VALUE |
|---|---|---|
| Welding Voltage | 3 | 26 volts |
| Gas Pressure | 1 | 0.84 kg/cm$^2$ |

### Table 15: S/N Results for width

| WIDTH | | | | | | | |
|---|---|---|---|---|---|---|---|
| | V | GP | GP XV | WIDTH | | | S/N RATIC |
| 1 | 1 | 1 | 1 | 10 | 11 | 11 | -20.569 |
| 2 | 1 | 2 | 2 | 12 | 13 | 12 | -21.8279 |
| 3 | 1 | 3 | 3 | 14 | 13 | 13 | -22.5042 |
| 4 | 2 | 1 | 3 | 12 | 12 | 12 | -21.5836 |
| 5 | 2 | 2 | 1 | 14 | 14 | 18 | -23.7779 |
| 6 | 2 | 3 | 2 | 17 | 17 | 11 | -24.609 |
| 7 | 3 | 1 | 2 | 10 | 12 | 11.5 | -20.9836 |
| 8 | 3 | 2 | 3 | 11 | 12 | 13 | -21.6037 |
| 9 | 3 | 3 | 1 | 14 | 12 | 15 | -22.7493 |
| | | | | | | | |
| S1 | -64.9012 | -63.1362 | -68.3551 | | | | |
| S2 | -69.9705 | -67.2096 | -67.4205 | | | | |
| S3 | -65.3365 | -69.8624 | -65.6915 | | | | |
| RANGE | 5.069324 | 6.726227 | 2.663629 | | | | |

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In the table 15 S/N ratio is calculated using the formula for minimizing of bead width

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

From the results obtained from table 15 a graph is plotted for S/N ratio values for width against different levels. From the graph we can conclude that optimum condition for voltage is at level 1 which is 22 volts and gas pressure at level 1 having value 0.84 kg/cm$^2$ represented in the table 16. From table 15 we can infer that Range is maximum at gas pressure so gas pressure influence width mostly.

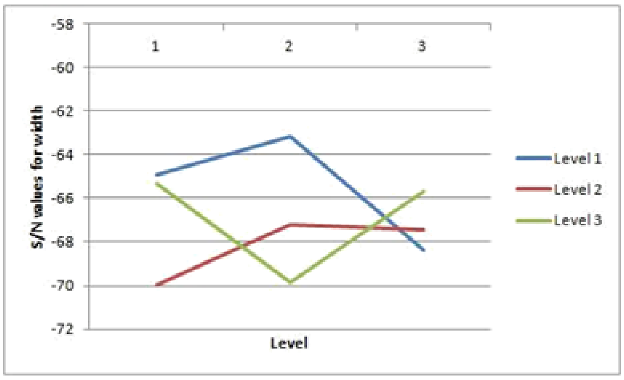


**Figure 9: Graph between levels and S/N values for width.**

### Table 16: Optimum condition

| PARAMETER | LEVEL | VALUE |
|---|---|---|
| Welding Voltage | 1 | 22 volts |
| Gas Pressure | 1 | 0.84 kg/cm$^2$ |

## ANOVA

An ANOVA table contains the sources of variation, the degrees of freedom, the sum of squares, the mean square, the F0 statistic, and sometimes the P-value. The following are the suggested steps to complete an ANOVA table.

1. Calculate the degrees of freedom for each factor and for the error.
2. Calculate the overall mean.
3. Calculate the means of each of the levels of each factor.
4. Calculate the sum of squares for each factor, of the error, and of the total experiment
5. Calculate mean square of the factors and of the error.
6. Calculate the F0 statistic for each factor.

### Table 17: ANOVA Results for penetration

| | SS | DOF | variance | F | p |
|---|---|---|---|---|---|
| v | 22.23148 | 2 | 11.11574 | 2.597641 | 20.48984 |
| gp | 0.23148 | 2 | 0.11574 | 0.027047 | 0.213346 |
| gp*v | 0.453704 | 2 | 0.226852 | 0.053013 | 0.41816 |
| SSR | 22.91667 | 6 | 3.819444 | | |
| SST | 108.5 | 26 | 4.173077 | | |
| SSE | 85.58333 | 20 | 4.279167 | 4.279167 | 78.87865 |

From F-Tables:

F(0.10,2,20)=4.4613 @ 97.5% confidence level.

But actual value F(0.10,2,20)=5.7048 which is greater than above value. Hence the following conclusion is made. From the ANOVA results it can be concluded that on Penetration, Gas Pressure has maximum contribution of 34.193% at 97.5% confidence level.

### Table 18: ANOVA Results for reinforcement

| | SS | DOF | variance | F | p |
|---|---|---|---|---|---|
| v | 0.07259 | 2 | 0.036295 | 0.202138 | 1.266923 |
| gp | 1.66259 | 2 | 0.831295 | 4.62973 | 29.01741 |
| gp*v | 0.403333 | 2 | 0.201667 | 1.123142 | 7.039431 |
| SSR | 2.138513 | 6 | 0.356419 | | |
| SST | 5.72963 | 26 | 0.22037 | | |
| SSE | 3.591116 | 20 | 0.179556 | 0.179556 | 62.67624 |

From F-Tables:

F(0.10,2,20)=4.4613 @ 97.5% confidence level.

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But actual value F(0.10,2,20)=4.629 which is greater than above value. Hence the following conclusion is made.
From the ANOVA results it can be concluded that on Reinforcement, Gas Pressure has maximum contribution of 29.019% at 97.5% confidence level.

**Table 19: ANOVA results for width**

| | SS | DOF | variance | F | p |
|---|---|---|---|---|---|
| V | 0.19593 | 2 | 0.097965 | 0.7143 | 4.28141 |
| GP | 1.56481 | 2 | 0.782405 | 5.704815 | 34.19381 |
| gp*v | 0.072593 | 2 | 0.036296 | 0.26465 | 1.586274 |
| SSR | 1.833333 | 6 | 0.305555 | | |
| SST | 4.576296 | 26 | 0.176011 | | |
| SSE | 2.742964 | 20 | 0.137148 | 0.137148 | 59.93851 |

From F-Tables:

F(0.10,2,20)=2.589 @ 90% confidence level.

But actual value F(0.10,2,20)=2.597 which is greater than above value. Hence the following conclusion is made. From the ANOVA results it can be concluded that on Bead Width, Gas Pressure has maximum contribution of 20.489% at 90% confidence level.

## CONCLUSIONS:

This study has discussed an application of the Taguchi method for investigating the effects of parameters on the characteristics of the MIG WELDING. From the analysis of the results using the conceptual signal-to-noise (S/N) ratio approach, analysis of variance (ANOVA), column effects method and Taguchi's optimization method, the following can be concluded from the present study.

- From 3 analysis it can be concluded that on Penetration, Gas Pressure has maximum contribution of 29.019% at 97.5% confidence level. Optimum condition for maximum Penetration is at 26 volts and 0.84 kg/cm$^2$ of gas pressure.
- From 3 analysis it can be concluded that on Reinforcement, Gas Pressure has maximum contribution of 29.019% at 97.5% confidence level. Optimum condition for maximum reinforcement is at 26 volts and 0.84 kg/cm$^2$ of gas pressure.
- From the ANOVA results it can be concluded that on Bead Width, Gas Pressure has maximum contribution of 20.489% at 90% confidence level. Optimum condition for maximum Bead Width is at 26 volts and 0.84 kg/cm$^2$ of gas pressure.

The analysis we have done gives us the optimum condition for the better output results of MIG welding i.e., penetration, reinforcement and width and these can be used for future projects to reduce the cost and welding time. By considering this analysis one can produce better MIG welding free from defects.

## REFERENCES:

[1]Taguchi techniques for quality engineering, Philip J. Ross, Mcgraw-hill book company, 1988.

[2] Anoop C A, Pawan Kumar, "Application of Taguchi Methods and ANOVA in GTAW Process Parameters Optimization for Aluminium Alloy 7039 ", International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 11, May 2013 M. Aagakhani.

[3] S. V. Sapakal, M. T. Telsang, "Parametric Optimization of MIG Welding using Taguchi Design Method", International Journal of Advanced Engineering Research and Studies, Vol. I/ Issue IV/July-Sept., 2012/28-30.

[4] K. Abbasi , S. Alam and Dr. M.I. Khan "An Experimental Study on the Effect of MIG Welding parameters on the Weld-Bead Shape Characteristics", IRACST – Engineering Science and Technology: An International Journal, Vol.2, No. 4, August 2012.

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