EXPERIMENTAL INVESTIGATION AND MULTI-OBJECTIVE OPTIMIZATION OF TIG WELDING PARAMETERS ON ALUMINUM ALLOY USING FIREFLY ALGORITHM.

GTU Team ID: 43555

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DEFINATION

Experimental investigation and multi-objective optimization of TIG welding parameters on Aluminum alloy using firefly algorithm.

Outline of Presentation

ABSTRACT

- To improve Welding quality of aluminum (Al) plate, TIG Welding system has been prepared, by which Welding current, Shielding gas flow rate and Current polarity can be controlled during Welding process. In the present work, an attempt has been made to study the effect of Welding current, current polarity, and shielding gas flow rate on the tensile strength of the weld joint. Based on the number of parameters and their levels, Response Surface Methodology technique has been selected as Design of Experiment. For understanding the influence of input parameters on Ultimate tensile strength of weldment, ANOVA analysis has been carried out. Also to describes and optimize TIG Welding using a new metaheuristic Nature - inspired algorithm which is called as Firefly algorithm which was developed by Dr. Xin-She Yang at Cambridge University in 2007. A general formulation of firefly algorithm is presented together with an analytical mathematical modeling to optimize the TIG Welding process by a single equivalent objective function.

PROJECT OBJECTIVE

- The main objective of our work is to get high quality weld joint in terms of **tensile strength** by optimizing the input parameters of TIG Welding.

- In this work, to perform welding on **6 mm thick Aluminum plate**, a TIG welding setup is prepared. Welding of Aluminum plate would be done by changing welding current, flow rate of shielding gas and current polarity to get high strength joint.

PROJECT OBJECTIVE

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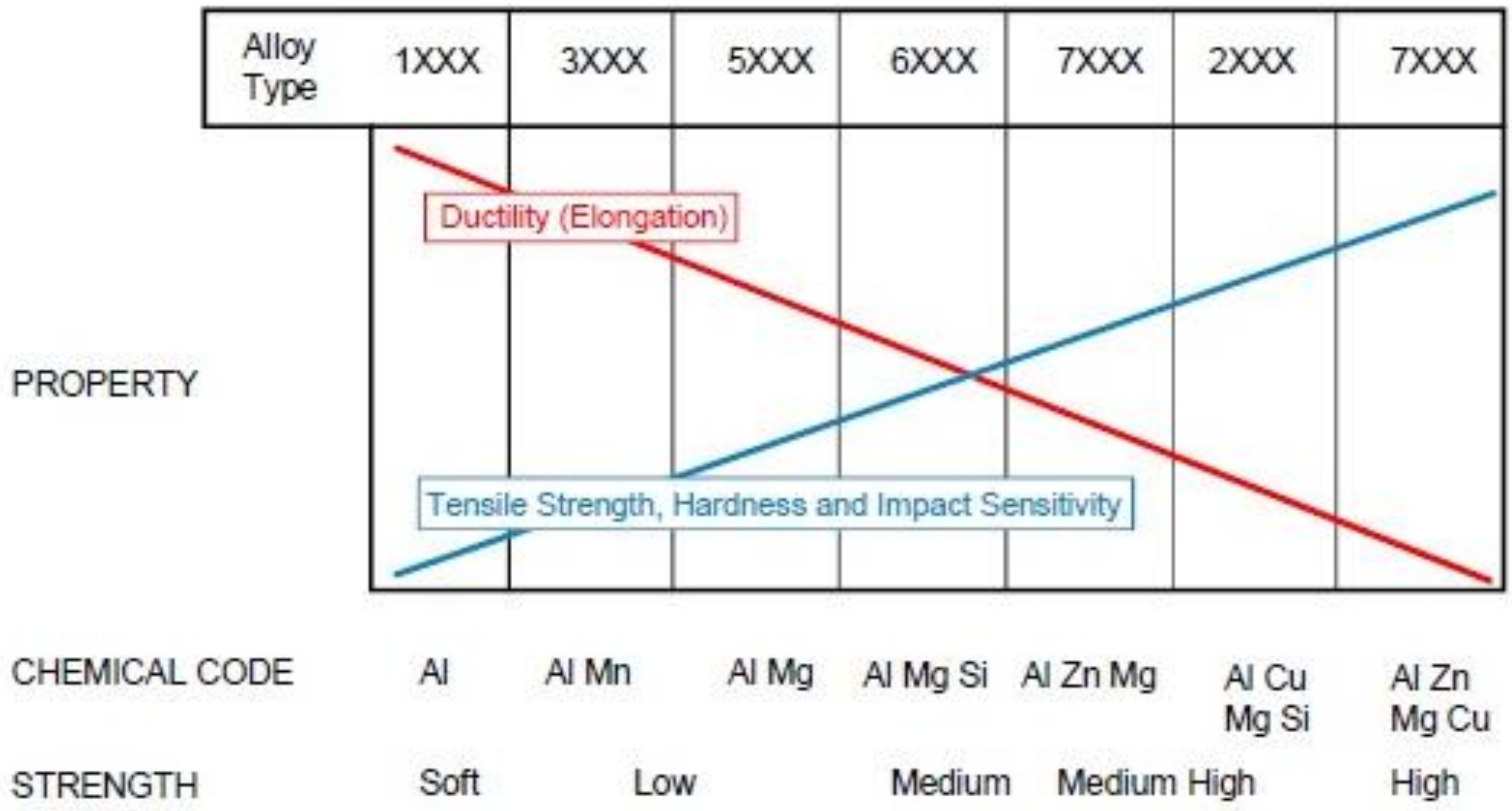
Introduction

Aluminum Alloy

- Aluminum is a very light weight metal (specific weight of 2.7 g/cm^3). Use of Aluminum in automobile and aerospace reduces dead-weight and energy consumption.
- Strength of Aluminum can be improved as per the required properties for various applications by modifying the composition of its alloys. Aluminum is a highly corrosion resistant material.
- Different types of surface treatment can further improve its corrosion resistance property.
- Aluminum is an excellent heat and electricity conductor and in relation to its weight is almost twice as good a conductor as copper. This has made Aluminum the most commonly used material in major power transmission lines.
- Aluminum is ductile and has a low melting point. In a molten condition it can be processed in a number of ways. Its ductility allows products of Aluminum to be basically formed close to the end of the product's design.

Characteristics of Aluminum Alloy Types



Composition of Aluminum Alloy 6061

Component	Amount (wt.%)
Aluminum	Balance
Magnesium	0.8-1.2
Silicon	0.4 – 0.8
Iron	Max. 0.7
Copper	0.15-0.40
Zinc	Max. 0.25
Titanium	Max. 0.15
Manganese	Max. 0.15
Chromium	0.04-0.35
Others	0.05

Key Properties

Typical properties of Aluminum alloy 6061 are as follow:

- Medium to highstrength
- Good toughness
- Good surface finish
- Excellent corrosion resistance
- Good corrosion resistance to sea water
- Can be anodized
- Good weldability and brazability
- Good workability
- Easily available

Application of Aluminum Alloy 6061

➢ Typical applications for Aluminum alloy 6061 include:

- Aircraft and Aerospace components
- Marine fittings
- Transport
- Bicycle frames
- Camera lenses
- Drive shafts
- Rail coaches
- Truck frames
- Rivets
- Ship building
  Bridges and Military bridges
- Aerospace applications including helicopter rotor
- skins
- Tube
- Pylons and Towers
- Boiler making
- Motorboats

DIFFERENT TYPE OF WELDING PROCESSES

❖ **Based on heat source used welding process can be categorized as follows:**

1. Arc welding
2. Gas welding
3. Resistance welding
4. High energy beam welding
5. Solid state welding

➢ **Arc welding:**

Among all these types of welding processes arc welding is widely used for different types of materials. Common types of arc welding process are:

1. SMAW/MMAW
2. GMAW/MIG/MAG
3. **GTAW/TIG**

WHY TIG WELDING IS USED FOR ALUMINUM?

- The TIG Welding process was specifically invented to weld Aluminum, magnesium, and its alloy. It is best suited for metal plate of thickness around 5- 6 mm. Thicker material plate can also be welded by TIG.

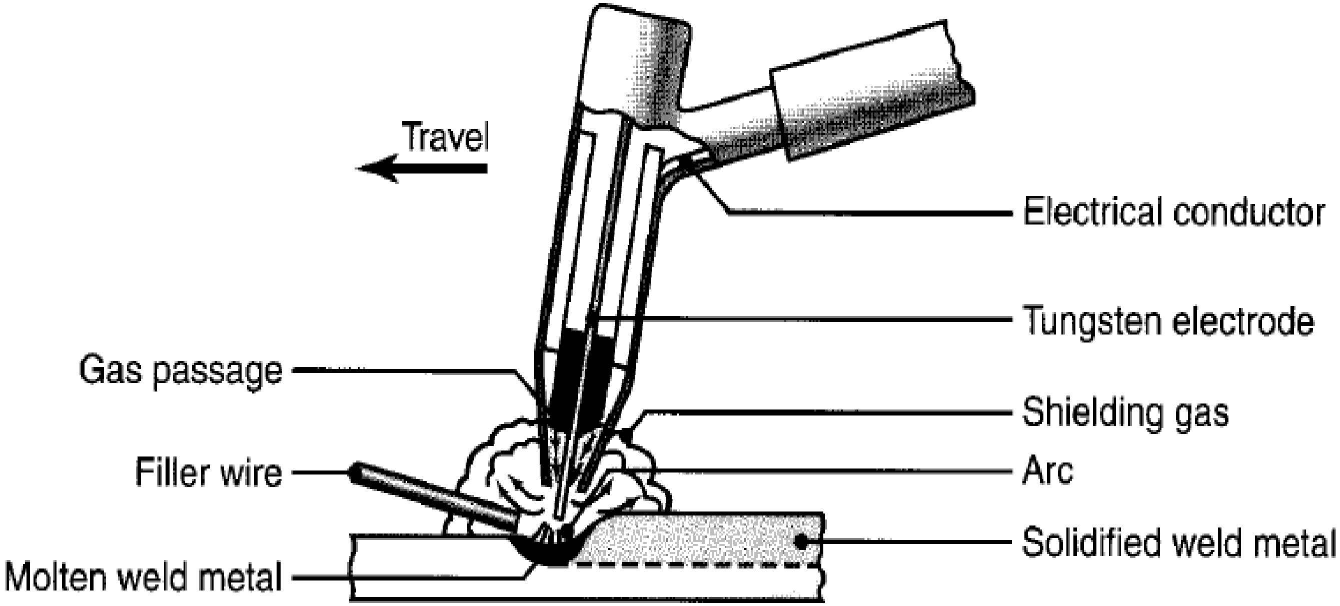
- Aluminum is reactive metal that quickly forms an oxide layer on the surface and strength of the weld area become wick.

- To Peel Off the oxide layer over the work-piece, Cathodic Cleaning Process is required, without this Aluminum is not possible to weld.

- High-tech industry applications such as:
  1. Nuclear Industry Aircraft.
  2. Maintenance and Repair Work.
  3. Precision Manufacturing Industry.
  4. Automobile Industry.

BASIC *MECHANISM OF TIG WELDING*

- In the TIG welding process, electrode is non consumable which is used to generate the arc between electrode and work piece.
- Weld or weld pool is protected from atmosphere by the flow of gases.
- A separate filler rod is provided to fill the gap.



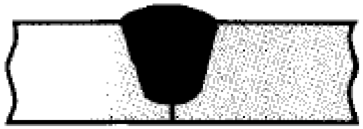
PROCESS PARAMETERS OF TIG WELDING

- ❖ The parameters that affect the quality and outcome of the TIG welding process are given below.

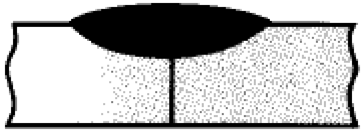
    1. Welding Current
    2. Welding Voltage
    3. Inert Gases
    4. Welding Speed
    5. Welding Geometry
    6. Flow Rate of Inert Gases
    7. Current Polarity

TYPES OF WELDING CURRENT USED IN TIG WELDING

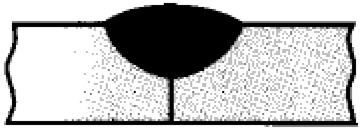
1. **DCSP (Direct Current Straight Polarity)**



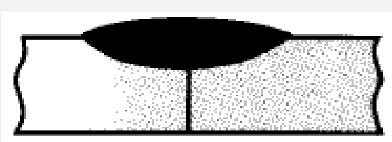
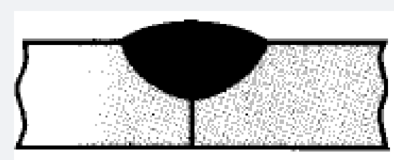
2. **DCRP (Direct Current Reverse Polarity)**



3. **AC (Alternating Current)**



CONCEPT OF POLARITY

DC		AC
DCRP	**DCSP**	
Electrode (+ve)	Electrode (-ve)	-
Workpiece(-ve)	Workpiece(+ve)	-
Heat generation →2/3Electrode →1/3 Workpiece	Heat generation →1/3Electrode →2/3 Workpiece	Heat generation →1/2Electrode →1/2 Workpiece
Penetration 	Penetration 	Penetration 

Design
of
Experiments

- It is important to obtain maximum realistic information with the minimum number of well designed experiments. So in order to get the minimum number of well designed experiment a technique called DOE is used.
    1. Full factorial design
    2. Taguchi method
    3. Response surface methodology
    4. Random design

- **Option1: FACTORIAL DESIGN**
  - Small no. of variables with few states (1 to 3)
  - Interaction between variables are strong and important.
  - Every variables contributes significantly.
- **Option 2 : TAGUCHI METHOD**
  - Intermediate no. of variables (3 to 5)
  - Few interaction between variables
  - Only a few variables contributes significantly
- **Option 3 : RANDOM DESIGN**
  - Many variables (50+)
  - Few interaction between variables.
  - Very few variables contribute significantly.

Option 4 : RESPONSE SURFACE METHODOLOGY

- Interaction between variables is very very strong.
- RSM perform better, depending on size and assumption.
- From the literature survey, we found that no work has been done on our input parameters using RSM.
- **Factorial design are easy to construct, but can be impractically large.**

How do we analyze the data?

1. **Plot the data** and look at it (visual inspection)

2. **ANOVA(Analysis of Variance)**

- 1-way : effect of welding current on tensile strength.
- 2-way : effect of welding current and current polarity on tensile strength.
- Test multiple combination

3. FISHER'S EXACT TEST
OR
CHI SQUARRD TEST

} To see if any effect is significant.

FIREFLY Algorithm

- **Nature inspired algorithm, are among the most powerful algorithm for optimization.**

    - METAHEURISTIC ALGORITHM:

        1. Particle swarm optimization (PSO)
        2. Genetic algorithm (GA)
        3. Firefly algorithm (FA)

- **Conclusion** from Xin- She- Yang literature:

    - Simulation results for finding the global optima of various test functions suggest that particle swarm often outperforms traditional algorithms such as genetic algorithms, while the new firefly algorithm is superior to both PSO and GA in terms of both efficiency and success rate.

    - **This implies that FA is potentially more powerful in solving hard problems.**

Literature Review

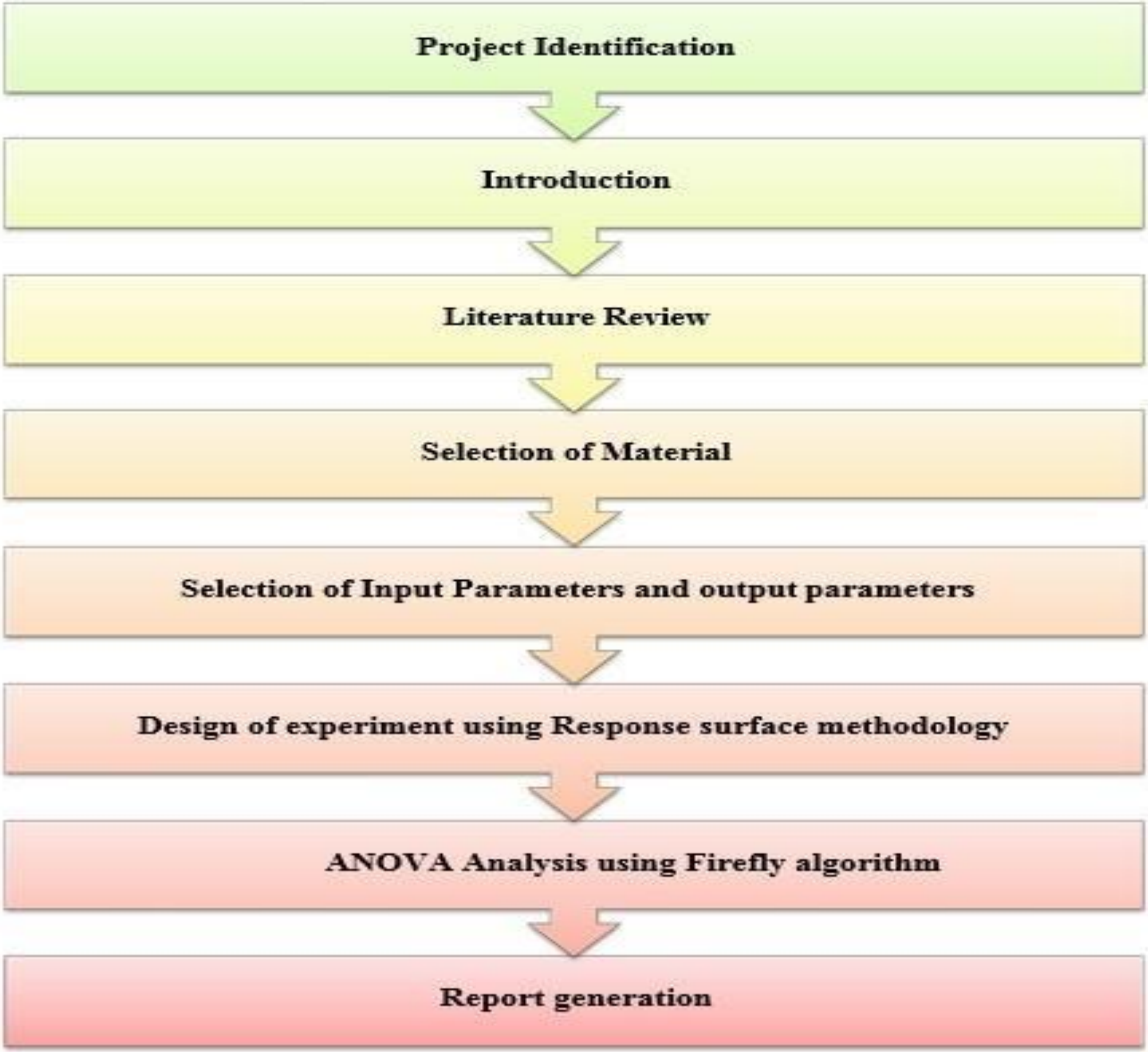
- **Sanjeev kumar et. al [1]** attempted to explore the possibility for welding of higher thickness plates by TIG welding. **Aluminum Plates (3-5mm thickness**) were welded by **Pulsed Tungsten Inert Gas Welding** process with **welding current** in the range **48-112 A** and **gas flow rate 7 -15 l/min**. **Shear strength** of **weld metal (73MPa)** was found **less than parent metal (85 MPa).** From the analysis of photomicrograph of welded specimen it has been found that, tensile fracture occur near to **fusion line** of weld deposit.
- **Indira Rani et. al [2]** investigated the **mechanical properties** of the **weldments** of AA6351 during the GTAW /TIG welding with **non-pulsed and pulsed** current at different frequencies. Welding was performed with **current 70-74 A**, arc **travel speed 700-760 mm/min**, and pulse **frequency 3 and 7 Hz**. From the experimental results it was concluded that the tensile strength and YS of the weldments is closer to base metal. Failure location of weldments occurred at **Heat Affected Zone** and from this we said that weldments have better weld joint strength.

- **Ahmed Khalid Hussain et. al [3]** investigated the effect of **welding speed** on **tensile strength** of the welded joint by TIG welding process of AA6351 Aluminum alloy of **4 mm thickness**. The strength of the welded joint was tested by a **universal tensile testing machine**. Welding was done on specimens of **single v butt joint** with **welding speed** of **1800 -7200 mm/min**. From the experimental results it was revealed that **strength of the weld zone** is **less than base metal** and **tensile strength increases** with **reduction of welding speed.**
- **Tseng et. al [4]** investigated the effect of activated TIG process on **weld morphology**, **angular distortion, delta ferrite content and hardness of 316 L stainless steel** by using **different flux like TiO_2, MnO_2, MoO_3, SiO_2 and Al_2O_3**. To **join 6 mm thick plate** author uses **welding current 200 Amp**, **welding speed 150 mm/min** and **gas flow rate 10 l/min**. From the experimental results it was found that the use of **SiO_2 flux** improve the **joint penetration**, but **Al_2O_3 flux deteriorate** the **weld depth.**

- **Narang et. al [5]** performed TIG welding of structural **steel plates** of **different thickness** with **welding current** in the range of **55 -95 A**, and **welding speed of 15-45 mm/sec**. To predict the weldment **macrostructure zones**, **weld bead reinforcement**, **penetration and shape profile** characteristics along with the shape of the **heat affected zone** (HAZ), **fuzzy logic based simulation** of TIG welding process has been done.
- **Karunakaran et. al [6]** performed TIG welding of **AISI 304L stainless steel** and **compare** the **weld bead profiles** for **constant current** and **pulsed current** setting. Effect of welding current on **tensile strength, hardness profiles, microstructure and residual stress distribution** of welding zone of steel samples were reported. **Lower magnitude of residual stress** was found in **pulsed current** compared to **constant current welding**. Tensile and hardness properties of the joints enhanced due to formation of **finer grains**.

- **Norman et. al [7]** investigated the microstructures of **autogenous TIG welded Al-Mg- Cu- Mn alloy** for a wide range of welding conditions. Welding was done with **current** in the range **100-190 A** and **welding speed 420-1500 mm/min.** The **fine microstructure** was observed at the **centre** of the **weld** which was form due to **higher cooling rate** at the **weld centre** compared to the **fusion boundary**. It was observed that as the **welding speed increases**, the **cooling rate** at the centre of the weld also **increases** and produces **fine grain structure**.
- **Song et. al [8]** successfully joined **dissimilar metals** of 5A06 **Al alloy** and AISI 321 **stainless steel** of **thickness 3 mm** by **TIG welding-brazing** with different filler materials. TIG welding– brazing was carried out by **AC-TIG** welding source with **welding current 135 A**, **arc length 3.0–4.0mm**, **welding speed 120 mm/min** and **argon gas flow rate 8–10 lit/min**. The author also investigated **(Song et. al 2009) spreading behaviour** of **filler metal** on the **groove surface** and microstructure characteristics for **F-butt joint**. For the experimentation **welding current** in the range of **90-170 A** and **welding speed** in the range of **100-220 mm/min**, were used for **2 mm thick plate**.

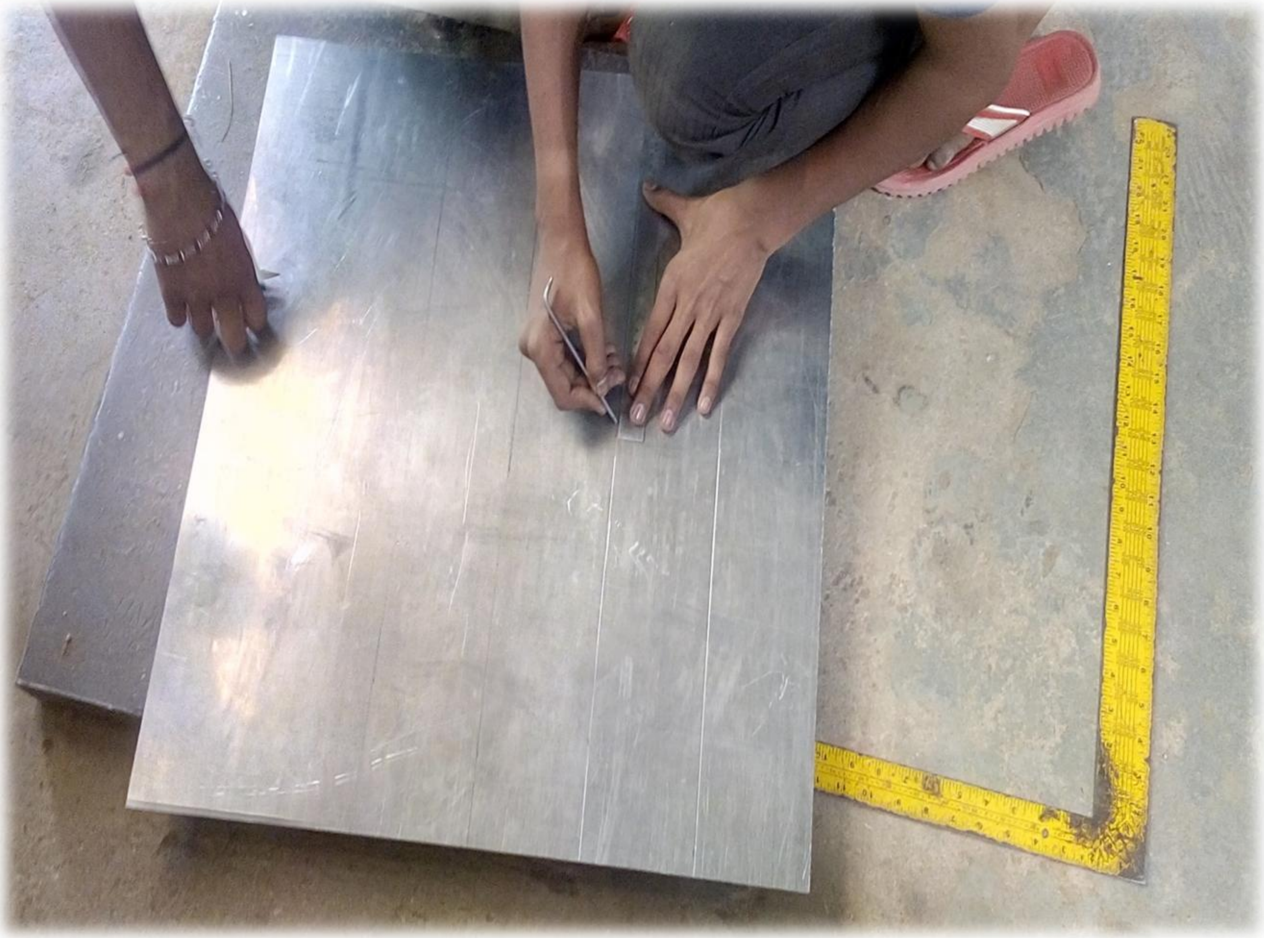
METHODOLOGY


Project Identification
Introduction
Literature Review
Selection of Material
Selection of Input Parameters and output parameters
Design of experiment using Response surface methodology
ANOVA Analysis using Firefly algorithm
Report generation

Experimentation

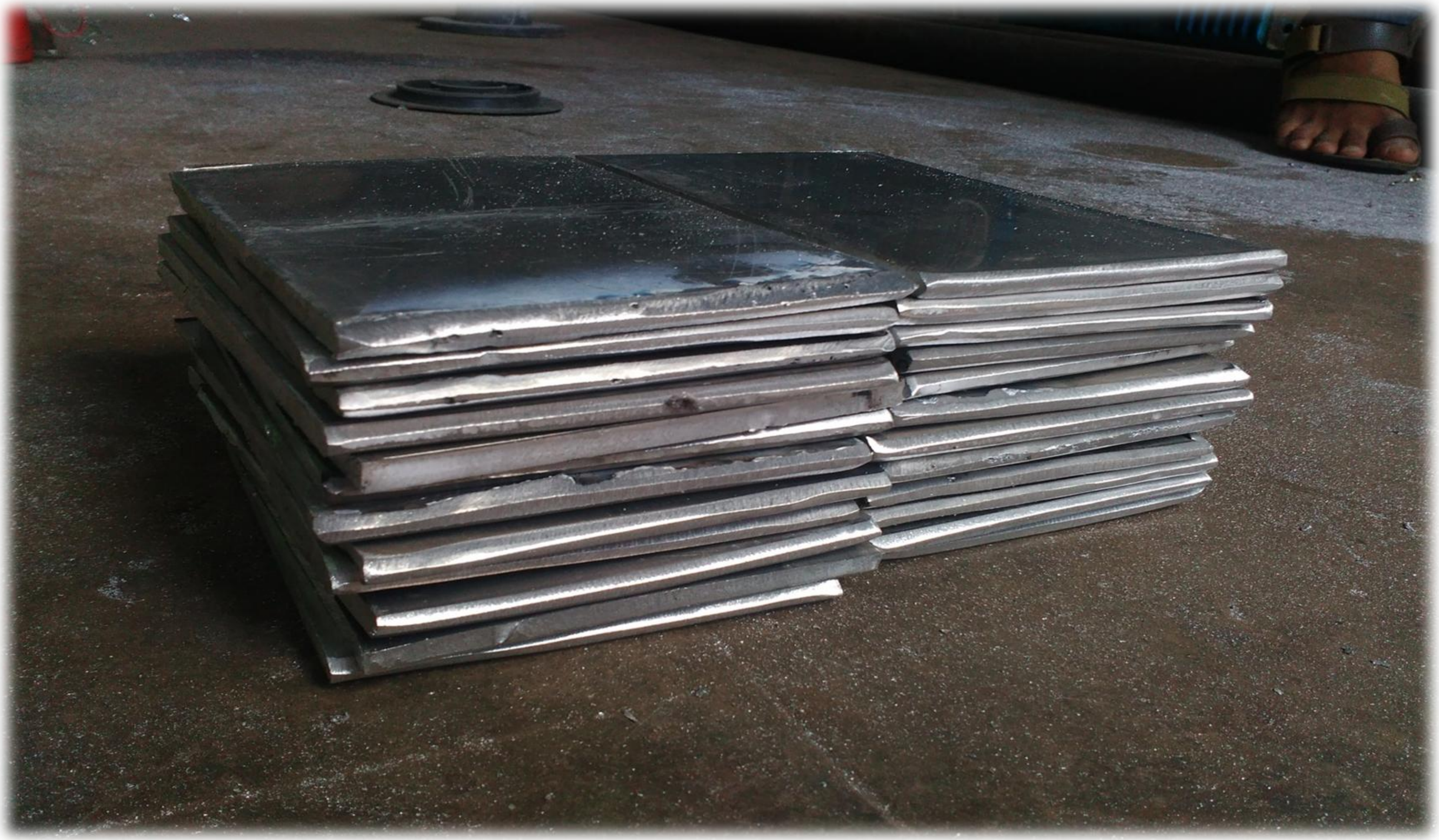
Step 1:- Ordering the plate (2 Feet X 2 Feet)

Step 2:- Marking And Cutting of Plate



Step 3:-Grooving Operation

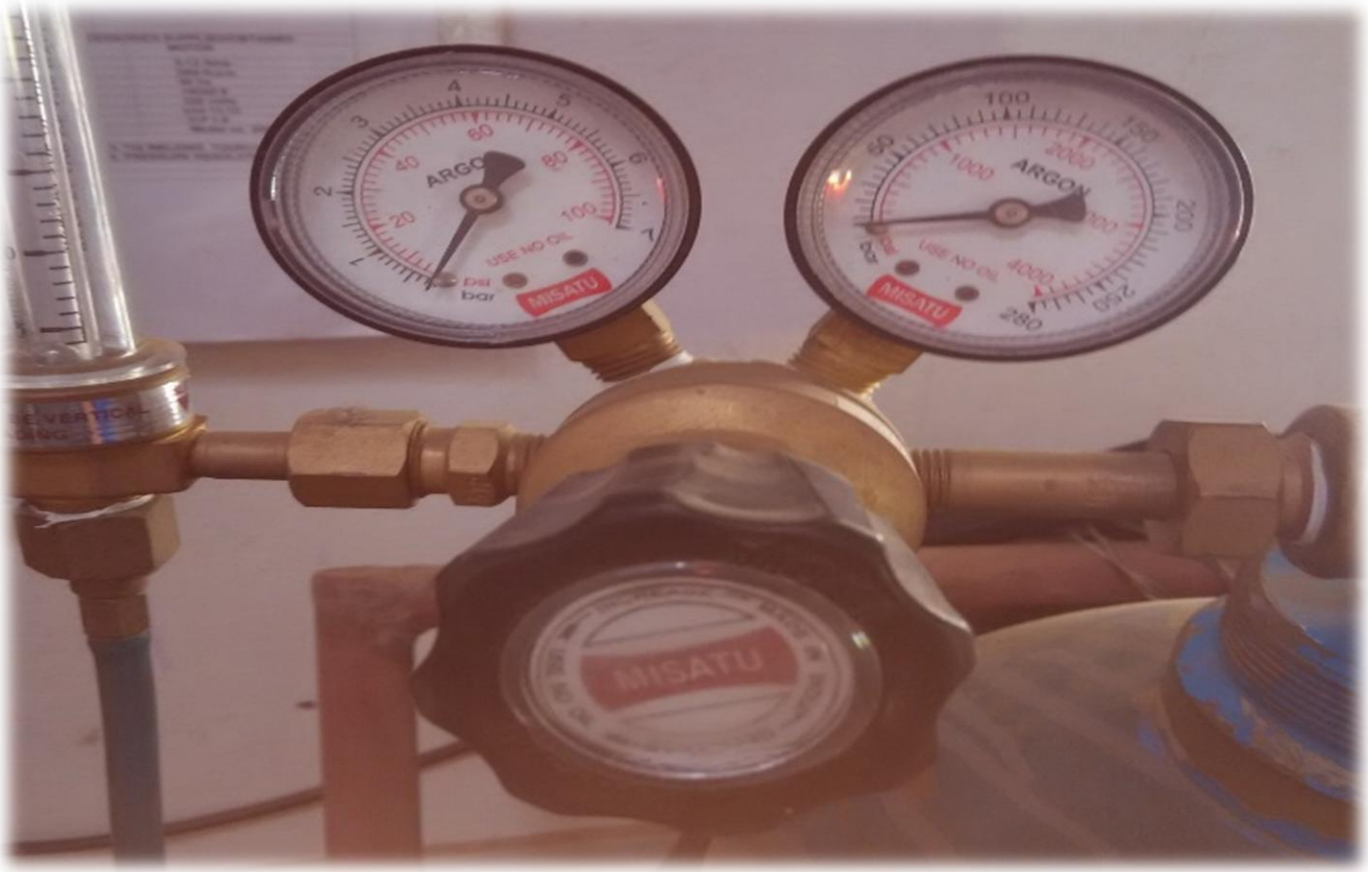
Grooved Plates



Step 3:- Welding Operation

A) Current Controller

B) Gas Flow Rate Controller

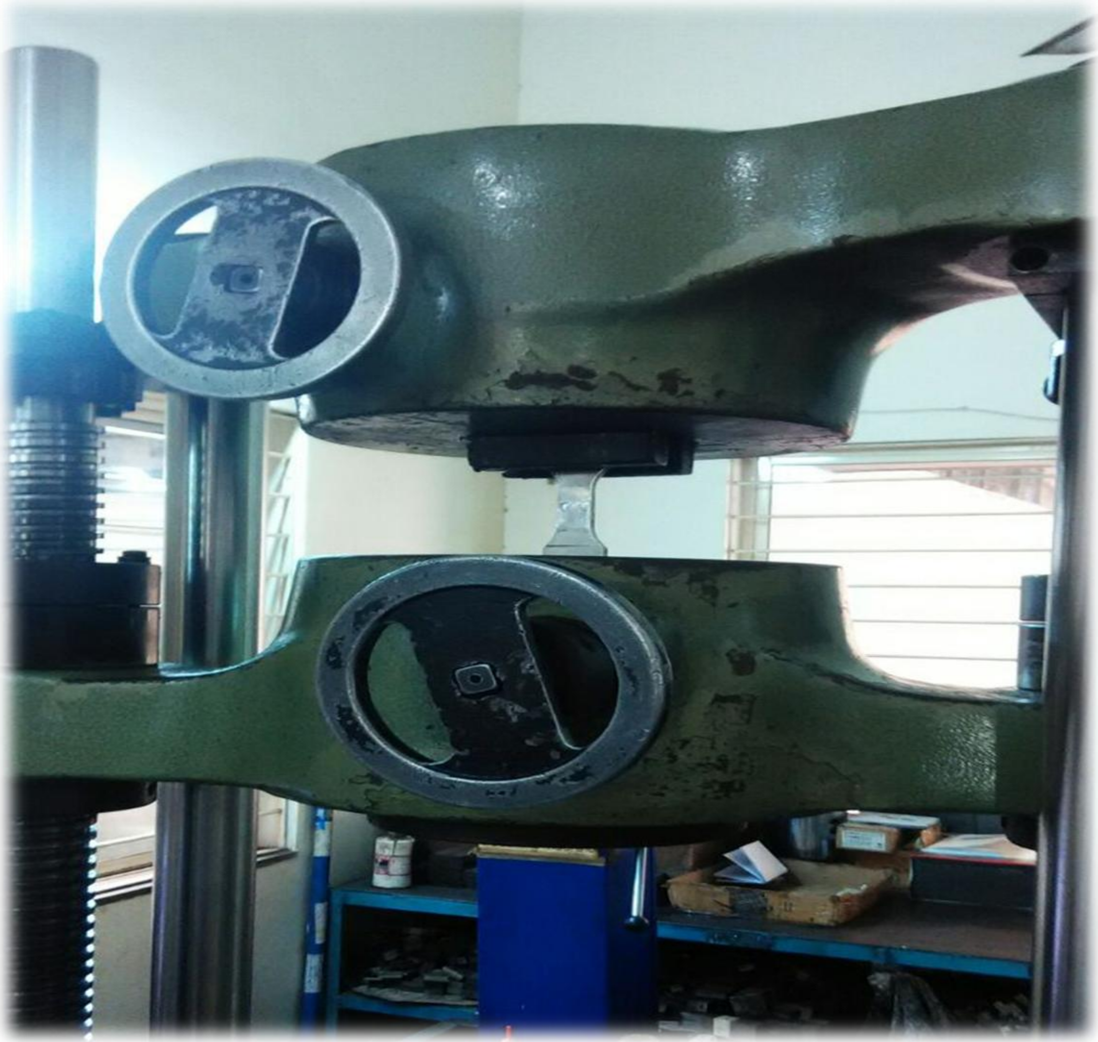


C) Welding Torch

D) Welding Operation

E) Welded Plate

Step 4 :-Testing




T-14410
Tig welding
T-14409
Tig welding

Testing Reports

Experimental Design
By
RSM in Minitab Software

Range of Input Variables

Sr.no	Variables	Unit	Minimum value	Maximum value
1	Welding current	Ampere	150	200
2	Shielding current	Liter/min	8	10
3	Current polarity	-	-1	+1

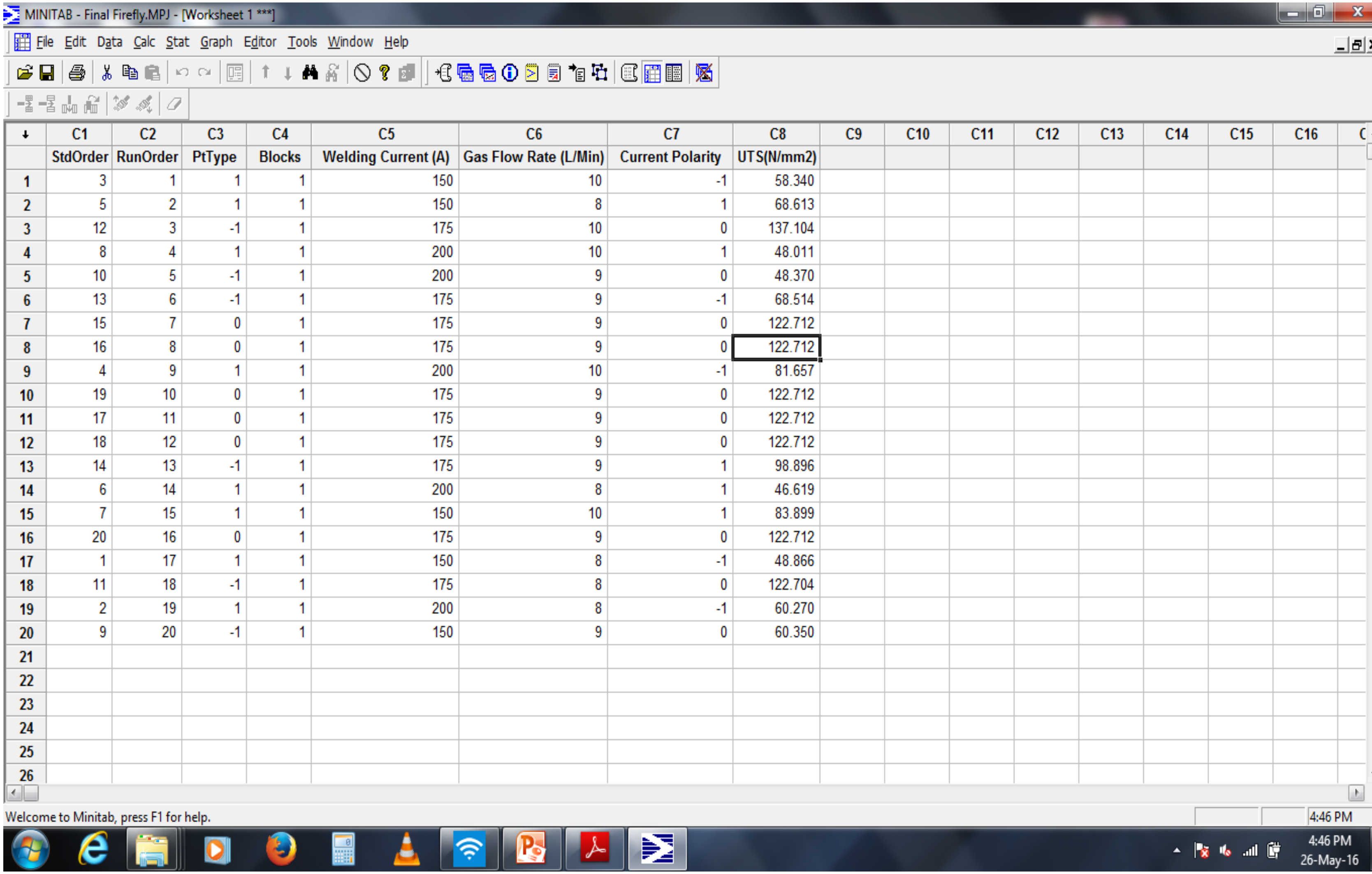
Levels of Parameter

Factors Level			
Experiment No	Welding Current(A)	Shielding Gas Flow Rate(Lit/Min)	Current Polarity
1	150	10	-1
2	150	8	1
3	175	10	0
4	200	10	1
5	200	9	0
6	175	9	-1
7	175	9	0
8	175	9	0
9	200	10	-1
10	175	9	0
11	175	9	0
12	175	9	0
13	175	9	1
14	200	8	1
15	150	10	1
16	175	9	0
17	150	8	-1
18	175	8	0
19	200	8	-1
20	150	9	0

Testing Results

Factors Level				
Experiment No	Welding Current(A)	Shielding Gas Flow Rate(Lit/Min)	Current Polarity	UTS (N/MM^2)
1	150	10	-1	98.896
2	150	8	1	68.613
3	175	10	0	58.340
4	200	10	1	83.899
5	200	9	0	48.866
6	175	9	-1	122.712
7	175	9	0	137.104
8	175	9	0	48.370
9	200	10	-1	122.712
10	175	9	0	68.514
11	175	9	0	122.704
12	175	9	0	122.712
13	175	9	1	48.011
14	200	8	1	122.712
15	150	10	1	46.619
16	175	9	0	122.712
17	150	8	-1	81.657
18	175	8	0	60.270
19	200	8	-1	122.712
20	150	9	0	60.350

Screen Shot of Minitab



	C1 StdOrder	C2 RunOrder	C3 PtType	C4 Blocks	C5 Welding Current (A)	C6 Gas Flow Rate (L/Min)	C7 Current Polarity	C8 UTS(N/mm2)
1	3	1	1	1	150	10	-1	58.340
2	5	2	1	1	150	8	1	68.613
3	12	3	-1	1	175	10	0	137.104
4	8	4	1	1	200	10	1	48.011
5	10	5	-1	1	200	9	0	48.370
6	13	6	-1	1	175	9	-1	68.514
7	15	7	0	1	175	9	0	122.712
8	16	8	0	1	175	9	0	122.712
9	4	9	1	1	200	10	-1	81.657
10	19	10	0	1	175	9	0	122.712
11	17	11	0	1	175	9	0	122.712
12	18	12	0	1	175	9	0	122.712
13	14	13	-1	1	175	9	1	98.896
14	6	14	1	1	200	8	1	46.619
15	7	15	1	1	150	10	1	83.899
16	20	16	0	1	175	9	0	122.712
17	1	17	1	1	150	8	-1	48.866
18	11	18	-1	1	175	8	0	122.704
19	2	19	1	1	200	8	-1	60.270
20	9	20	-1	1	150	9	0	60.350

ANOVA Analysis by Minitab

MINITAB - Final Firefly.MPJ - [Session]

File Edit Data Calc Stat Graph Editor Tools Window Help

Response Surface Regression: UTS(N/mm2) versus Welding Curr, Gas Flow Rat, ...

The analysis was done using coded units.

Estimated Regression Coefficients for UTS(N/mm2)

Term	Coef	SE Coef	T	P
Constant	116.968	3.707	31.550	0.000
Welding Current (A)	-3.514	3.410	-1.030	0.327
Gas Flow Rate (L/Min)	6.194	3.410	1.816	0.099
Current Polarity	2.839	3.410	0.833	0.425
Welding Current (A)* Welding Current (A)	-53.992	6.503	-8.302	0.000
Gas Flow Rate (L/Min)* Gas Flow Rate (L/Min)	21.552	6.503	3.314	0.008
Current Polarity*Current Polarity	-24.647	6.503	-3.790	0.004
Welding Current (A)* Gas Flow Rate (L/Min)	-0.248	3.813	-0.065	0.949
Welding Current (A)*Current Polarity	-11.575	3.813	-3.036	0.013
Gas Flow Rate (L/Min)* Current Polarity	-1.773	3.813	-0.465	0.652

S = 10.78   R-Sq = 94.4%   R-Sq(adj) = 89.3%

Analysis of Variance for UTS(N/mm2)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	9	19436.5	19436.5	2159.62	18.57	0.000
Linear	3	587.7	587.7	195.91	1.68	0.233
Square	3	17751.3	17751.3	5917.09	50.88	0.000
Interaction	3	1097.5	1097.5	365.85	3.15	0.074
Residual Error	10	1163.0	1163.0	116.30		
Lack-of-Fit	5	1163.0	1163.0	232.60	*	*
Pure Error	5	0.0	0.0	0.00		
Total	19	20599.5				

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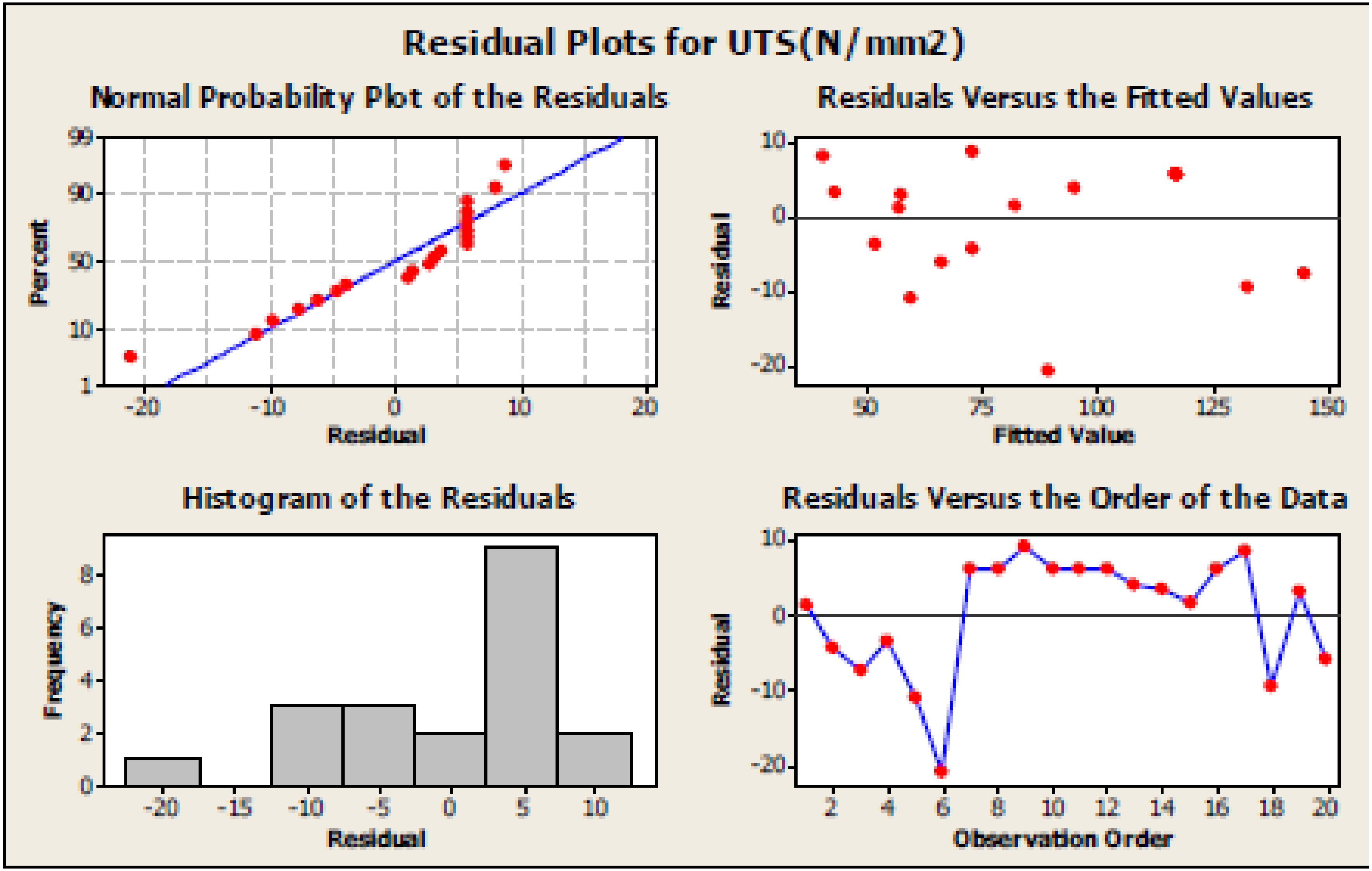
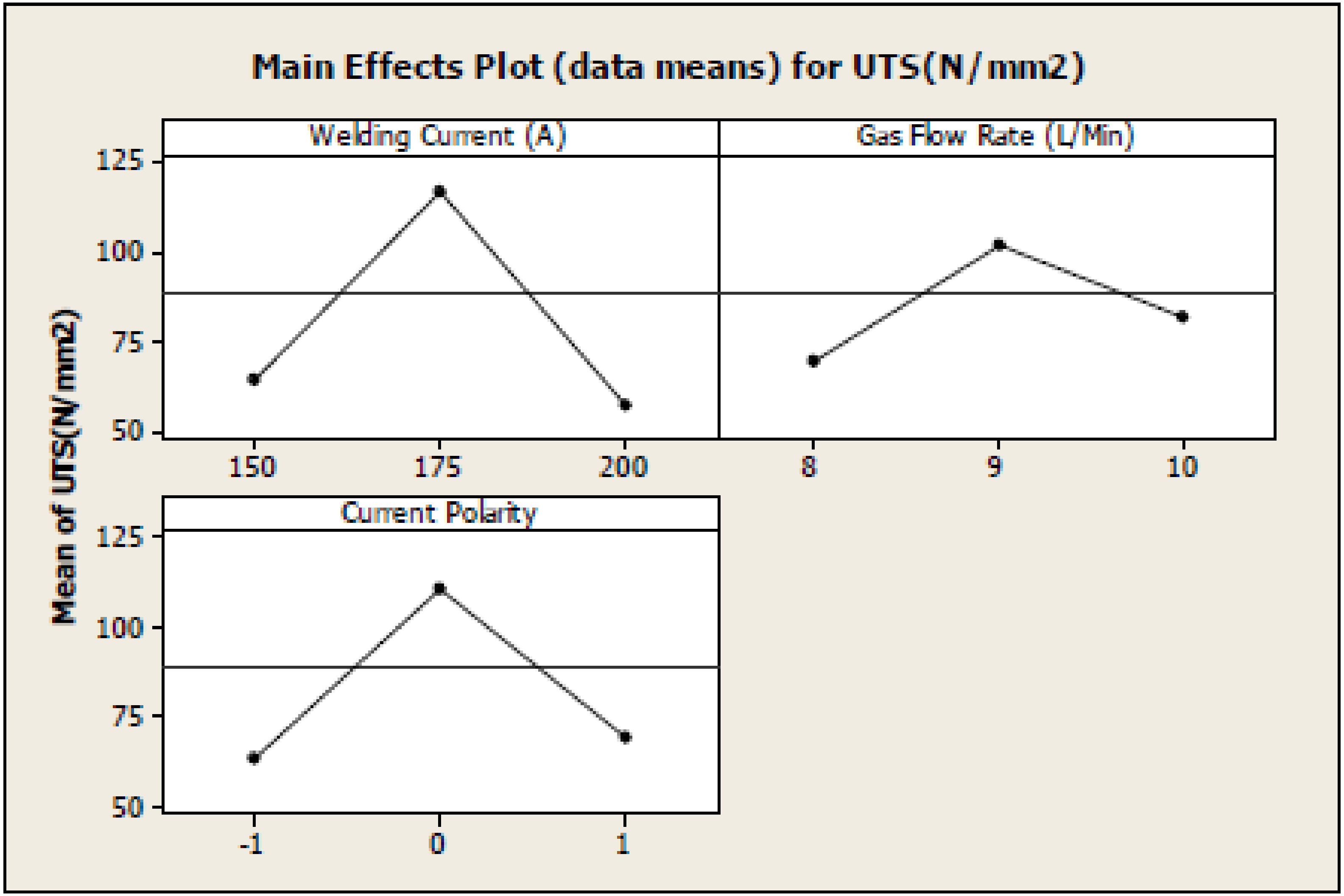
4:50 PM 26-May-16

Percentage Contribution of Input Parameters

Parameter	% Contribution
Welding Current (A)	32.70
Gas Flow Rate (L/Min)	9.90
Current Polarity	42.50
Welding Current (A)* Welding Current (A)	0.00
Gas Flow Rate (L/Min)* Gas Flow Rate (L/Min)	0.8
Current Polarity*Current Polarity	0.4
Welding Current (A)* Gas Flow Rate (L/Min)	94.9
Welding Current (A)*Current Polarity	1.3
Gas Flow Rate (L/Min)* Current Polarity	65.2


Residual Plots for UTS(N/mm2)
Normal Probability Plot of the Residuals
Percent
Residual
Residuals Versus the Fitted Values
Residual
Fitted Value
Histogram of the Residuals
Frequency
Residual
Residuals Versus the Order of the Data
Residual
Observation Order



Main Effects Plot (data means) for UTS(N/mm2)
Welding Current (A)
Gas Flow Rate (L/Min)
Current Polarity
Mean of UTS(N/mm2)
125
100
75
50
150
175
200
8
9
10
-1
0
1

Analysis Of
Variance
Using Statistical Calculations

Now:

Total number of runs, **n**=20

Total degree of freedom f_T=**n-1**=19

Six Factors and their levels:

Welding Speed – A_1, A_2, A_3,

Welding Current – B_1, B_2, B_3

Gas Flow Rate – C_1, C_2, C_3

Degree of Freedom:

Factor A – Number of level of factors, f_A = **A–1** = 2

Factor B – Number of level of factors, f_B = **B–1** = 2

Factor C – Number of level of factors, f_C = **C–1** = 2

For error, $F_e = f_T - f_A - f_B - f_C = 19 - 2 - 2 - 2 = 13$

❖ Analysis of Variance:

Response – 1: Tensile Strength

T = Total of all results of Tensile Strength = 1768.485

Correction Factor **C.F.** = **(T^2 / n)** = $(1768.485)^2$ / 20= 156376.9598

Total sum of squares, $S_T = \sum_{i=1}^{n}(y_i^2) - C.F$

=176976.5079 – 156376.9598

=20599.54807

Total contribution of each factorial level:

A_1 = 48.866 + 68.613 + 58.340 + 83.899 + 60.30

= 320.18 (All Tensile Strength reading total at 150 A)

A_2 = 122.712 + 98.896 + 122.712 + 122.712 + 68.514 + 122.712 + 137.104 + 122.712 + 122.704 + 122.712

= 1163.49 (All Tensile Strength reading total at 175 A)

A_3 = 81.657 + 46.619 + 60.270 + 48.011 + 48.370

= 284.927 (All Tensile Strength reading total at 200 A)

B_1 = 48.866 + 68.613 + 122.704 + 46.619 + 60.270

=347.072 (All Tensile Strength reading total at 8 lit/min)

B_2 = 60.350 + 122.712 + 98.896 + 122.712 + 122.712 + 68.514 + 122.712 + 122.712 + 122.712 + 48.370

= 1012.402 (All Tensile Strength reading total at 9 lit/min)

B_3 = 58.340 + 83.899 + 137.104 + 81.657 + 48.011

= 409.011 (All Tensile Strength reading total at 10 lit/min)

C_1 = 48.866 + 58.340 + 68.514 + 81.657 + 60.270

= 317.647 (All Tensile Strength reading total at -1)

C_2 = 60.350 + 122.712 + 122.712 + 122.712 + 122.712 + 137.104 + 122.712 + 122.704 + 122.712 + 48.370

= 1104.8 (All Tensile Strength reading total at 0)

C_3 = 68.613 + 83.899 + 98.896 + 46.619 + 48.011

= 346.038 (All Tensile Strength reading total at 1)

Factor sum of squares

$$S_A = \left(\frac{A_1{}^2}{NA_1} + \frac{A_2{}^2}{NA_2} + \frac{A_3{}^2}{NA_3}\right) - C.F$$

= (20482.3 + 135370.9 + 16236.7) – 156376.9598

= 15712.92

$$S_B = \left(\frac{B_1{}^2}{NB_1} + \frac{B_2{}^2}{NB_2} + \frac{B_3{}^2}{NB_3}\right) - C.F$$

= (24091.8 + 102495.8 + 33458) – 156376.9598

= 3668.6

$$S_C = \left(\frac{C_1{}^2}{NC_1} + \frac{C_2{}^2}{NC_2} + \frac{C_3{}^2}{NC_3}\right) - C.F$$

= (20180 + 122058.3 + 23948.5) – 156376.9598

= 9809.73

$S_O = S_T - (S_A + S_B + S_C)$

=20599.54807 – (29191.26275)

= –8591.7154683

Mean Square (Variance):

$$V_A = \frac{S_A}{f_A} = \frac{15712.92}{2} = 7856.5$$

$$V_B = \frac{S_B}{f_B} = \frac{3668.6}{2} = 1834.31$$

$$V_C = \frac{S_C}{f_C} = \frac{9809.73}{2} = 4904.86$$

$$V_O = \frac{S_T}{f_O} = \frac{-8591.72}{19} = 1084.2$$

Variance Ratio:

$$F_A = \frac{V_A}{V_O} = \frac{7856.5}{1084.2} = 7.246$$

$$F_B = \frac{V_B}{V_O} = \frac{1834.31}{1084.2} = 1.692$$

$$F_C = \frac{V_C}{V_O} = \frac{4904.86}{1084.2} = 4.52$$

$$F_O = \frac{V_O}{V_O} = \frac{1084.2}{1084.2} = 1$$

Percentage Contribution:

$$P_A = \frac{S_A}{S_T} = \frac{15712.9}{20599.6} = 0.7627 = 76.27\%$$

$$P_B = \frac{S_B}{S_T} = \frac{3668.6}{20599.6} = 0.1781 = 17.81\%$$

$$P_C = \frac{S_C}{S_T} = \frac{9809.7}{20599.6} = 0.4762 = 47.62\ \%$$

$$P_O = \frac{S_O}{S_T} = \frac{-8591.7}{20599.6} = -0.4170 = -41.70\ \%$$

Excel Programming

Mathematical Modeling

Welding Current = X_1

Gas Flow Rate = X_2

Current Polarity = X_3

Ultimate Tensile Strength = Y

$$Y=116.968-3.514X_1+6.194X_2+2.839X_3-53.992X_1^2$$

$$+21.552X_2^2-24.647X_3^2-0.248X_1*X_2-11.575X_1X_3-1.773X_2X_3$$

Optimization
Using
Firefly Algorithm

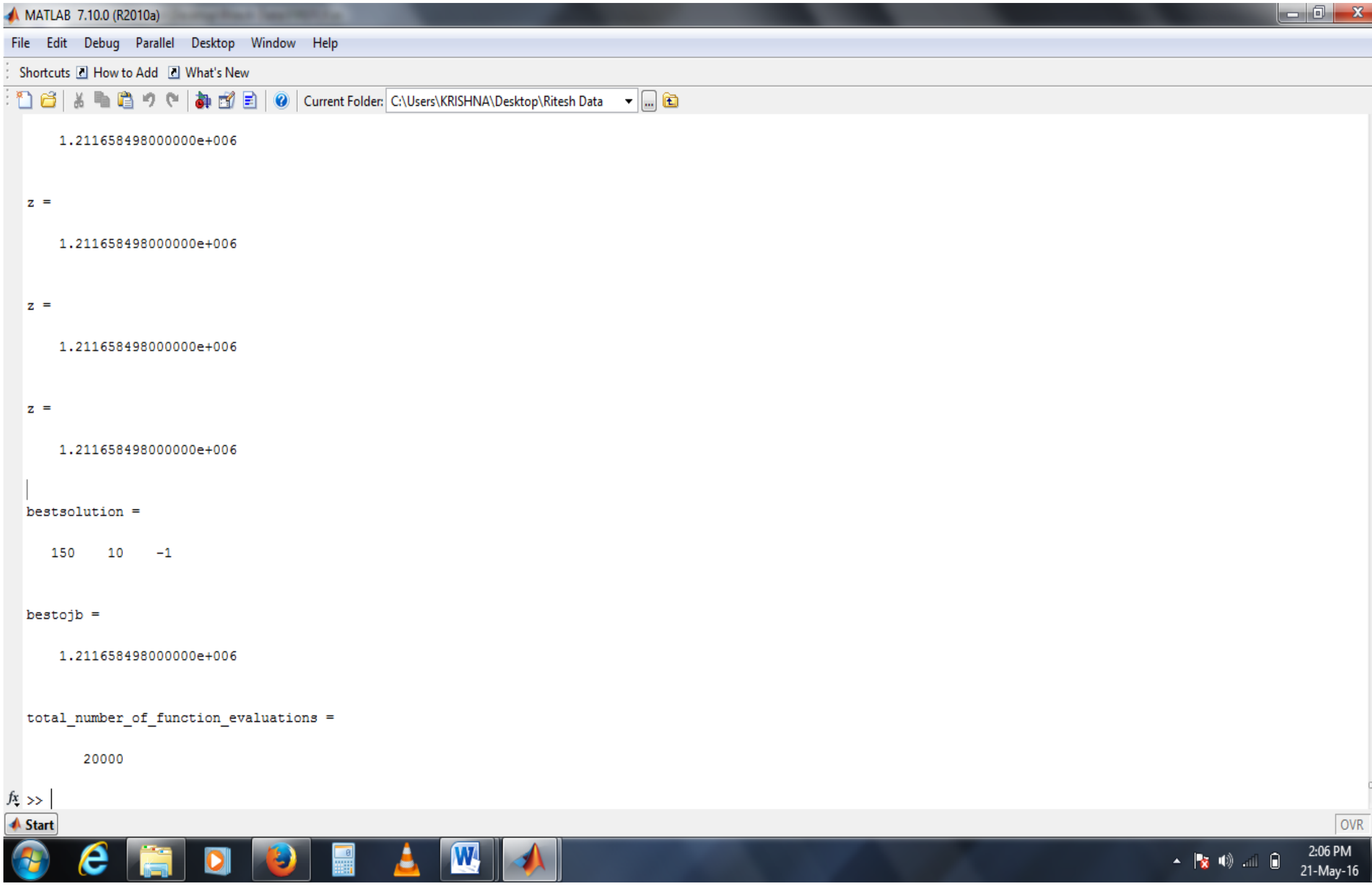
- Optimization is a technique of finding an alternative with the most cost effective or highest achievable performance under the given constraints, by maximizing desired factors and minimizing undesired ones.
- The application of optimization in engineering has a very long history. It is well known that two special classes of optimization problem, linear least squares and linear optimization problems, have been widely used in tremendous number of application areas, such as transportation, production planning, design and data fitting.
- Nature inspired algorithm, are among the most powerful algorithm for optimization.

1. Particle swarm optimization (PSO)
2. Genetic algorithm (GA)
3. Firefly algorithm (FA)

Optimum Values of Parameters

Parameter	Value
Welding Current	150
Gas Flow Rate	10
Current Polarity	-1

Screenshot of Matlab Output



Conclusion

- In this study the parametric optimization of tig welding parameters using Firefly Algorithm on Aluminum Alloy 6061was carried out.
- The 3 parameters were control during the experiment. The variables and levels are as below.
- The output parameter is the tensile strength in optimization is carried out for ultimate tensile strength.
- 15 specimens were welded according to specific values of the parameter given by RSM and tensile strength was measured by tensile testing machine at Divine laboratory Ahmedabad.
- ANOVA analysis using response surface methodology was effectively carried out.
- Percentage Contribution of the parameters in the ultimate tensile strength of the weldments was obtain by two methods
    1. Using RSM
    2. Using Statistical Calculation

- Mathematical model showing the relationship between input and output parameter was obtain using bounded points.
- Various contours and surfaces are plotted in order to understand the relationship among input and output parameters.
- Optimization is carried out using Firefly algorithmin the Matlab Software.
- Optimum Value of the parameters obtain are as follow.

Parameter	Value
Welding Current	150
Gas Flow Rate	10
Current Polarity	-1

Miscellaneous Work

www.tigweldingproject.wordpress.com

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Thank You