Tensile Strength Evaluation of Butt Weld Joint Using Design of Experiment

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I. INTRODUCTION

Butt weld joint is widely used in varieties of application in the mechanical manufacturing sector. The tensile strength of the weld joint is one of the important and crucial parameter to be considered for the quality and reliability of the weld joint. Tensile strength of the butt V- joint depends on the cross section of the weld joint and the size of the welding material. The projects talks about the variation of the tensile strength of the butt V-joint for the different height of the weld joint. The project is not only limited to variation of the height of the welding plate but it also gives the result of the variation in the V-angle called as bevel angle, bevel height and speed of the weld. Analytical solution of the various combinations is obtained by numerical equations available to calculate tensile strength and are compared with the experimental results obtained by the specimen welding and testing. The experimentation is performed using design of experiments. Various results received by analytical and experimental test are interpreted and compared for the optimum combination.

FLOW CHART OF THE PROJECT

Selection of appropriate process parameters is one of the dependency on which thequality of TIG weld greatly depends. Theseparameters include welding speed,welding current, welding wire diameter, welding arc voltage, distancebetween arc and base material, shielding gas flow rate.TIG welding was performed on the SS 304test piecesin two phases. In the first phase, TIG weldingwas performed by keeping welding bevel angleand weld speed as variable and bevel height constant.

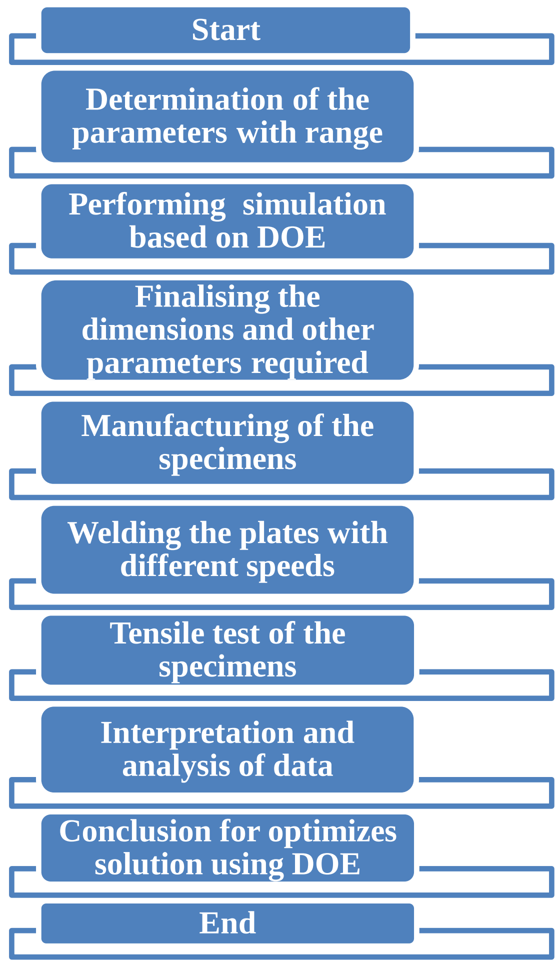

Fig.1.1 Flow chart of process

During the second phase TIG welding was performed by taking bevel angle and bevel height as variable and welding speed constant. A number of inspections including the variation of the tensile strength of the weld joint with two different phases are considered and analyzed during the project. The flow chart of the whole process is shown in Fig. 1.1

SPECIMEN DETAILS AND PROCESS PARAMETERS

The specimen used for the test (Fig.1.2) is 5cm in width and 5cm in length. Bevel height varies according to the requirement. Also one of the height sides of the specimen is with bevel angle as per the variation in the range of 25^0 and 45^0.

The results after the phase one and phase two are tabulated and also the variation of the tensile strength is observed.

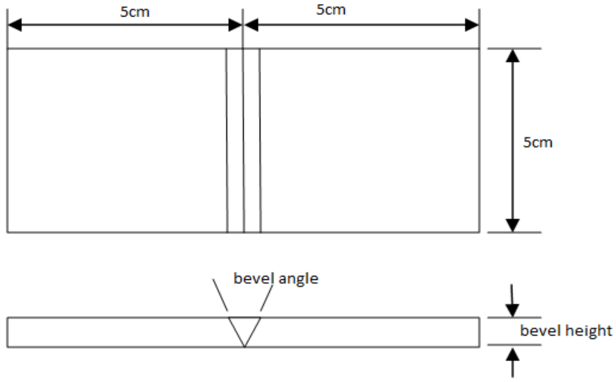

Fig.1.2.Specimen for the test

Process parameters considered for the analysis are speed of the weld, Bevel height and Bevel angle of the weld. The details of the process parameters are shown in the table 1.1 given below.

Sr.No.	Parameters	Unit	Min(-1)	Max(+1)
1	Speed (x_1)	Cm/s	3	7
2	Bevel Height (x_2)	cm	1	1.5
3	Bevel Angle (x_3)	degree	25^0	45^0

Table 1.1 Process parameters and there level

II. MANUFACTURING AND EXPERIMENTATION

Different operations on the plates are carried out for the specimen to be with the decided dimentions. The operation performed are grinding and surface finishing to the plate for the test, angle cutting at the joint of weld as per requirement etc.

Fig.1.3. Plates with various thickness

Welding

Welding of the specimen is achieved by controlling the speed of the weld manually.

TIG weld with filler material is SS304 is used for welding. Two speeds to be controll for the experiment are 3cm/s anf 7cm/s as per requirement. These two speeds are decided according to the ergonomics and comfort of the operator.

Fig. 4.8 Welding operation

TESTING

Data is obtained on universal testing machine (UTM). UTM has compatibility and interfacing with computer from where the graphs and tables of data of various parameters are achieved.

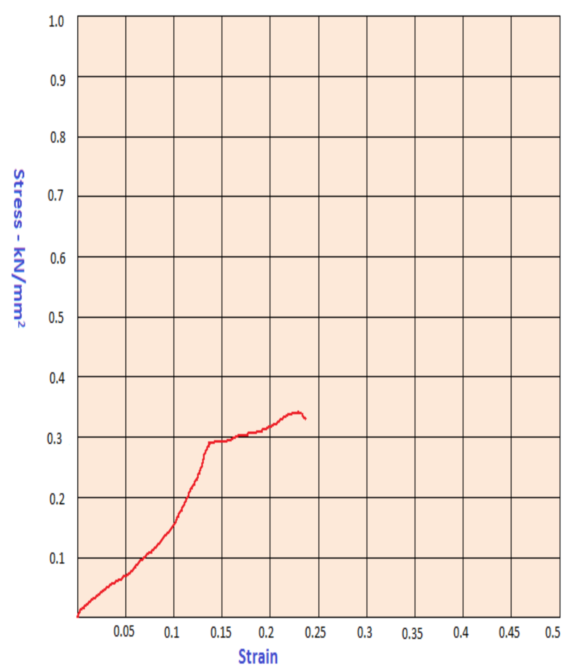

Fig.1.4 Stress v/s Strain for SS31.025

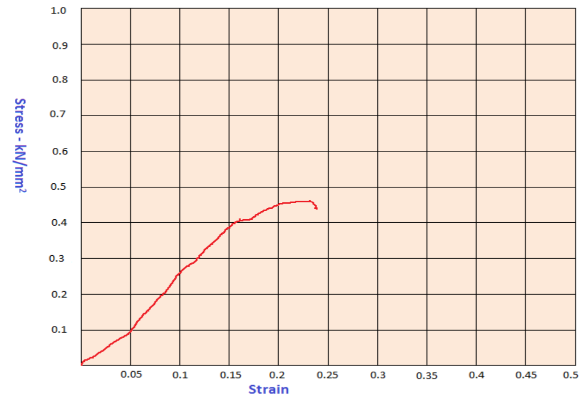

Fig.1.5 Stress v/s Strain for SS31.045

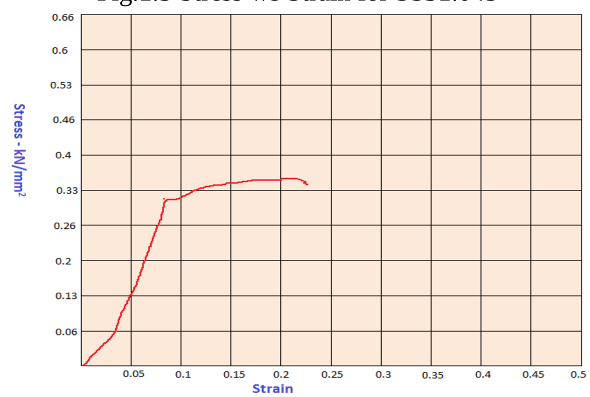

Fig.1.6 Stress v/s Strain for SS31.525

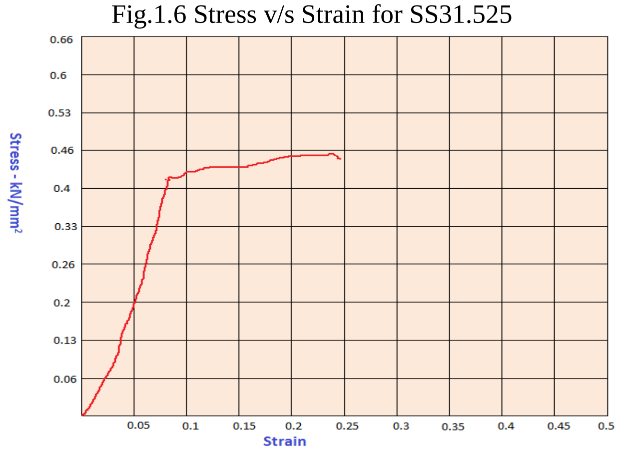

Fig. 4.21 Stress v/s Strain for SS31.545

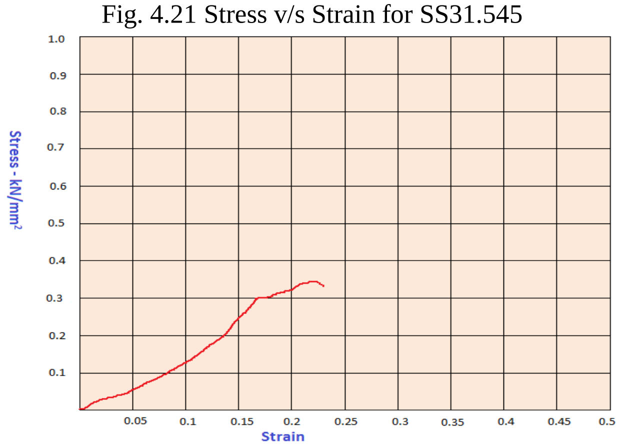

Fig 1.7 Stress v/s Strain for SS71.025

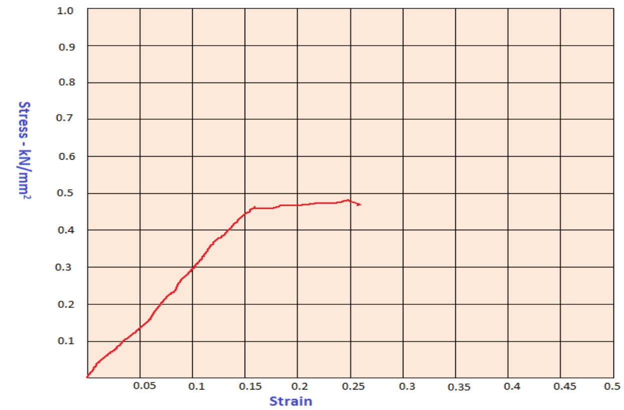

Fig 1.8 Stress v/s Strain for SS71.045

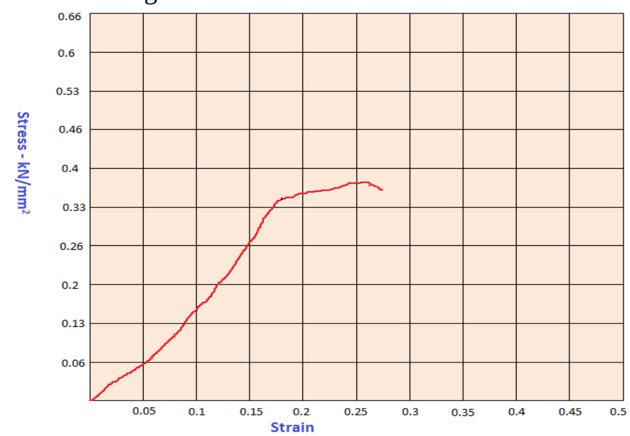

Fig. 1.9 Stress v/s Strain for SS71.525

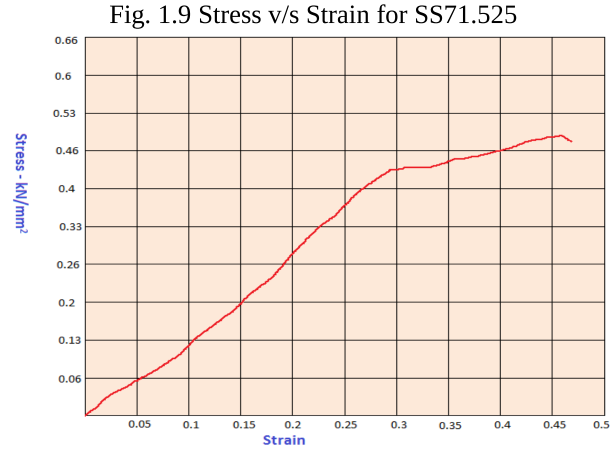

Fig. 1.10 Stress v/s Strain for SS71.545

Result obtained from the test shows various parameters including yield point load, yield point stress, elongation at yield point, stress at upper yield point, stress at lower yield point, ultimate load, ultimate stress, elongation at ultimate load, load at breakage, stress at breakage, and elongation at breakage. Result table also shows the maximum, minimum, and average values of stresses at yield, ultimate, and breakage respectively.

Among the values of the various parameters obtained from the test, ultimate tensile stress is considered for the further analysis of the project. It is simply because of the fact that maximum value of the stress talks about the failure of the specimen.

Sr. No.	Specimen	Actual Observation (y)	Result(N/mm^2)
1	SS31.025	y_1	0.337
2	SS31.045	y_2	0.341
3	SS31.525	y_3	0.348
4	SS31.545	y_4	0.359
5	SS71.025	y_5	0.458
6	SS71.045	y_6	0.473
7	SS71.525	y_7	0.464
8	SS71.545	y_8	0.487

Table 1.2 Ultimate tensile strength after test

III. RESULT AND DISCUSSION

1. Linear regression model

In general the response variable y may be related to k regression variable by following relation,

$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k + \epsilon$

The model is called a multiple linear regression model with k regression variable. The parameter β_j , j= 0,1,2,.........,k, are called the regression coefficients. The model describes hyper plane in the k-dimensional space of the regressor variables $\{x_j\}$. The parameter β_j represents the expected change in response y per unit change in x_j when all the remaining impendent variables x_j ($i \neq j$) are held constant.

Table 1.3 Residual values

Sr. No.	Actual Observation (y)	Fitted Value ($\hat{y}$)	Residual ($\epsilon = y - \hat{y}$)
1	0.337	0.3336	0.0034
2	0.341	0.3468	-0.0058
3	0.348	0.3458	0.0022
4	0.359	0.3590	0
5	0.458	0.4578	0.0002
6	0.473	0.4710	0.002
7	0.464	0.4700	-0.006
8	0.487	0.4832	0.0038
$\sum \epsilon = y - \hat{y}$			0.000

Therefore the values of regression coefficient are,

β_0 = 0.4080
β_1 = 0.0066
β_2 = 0.0061
β_3 = 0.0621

and the corressponding equation for fitted regression model is given by,

$\hat{y}$ = 0.4084+ 0.0066x_1 + 0.0061x_2 + 0.0621x_3

Calculating the values of the y for the corresponding values of the parameters used in the equation of fitted regression model,

$\hat{y}_1$ = 0.4084+ 0.0066(-1) + 0.0061(-1) + 0.0621(-1)
= 0.3336
$\hat{y}_2$ = 0.4084+ 0.0066(1) + 0.0061(-1) + 0.0621(-1)
= 0.3468
$\hat{y}_3$ = 0.4084+ 0.0066(-1) + 0.0061(1) + 0.0621(-1)
= 0.3458
$\hat{y}_4$ = 0.4084+ 0.0066(1) + 0.0061(1) + 0.0621(-1)
= 0.3590
$\hat{y}_5$ = 0.4084+ 0.0066(-1) + 0.0061(-1) + 0.0621(1)
= 0.4578
$\hat{y}_6$ = 0.4084+ 0.0066(1) + 0.0061(-1) + 0.0621(1)
= 0.4710
$\hat{y}_7$ = 0.4084+ 0.0066(-1) + 0.0061(1) + 0.0621(1)
= 0.4700
$\hat{y}_8$ = 0.4084+ 0.0066(1) + 0.0061(1) + 0.0621(1)
= 0.4832

The difference between the actual obsevation y and corressponding fitted value $\hat{y}$ is the residual, say $\epsilon = y - \hat{y}$. The residual for the case is given in table 1.3

Results obtained from MINITAB software are also checked for verification.

IV. OBSERVATIONS AND CONCLUSION

From the available reading the general observations that can be drawn from the study is that the variation in the bevel angle of weld joint results in the variation of tensile strength. The variation is nonlinear variation and it increases between the ranges 35 degree to 55 degrees of bevel angle. In spite of speed and bevel height variation the behavior of the tensile strength of weld joint shows first increase and then decrease graph. The discussion come near to the result that there is an optimum angle of bevel which gives highest tensile strength.

The welding speed variation is also the parameter which in general shows same variation of the tensile strength as that of variation in the bevel angle i.e. it increases first and then decreases. At the speed of 3 cm/s the tensile strength is less as compared with 7cm/s. It shows highest tensile strength at the 7cm/s speed. The optimum speed in the said value will yield the highest tensile strength of the weld joint.

Third parameter of the analysis i.e. bevel height is also behaving same as that of the above two parameters of the analysis. The bevel height 1cm gives low tensile strength as compared with the height 1.5cm. It means the optimum bevel height is 1.5cm bevel height which will result in highest tensile strength of the weld joint.

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