











Graph No. 10: Average Response (Y<sub>2</sub>) vs Process Parameter Level

### 5. Regression Statistics and Analysis of Variance

#### A. For Tensile Strength (Y<sub>1</sub>)

Regression Statistics	
Multiple R	0.90143134
R Square	0.812578461
Adjusted R Square	0.625156923
Standard Error	22.97325102
Observations	9

ANOVA	df	SS	MS	F	Significance F
Regression	4	9152.73135	2288.183	4.33556606	0.092213449
Residual	4	2111.08105	527.7703		
Total	8	11263.8124			

	Coefficients	Standard Error	t Stat	P-value
Intercept	521.765	194.6334417	2.680757	0.05518515
X1 Amp	-2.292	0.937879046	-2.44381	0.07091641
X2 sec	1103.5	468.9395228	2.353182	0.07824297
X3 sec	254.75	468.9395228	0.543247	0.61581656
X4 bar	-110.35	46.89395228	-2.35318	0.07824297

#### B. For Hardness in Vickers (Y<sub>2</sub>)

Regression Statistics	
Multiple R	0.71893094
R Square	0.5168617
Adjusted R Square	0.03372339
Standard Error	3.74695284
Observations	9

ANOVA	df	SS	MS	F	Significance F
Regression	4	60.07853333	15.01963	1.069801	0.474717
Residual	4	56.15862222	14.03966		
Total	8	116.2371556			

	Coefficients	Standard Error	t Stat	P-value
Intercept	53.0777778	31.74484646	1.672012	0.169839
X1 Amp	0.05	0.152968709	0.326864	0.76016
X2 sec	131.666667	76.48435449	1.721485	0.160271
X3 sec	-14.5	76.48435449	-0.18958	0.858869
X4 bar	8.28333333	7.648435449	1.08301	0.339724

### 6. Mathematical Formulation

#### Tensile Strength Y<sub>1</sub>

$$= 521.765 - 2.292X_1 + 1103.5 X_2 + 254.75X_3 - 110.35X_4$$

#### Hardness Y<sub>2</sub>

$$= 53.07778 + 0.05X_1 + 131.6667X_2 - 14.5X_3 + 8.283333X_4$$

Where,

50 ≤ Tensile Strength ≤ 170

85 ≤ Hardness in Vickers ≤ 105

$$150 \leq X_1 \leq 170$$

$$0.12 \leq X_2 \leq 0.16$$

$$0.08 \leq X_3 \leq 0.12$$

$$1.8 \leq X_4 \leq 2.2$$

### 7. Conclusions

The Taguchi Method has been applied for simultaneous consideration of multiple responses such as Tensile strength and the hardness to optimize the resistance spot welding parameters, such as weld current, weld time, hold time, and electrode pressure.

Based on the modelling and optimization results it can be concluded that.

- 1) Considering Higher the better criteria for the response Y<sub>1</sub>, Tensile shear strength, the Local Optimum values for the RSW process parameters are weld current 160 Amp, weld time 0.14 sec electrode pressure 1.8 bar.
- 2) Considering Higher the better criteria, for the response Y<sub>2</sub>, Hardness, the Local Optimum Values for the RSW process parameters are weld current 160 Amp, weld time 0.16 sec electrode pressure 2 bar.
- 3) In the present case study, the degree of freedom for the error is zero. Hence an approximate estimate of the error sum of squares is obtained by pooling the sum corresponding to the factors having the lowest mean square. [5]
- 4) In the present case the factor X<sub>3</sub>, hold time is used to estimate the error sum of squares. The factor X<sub>3</sub> contributes to 6.49% for the response Tensile shear strength Y<sub>1</sub> and 3.48% for the response hardness, Y<sub>2</sub>.

Response Variable	Actual Value	Estimated Value	% Error
i. Tensile Strength	162.98	141.475	13.194%
ii. Hardness	101.67	97.5	4.1%

5) The Sample Specimens used are IS 410:2006 Grade CuZn 40 Brass material, In Future there is a wide scope for the Resistance spot welding process of Brass Material.

### 8. Acknowledgements

The authors would like to express their gratitude to Mr. Sunil Parab and Mr. Sushil Parab, the Proprietor of PARAB ELECTRIC WORKS for availing the facility of the Resistance spot Welding of Brass material in their premises. PARAB ELECTRIC WORKS is a Manufacturers and Repairers of Spot Welding Machine, Butt Welding Machine, Seam Welding Machine. This Industrial Unit is Located at Rane Estate, Behind Giriraj Apt, Kadam Wadi, Marol Pipe Line, A.K. Road, Andheri (E), Mumbai-59, Maharashtra, India. Mob. No: 9892001388/9869620795.

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