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Analysis of Process Parameters for Resistance Spot Welding on Cold Reduced Low Carbon Steel

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Mr. C. B. Vaghela
Pursuing M.E. Mech. (Prod. Engg.)
Atmiya Institute of Technology & Science, Rajkot(GTU)
chiragsinh0026@gmail.com

Prof. P. T. Kikani
Assistant Professor (Mech. Engg.)
Atmiya Institute of Technology & Science, Rajkot(GTU)
ptkikani@aits.edu.in

Mr. N. J. Chotai
Managing Partner
Saurashtra Tin & Metal Industries, Rajkot
nitin@saralgroup.com

***Abstract*:** Resistance Spot Welding (RSW) is generally used for joining reason particularly in vehicles industry and manufacture of sheet metal because of its vigor, velocity, adaptability and minimal effort operation. In any auto, there are 3000-6000 spot welds which demonstrate the level significance of the resistance spot welding. The metal sheets are all the more every now and again utilized as a part of car industry particularly as an option material for auto bodies. In this article the far reaching rundown concerning innovation of resistance spot welding of combinations was exhibited. Since terminal power is an essential procedure parameter in little scale resistance spot welding (SSRSW), its impacts on the electrical, warm and mechanical conduct of the welding process The welding timetables, electric parameters of welding, anodes materials and cathodes life time by resistance spot welding metal were depicted. Couples of illustrations specifically from car industry were displayed and focal points of material sheets as a material for some vehicle parts were likewise talked about. It is an entangled procedure, which includes associations of warm, mechanical, electrical and metallurgical marvel. Controlling the welding parameters assumes an imperative part on the nature of the weld. It relies on upon the resistance of the base metal and the measure of current streaming to deliver the warmth important to make the spot weld. There are different procedure parameters (weld current, weld time, cathode power) which influence the weld chunk and its quality. So it is important to upgrade the procedure parameters of resistance spot welding procedure. The test studies have been led under shifting weight, current and time on quality trademark, Hardness and Weld life. In this paper, different improvement strategies are examined and the utilization of the Taguchi technique to decide the ideal procedure parameters is accounted for. The setting of welding parameters was resolved utilizing Taguchi test plan technique and L9 orthogonal cluster was picked. The ideal welding parameter for multi-targets was acquired utilizing multi sign to commotion proportion (MSNR). This is on account of the Taguchi strategy is an orderly utilization of outline and examination of tests with the end goal of planning and enhancing item quality at the configuration stage.
Using so as to weld parameters settings were dictated the Taguchi trial plan strategy. The level of significance of the welding parameters on the ductile shear quality is dictated by utilizing examination of difference (ANOVA).

Keywords: Resistance Spot Welding, Taguchi Method, ANNOVA Method, Process Parameters, Cold Reduced Low Carbon Steel, Minitab Software.

I. INTRODUCTION

Spot welding is one of the most seasoned welding procedures. It's one type of resistance welding, which is a strategy for welding two or more metal sheets together without applying so as to utilize any filler material weight and warmth to the territory to be welded. Resistance spot welding is a broadly utilized joining procedure for manufacturing sheet metal gatherings, for example, autos, truck lodges, rail vehicles and home applications because of its points of interest in welding effectiveness and suitability for mechanization. For instance, a cutting edge auto-body get together needs 7000 to 12,000 spots of welding as indicated by the extent of an auto, so the spot welding is a vital procedure in auto-body gathering. Spot welding is a sparing and basically technique for joining metals in light of the fact that its rate, accuracy, proficiency, and coming about expense diminishments managed via robotized resistance spot welding are very much recorded and acknowledged, really in car industry. The strategy is versatile to rapid computerization and is under strict process durations.
The spot welding procedure is utilized to join sheet materials and uses molded copper compound anode to apply weight and pass on the electrical current through the work pieces. In all types of resistance welding, the parts are privately warmed. The material between the terminals yields and is pressed together. It then melts, annihilating the interface between the parts. The current is exchanged off and the "chunk" of liquid materials sets shaping the joint. The material has a higher electrical resistivity and lower warm conductivity than the anode utilized is suitable to pick, for example, steel in light of the fact that it making welding moderately simple. For another material, for example, aluminum, it's electrical resistivity and warm conductivity is closer to copper yet the liquefying point for this material is lower than copper, make a welded is conceivable.
In the spot welding it has some parameter to be considered. These parameters will influence the nature of the welds. The suitable mix of the spot welding parameter will deliver solid joining and have a decent nature of weld.

II. LITERATURE REVIEW

Manjunath R. Rawal1, Dr. K. H. [1] found that reaction of S/N proportion for malleable shear quality demonstrates that, Welding current is the most noteworthy parameter that

controls the weld quality. Though terminal compel and weld time are less critical.

A. K. Pandey, M. I. Khan, K. M. Moeed [2] investigated that the reaction of S/N proportion as for elasticity shows the welding current to be the most critical parameter that controls the weld rigidity where's the holding time and weight are Nearly less huge in such manner.

R. Neugebauer, T. Wiener, A. Zosch [3] concluded that Resistance characteristics during welding process deliver information on formation of weld nugget and reached nugget diameter.

Kamble Vijay Ananda [4] investigated that the affirmation tests showed that it is conceivable to build pliable shear quality essentially by utilizing the Proposed measurable method.

Rajesh Sharma, Harpreet Singh [5] investigated that for ASS316 by increasing weld current, weld time and electrode force results in an increase in weld nugget diameter and width as well as results in an increase in electrode indentation.

Mr. Niranjan Kumar Singh, Dr.Y.Vijaykumar [6] concluded that taking into account ANOVA strategy, the very successful parameters on space are found as weld cycle, communication between weld current and weld cycle, association between weld current, weld cycles and hold time while weld current, hold time and cool time were less powerful elements.

Norasiah Muhammad, Yupiter HP Manurung,et.al [7] found that the exceedingly viable parameter for the improvement of sweep weld chunk and width of HAZ is the welding current.

A.G.Thakur et.al.[8] found that this study exhibits a precise way to deal with decide impact of procedure parameters (weight, weld time and current) on elastic shear quality of resistance weld joint of austenitic stainless steel AISI 304 utilizing Taguchi Method.

M. Pouranvari. [9] Found that weld nugget size and weld fusion penetration are the main controlling factors for spot weld quality in terms of peak load and energy absorption.

A.M. Pereira a, J.M. Ferreira b, A. Loureiro b, J.D.M. Costa b, P.J. Bártolo [10] concluded that the increase in weld current and duration increased the nugget size and the weld strength. Beyond a critical nugget diameter the failure mode changed from interfacial to pullout.

Oscar Martin, Pilar De Tiedra, Manuel San-Juan, Cristina Garcia, Fernando Martin[11] investigated that Tensile Shear Load Bearing Capacity (TSLBC) increases initially with increasing Welding Time(WT) and Welding Current(WC) ,but excessive values of WT and WC cause expulsion of molten metal and consequently TSLBC decreases.

Feramuz Karci, Ramazan Kacar, Suleyman Gunduz [12] found that the the primary cause of weakening of the weldment was identified as the grain growth occurred in heat affected zone (HAZ) adjacent to the weld nugget.

Dursun Ozyurek [13] concluded that the increase in heat input related with current caused coarsening of the microstructure of weld nugget and also of heat affected zone (HAZ).

S.Aslanlar, A.Ogur, U.Ozsarac, E.Ilhan [14] found that Maximum tensile-shear strength value of galvanized chromate steel sheets' resistance spot welding was obtained in 10kA welding current for 12 and 15 periods welding time.

Ugur Esme [15] found that For SAE 1010 steel sheets, taking into account ANOVA system, the profoundly viable parameters on the elasticity were found as welding current and terminal power. The outcomes demonstrated that welding current was around two times more critical than the second positioning variable (anode power) for controlling the elasticity.

A.Ambroziak, M. Korzeniowski [16] investigated that according to the newest studies, automotive industries tends to use light alloys like aluminium and magnesium alloys. It requires high power welding gun and precious steering of current and time. The aspects of rapid deterioration of tips must be taken into account.

Nizamettin Kahraman [17] found that the Increasing welding time and electrode force increased tensile-shearing strength of the resistance spot welded specimens.

B. Bouyousfi a, T. Sahraoui a, S. Guessasma b, K. Tahar Chaouch [18] found that Microhardness and tensile test results show that the weld resistance is important and highly correlated to the value of the process parameters especially the applied load.

M.Vural, A. Akkus, B. Eryurek [19] investigated that the endurance limit of the similar steel sheet combination is higher than that of different steel sheet combinations which occurs due to heat unbalance between the steel sheets during spot welding operations of steel sheets having different material properties especially electrical resistance.

B.H. Chang, Y. Zhou [20] concluded that the figured results demonstrate that expanding anode power will build the contact sweep at the Contact interfaces and diminishing the welding current thickness, and henceforth defer chunk start and development. Expanding terminal compel additionally diminishes the cooling rate at the chunk focus after the welding current is killed.

Min Jou [21] investigated that it explores the phenomena of how changes of percent heat input affect the electrode displacement curve. Developing control methods by compensation for the process variations and errors arising from these sources.

III. METHODOLOGY

A) Define Phase Overview

The primary aim of this phase is to identify, within each sub-process, the possibilities for defects or weld quality problems which can be arrived at through the use of different statistical tools. Whatever forms a quality problem takes – the taguchi methodology is used to translate it into measurable form.

Define the problem

Developing a good problem statement helps to study the right variables. Each air filter has 6 spot welds on its periphery for

outcome of strengthening of air filter during its utilization. Due to more numbers of spot welds are to be made on air filter periphery, resistance spot welding machine is used. Resistance Spot Welding is carried out on Cold Reduced Low Carbon Steel sheets Grade D - two sheet of 0.4mm without galvanization. The material specification of given air filter is shown in Table 1.

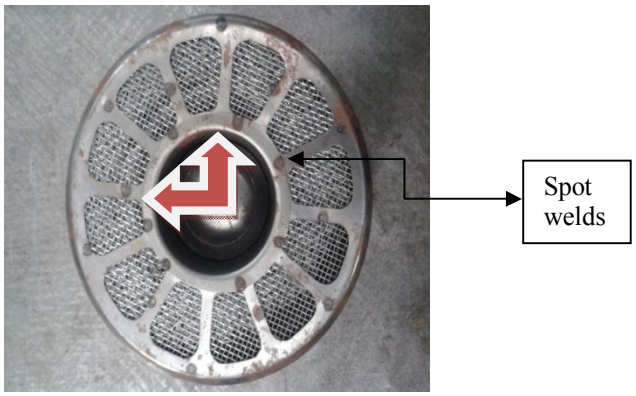

Fig. 1. Air Filter - work piece

Table 1. Work piece material specification

Sr. No.	Work piece material specification	
1	Material	Cold Reduced Low Carbon Steel
2	Grade	D
3	Hardness Number	65 HRB
4	Thickness of sheet	0.4 mm(non Galvanized)
5	Chemical Composition	C – 0.12% Mn – 0.50% S – 0.035% P – 0.040%

Activities carried out for defining the problem

(1) Brainstorming is a technique used to gather multiple ideas about the given problem. These ideas may primarily be concerned with diagnosing the causes of given problem and/or ways of tackling it. Every member involved in problem gets a turn to suggest his idea.
(2) Voice of Customer is taken into consideration by rejection level.
(3) Major noticeable defect is separation of weld joints from air filter due to low tensile weld strength.

Problem Definition

"Resistance Spot Weld Tensile Strength is required to be increased for reduction in current rejection level."

Preparation of Test Specimen for Ultrasonic testing and Tensile Testing.

For preparation of test specimen, the resistance spot welding machine VS-10 model is used.
The test specimen size such as length, width and overlap is mentioned in Table 2.

Table 2. Test Specimen Size

Sr.No.	Parameter	Size (mm)
1	Length	76
2	Width	19
3	Overlap	19

Based on this size herein we have taken into consideration the Welding Current and Cycle time value using L_9 array as shown in Table 3.

Table 3. Welding Current and Weld Cycle Time value for Test Specimen

Sr.No.	Welding Current(kA)	Weld Cycle Time
Specimen 1	2	18
Specimen 2	2	20
Specimen 3	2	22
Specimen 4	3	18
Specimen 5	3	20
Specimen 6	3	22
Specimen 7	4	18
Specimen 8	4	20
Specimen 9	4	22

Now, test specimens are prepared as per table 3 and their image is shown in Fig. 2 as below.

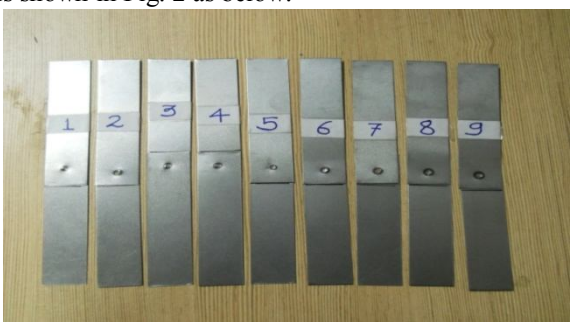

Fig. 2. Test Specimen after spot welding for Ultrasonic and Tensile Testing

Electrode and Facts about its effect on Weld Quality

This is the effective factor on weld quality. The functions of the electrode are mentioned below:

1. It is used to conduct the welding current to the work pieces.
2. It is used for withstanding and transmitting the necessary force to the work pieces to produce satisfactory weld.
3. It is used for dissipating a part of the heat from the work and thus prevents surface fusion.

Ultrasonic Testing of test specimens

After preparation of the test specimens, they are inspected with non-destructive testing known as ultrasonic testing.

Einstein – II TFT Ultrasonic Flaw detector machine is used for carrying out the test is as shown in Fig.3.

Fig. 3. Einstein – II TFT Ultrasonic Flaw detector machine

Each specimen is assessed by using this machine. The test results are shown in Table 4.

Table 4. Ultrasonic test results for test specimens

Sr. No.	Specimen	Nugget Diameter (mm)	Internal Defect
1	Specimen 1	2.25	NIL
2	Specimen 2	2.00	NIL
3	Specimen 3	3.00	NIL
4	Specimen 4	2.50	NIL
5	Specimen 5	2.10	NIL
6	Specimen 6	2.00	NIL
7	Specimen 7	2.25	NIL
8	Specimen 8	2.15	NIL
9	Specimen 9	2.50	NIL

Tensile Testing of test specimens

After completion of ultrasonic testing, there is another test known as a tensile test is carried out on the test specimens. The Universal Testing Machine used for tensile testing is shown in Fig.4.

Fig. 4. Universal Testing Machine

After testing the test specimens are failed at a particular tensile strength in N/mm^2 and their image is shown in Fig.5.

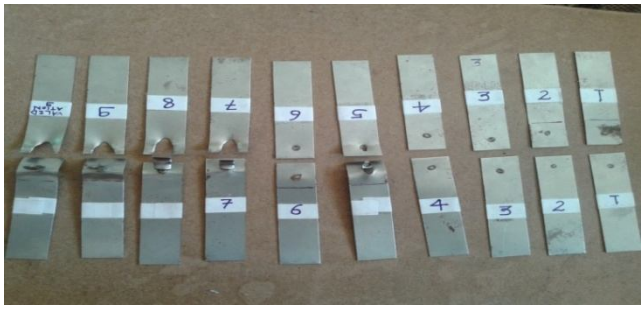

Fig. 5. Specimen failure after Tensile Testing

The results which we obtained of tensile testing of the test specimens are used for finding out the optimum value of the welding current and cycle time to optimize the weld tensile strength and reducing the current rejection level. The result related to tensile testing for specimens are shown in Table 5.

Table 5. Tensile test results for test specimens

Sr. No.	Specimen	Tensile Strength (N/mm^2)
1	Specimen 1	140.845
2	Specimen 2	130.531
3	Specimen 3	84.889
4	Specimen 4	154.849
5	Specimen 5	340.745
6	Specimen 6	286.532
7	Specimen 7	347.082
8	Specimen 8	374.655
9	Specimen 9	297.473

Taguchi method is used for finding out the optimum value of welding current and weld cycle time for improving weld tensile strength.

Taguchi method application for problem

For this phase statistical software is used for creating and analysing the Taguchi design and its analysis.

(1) Then after we can get Main effect plots for S/N ratio – Tensile Strength which is shown in Fig.6 and Response Table for Signal to Noise Ratios- Tensile Strength which is shown in Table 6.

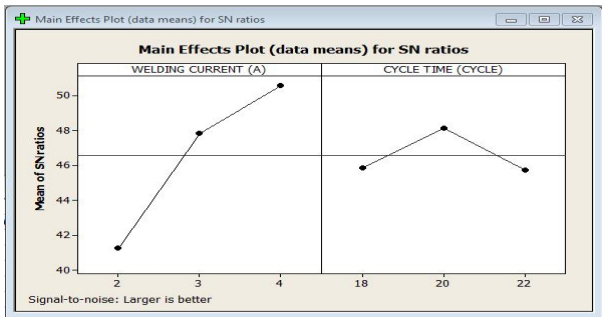

Fig. 6. Main effect plots for S/N ratio – Tensile Strength

Table 6. Response Table for Signal to Noise Ratios – Tensile Strength

Level	Welding Current(Ampere)	Cycle Time(Cycle)
1	41.29	45.86
2	47.86	48.15
3	50.58	45.73
Delta	09.29	02.42
Rank	1	2

From this plot of Fig. 6 and response Table 6, we can conclude that welding current with 4kA and cycle time of 20 gives us a high signal to noise ratio. Welding current is highly effective as compared to the Weld Cycle Time.

(2)Then after we can get the Main effect plots for Mean – Tensile Strength which is shown in Fig.7 and Response Table for Means – Tensile Strength is shown in Table 7.

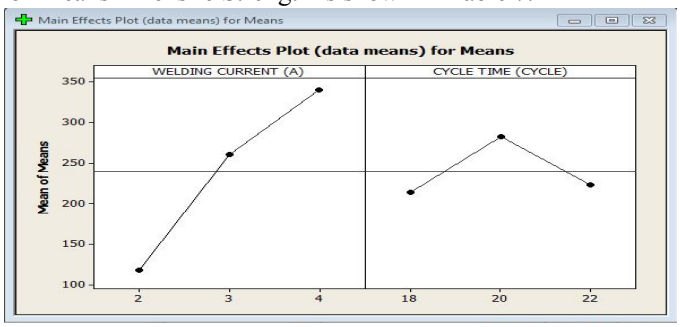

Fig. 7. Main effect plots for Mean – Tensile Strength

Table 7. Response Table for Means – Tensile Strength

Level	Welding Current(ampere)	Cycle Time(Cycle)
1	118.8	214.3
2	260.7	282.0
3	339.7	223.0
Delta	221.0	067.7
Rank	1	2

From this plot of Fig. 7 and response Table 7, we can conclude that welding current with 4kA and cycle time of 20 gives us a high mean of means. Welding current is highly effective as compared to the Weld Cycle Time.

(3)Interaction plot for S/N ratio – Tensile Strength is shown in Fig.8 and interaction plot for Means – Tensile Strength is shown in Fig.9.

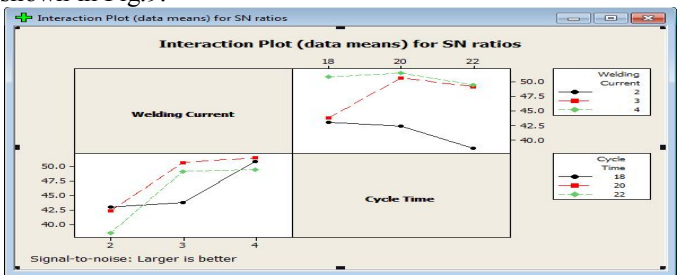

Fig. 8. Interaction plot for S/N ratio – Tensile Strength

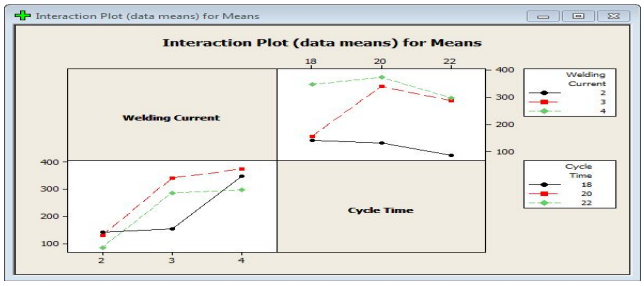

Fig. 9. Interaction plot for Means – Tensile Strength

ANOVA for problem

ANOVA is carried out for finding out the highly effective factor as shown in Table 8. It is found that welding current is highly effective.

Table 8. ANOVA results

Source	DF	SS	MS	F
Welding Current	2	75229.2	37614.6	10.05
Cycle Time	2	8144.0	4072.0	01.09
Error	4	14967.9	3742.0	
Total	8	98341.1		

The data is applied for the month of April-2015. Then improvement in the result is compared with previous month of March- 2015. There is an improvement in the process output which is shown in Table 9.

Table 9. Process improvement and result

Parameters	Before	After	Improvement
Welding Current (kA)	3	4	Optimized Current
Cycle Time	22	20	Optimized Cycle Time
Nugget Diameter(mm)	2.00	2.15	Optimized Nugget Diameter
Tensile Strength(N/mm^2)	286.532	374.655	168.21
Internal Defect	NIL	NIL	Assurance of No Internal Defect
Rejection	4 out of 29 Air Filter (May'15)	2 out of 25 Air Filter (May '15)	Reduced Rejection
Rejection Cost(Rs.)	2200	1100	1100
Rejection Cost (%)	13.79 (June 15)	8.00 (June 15)	5.79

B) Results and Discussion

By implementation of Taguchi method, it is possible to arrive at a solution. The improvements are,

1) The trial results demonstrate that the right areas of the data parameters are: High Welding Current and Medium Cycle Time.
2) The commitment of welding current and process duration towards elasticity is *76.49%* and *8.28%* individually as controlled by the ANOVA method.
3) There is an optimization of welding current and weld cycle time for optimization of spot weld tensile strength. The value for welding current 4 kA and weld cycle time 20, there is an optimized spot weld tensile strength of 374.655N/mm^2.
4) The nugget diameter is optimized of 3.630 mm diameter.
5) There is an assurance of no internal defect.
6) There is a reduction of rejection of Air Filter from 4 out of 29 (February 2015) to 2 out of 25(March 2015)
7) There is a reduction of rejection of 13.79% to 8.00%. So, there is an improvement of 5.79%.

IV. CONCLUSION

By application of Taguchi method it is possible to reduce rejection level of Air filter and it is found that welding current is highly effective.

REFERENCES

[1] Manjunath R. Rawal1, Dr. K. H. Inamdar (2014), " Application of Taguchi Method for Resistance Spot Welding of Stainless Steel-304 Grade". International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064

[2] K. Pandey, M. I. Khan, K. M. Moeed (2013), " Optimization of Resistance Spot Welding Parameters using Taguchi Method" International Journal of Engineering Science and Technology (IJEST) ISSN : 0975-5462

[3] R. Neugebauer, T. Wiener, A. Zosch(2013) ,"Quality control of resistance spot welding of high strength steels", Procedia CIRP 12(2013)139-144

[4] Kamble Vijay Ananda(2013), " Analysis of effect of Process Parameters on Resistance Spot Welding shear strength" international journal of scientific research(ijsr) ISSN NO. 2277-8179

[5] D.S.Sahota, Ramandeep Singh, Rajesh Sharma, Harpreet Singh(2013), "Study of effects of parameters on resistance spot weld of ASS316 material" Mechanica Confab ISSN No. 2320-2491

[6] Mr. Niranjan Kumar Singh, Dr.Y.Vijaykumar(2012), "Application of Taguchi method for optimization of resistance spot welding of austenitic stainless steel AISI 301L"Innovation Systems Design and Engineering ISSN No. 2222-2871

[7] Norasiah Muhammad, Yupiter HP Manurung,et.al(2012), "A Quality Improvement Approach for Resistance Spot Welding using Multi-objective Taguchi Method and Response Surface Methodology" International Journal on Advanced Science Engineering information Technology, ISSN No. 2088-5334

[8] A.G.Thakur et.al(2012), "Application of Taguchi Method to Determine Resistance Spot Welding condition of austenitic stainless steel AISI 304", Journal of Scientific and Industrial Research, PP: 680-683.

[9] M. Pouranvari(2011), "Effect of Welding Current on the Mechanical Response of Resistance Spot Welds of Unequal Thickness Steel Sheets in Tensile-Shear Loading Condition" International Journal Of Multidisciplinary Sciences And Engineering, ISSN No. 2045-7057

[10] A.M. Pereira a, J.M. Ferreira b, A. Loureiro b, J.D.M. Costa b, P.J. Bártolo(2010), " Effect of process parameters on the strength of resistance spot welds in 6082-T6 aluminium alloy" Elsevier, Materials and Design 31 (2010) 2454–2463

[11] Oscar Martin, Pilar De Tiedra, Manuel San-Juan, Cristina Garcia, Fernando Martin(2009), "Quality prediction of resistance spot welding joints of 304 austenitic stainless steel", Materials and Design 30(2009)68-77

[12] Feramuz Karci, Ramazan Kacar, Suleyman Gunduz(2009), "The effect of process parameters on the properties of spot welded cold deformed AISI304 grade austenitic stainless steel",Journal of Materials Processing Technology 209(2009)4011-4019

[13] Dursun Ozyurek(2008), "An effect of weld current and weld atmosphere on the resistance spot weldability of 304L austenitic stainless steel", Materials and Design 29(2008) 597-603

[14] S.Aslanlar, A.Ogur, U.Ozsarac, E.Ilhan(2008), "Welding time effect on mechanical properties of automotive sheets in electrical resistance spot welding",Materials and Design 1427-1431

[15] Ugur Esme(2008) "Application of Taguchi method for the optimization of resistance spot welding process" The Arabian Journal for Science and Engineering.Volume 34.Number 2B.October 2009.519-528

[16] Ambroziak, M. Korzeniowski(2007), "using Resistance Spot Welding For Joining Aluminium Elements In Automotive Industry", archives Of Civil And Mechanical Engineering, wrocław University Of Technology, Łukasiewicza 5, 50-371

[17] Nizamettin Kahraman(2007), " The influence of welding parameters on the joint strength of resistance spot-welded titanium sheets" Elsevier, Materials and Design 420–427

[18] B. Bouyousfi a, T. Sahraoui a, S. Guessasma b, K. Tahar Chaouch(2007), " Effect of process parameters on the physical characteristics of spot weld joints" Elsevier, Materials and Design 28 (2007) 414–419

[19] M.Vural, A. Akkus, B. Eryurek(2006), "Effect of welding nugget diameter on the fatigue strength of th resistance spot welded joints of different steel sheets", Journal of Materials Processing Technology 176(2006)127-132

[20] B.H. Chang, Y. Zhou(2003), "Numerical study on the effect of electrode force in small-scale resistance spot welding" Journal of Materials Processing Technology 139 (2003) 635–641

[21] Min Jou(2003), "Real time monitoring weld quality of resistance spot welding for the fabrication of sheet metal assemblies", Journal of Materials Processing Technology ISSN No. 102-113.

[22] M. ZHOU, S. J. HU AND H. ZHANG (1999), "Critical Specimen Sizes for Tensile-Shear Testing of Steel Sheets", Welding Research Supplement | 305-s.