APPLICATION OF SPOT WELDING UNDER CONDITIONS OF SOUTHEAST ASIA

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Abstract. Effect determination of environmental influences on mechanical properties of spot welded bonds is necessary owing to export activities of particular companies. The experimental determination of the climatic and geographic different environment influence on the strength characteristics was the aim of the laboratory testing. Considering the globalized society and the export possibilities the knowledge of the experimental study will be used for further testing. The test results did not confirm the substantial influence of different climatic and geographic conditions on the spot welding strength. The welded bond was always failed in the interface of the heat affected zone and the bonded material. Corrosion of bonded materials is a significant factor of the welded bond strength.

Keywords: bonding, degradation, globalization, testing.

Introduction

A common attribute of production companies is a requirement for a bond creation. Also unremitting innovations and searching for new prospective technologies which enable the production process are connected with it [1-4]. A choice of a suitable bonding method is one of the basic steps which are needed for ensuring competitiveness. It is possible to characterize three basic ways of bonding – mechanical, heat and chemical one. When applying a particular bonding technology knowledge of technologic principles which influence qualitative features of the final bond is important. When deciding about the bond type advantages and the limits of the applied technologies comparing with other ways of bonding have to be taken into regard.

A prospective method of metal materials bonding is spot welding. The bonding method "Clinching" can be classified among significant other methods. This method used shaping for the bond creation. It serves for bonding of materials using one or multi-degree production process. This principle can be characterized by transfer of the material combined with a local cut or a plastic deformation and subsequent cold pressing [2-4].

The method Clinching becomes an alternative to the traditional spot welding, namely due to an increasing usage of alternative materials which can be with difficulty or cannot be welded [4]. Prospectively, the production technology does not allow to heat-affect an area. A limit is bonding of plates of a thickness 0.5 to 3 mm during which relatively high local plastic deformation occurs. This fact has to be accepted and only materials with sufficient ductility have to be bonded [2]. Abe et al. performed a research of the Clinching method and they revealed that thickness of the bonded layer can be increased depending on a modification of application tongs and shapes of pressing punch [3; 5; 6].

Another significant group of bonding different materials is an adhesive bonding technology. Its application has become more significant recently. The adhesive bonding technology usage considerably increases and it is used in a number of industrial branches. Its significance as the bonding technology is increasing owing to a number of advantages comparing with other bonding methods [7]. However, it is influenced by many factors which have a considerable significance from the bond strength and service life point of view.

Also combined bonds occur in technical practice, e.q., welding and adhesive bonding. Al Samhan a Darwish dealt with a prediction of the strength of welded/adhesive bonded bonds [6]. Their work presents results synergically combining properties of the adhesive bonded layer and the welded bond.

The production of bonds by the spot welding technology belongs among simple that means technologically less demanding. The spot welding belongs among resistance welding that means a metallurgical bond is created.

All above stated possibilities of bonding depend on the factors of the environment [8-10]. Importance of regarding various climatic conditions is visible from the experiment performed by Müller et al. who judged the environment effects on the strength of the adhesive bonds exposed to this environment for 8 months [7; 11]. These effects were mostly negative. Effect determination of

environmental influences on the mechanical properties of spot welded bonds is necessary owing to export activities of particular companies.

The experimental determination of the climatic and geographic different environment influence on the strength characteristics was the aim of the laboratory testing. Considering the globalized society and the export possibilities the knowledge of the experimental study will be used for further testing.

Materials and methods

Test samples made from the constructional steel S235J0 were used for the experimental research. The sizes of the test sample which was welded were 1x15x100 mm. The surface of test samples was treated by grit blasting by corundum of a fraction size F80. Mechanical treatment of the surface belongs among significant factors. Many authors deal with research of the surface treatments [12; 13].

Resistance electrode holder BV2 5 21, was used for the spot welding, maximum welding current 6.4 kA, maximum force among electrodes is 2 kN. It is declared a nugget of a size 3 to 3.5 mm. The soft spot welding mode, (that means low currents and long welding time intervals) was used at the samples production.

The principle of the bond rise is the following:

- Mechanical treatment of the surface,
- Setting of parameters on a regulator that means the welding time 0.2 s for materials of the thickness 1 + 1 mm (Fig. 1),
- Putting welded materials (overlapped) among welding electrodes (Fig. 2),
- Pressing of welding electrodes – transit of the electric current for the stated time.

Fig. 1. **Regulator of resistance electrode holder – soft mode**

Fig. 2. **Welding of steel test samples**

The created overlapped bonds were placed in laboratory and outside (Europe, Indonesia). The operating conditions and degradation processes influence were examined in Central Europe, Indonesia and laboratory (comparing etalon) during 2, 4 and 6 months. After passing the time exposition to which the welded overlapped bonds were exposed these bonds were closed into vacuum packing. In case of the samples in Indonesia these samples were brought back to Europe after passing the last time interval. Consequently, destructive testing was performed.

Destructive testing means that tensile shear strength was performed on a universal testing machine LABTest 5.50ST (sensing unit AST type KAF 50 kN, evaluating software Test&Motion). The speed of the deformation corresponded to 6 $mm \cdot min^{-1}$. The destructive testing is visible in Fig. 3. An evaluating criterion was the set loading force (N) and the type of the weld failure. The size of the nugget was evaluated on the basis of a picture analysis (Fig. 4).

Microhardness HV0.2 was measured in a cut of the destroyed bond. Places of the microhardness measuring are visible from Fig. 5.

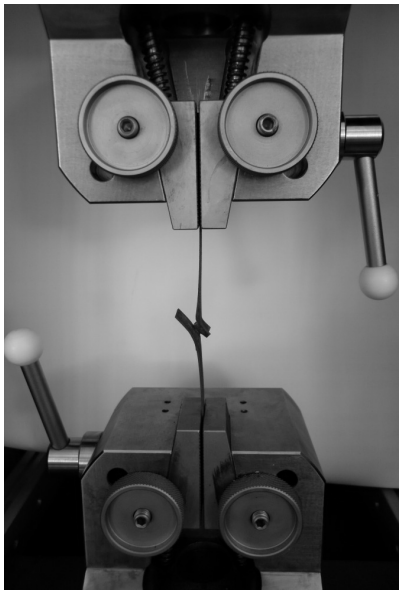

Fig. 3. **Destructive testing of test samples**

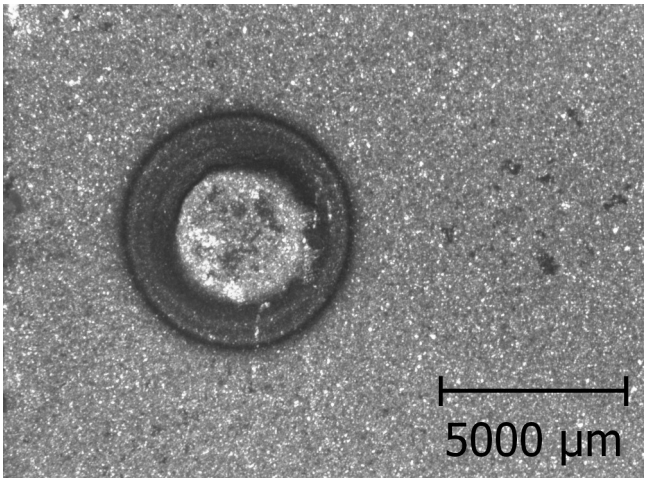

Fig. 4. **Weld bond – heat affected zone**

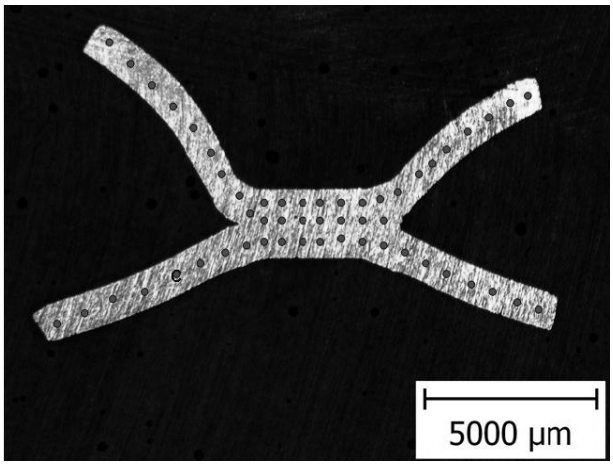

Fig. 5. **Scheme of places of microhardness HV0.2 measuring in cut of destroyed bond**

Results and discussion

The soft spot welding mode is distinguished for higher heat affecting of welded materials. This fact was certified at measuring of the microhardness HV 0.2. The nugget reached 379±41 HV0.2, the primary phase of the heat affected zone reached the value 228±20 HV0.2. The hardness of the basic material was 176±11 HV0.2. The average value of the nugget was 3.57±0.09 mm. The heat affected zone around the nugget was measured as 0.98±0.29 mm.

Graphical presentation of the results of the spot bonds strength was performed by means of ANOVA by the least squares methods (Fig.6). The results present an arithmetical mean of the data ascertained in the reliability interval α 0,05. The Tukey's HSD test was used for the statistical comparison of the mean value. It is possible to say on the basis of the results of the Tukey's HSD test that they are statistically non-homogeneous groups (Table 1).

The test results did not confirm the substantial influence of different climatic and geographic conditions on the spot welding strength.

The bond failure occurred always in the interface of the nugget and bonded materials (Fig. 7). Corrosion of bonded material is a significant factor of the welded bond strength.

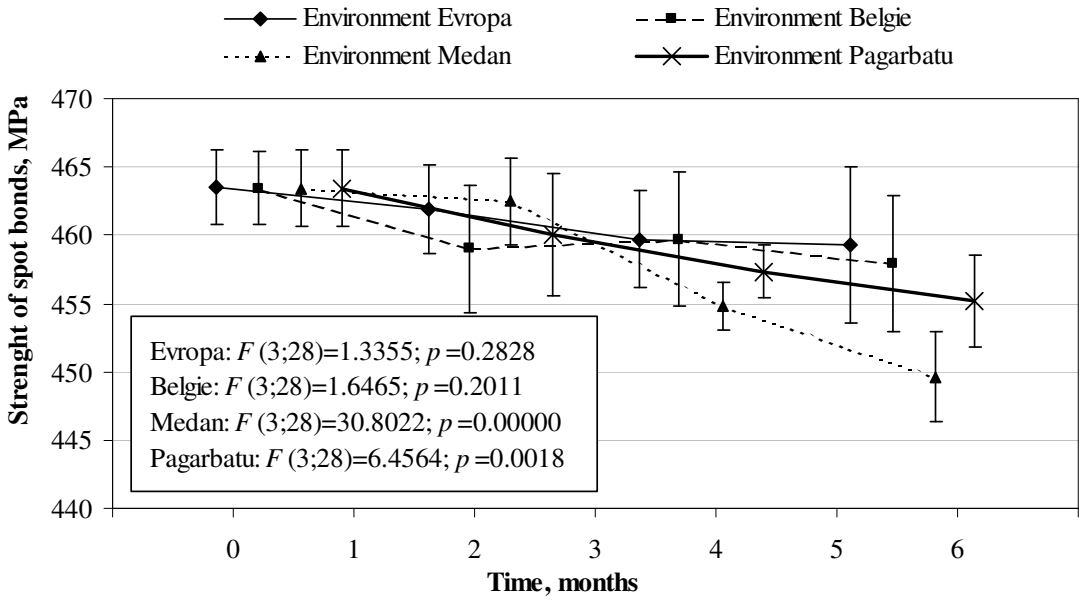

Fig. 6. **Influence of time and environment on strength of spot bonds**

Table 1

Statistical comparison of mean values – Tukey's HSD test

Time, months	Destination	Arithmetical mean, MPa	Agreement		
			1	2	3
6	Medan	449.66±3.69	*		
4	Medan	454.91±1.83	*	*	
6	Pagarbatu	455.28±3.71	*	*	
4	Pagarbatu	457.41±2.23		*	*
6	Balige	458.03±5.60		*	*
2	Balige	459.16±5.07		*	*
6	Europe	459.41±6.44		*	*
4	Europe	459.78±4.00		*	*
4	Balige	459.78±5.47		*	*
2	Pagarbatu	460.03±5.16		*	*
2	Europe	462.03±3.53		*	*
2	Medan	462.53±3.60		*	*
0	Etalon	463.53±3.07			*

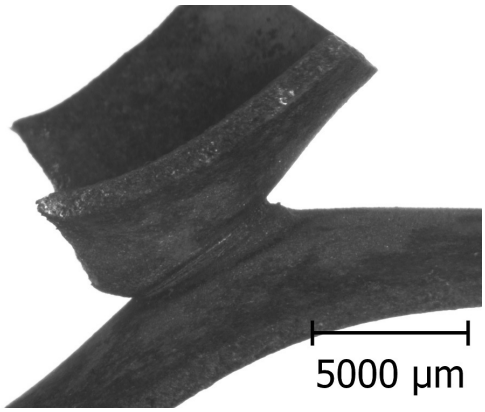

Fig. 7. **Destruction of weld bond – Medan, 2 months**

Conclusions

The following conclusions can be concluded from the performed experiments:

1. The test results did not confirm substantial influence of different climatic and geographic conditions on the spot welding strength.
2. The welded bond was always failed in the interface of the nugget and the bonded material.
3. The strength of the weld bonds ranged in the interval 465 to 450 MPa.
4. It is possible to say from the results of the Tukey's HSD test that they are statistically non-homogeneous groups. There is no difference between Europe and particular regions of Indonesia from the statistical comparison except for the time interval 6 months in the region Medan (elevation 0 m, average day temperature 31 °C, relative humidity 90 %) and Pagarbatu (elevation 1350 m, average day temperature 25 °C, relative humidity 90 %). Lower values of the relative humidity are in the region Balige.
5. Corrosion of bonded material is a significant factor of the welded bond strength.

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References

1. Lancaster, J. F. (2001). Metallurgy of welding. Cambrige: Abington Publishing. 446 p.
2. Bellhoff, [online]. 2010, [2011-26-08]. Available at: http://www.boellhoff.com/en/in/assembly_systems/rivclinch_clinching.php
3. Abe, Y., et al. (2009). Joining of hot-dip coated steel sheets by mechanical clinching. International Journal Material Form, 2. pp. 291-294.
4. Mucha, J., Kaščák, L., SPIŠÁK, E. (2011). Joining the car-body sheets using clinching process with various thickness and mechanical property arrangements. Archives of civil and mechanical engineering. vol. XI., No. 1, 13 p.
5. Mucha, J. (2011). The analysis of rectangular clinching joint in the shearing test. Maintenance and Reliability, 3, pp. 45-50.
6. Al-Samhan, A., Darwish, S.M.H. (2003). Strength prediction of weld-bonded joints. International Journal of Adhesion and Adhesives, 23. pp. 23-28.
7. Muller, M., Herak, D. Application possibilities of adhesive bonds – Europe, Indonesia. *Scientia Agriculturae Bohemica,* 2013, vol. 44, no. 3, pp. 167-171.
8. Muller, M., Valasek, P. Degradation medium of agrokomplex - adhesive bonded joints interaction. *Research in Agricultural Engineering,* 2012, vol. 58, no. 3, pp. 83-91.
9. Muller, M., Valasek, P. Assessment of bonding quality for several commercially available adhesives . *Agronomy Research,* 2013, vol. 11, no. 1, pp. 155-162.
10. Muller, M. Research of liquid contaminants influence on adhesive bond strength applied in agricultural machine construction. *Agronomy Research,* 2013, vol. 11, no. 1, pp. 147-154.
11. Muller, M., Herak, D., Valasek, P. Degradation limits of bonding technology depending on destinations Herak, Indonesia. *Tehnicki Vjesnik-Technical Gazette,* 2013, vol. 20, no. 4, pp. 571-575.
12. Novák, M. Surfaces with high precision of roughness after grinding. *Manufacturing technology,* 2012, vol. 12, no.12, pp. 66 -70.
13. Novák, Martin. Surface quality of hardened steels after grinding. *Manufacturing technology,* 2011, vol. 11, no. 11, pp. 55 -59.