Analysis of Resistance Spot Welding (RSW) on 22MnB5 material after hot stamping for automotive applications (B-pillar).

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ABSTRACT

One of the major concerns that arose in recent years within the automotive industry has been making cars sustainable, safe and economic. One of the ways to solve this equation is to use lighter materials that reduce the weight of vehicles and increase the energy absorption mainly on the B-pillar. This paper aims to study the RSW cycle of the welding parameter known as P1. The parameter were defined to reach the maximum load during the tensile test according to the norm AWS D8.9. The test samples were assembled with a GAP to reproduce real vehicle welding conditions, and the parameter P1 weld 22MnB5 steel samples with heat treatment, known as Press Hardening Steel (PHS). The influence of these parameters on the PHS mechanical properties was evaluated with Vickers hardness test (HV), metallographic technique, conducting ultrasonic and tensile test. The results confirmed the difference at the Heat affected zone (HAZ) mechanical strength over fusion zone. It was possible to visualize a softening region in the HAZ and increasing to the weld point, which is demonstrated in the microstructural analysis and thus justifies the detachment of the weld button of the base material in tensile test. Keywords: PHS, HAZ, RSW.

RESUMO

Uma das principais preocupações que surgiram nos últimos anos na indústria automotiva foi tornar os carros sustentáveis, seguros e econômicos. Uma das maneiras de resolver essa equação é usar materiais mais leves que reduzam o peso dos veículos e aumentam a absorção de energia principalmente no pilar B. Este artigo tem como objetivo estudar o ciclo RSW do parâmetro de soldagem conhecido como P1. Os parâmetros foram definidos para atingir a carga máxima durante o teste de tração de acordo com a norma AWS D8.9. As amostras foram montadas com um GAP para reproduzir as condições reais de soldagem do veículo, e o parâmetro P1 soldou amostras de aço 22MnB5 com tratamento térmico, conhecido como Press Hardening Steel (PHS). A influência desses parâmetros nas propriedades mecânicas do PHS foi avaliada com o teste de dureza Vickers (HV), técnica metalográfica, realização de ensaios ultrassônicos e de tração. Os resultados confirmaram a diferença na resistência mecânica da zona afetada pelo calor (HAZ) sobre a zona de fusão. Foi possível visualizar uma região de amolecimento na ZAC e aumentar até o ponto de solda, o que é demonstrado na análise microestrutural e, assim, justifica o desprendimento do botão de solda do material de base no teste de tração. Palavras-chave: PHS, HAZ, RSW.

1. INTRODUCTION

When the vehicles appeared, they had no doors, hoods, headlights and bumpers. The changes started when it was necessary to protect the occupants from rain, wind, the sun and especially other cars. Safety has become more than a necessity, it has become a priority. Over the years, one of the major concerns that emerged was to make cars more economical, sustainable and safe. Thus, the automobile industry seeks new technologies and new materials to present in its launches [1].

One of the options used to reduce the weight of vehicles is to reduce the weld points on the body. The welding technique is used on a large scale in industries in general, and is highly important in the final composition of the cost of manufacturing a product [2].

The spot welding technique is a process in which the surfaces of the plates in question are joined by means of one or more points on which the heat and pressure efforts are applied. The spot welding process, although relatively old and well studied, has recently ensured a new line of research for the use of hot stamped materials [3].

Hot stamping has achieved success in the manufacture of parts with complex shapes, greater mechanical resistance and less weight. The main advantage of Press Hardening Steel (PHS) is its ability to conform to complex geometries, eliminate the need to include reinforcements, resist impact and its reduced weight [4]. Due to these special characteristics, it is important to establish a line of study for this material, since it presents numerous chances to improve the quality of vehicle safety [5].

Thus, the objective of this study is to evaluate the characteristics of the spot weld in PHS. Identify possible problems that may occur in this process and demonstrate the viability of this technique.

2. MATERIALS AND METHODS

The material used for making the specimens in this experiment, were PHS steel sheets of chemical composition 22MnB5, hot stamped, for the purpose of building components for the automobile industry, more specifically pillar B. In this work, 20 samples of hot stamped PHS were used. The dimensions were 123 x 29mm and thickness of 1.30. After the welding process in table 1 are described the parameters used for P1. The welding parameters were previously tested in order to achieve full nugget detachment.

Table 1: Parameters of resistance spot welding.

Welding parameters	**Unit**	**P1**
Pre burn current	A	5
Pre burn time	ms	60
Welduz current	A	9
Welduz time	ms	200
Pulse	-	2
Post heat treatment current	A	6
Post heat treatment time	ms	80
Hold time	ms	200

Source: Author.

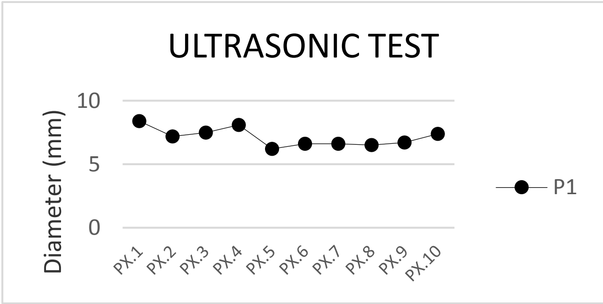
The parameter were defined to reach the maximum load during the tensile test according to the norm AWS D8.9 [6]. The test samples were assembled with a GAP to reproduce real vehicle welding conditions. The influence of these parameters on the PHS mechanical properties was evaluated with Vickers hardness test (HV), metallographic technique, conducting ultrasonic and tensile test.

3. RESULTS AND DISCUSSION

3.1. Spot welding ultrasonic analysis

From the analysis in Figure 1 which presents the diameters obtained through ultrasonic test, it is possible to identify the minimum and maximum values, noting that the smaller diameters were obtained in the weld P1.5.

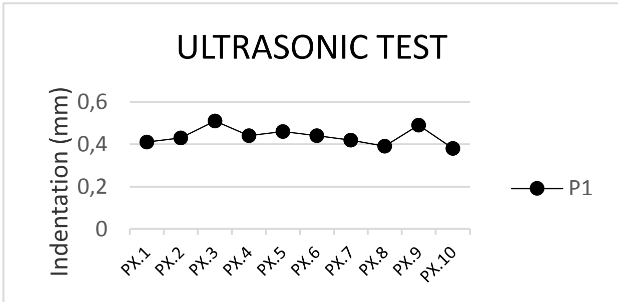
Figure 1: Diameter obtained through ultrasonic test.



Source: Author.

Figure 2 presents the values of indention, obtained by ultrasonic test for P1. The results of indentation over 30% are not acceptable according to the AWS standard [6]. However, the tensile tests results were acceptable with no partial fracture.

Figure 2: Indentation obtained though ultrasonic test.



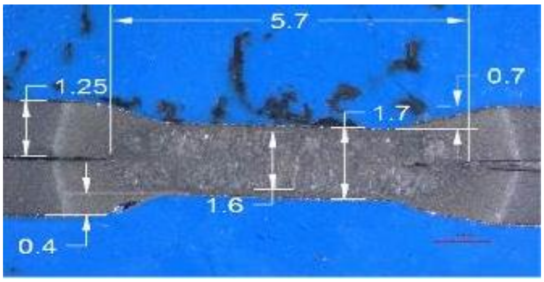
Source: Author.

After the ultrasound tests, the specimen P1.5, which obtained the smallest diameter, was selected to perform the tensile tests, hardness and metallography.

3.2. Comparisons of measurements made using ultrasonic and macrography.

Based on the macrographic analysis, it was possible to identify the base metal thickness, indentation, weld diameter and weld thickness, as shown in figure 3.

Figure 3: Measurements obtained through macrography in sample P1.5.



Source: Author.

Table 2 lists the diameters obtained for the samples through the analysis of ultrasonic and macrography. The sample P1.5 showed variation between the measured diameters of 1 mm.

Table 2: List of values obtained for the diameter through analysis by ultrasonic and macrography.

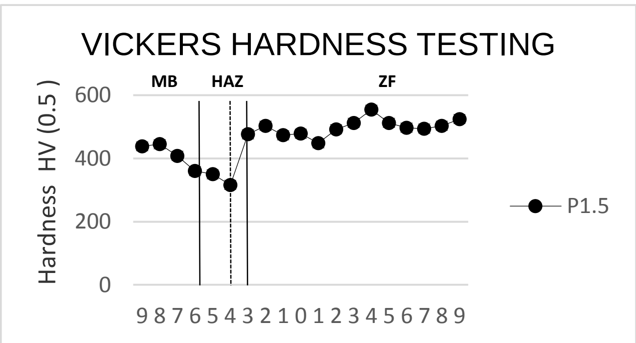
ID. Sample	Diameter US (mm)	Diameter MG (mm)
P1.5	6,20	5,7

Source: Author.

3.3. Analysis of Vickers hardness testing.

Were performed microhardness points 19, maintaining the 0.25 µm distance set out in the standard. For convenience, the measuring point 0 on the x-axis would be the center of the weld point, setting up 9 points to the left and 9 measuring points to the right. In figure 4 you can see that there has been an exponential increase in the hardness from the ZTA, following to the weld point.

Figure 4: Vickers hardness testing, dividing MB (Base metal), HAZ (Heat affected zone) and ZF (Fusion zone).

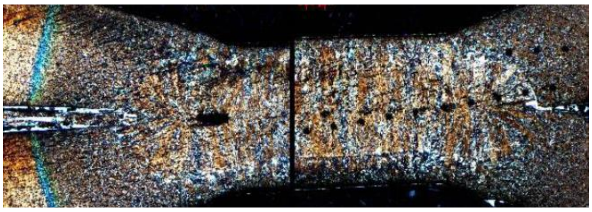


Source: Author.

3.4. Analysis of microstructure tests

To evaluate and identify the homogeneity of the weld point, the ZTA, when compared to the base metal, was used the test of optical microscopy. In Figure 5, it is possible to identify a change in the ZTA, in the sample P1.5, confirming also visually the detachment of weld point on the traction test, and low hardness. The hardness of the fall between the base metal and the ZTA is due to microstructure of ferritic structure array with Bainite, with a training range intermetallic phase result of a slow annealing in the area affecting the welded joint

Figure 5: Optical microscopy of samples P1.5.



Source: Author.

3.5. Determination of resistance through the tensile test.

For the group P1, as table 3, the weaker sample became for the sample P1.1, around 10.7 kN and 8.40 mm diameter. It can be observed that the diameter is not the main reason of tensile strength reduction. The reduction of tensile strength could be related to intermetallic of Al-Si formation at the HAZ area.

Table 3: Maximum load obtained for sample P1.

ID. Sample	Diameter (mm)	Maximum load (N)
P1.1	8.40	10693,30
P1.2	7.20	15691,30
P1.3	7.50	15142,00
P1.4	8.10	14955,20
P1.6	6.60	16853,80
P1.7	6.60	15744,90
P1.8	6.50	14425,90
P1.9	6.70	15262,30
P1.10	7.40	16017,30

Source: Author.

With maximum load values obtained in P1 was checked that all the nuggets of weld presented acceptable results even those that were not approved by AWS, as they are with the percentage of indentation above 30%. The nugget occurred in the trials were equal to that provided for by the standard and showed that the region remain intact and the fracture occurred from a tear strength of the base material started by HAZ (Heat affected zone) [6].

4. CONCLUSION

According to the results obtained in the experiments for this work (Ultrasonic, Tensile Test, Vickers Hardness Testing and Optical Microscopy), it is concluded that it was possible to analyze the resistance difference in HAZ. All samples in the P1 set showed a drop in resistance in the HAZ region. This was due to intermetallic resistance up to the welding point. However, in the traction test, the results were in accordance with the AWS D8.9 standard.

5. REFERENCES

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