23rd ABCM International Congress of Mechanical Engineering
December 6-11, 2015, Rio de Janeiro, RJ, Brazil

ANALYSIS ON THE WELD PROCESS OF THE STEERING COLUMN IN TWO-WHEELERS VEHICLES

Bruno Mello de Freitas
UEA-EST, Av. Darcy Vargas 1200, Parque Dez, Manaus-AM / Brasil CEP 69050-020.
bruno_m_freitas@hotmail.com

Gilberto Garcia Del Pino
UEA-EST, Av. Darcy Vargas 1200, Parque Dez, Manaus-AM / Brasil CEP 69050-020.
ggdelpin@usp.br

Gabriel Federico Rivero LLerena
UEA-EST, Av. Darcy Vargas 1200, Parque Dez, Manaus-AM / Brasil CEP 69050-020.
gaborive@usp.br

Raimundo Nonato Alves da Silva
UEA-EST, Av. Darcy Vargas 1200, Parque Dez, Manaus-AM / Brasil CEP 69050-020.
raimundo.nonato.silva@gmail.com

José Costa de Macêdo Neto
UEA-EST, Av. Darcy Vargas 1200, Parque Dez, Manaus-AM / Brasil CEP 69050-020.
jotacostaneto@gmail.com

Abstract. *In mechanical assembly of two-wheelers, a leading systems seekers effort is the steering column, which provides part in the handling of the motorcycle. The theoretical and experimental approaches, the column weldability parameters are developed and analyzed in the automotive industry for the quantitative determination of weld solidification variables such as current, voltage and bead deposition rate and later, diluting, height, depth and heat affected zone. The paper analyzes the weld bead tensions in relation to external variables that impair its effectiveness. Such parameters suffered induced variations and are compared with other models within its standards and welding specifications provided by the product manufacturer. The experimental results, the mechanical stress of 12 samples are obtained through mechanical tests on 10 samples.*

Keywords: *Welding, Weldability, Heat Affected Zone, Tensile test.*

1. INTRODUCTION

The two-wheeler industries are installed in the Manaus Industrial Pole (PIM), this is the largest in Latin America, both in terms of number of companies and in terms of production. Currently, the sector has the highest production chain density rate of the Manaus Free Trade Zone, with record levels of regionalization and nationalization of inputs. Polo is currently made up of about 70 companies, including manufacturers of finished goods and components, parts and accessories (Suframa, 2015a).

According to Gallo data (2015), the two-wheeler is the third sector with the highest sales at the PIM, totaling R$ 13.6 billion (US$ 5.8 billion) in revenue in 2014, representing 15.71% of total revenue of PIM in the same year. Still, according to data for the year 2014 released by Suframa quantitatively the two-wheeler sector is the second largest employer at PIM with 17,730 workstations assets, loosing only to the Electronics sector. This amount represents approximately 15.57% workstations assets of PIM in 2014 (Suframa, 2015b).

In the mechanical assembly of two-wheeled vehicles, a major effort applicants system is the steering column, which can be characterized as the set of the tube / column and the lower table, where the set of fixed front suspension forks, known as a buffer. Its main function is to allow the driver of the motorcycle turn the handlebars to the left or right, making it easier directional control and stability when the motorcycle is moving.

According to Groover (2014), the MIG/MAG processes includes three different techniques of metal transfer mode: short arc, spray and globular. These techniques describes the manner in which metal is transferred from the wire to the weld pool. The transfer by short circuit, used in this research, the transfer occurs when an electrical short circuit is established. This happens when the molten metal at the tip of the wire touch the weld pool.

For the manufacture mentioned before, the tree of the steering column must pass a welding process MIG / MAG (ig: MIG - Metal Inert Gas and MAG - Metal Active Gas) with tubular a wire, so it can be permanently attached the lower table, thus forming the steering column itself. According to Ueyama, *et. al*., (2005), MIG / MAG is the most important metal joining processes today, in the welding processes. This is due to its versatility and high production capacity, constantly wanted characteristics by industries in their manufacturing processes.

Easterling (1983), the dilution weld pool area between the base metal and the weld metal is characterized by a high degree of homogeneity, and the mixture is motivated mainly by fusion of the weld pool. This heat in the weld puddle causes changes in the microstructure of metals to be joined (heat affected zone - HAZ) and the addition of metal (fusion-zone ZF). Fleming, (1974); Kou, (2002); Kurz and Fisher (1986), noted that these changes cause therefore disorders in the mechanical properties of welded metals are not always desirable or acceptable, which can occur in the welded joint, an example is mechanical stresses. Most of these changes depends on the reactions occurring during solidification and adding metal cooling.

In a rigorous analysis of both the materials submitted to welding as the welding processes and tensions in the welded joint of the steering column is extremely important because they provide data that can collaborate to prevent the part that will break prematurely during use. Oliveira (2010) describes that changes in values of the mentioned variables, such as current and voltage in the welding process, might lead to changes in the characteristics of the material in the welded area as well as the residual tensile observed in the weld. Another parameter, not least, it must be considered is the deposition rate (speed) of the weld bead.

Antunes (1995) and Zeemann (2015), discloses that can be expected to occur in the sudden expansion of the weld metal and heat affected zone (HAZ). However, due to restrictions of the remaining unheated material such expansion does not occur, producing however a compression and plastic deformation to accommodate localized dilation. When the weld metal starts to cool down and as the weld pool solidifies, begins to occur around an elastic laminated region and the reverse process occurs, generating tensile stresses in the weld.

However, according to Souza, *et. al.* (2013), the metal can only be deformed in higher tension than their yield strength. The maximum value in module that residual stresses can achieve, will be the yield strength of the material. The weldability of the control parameters of the column, therefore, is essential for automotive industries in order to quantitatively determine the weld solidification variables, such as current, voltage, speed, and subsequently diluting, height, depth and heat thermally affected. In the weld strength subjected to external stresses.

Following this context, this research will analyze the mechanical behavior of the weld on the steering column of motorcycles produced in the Industrial Pole of Manaus - PIM, varying the current parameters, voltage and weld deposition rate, thus studying through mechanical testing traction, the tensions present in the arc welding according to the variations of the process.

2. EXPERIMENTAL PROCEDURE

2.1 Materials

The analysis was performed in a metallurgical multinational pioneer in manufacturing of motorcycle steering column produced in the Industrial Pole of Manaus - PIM, among other components for motorcycles.

The steel column SAE 1025 is manufactured seamless cold drawn, cold tip of by Vallourec de Tubos do Brasil S.A. The bottom table (round rolled bar) SAE 1035 is manufactured by forging, the long steel Gerdau Vallourec de Tubos do Brasil S.A. The machine used for welding is pneumatic system, the Masato series 2 manufacturer, model / manufacturer Masato automation LTDA. The tubular wire welding is supply by Belgo Bekaert wires - Arcelo Mittal and has a diameter of 1.2 mm. It is used weld shielding gas Praxair, with a mixture of 2% of carbon dioxide (CO_2) and 98% of argon (Air). The universal testing machine is brand INSTRON model 5582, System ID Number: 5582P6012, Main program: Version 5:31:09 S / N 611238C.

2.2 Methods

Welding was performed in the welding sector, in a multinational industry of the Manaus Industrial Pole (PIM), said tube / column and bottom table, which has resulted in 12 parts called steering column.

According to Wainer (2013), the transfer occurs when a short circuit is established the contact between the molten metal at the tip of the wire and the weld pool. In welding with a short circuit transfer are used in wire diameter of from 0.8 to 1.2 mm range. The tubular wire used has dimensions of 1.2 mm where a pool of melting rapid solidification is obtained.

The nozzle to be used was two sizes that used for steel sheets of the same thickness. The flame was adjusted to neutral or slightly reduced. The tip of the inner cone is kept away from the molten material approximately 6.3 mm to 9 mm, in order to maintain the solder involved in the reducing gases produced by the flame, thus preventing oxidation. The cord was run through the "left" 180° with a deposition rate (speed) of 15 ± 2 (rpm).

The machine parameters, for MIG welding, are in accordance with the welding parameters for the manufacture of the steering column and consistent with parameters established by the industry, which uses the current 230 ± 30 (A) and voltage of 23 ± 3 (V). But for the tests and study effects, variations were analyzed according to the limitations of the machine and the process, in or out the specifications of the welding parameters, as Tab. 1.

After welding were made the tensile tests of the steering column with minimum specification manufacturer of 3,400 kgf. The tensile test was conducted on 10 specimens (part # 1, 2, 3, 6, 7, 8, 9, 10, 11, 12), as shown in Tab. 1, in an universal testing machine, by fixing the lower table in the machine's lower end and pull on the steering column shaft via a claw fixed to the upper end of the machine where is located the load cell.

The values resulting from tests on ten samples were verified by the maximum voltage value (σ) tensile the steering column, in Kgf.

Table 1. Variations of welding parameters of the steering column and identification of the tensile test the parts.

Samples	Current (A) 230±30	Volts (V) 23±3	Speed (rpm) 15±2	Tensile test (Yes/No)
1	250	25	17	Yes
2	220	24	17	Yes
3	220	23	17	Yes
4	220	24	17	Yes
5	220	24	17	No
6	190	18	15	Yes
7	200	20	15	Yes
8	300	16	15	Yes
9	280	15	15	Yes
10	240	14	15	Yes
11	320	14	15	Yes
12	190	25	15	Yes

3. RESULTS AND DISCUSSION

In mechanical assembly, called the steering column, the applicant tractive effort during motorcycle riding suffers a lot of strength in the weld joint, mainly due to uneven ground of the shooting lanes. Following this concept, it performed tensile test after changes in welding parameters (voltage and amperage) of the joint of the steering column, in order to verify the consequences of these parameters can have on the final outcome of the mounted assembly. The results been taken into consideration with the values of the minimum specification of 3,400 kgf of tensile test established by the manufacturer.

All twelve photographs of samples after welding and results of tensile tests performed on ten of the twelve samples are shown in Tab. 2. Test was not performed on the samples # 4 and # 5, because these have suffered the same variation of the parameters sample # 2, then the results will be considered similar.

Samples # 1, # 2 and # 3 was held welding parameters with the specifications established by the manufacturer for the average check of tensile tests, which obtained a mean value of 19,268.8 kgf, a value very significant and above 400% of 3,400 Kgf minimum specification for this assay. The visual aspect of the weld on the three samples obtained no irregularities.

In the sample # 6 study was carried out with the parameters of amperage and voltage below specifications, but the same have got a result in the tensile test above the minimum specification, explained that when both parameters are specified below, the integrity of the part will not be compromised.

Sample # 7 suffered a change in the minimum specifications of amperage and voltage, resulting in a well above specification value and similar to the average found in the samples # 1, # 2 and the result for the tensile test on sample # 8 was not significant, but is above the minimum specification for the test, this sample was carried up amperage and voltage below specifications. Compared to the mean value of 19,268.8 kgf with the result of 5,938.5 kgf, the part is analyzed below the average.

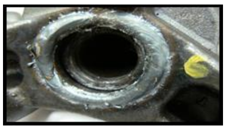
In the sample # 9 the amperage was analyzed 20A and above the 5V voltage below the established specifications. The result of 120.9 kgf above the minimum specification of 3,400 kgf is not significant, especially compared to the average of the first three samples, but due to a safety factor, this sample is considered non-conforming.

The result of the tensile test in the sample # 10 was the only one resulted in a value well below the minimum specification. For this test the only parameter out of specification was the Voltage, with a value of 6V or 30% below the minimum specification for this parameter. Following this result, the sample is non-conforming because it reached a value greater than 50% below the minimum value for tensile. Another relevant factor is the visual aspect of welding, where it has a weld pool not well defined with failures and apparent discontinuity.

The sample # 11 was performed with the amperage (largest Between the tests) well above and below the voltage specifications The result of tensile test is above specification but the value was not significant compared with the average established on the first samples and also with the sample #8 in addition to the visual appearance of solder not be excellent as the samples # 1, # 2, # 3, # 4, # 5 and # 7. Following the same analysis that the sample # 8, the part is non-conforming.

The last sample # 12 was performed with amperage and voltage between 10A below the specification. This sample conforms, as the result of tensile test is above the minimum value and close to the average value found for analysis. And in addition to these factors, there aren't problem with visual aspect.

Table 2. Pictures after welding the steering column and results and their pictures after the tensile test.

Samples	Pictures after welding	Tensile test (Minimum 3,400 kgf)	Pictures after tensile test
#1		17,910.4	
#2		18,438	
#3		21,458	
#4		No	-
#5		No	-
#6		25,990.3	
#7		19,429.4	
#8		5,939.5	
#9		3,520.9	
#10		1,236.1	

Samples	Pictures after welding	Tensile test (Minimum 3,400 kgf)	Pictures after tensile test
#11		4,389.8	
#12		20,953.3	

4. CONCLUSIONS

The welding process in automotive structures requires the use and care of criteria that other parts do not require joining processes. In particular, due to the heating required for the welding is conducted, care is very important to the amperage and voltage parameters, and therefore the strict control of temperature and heat affected zone (HAZ). Due to these uncertainties, greater safety factor should be used than other common applications, where for example the analysis and conclusion performed in samples # 8, # 9 and # 11, where the values although they are above the minimum specified 3,400 kgf, were considered non-conforming.

The dimensions of the welds is made taking into account the shear stress and the area defined by the thickness of the plate. This tension must be compared with the flow resistance limit or tensile depending on the type of failure that you want to avoid. As reported, the study was performed with the data analysis of tensile strength of welded joint according to minimum specification established by the supplier.

It was reported that samples (# 1, # 2, # 3 and # 7), simulated within the established specifications presented above the minimum parameter values for the mechanical tests and are considered approved also the visual aspect, justified by the theoretical foundation that an increase in voltage will provide a broadening and flattening of the weld bead and increase the width of the merger will result in a mechanical strength much higher than specified. Sample #10 was the only data presented below that specified, but due to the play safety factor to be considered a high safety critical level by the supplier, the samples # 8, # 9 and # 11 were also considered failure, because the voltage tends to narrow the lower weld bead and thus a lower mechanical strength as demonstrated in Tab. 2 through the figures and values obtained. A factor that is observed in all these non-conforming samples is that when the machine voltage parameter is specified below, the tensile stress has low values, except for the sample # 6, but justified by the amperage specified below.

According to the tests and analysis, it was found that the main parameter to control is the voltage, which can not have values specified below, with the exception case has also a low amperage because present value close to or below minimum of mechanical tensile value, thus compromising the integrity of the part and the user during the handling of the motorcycle.

5. ACKNOWLEDGEMENTS

The authors wish to thank the University of the State of Amazonas - UEA and metallurgical Multinational company in the Industrial Pole of Manaus - PIM, the infrastructure of support to carry this out.

6. REFERENCES

Antunes, A.E.B., 1995. “Tensões Residuais na Soldagem, Aspectos Básicos”. *Revista Brasileira de Ciências Mecânicas.* Rio de Janeiro, Vol. 17, n. 4, p. 394-403.

Easterling, K.E., 1983. *Introduction to Physical Metallurgy of Welding*. London: Butterworths.

Flemings, M.C., 1974. *Solidification Processing*. New York, McGraw Hill.

Gallo, M., 2014. “PIM fecha 2014 com faturamento de R$ 87,2 bilhões”. 9 Mai. 2015 <http://www.suframa.gov.br/suf_pub_noticias.cfm?id=16896>.

Groover, M.P., 2014. *Introdução aos processos de fabricação*. LTC, Rio de Janeiro, 737p., 1ª edição.

Souza, E.L.C., Garuzzi, J.M., Durão, B.R., 2013. “Influência da soldagem na geração de tensões residuais e distorções em painéis soldados na indústria naval”. 26 Mai. 2015 <http://www.ipen.org.br/downloads/rincon/soldadura.pdf >.

SUFRAMA Invest. “Onde investir: veículos de duas rodas”. 9 Mai. 2015 <http://www.suframa.gov.br/invest/onde-duas-rodas.cfm>.

SUFRAMA-COISE/CGPRO/SAP, 2015. “Indicadores de Desempenho do Polo Industrial de Manaus 2010-2015”. 10 Mai. 2015 <http://www.suframa.gov.br/downloads/download/indicadores/RelIndDes_4_2015_fev.pdf>.

Kou, 2002. *Welding Metallurgy*. John Wiley & Sons, New York, 2ª edição.

Kurz, W., Fisher, D.J., 1986. *Fundamentals of Solidification*. Trans-Tech Publications, Switzerland. 242p.

Oliveira, G.L.G., Silva T.F., Miranda, H.C., Motta, M.F., 2010. "Avaliação do efeito da energia de soldagem sobre as tensões residuais resultantes em juntas soldadas com multipasse". *Soldagem & Inspeção*. Vol. 15, Issue 3, p. 218-224.

Ueyama, T., Tong, H., Harada, S., Passmore, R., Ushio M., 2005. "AC Pulsed GMAW Improves Sheet Metal Joining". *Welding Journal*. Issue 84(2), p. 40-46.

Wainer, E., 2013. *Soldagem: processos e metalurgia*. Blucher, São Paulo, 9ª reimpressão.

Zeemann, A., 2003. "Tensões Residuais de Soldagem - Novo Infosolda". 10 Mai. 2015 <http://www.infosolda.com.br/images/Downloads/Artigos/metal/tenses-residuiais-na-soldagem.pdf>.

7. RESPONSIBILITY NOTICE

The author(s) is (are) the only responsible for the printed material included in this paper.