18th International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2014, Budapest, Hungary 10-12 September, 2014

IMPACT OF PARAMETERS OF PLASMA TRANSFERRED ARC WELDING PROCESS ON THE WELD LAYER GEOMETRY

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ABSTRACT
In many cases parts of machines and structures are exposed to wear or action of aggressive corrosive environments. In such cases, the structure integrity can be compromised in a relatively short period of time. Therefore, to extend the service life of machine elements the common practice is to protect their surfaces by coating. One of the possible protection methods is surfaceing. Due to a number of advantages the plasma transferred arc welding (PTAW) process has found significant use in the field of surface protection. This paper presents the impact of parameters of PTAW process on the weld layer geometry and on dilution of the base material and filler material.
Keywords: plasma transferred arc welding, welding parameters, weld layer geometry

1. INTRODUCTION
In many cases, parts of machines and structures are exposed to wear or action of aggressive corrosive environments, which can lead to distortion of structure integrity in a relatively short period of time. Therefore, the common practice of surface protection is coating of machine elements to prolong their service life. One of the possible protection methods is surfacing, which means applying of a material layer of a suitable chemical composition, mechanical properties and a certain thickness, on the surface of base material. Due to a number of advantages, the plasma transferred arc welding (PTAW) process has found significant use in the field of surface protection. This process is characterized by exellent relation between price and achieved properties [1, 2]. One of the important advantages of PTAW process is the ability to use a much wider range of metal and ceramic filler materials, compared to other common processes. Filler material is in the form of powder of certain granulation, compared to conventional processes where the filler material is in a form of cast rod or wire. Properties of welded layer depend on the properties of the base material, filler material, PTAW process parameters, thermal cycle and dilution of the base material and filler material [3]. In order to determine the influence of welding current intensity on the geometry of welded layer and dilution, surfacing of stainless steel 316L was apply to the surface of structural steel S235JR. Surfacing was performed by PTAW process. Total of 5 samples were surfaced, by using different welding current intensities. Dimensional control of welded layers and estimation of dilution of the base material and filler material was performed. The results are presented in this paper.

2. EXPERIMENT

Surfacing was carried out on steel plates 100x50x10 mm, made of non-alloyed structural steel S235JR. The chemical composition of the base material is: Fe balance - 0,19 % C - 1,50 % Mn - 0,045 % P - 0,035 % S - 0,0014 % N - 0,60 % Cu. Surfacing was performed by using commercially available filler material, in the form of powder, EuTroLoy 16316, of manufacturer "Castolin Eutectic". This filler material corresponds to the chemical composition of the stainless steel with a low carbon content and the delta ferrite content between 8 % and 10 %, and it can be classified as stainless steel 316L. It is designed for PTAW process and application on the surface of unalloyed, low-alloyed and high-alloyed steels used in chemical and food industry. This filler material is resistant to pitting and intercrystalline corrosion up to a temperature of 401 °C, and to oxidation up to a temperature of 800 °C. The particle size of powder is between 32 μm and 125 μm. The chemical composition of the filler material is: Fe balance - 0,03 % C - 17,5 % Cr - 13 % Ni - 2,7 % Mo [4]. PTAW device Eutronic Gap 3001 DC, from manufacturer "Castolin Eutectic" was used. This device has a numerical control unit, which provides movement control of the torch and maintain a constant length of electric arc during surfacing. In this way the necessary reproducibility in terms of trajectory and velocity of welding torch and the length of the electric arc is achieved during surfacing. Surfacing was performed on the prepared samples. Dimensions of the samples, and the movement pattern of the welding torch during the surfacing process are shown in figure 1. Process parameters were chosen to achieve optimal stability of the electric arc, satisfactory protection of the weld bath and the thickness of surfaced layer of approximately 1,5 mm. The following parameters were used: welding current in range from 80 A to 120 A; electric arc length - 10 mm; deposition of filler material - 35 g/min; ionized gas - Ar; flow of ionized gas - 2 l/min; shielding gas - 95 % Ar + 5 % H_2; shielding gas flow - 15 l/min; torch speed in the longitudinal direction - 0.6 mm/s; torch speed in the transverse direction - 15 mm/s; width of the surfacing zone - 28 mm.

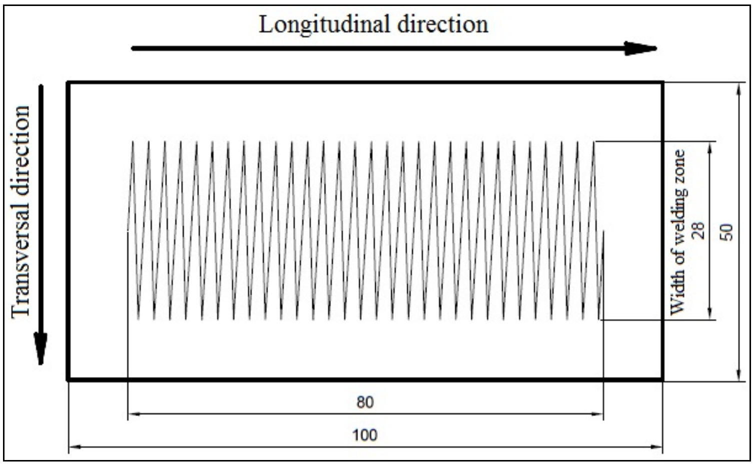

Figure 1. Geometry of the samples and the pattern of the welding torch movement

3. RESULTS

Width of welded layers are greater than the width of the surfacing zone. Due to increase of welding current width of the welded layer also increases. This is the result of melting larger amount of the base material. Figure 2 shows the dependence of layer with on the applied welding current. If the welding current intensity of 80 A is used then the width of welded layer is greater than the predefined width of the surfacing zone for 5,5 mm (about 20%), and if the current of 120 A is used then the width of welded layer is wider than the predefined width of the surfacing zone for 8,5 mm (about 30%). Reinforcement of welded layer and depth of penetration were measured in the cross section of each sample. The results are shown in figure 3 and 4. Figure 3 shows that welding current intensity, in this particular case, has no significant impact on the height of excess weld metal. The maximum depth of penetration was achieved near the edges of the surfaced layer. The greatest difference between the depth of penetration near the edge of the layer and depth of penetration in the central region of the layer appeared when minimal welding current was used. Due to increase of welding current intensity this difference decreases. Dependence of the penetration depth on the welding current intensity is shown in figure 4. Increase of welding current intensity leads to the increase of penetration depth. This affects dilution of the base material and filler material, which also increases. Figure 5 shows the dependency of dilution on the applied welding current intensity. In cases when PTAW process is applied without moving the torch in transversal direction, dilution of the base material and filler material typically ranges between 1 % and 10 % [5]. However, if it is required to achieve greater width of welded layers during one pass, and if metal powder is used as filler material, dilution of the base material and filler material can reach a much higher value [6].

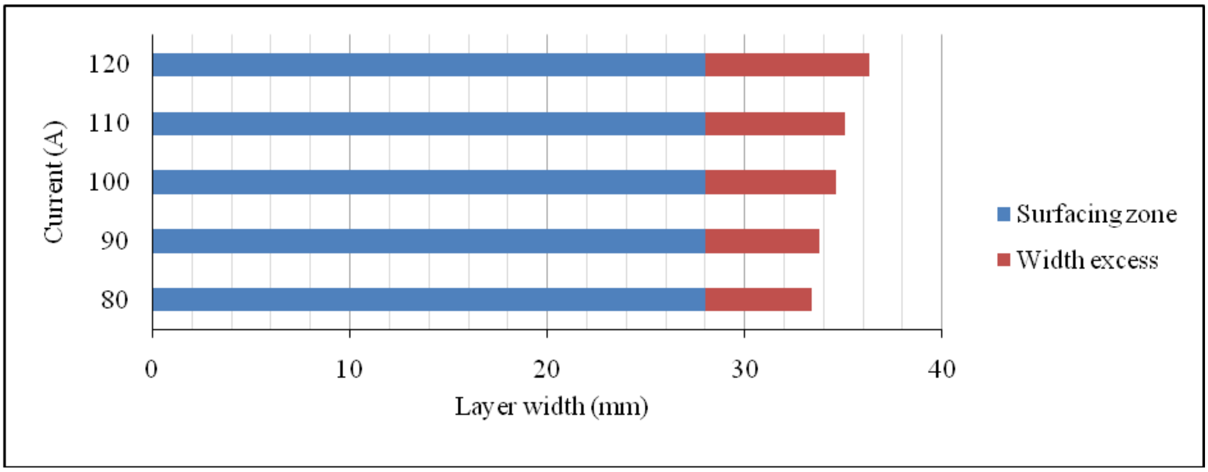

Figure 2. Impact of welding current intensity on the width of the welded layer

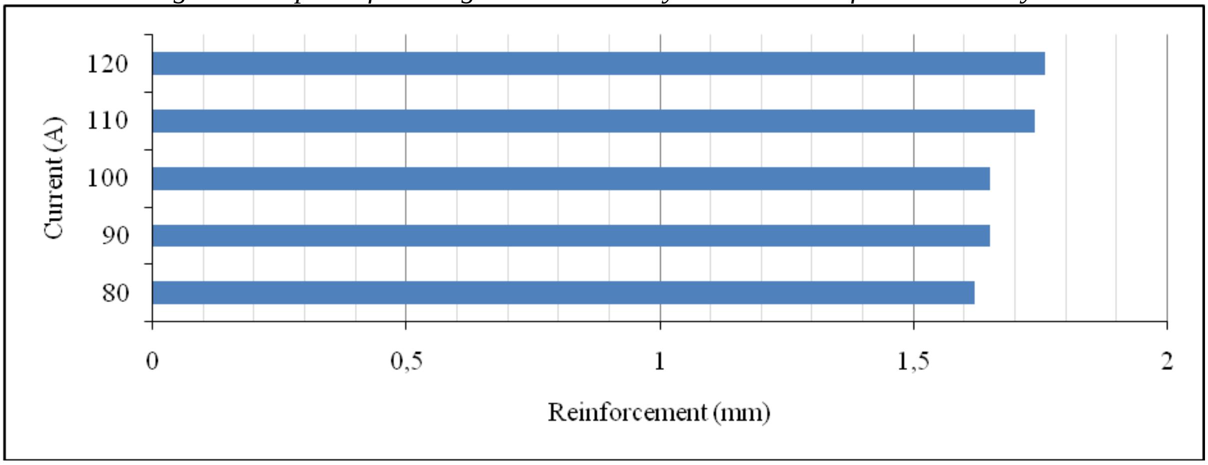

Figure 3. Impact of welding current intensity on the weld layer reinforcement

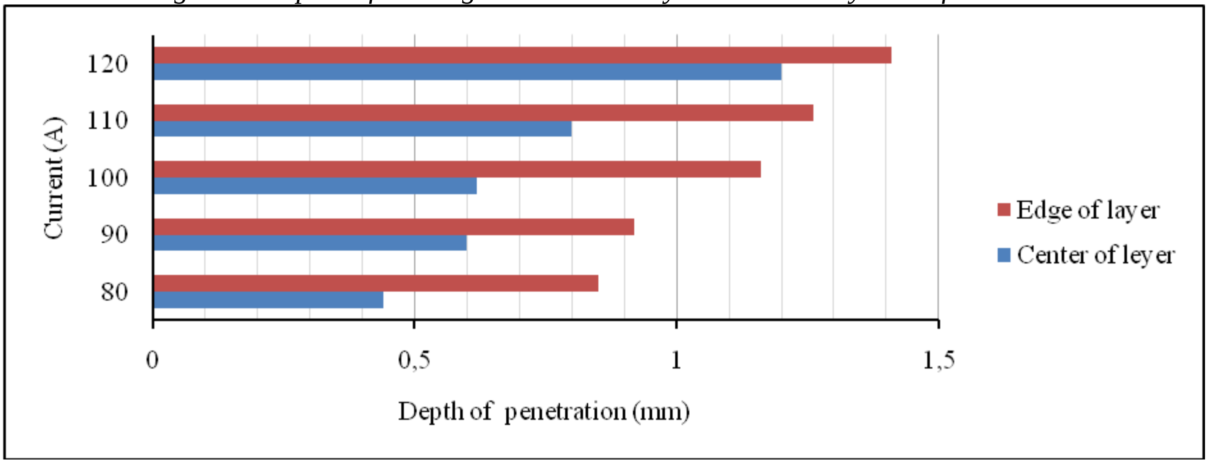

Figure 4. Impact of welding current intensity on the depth of penetration

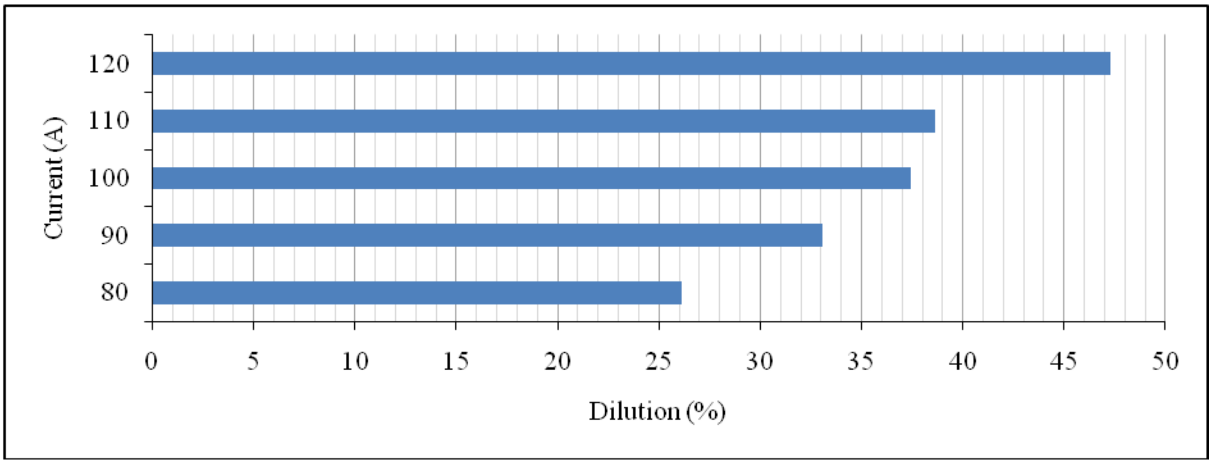

Figure 5. Impact of welding current intensity on dilution of base material and filler material

4. CONCLUSIONS

Based on the analysis of results, it can be concluded that the welding current intensity significantly affects the width of the welded layer, when PTAW process is used. This is the result of melting larger amount of the base material. Due to the increase of welding current from 80 A to a value of 120 A width of welded layer increases for 10 %. On the other hand, welding current intensity has no significant impact on the height of welded layer reinforcement. It can be concluded that the height of welded layer reinforcement depends on other process parameters, such as deposition of filler material, velocity of welding torch and electric arc voltage. Increase of welding current intensity leads to the increase of penetration depth. This directly affects dilution of the base material and filler material, which also increases. Increase of the welding current intensity from 80 A to 120 A leads to the increase of penetration depth for 72 %, and to the increase of dilution from value of 26 % to 47 %. These values are much higher than the value of dilution when the surfacing is done on a straight line path. Increase of dilution of base material and filler material significantly affects the chemical composition and structure of weld and thus the mechanical properties of surfaced layer.

5. REFERENCES

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6. ACKNOWLEDGEMENT

The research was performed in the frame of the national project TR 35024 financed by Ministry of Education, Science and Technological Development of the Republic of Serbia.

The authors wish to thank Messer Tehnogas – Eutectic+Castolin, Serbia, for providing facilities, supply of consumables and machine to conduct the experiment.