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Zinc Electroplated Coating and Post Weld Heat Treatment on Micro Dissimilar Metal Inert Gas Welding

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Abstract. The welding process could reduce the performance of the material both microstructure and mechanical strength. Therefore, handling the welding results was necessary. There are several ways to improve the performance of welded joints, namely heat treatment and coating using electroplating. The materials used were galvanized and stainless steel 201 with a size of 100 x 50 x 0.5 mm. Welding used the Metal Inert Gas (MIG) method, while the filler metal used was AWS ER70S-6. The results of the welding were coated by electroplating, while the post-weld heat treatment was carried out to determine the effect of electroplating and heat treatment on the hardness of the joints. There were three temperature variations namely 250 °C, 300 °C, and 350 °C, and three variations of holding time, namely 30 minutes, 60 minutes, and 90 minutes. The highest value of roughness (116.68 VHN) was obtained from a combination of a temperature of 300 °C and a holding time of 30 minutes. While the lowest hardness value (54.93 HVN) was obtained from a temperature of 300 °C with a holding time of 90 minutes.

1 INTRODUCTION

Post Weld Heat Treatment (PWHT) process could generate thermal stresses on weld joint (Cattivelli, Roy, Burke, Dhers, Lee, & Francis, 2023). Process of welding also affected to weld joint performance (Sabarudin Akhmad, 2019), welding could also affect to brittle and residual stress. Crack propagation and arrest properties could be affected by aging mechanism (Lindqvist, Que, Nevasma, & Hytonen, 2023). PWHT can repair the microstructure on weld zone which increase local strength better (Zhang, Li, Li, Mariusz, & Senkara, 2021) (Liu, Zhao, & Xu, 2022). Ferro et al studied PWHT improving mechanical properties in Ti-6Al-4V (Ferro, Bertob, Bonoll, Romanina, & Salemi, 2020). PWHT have been studied by some researchers such as Zhong-yu Dang et al characterized the Mechanical properties and Microstructure of friction weld joint of Ti6262 alloy (DANG, QIN, MA, & GENG, 2023). Ali and Homan studied effect of pulse duration of laser welding and PWHT of NiTi alloy (Rasouli & Naffakh-Moosavy, 2023). Bing Wang et al analysed residual stress relief of Ti26A weld joint affected to creep (Wang, Zhou, Cao, Xue, & Wu, 2023). Dan Zhao et al studied the improving ductility and corrosion resistance of laser weld joint with PWHT (Zhao, Liu, Tan, Shi, & Xiang, 2023). Haiqing Dang and Haiping Yu repair weld joint of Al-Fe tubes with annealing of PWHT (Dang & Yu, 2021). Karim Agrebi et al stated that preheating affected the austenitic grain size (Agrebi, Belhadj, Bessrou, & Bouhafs, 2022). Differences of both based metal were problem in the dissimilar welding (Muzakki, Baskoro, Kiswanto, & Winarto, 2018).

Dissimilar welding and micro welding still has problem. Welding process reduce weld joint

performance (Muzakki, Prasetyo, Umam, Lumintu, & Hartanto, 2020). The problem in dissimilar welding because of the differency of thermal properties from based metal materials (Muzakki, Mualim, & Yusuf, 2019). Suwarsono et al stated that micro welding or welding process of metal less than 1 mm has unique problem (Suwarsono, Muzakki, Millaily, & Ahmadi, 2020). Chao Xiang studied improving properties of Ni-ZrO₂ composit with electroplating (Xiong, et al., 2018). Zhen He et al. studied preparation and properties of Ni-W-P-TiO₂ Nano composite which was coated by a sol-enhanced electroplating method (He, et al., 2022). Erik Zall et al choose cobalt-chromium coating on surface of stainless steel to absorb and convert solar irradiance to thermal energy (Zall, Nordenstrom, Jarn, Mossegård, & Wågberg, 2022). Yu Tan et al used Pulse electroplating to fine grain size of Zinc coated on 316L Stainless Steel and also repaired its corrosion behavior (Tan, Xu, Zhang, Sun, Liang, & Zhang, 2019). Xue MENG et al also used electroplating for coating Zn-Fe on magnesium alloy to corrosion protection (MENG, WANG, ZHANG, NIU, GAO, & YAN, 2022). Stainless steel has corrosion resistance properties and Galvanized is steel which is coated by zinc to resist corrosion.

Metal Inert Gas welding process affects microstructure evolution. MIG was used to join stainless steel and galvanize plate, the thickness of both metals are 0.5 mm. This study studied zinc coated on weld joint by electroplating, PWHT was also studied. Macrostructure on weld joint and effect PWHT to hardness performance were discussed in this study.

2 MATERIAL AND METHOD

2.1 Material

Stainless steel or stainless steel is steel that has high resistance to corrosion and high ductility. This study used SS 201 plate with chemist composition Cr 17, Ni 7, N 0.2 with C 0.05, this has strength around 775 Mpa. Galvanic sheet was used as based metal which was welded to SS 201 sheet. This galvanize plate was common sold in Indonesian market according to Indonesia Standard (SNI). Both materials welded was shown in Figure. 1.



Fig. 1. Dissimilar Weld Joint

Galvanic and SS 201 were succeed welded by arm robotic welding. This welded was butt joint which was welded by metal inert gas (MIG).

2.2 Method

2.2.1 Heat Treatment

Heat treatment is a way to improve the microstructure by adjusting heat and cooling. Heat treatment also greatly influenced the mechanical properties such as strength, hardness, ductility, toughness and wear resistance. Furnace used as heat treatment process shown by Figure. 2.



Fig. 2. Muffle-Furnace

Electroplating is carried out with the aim of coating the surface of the welded joint between galvanized and stainless steel. The coating uses liquid HCL as electrolyte and zinc as electrodes with a holding time of 25 minutes. Coating and PWHT process was shown by Figure. 3

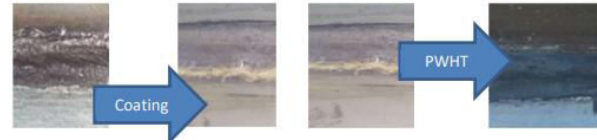


Fig. 3. Coating and PWHT process

2.2.2 Macro Structure

Examination of the macro structure is observed visually or with a camera with a magnification of 10x. In this study, macro structure examination was used to determine the macro structure formed from electroplating after being given heat treatment. Macro-structural observations focused on zinc attached to the material.

2.2.3 Hardness Testing

Hardness Testing Hardness testing is done to determine the level of hardness of the material. Hardness testing is carried out in the weld pool between galvanized and stainless steel 201. Hardness testing will be carried out using the Vickers method.

3 RESULT AND DISCUSSION

PWHT process the temperature was increased at 250°C and holding time at 30 minute, cross section zinc coating and PWHT condition before and after polishing and etching was shown in Figure. 4.

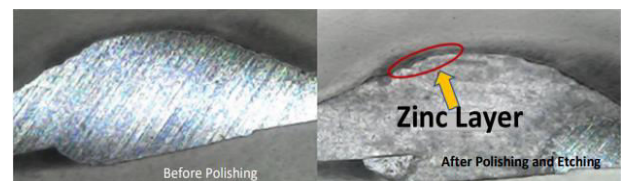


Fig.. 4. PWHT at 250°C, holding time at 30 minute

Figure 4 with parameters of 250 °C with a holding time of 30 minutes shows that the filler metal and parent metal mix well. This situation can be seen in the image after the material is etched/etched. The state of the zinc coating on the surface of the weld pool is coated but not perfectly uniform. Figure before polishing zinc layer was not show clearly.



Fig.. 5. PWHT at 250°C, holding time at 60 minute

Figure 5 with parameters of 250 °C with a holding time of 60 minutes shows that the filler metal and parent metal mix well. This situation can be seen in the image after the material is etched. The state of the zinc coating on the surface of the weld pool is coated but very little and uneven.



Fig.. 6. PWHT at 250°C, holding time at 90 minute

Figure 6 with parameters of 250 °C with a holding time of 90 minutes shows that the filler metal and parent metal mix well. This situation can be seen in the image after the material is etched/ tchching. The state of the zinc coating on the surface of the weld pool is coated but very little and uneven

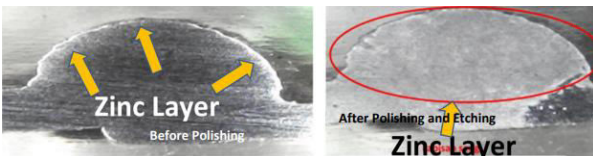


Fig.. 7. PWHT at 300°C, holding time at 30 minute

Figure 7 with parameters of 300 °C with a holding time of 30 minutes shows that the filler metal and parent metal mix well. This situation can be seen in the image after the material is etched/ tchching. The state of zinc coating on the surface of the weld pool is evenly coated on the surface of the weld.

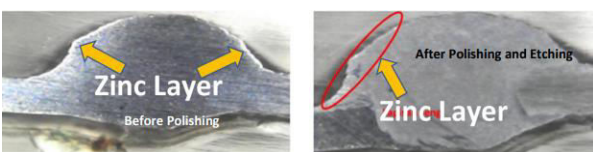


Fig. 8. PWHT at 300°C, holding time at 60 minute

Figure 8. with parameters of 300 °C with a holding time of 60 minutes shows that the filler metal and parent metal mix well. This situation can be seen in the 30 images after the material is etched/ tchching. But on

the galvanized part there is a slight crack after etching. The state of the zinc coating on the surface of the weld pool is coated but not evenly distributed on the surface of the weld.

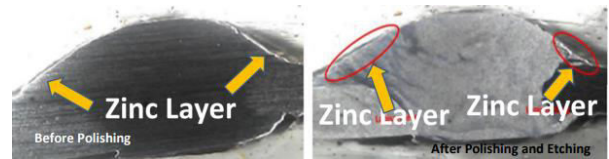


Fig. 9. PWHT at 300°C, holding time at 90 minute

Figure 9. with parameters of 300 °C with a holding time of 90 minutes shows that the filler metal and parent metal mix well. This situation can be seen in the image after the material is etched/etched. The state of the zinc coating on the surface of the weld pool is coated but very little and uneven

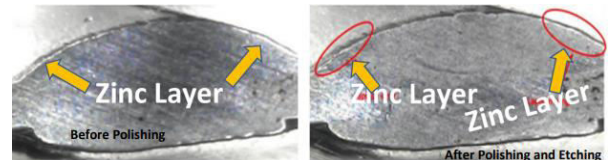


Fig. 10. PWHT at 350°C, holding time at 30 minute

Figure 10. with parameters of 350 °C with a holding time of 30 minutes shows that the filler metal and parent metal mix well. This situation can be seen in the image after the material is etched/ tchching. The state of the zinc coating on the surface of the weld pool is coated but not evenly distributed on the surface of the weld.

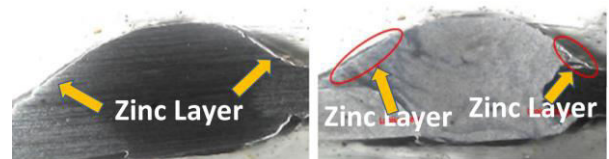


Fig. 11. PWHT at 350°C, holding time at 60 minute

Figure 11. with parameters of 350 °C with a holding time of 60 minutes shows that the filler metal and parent metal mix well. This situation can be seen in the image after the material is etched/ tchching. There is no coating of zinc on the surface of the weld pool.

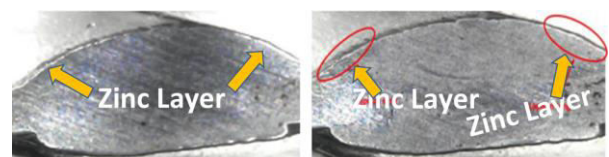


Fig. 12. PWHT at 350°C, holding time at 90 minute

Figure 12. with parameters of 350 °C with a holding time of 90 minutes shows that the filler metal with the base metal is mixed with it but there are gaps in the galvanized part. This situation can be seen in the image after the material is etched. The state of the zinc coating on the surface of the weld pool is coated but very little and uneven.

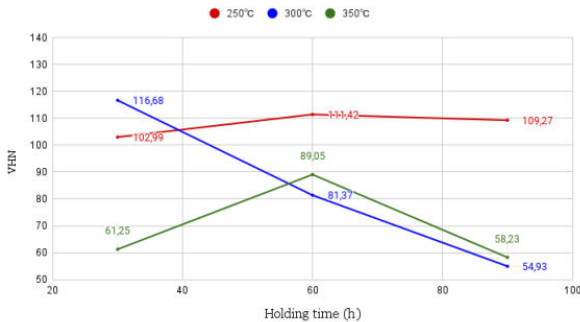


Fig. 13. Hardness Test

Figure 13 show that the combination of a heating temperature of 250 °C with a holding time of 60 minutes gave the highest hardness number (111.42 VHN) compared to a holding time of 30 minutes and 90 minutes (102.99 and 109.27 VHN). At a heating temperature of 300 °C with a holding time of 30 minutes the hardness value was obtained (116.68 VHN), while at 60 minutes and 90 minutes the hardness value decreased (81.37 and 54.93 VHN). Treatment with a combination of a heating temperature of 350 °C and a holding time of 60 minutes gave a hardness value of 89.05 VHN, while a combination of treatments with a heating temperature of 350 °C and a holding time of 30 minutes and 90 minutes obtained a lower hardness number (61.25-58 ,23 VHN).

4 CONCLUSION

In this study the materials used were galvanized and stainless steel welded joints. Then the material is coated with zinc, then given heat treatment (PWHT) with 3 levels of holding time (30 minutes, 60 minutes, 90 minutes) and three levels of temperature (250 °C, 300 °C, 350 °C) and using air cooling.

The results of macro photo analysis show that the weld pool between the base metal and filler metal is well mixed. This can be seen in the results of images that have been etched/etched. The zinc coating on the weld surface looks to stick perfectly, especially at a temperature of 300 °C with a holding time of 30 minutes. However, at other temperatures, the zinc coating is not uniform on the weld surface. The cause of the uneven coating is the occurrence of bubbles of hydrogen gas (H₂) during the coating process and the appearance of dirt due to the coating process.

The temperature of 250 °C with a holding time of 60 minutes obtained the highest hardness value (111.42 VHN) compared to a holding time of 30 and 90 minutes (102.99 and 109.27 VHN). At a temperature of 300 °C with a holding time of 30, the hardness value is

the highest (116.68 VHN). Meanwhile, at 60 minutes and 90 minutes of detention time, the hardness value decreased (81.37 and 54.93 VHN).

Treatment with a temperature of 350 °C for 60 minutes obtained the highest hardness value (89.05 VHN). Whereas treatment with a temperature of 350 °C for 30 and 90 minutes obtained a lower hardness value (61.25-58.23 VHN). The temperature of 300 with a holding time of 30 obtains the highest average hardness value due to the density of the grains, the fineness of the grains and the expansion of the intermetallic in the weld area

PWHT process the temperature was increased at 250°C and holding time at 30 minute, cross section zinc coating and PWHT condition before and after polishing and etching was shown in Fig. 4.

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