Effect of Welding Process to the Porosity Formation in as Welded Carbon Steel

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Abstract

The effect of the welding process on porosity formation in SPCC carbon steel was studied by comparing MIG, MAG, and TIG welding processes. In this work, the main consideration relates to the welding processes, which are welding current, welding speed, and heat input were investigated. Industrial x-ray observation was performed to study the distribution of porosity within the weld bead. Analysis of bead geometry shows the deepest penetration in TIG welding. The most significant size of porosity was shown in MAG welding compared to MIG and TIG welding. The result indicates that an increase in heat input affects the size of porosity distribution and depth penetration of the weld bead.

Keywords: MIG welding, MAG welding, TIG welding, Porosity

1. Introduction

Considering the demand for a low cost-effective with reliable technique, arc welding processes like metal active gas (MAG), metal inert gas (MIG), and tungsten inert gas (TIG) welding process were widely used in many industries to weld carbon steel. However, metals experienced a challenging task, which can cause low weld forming quality during or after the welding process; for example, porosity and cracking that can influence the mechanical properties [1]. Thus, to obtain the positive welding performance, the welding parameters such as current and voltage, travel angle, and also travel distance must be considered.

Heat input is one of the factors that influence the porosity formation inside the weld bead of welded materials. A study reported that the heat content in metal droplets contributes approximately 40% of the total heat input into the weld zone during the welding process [2]. Heat input cannot be determined directly, but it can be distinguished from the arc voltages, current, and travel speed values [3] as given in

Increasing heat input is believed to reduce the tendency of porosity formation within the weld bead of welded metals, which is associated with a lowering in the cooling rate process during the welding. Thus, reduced the molten pool solidification process [4].

$$\text{Heat input, } Q = \frac{\text{Current (A)} \times \text{Voltage (V)}}{\text{Travel speed (mm/s)}} \qquad (1)$$

2. Material Section

In this study, SPCC carbon steel plates with dimension 180 mm × 100 mm × 5 mm and 100 mm × 75 mm × 3 mm were used for bead-on-plate welding. Pure argon shielding gas was used in both MIG and TIG welding processes. While for MAG welding, CO_2 was used as shielding gas.

3. Methodology

DCEP (Direct current electrode positive) was used in MIG and MAG welding process while DCEN (Direct current electrode negative) was used in TIG welding. Parameters of the welding processes are shown in Table 1.

Table 1: parameter of the welding processes

Parameter	MIG Welding	MAG Welding	TIG Welding
Welding Speed (mm/s)	3-4	3-4	3-4
Current (A)	160-180	160-180	160-180
Voltage (V)	23-25	23-25	23-25

Next, the metallographic of the MIG, MAG, and TIG welding samples were observed under an optical microscope with 2% of Nital solution as an etching solution. ผิดพลาด! ไม่พบแหล่งการอ้างอิง shows the dimensions of

MIG, MAG, and TIG welding samples. The formation of porosities was then analyzed by x-ray inspection that will be discussed further in Section III.

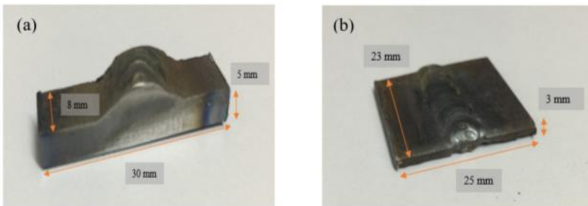


Fig. 1 Samples dimension of (a) MIG welding, MAG welding, and (b) TIG welding

3. Results and Discussion

3.1 Effect of Heat Input

Fig. **2** shows the average data of heat input in each welding process that was calculated as Heat input, $Q = \frac{\text{Current (A)} \times \text{Voltage (V)}}{\text{Travel speed (mm/s)}}$ (1). TIG welding shows the highest value of heat input, compared to MIG and MAG welding. Increasing heat input will decrease the cooling rate as well as the solidification process on the molten pool. As a result, low porosity formation and high depth penetration can be achieved.

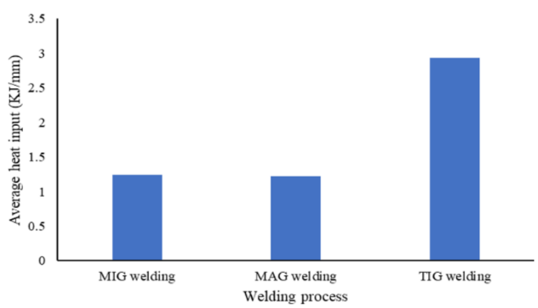


Fig. 2 Average value of heat input in welding processes

3.2 Weld Bead Penetration

Fig. 3 shows the cross-section of weld bead profile for MIG, MAG, and TIG welding. Full penetration with a value of 0.4 cm was obtained in TIG welding, which is higher than the others. This phenomenon occurred due to high heat input that significantly produces an extensive depth penetration due to a tremendous amount of heat input into the weld zone [5].

The use of MAG welding process results in a deep penetration to the specimen. It is believed that the CO_2 causes a higher penetration compared with the other gases due to increase in oxidation potential and outstanding thermal conductivity [6].

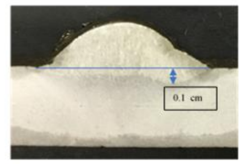
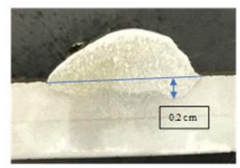
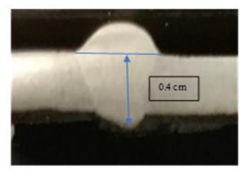
Type of Welding Process	Length of Penetration
MIG Welding	
MAG Welding	
TIG Welding	

Fig. 3 Observation of the weld bead penetration\

3.3 Porosity Evaluations

Based on

Fig. **4**, sample 1 in MIG welding shows the highest number of porosities. In contrast, sample 4 indicates the lowest number of porosity compared to the other samples with different welding processes. Compared with other welding processes, MIG welding shows a higher average of porosity. The increase of porosity inside the welded carbon steel in MIG welding is due to low heat input absorbed by carbon steel and low in-depth penetration. Thus, it can increase the tendency of porosity formation inside the weld bead of the welded carbon steel.

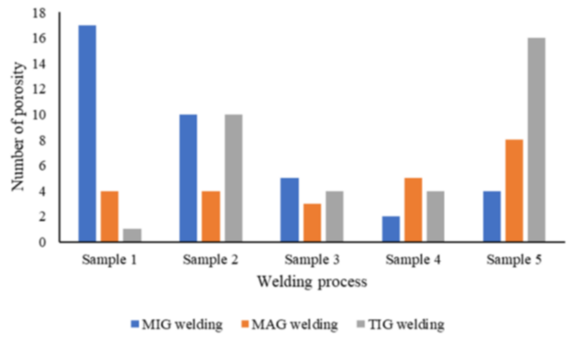


Fig. 4 Number of porosities based on welding processes

Fig. 5 imply the average size of porosity in MIG, MAG, and TIG welding process. A higher value of porosity size was measured in MAG welding, followed by MIG and TIG welding. The molten pool solidification process influenced the size of porosity formation inside the weld bead of welded carbon steel. The decrease in molten pool heat input will reduce the solidification process time [4]. Thus, enhance the porosity size formation in consequence of the gases within the weld pool to escape adequately during the weld pool solidification process.

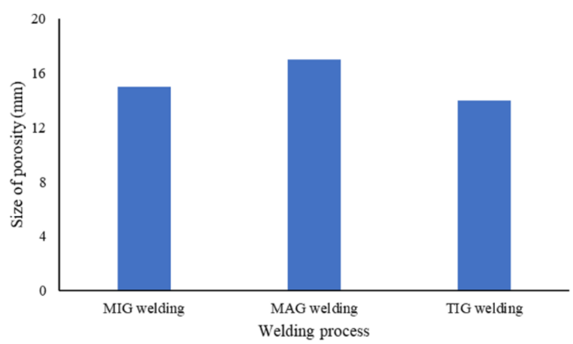


Fig. 5 Average size of porosity based on welding processes

4. Conclusion

From the above results, the main conclusions are as follows:

1. Increase in heat input decreases the cooling rate and delay the solidification process of the weld pool. Thus, result in the depth penetration of the weld bead.
2. Low heat input and depth penetration of welded carbon steel by using MIG welding is believed to increase the tendency of porosity formation inside the carbon steel weld bead.
3. A larger size of porosity in MAG welding due to a decrease in molten pool heat input that will reduce the process of the molten pool to solidified.

However, the result of this project is from a preliminary study and the research about the effect of the welding processes (MIG, MAG, and TIG welding) on porosity formation is still ongoing.

References

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