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Identifying of Crack Shape Obtained From Various Welding Process and Sensitivity Detecting by Using Liquid Pentrant Testing

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Liquid penetrant testing(PT) is a nondestructive testing (NDT) method commonly used to detect surface cracks in weld. This paper presents the method to create the work piece used to practice the PT trainee. Three welding processes, Sheild Metal Arc Welding (SMAW), Flux Core Arc Welding (FCAW) and Gas Tungsten Arc Welding (GTAW), are selected to create the surface fine crack on the work piece. Proper size of copper is carried out to fill in weld to create solidification crack on the surface. Then solvent removable and non-aqueous developer technique is applied to build up the crack indication. The shape of the indication received from each process is recorded in digital file and then compared. The results found that the sensitivity of detection is not much different, but the shapes are unlike. The benefit of the paper is the knowledge base used to create the work piece for PT training.
Keywords; Nondestructive testing, Liquid penetrant testing, Welding process, Crack

1. Introduction

Non-destructive testing (NDT) is widely acceptable methods used to find out discontinuity such as crack on surface or subsurface. There are various types of NDT namely surface and volumetric methods. For surface method, liquid penetrant testing (PT) is generally implemented for the reason that it is costly and eases of use. Although it is simple method, qualification and expertise personal is required. Training and certification is usually complied to achieve competence personal. It needs several of work pieces used to train and to test the performance level of the personal. For the work pieces it must not be able to see the discontinuity by naked eye but clearly seen when inspecting by PT.

In order to have adequate work piece, several procedures has been attempted. From the previous researches, crack in weld has been created from different procedures such as the use of chemical composition of weld metal, gas hydrogen volume control, capture force at base metal and cooling rate control. Submerge arc welding (SAW) was used to weld carbon steel which put a copper rod in the root gap before weld. It can make crack on surface that can be seen after using PT. The limitation is the sizes of indications are uncontrolled and the indication looks unnaturally [1]. SMAW was also attempted to make by using the manganese powder. The manganese was put in to a drilled hold in the base metal to control the weld size [2]. SMAW was also studied to create the cracks by varying the welding current. The results showed that the length of cracks is similar to the size of cupper. In addition, the length of crack can be easier control when using the lower current [3]. Theory of residual stress has been applied by welding with SMAW at the first layer and then covered with two more layers by GTAW. [4]. However, the comparison the shape cracks between welding processes has not been performed.

In this paper, cracks on weld surface generated by copper will be done. PT with solvent removable penetrant with non aqueous developer will be applied. Cracks on surface obtained from three welding processed; SMAW, FCAW and GTAW will be compared. The detection sensitivity of cracks by PT will be reported.

2. Theories

In this study, there are three different welding processes used to create cracks by the addition of copper. Three welding process are as follows;

2.1 welding process

2.1.1 Shielded metal arc welding (SMAW) is a manual arc welding process that uses a consumable electrode covered with a flux to lay the weld. An electric current is used to form an electric arc between the electrode and the base metals. The base metal and the electrode melt forming the weld pool and generating vapors that serve as a shielding gas and providing a layer of slag. The weld are was protected the weld area from atmospheric contaminant by the slag and the shielding gas

2.1.2 Flux-cored arc welding (FCAW) is a semi-automatic or automatic arc welding process. FCAW calls for a continuously-fed consumable tubular electrode containing a flux. The core is full of with the flux to generate a shielding gas for protecting the arc. The slag produced by the flux is easy to remove. Compare to SMAW, it generally produces welds of better and more consistent mechanical properties, with fewer weld defects.

2.1.3 Gas tungsten arc welding (GTAW) is an arc welding process that uses a non-consumable tungsten electrode to create the weld. It is called as tungsten inert gas (TIG) welding. The weld area is guarded from atmospheric contamination by an inert shielding gas. A filler metal is generally used. GTAW is comparatively more complicated and not easy. Moreover, it is significantly slower than most other welding processes.

2.2 Liquid penetrant testing (PT)

PT is based upon capillary action. Penetrant is applied to the weld by spraying. After adequate penetration time has been allowed, the excess penetrant is removed and a developer is applied. The solvent remover and lint-free cloth is used to wipe the excess penetrant. The developer helps to draw penetrant out of the flaw so that an invisible indication becomes visible. The inspection was done under control visible light with adequate intensity.

3. Experimental Setup

3.1 Preparation of weld plate and copper rod

Hot roll carbon steel of grade SS 400 was used as based metal. Two plates size 150x300x5 mm. shown in fig. 1 were prepared to join by three welding process SMAW, FCAW and GTAW respectively. Each plate end was notched to Double V-Groove edge with the angle of 60 degree. A small copper rod was inserted in to the middle of weld line to make fine crack. The proper size of copper was carried out. In this research, the copper of type SWG numbers 12,14,16,18 were used and compared the indication detection ability.

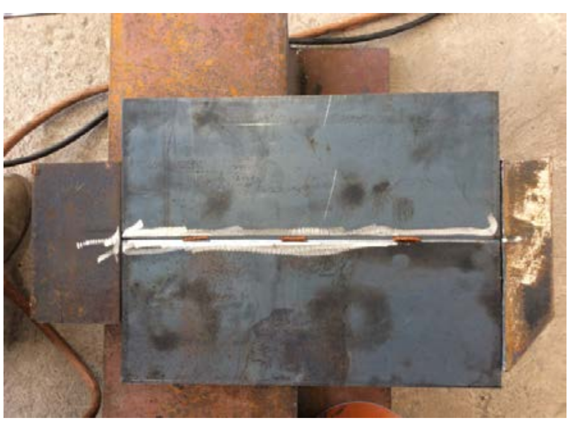

Fig. 1 Preparation of two plates for weld

3.2 Welding process

After preliminary test the copper rod of SWG 18 was selected to put in the weld join in order to make fine solidification crack. Three welding process used are SMAW, FCAW and GTAW. The electrode aspect and diameter are LB-52 KOBE , CSF-81K2 diameter 1.2mm. and TGS50 KOBE diameter 2.4 mm respectively. Each welding process was performed to join ten work pieces. The total numbers of work pieces are thirty. After that the penetrant testing was utilized to show the red indication caused by pulling up the red dye from the void of crack.

3.3 Penetrant Testing (PT)

A solvent of type SKC-S contained in aerosol can was used to clean the weld before inspection. Then the solvent removable penetrant of type SKL-SP2 was applied on the surface and the penetration dwell time used is 10 minute. Excessive penetrant was done by gently wipe with the removable solvent. Finally the thin layer of non aqueous developer of type SKD-s was spraying by using 15 minutes developer time.

3.4 Comparison of results

The indication was recorded in the digital file by a camera model Olympus OM-D E-M10. Its resolution is 16 megapixels. The distance between the camera and the indication is constantly controlled at 25 cm. and the light intensity is at 1000 lux. The ten pictures of crack indications obtained from each welding process were then record and compared between the three welding process in term of shape and sensitivity detection.

4. Results and Discussion

After the proper specification and code of cupper (SWG 18) was experimentally selected to put in to the gap of base metal to make the fine crack. By visual testing, the surface crack on weld cannot detect by naked eye. After liquid penetrant testing as were shown in fig. 2, it was found that all three processes provided crack indication. The shape of indication received from each welding process is different. It was expected that it is due to the different of electrode movement direction, fusion line and shape of grain boundary. Cooper is a contamination and segregate to the grain boundary. It causes low melting point and bring to the fine crack at the grain boundary.

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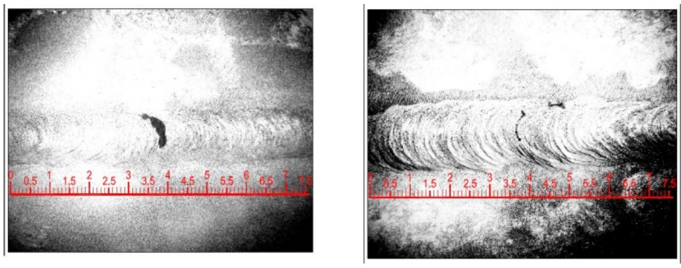

Figure 2.1a: the indication obtained from SMAW

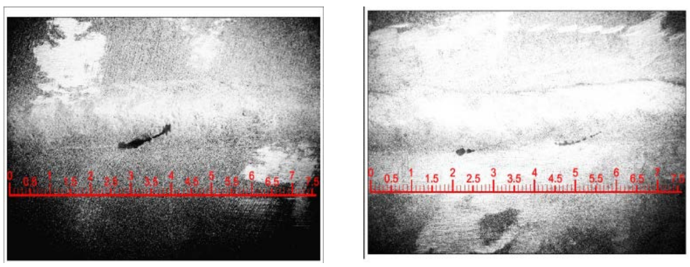

Figure 2.1b the indication obtained from FCAW

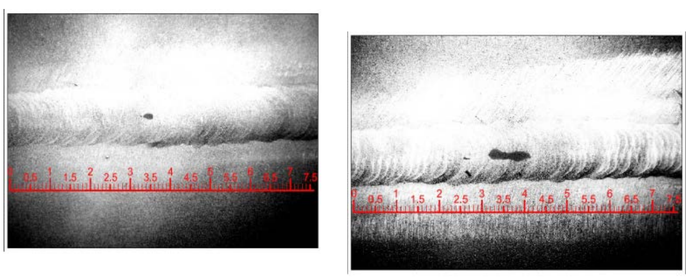

Figure 2.1c the indication obtained from GTAW

From GTAW, The cracks can be found in the form of lengthwise and appear especially in the center of the weld at the copper inserted area. When low melting point constituents such copper compounds in the admixture separate during the welding solidification process, low melting point component in the molten metal will be forced to the center of the joint during solidification. Since they are the last to solidify and the weld tends to separate as the solidified metal contracts away from the center region containing the low melting point constituents. For FCAW, the indication is clearly seen near the weld toe. The indication length is found the line and it is not upright with welding which close to the length of inserted copper. For SMAW, the indication exhibits transverse to the weld as the result of the longitudinal residual stress. The high strength of the surrounding steel in compression restricts the required shrinkage of the weld material due to the restraint of the surrounding base metal. The weld metal develops longitudinal stress which may facilitate cracking in the transverse direction. The benefit of the research is the knowledge base used to create a fine crack in specimen to train the new NDT inspector. The fine crack on weld which cannot see by naked eye will be easily found by PT. Moreover the shape of indication is different due to the welding process.

4. Conclusions

Fine crack on surface of weld was created by using the copper inserted in the weld gap before weld. Proper size of copper was selected to make the fine crack which is not able to detect by naked eye but appears clearly when using PT. Three welding processes were applied and found that the shape of cracks is different owing to theirs solidification process and stress. The benefit of the paper is to exhibit knowledge base to create the work piece used to train the new NDT personal.

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