Journal of Engineering and Applied Sciences
MEDWELL PUBLICATIONS

Study the Welding Defects and Mechanical Properties of Copper Pipes Weld Joints using Oxyacetylene Welding Process

Ezzet H. Abdulsalam, A.B.D. Saif Madhat and Dawood S. Abdulrahman
Dijlah University College, Baghdad, Iraq

Key words: Weldability, destructive, refrigeration systems, penetrant tests

Corresponding Author:
Ezzet H. Abdulsalam
Dijlah University College, Baghdad, Iraq

Page No.: 3152-3155
Volume: 15, Issue 17, 2020
ISSN: 1816-949x
Journal of Engineering and Applied Sciences

Abstract: This research deals with the welding technology of copper pipes which is mainly used in refrigeration systems and boilers. The chemical composition of this metal confirms that is to pure copper (≥99.99 Cu). This metal shows an excellent weldability. Oxyacetylene welding process with silver filler is used to join two pieces of copper pipes. Weld inspection for all welded samples involves the evaluation of the integrity and mechanical prosperities of the weld joint. That was conducted using several destructive and non-destructive tests on the weld joints such as, Tensile, hydrostatic, x-ray and Liquid penetrant tests). These tests procedure reveals that, the weld joint maintain a good mechanical properties and acceptable weld defect.

INTRODUCTION

Welding is the method of joining two or more pieces using heat and pressure and sometimes only heat. A filler material is needed to form a molten liquid substance at the weld. This region is called a weld joint. The heat is then removed and melting metal cools to form the weldment. The welding processes are a common methods in fabrication, manufacturing and industrial applications using different types of metals such as iron, steel, aluminum and copper[1].

Oxyacetylene welding process is widely used in joining and fabrication a refrigeration tube system, it consists of mixing two gasses oxygen and acetylene to produce a flame used of melting metals. It is a commonly used for maintenance and cutting. Oxyacetylene flame also used for brazing soft metals such as refrigeration copper tubes and bronze. Weld region must be cleaned with a wire brush and then cleaned from any paint, oxides, grease and any other types of contamination[2].

The ability to produce a small diameter copper tube using different technology gives a significant advantages in the application of copper tube in refrigeration system, also another advantages may obtained including, lowering the cost, achieving a higher energy efficiencies and reduction the refrigerant charge. In addition to that copper tubes joining can be easily conducted by different methods such as mechanical joining which can be assembled without the need of the heating when the heat source is highly recommended for brazing and soldering.

Copper and its alloys are mainly used in construction of refrigeration system, electrical industry and plumbing trades, that because copper has a good electrical conducting of and a high resistance to wear and corrosion[3]. Copper and copper alloys have need care in welding because of its high thermal conductivity. This may require a preheating prior to welding process.

By using the fusion welding process for joining copper materials, it was observed that the high content oxygen of the alloy caused embrittlement in the Heat

Affected Zone (HAZ) and porosities in the weld metal. However, a phosphorus deoxidized copper revealed better weldablity but the residual oxygen in the weld region may porosities. It can avoided the formation of Porosities by using suitable filler wire which contains deoxidants element such as aluminum, manganese, silicone, phosphor and titanium, also cleaning of the copper surface prior to welding is important to avoid the formation of porosities[4, 5]. Any weld defect such as cracks or porosities will be hardly affected the mechanical properties of the weld joint[6, 7].

Pure copper 99.3% minimum copper content which is the metal of the present research is widely used in refrigeration system. Copper is normally supplied in one of three forms, oxygen free copper, oxygen-bearing copper (tough pitch and fire-refined grades) the impurities and residual oxygen content of oxygen-bearing copper may cause porosity and other discontinuities when these coppers are welded or brazed and Phosphorous deoxidized copper[8, 9].

MATERIALS AND METHODS

Experimental procedure: The pipe metal used in this research is a pure copper. The chemical composition of this metal is analysis at the ministry of oil as given in Table 1. The mechanical properties of the pipes metals are given in Table 2. The specimens prepared in this research are in the form of pipes at a diameter of 28 mm and a diameter of 40 mm. All experimental tests were carried out using the laboratories at Heavy Engineering Equipment State Company-Ministry of oil.

Welding process: The V-groove weld joint design has been selected and the weld edges were made using mechanical machining as shown in Fig. 1.

The weld regions were cleaned before the beginning of performing welding operation in order to achieve a free and clear weld region from any contamination such as rust, water, oil, paint, dust or any foreign particles. Oxyacetylene welding method was used to join the two pieces of the copper pipes. The welding processes were performed by 6G skilled shown in Fig. 2.

Silver welding filler metal was used to achieve the required weld properties. The chemical composition and the mechanical properties of the welding joint are given in Table 3.

Pipes welding were conducted at several diameters of 28 and 40 mm the two parts of the copper pipes were climbed to achieve the alignment before running the welding pass as shown in Fig. 2.

X-ray test: X-ray technique was conducted on all welded specimens to examine the integrity of the weld regions of

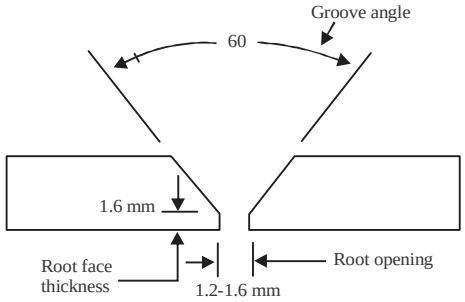

Fig. 1: Weld joint design type V-Groove

Fig. 2: Copper pipes before and after welding processes

Table 1: Chemical composition of the tested copper pipe metal

Sample	Zn (%)	Pb (%)	Sn (%)	P (%)	Mn (%)	Fe (%)	Ni (%)	Si (%)	Cu (%)
Pipe	0.004	0.000	0.000	0.012	0.000	0.016	0.002	0.001	Bal.

Table 2: Mechanical properties of the pure pipe metal

Yield strength (MPa)	Tensile strength (MPa)	Young modulus (MPa)	Elongation (%)	Hardness BHN
90	224	132	45	85

Table 3: The mechanical properties of the welding joint

Materials	Tensile strength	Yield strength	Elongation (%)
Copper	261 (MPa)	160 (MPa)	37

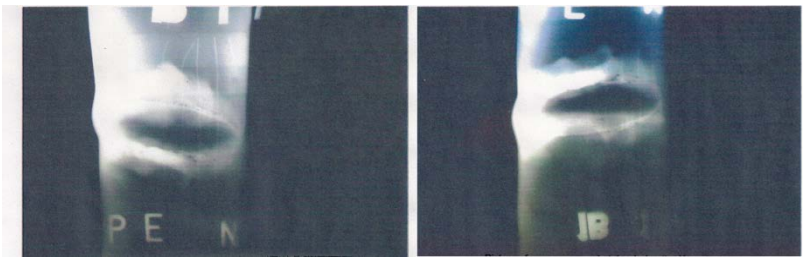

Fig. 3: Image of X-ray test of welded copper pipe

Fig. 4: The tensile testing specimens for different diameters

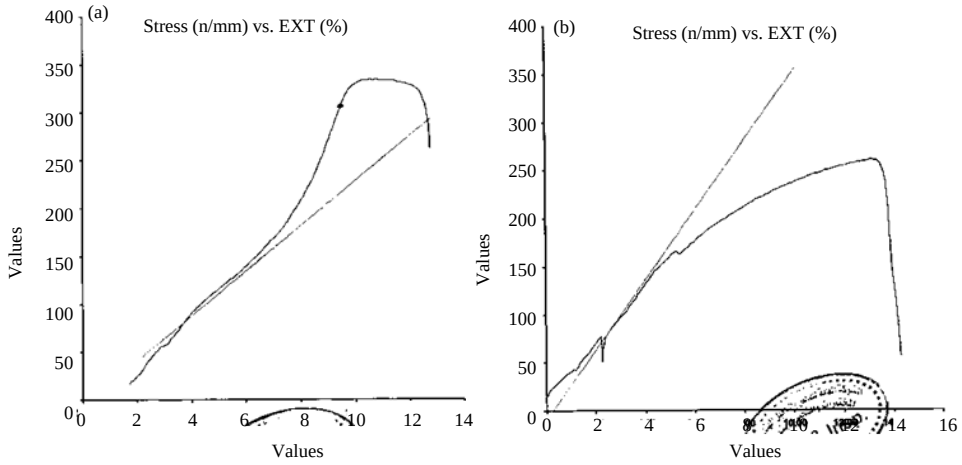

Fig. 5(a, b): Stress-strain curve for unwelded specimen and welded specimen

this test will help to detect the presence of any weld defect such as inclusions, slags, porosities, cracks or any other defects which will be badly influence the weld mechanical properties.

Figure 3 shows some of X-ray negatives for welded specimens. The analysis of the X-ray images was done and it clearly shows weld porosity and slag which need to be repaired before fabrication.

Tensile test: Tensile specimens were manufactured from copper pipes, so that, the weld joint was positioned at the middle of the gauge length. The welded specimens were tested using the tensile testing machine at Ministry of oil-HESCO. The tested specimens and the corresponding stress-strain curve are shown in Fig. 4 and 5. Using the tensile test curve shown in Fig. 5, the tensile properties of the welded samples are calculated and tabulated as given in the study.

Fig. 6: Welded copper pipe (D = 40 mm) after hydrostatic test

Hydrostatics test: Hydrostatic test is conducted by filling the pipe fluid and pressurizing the pipe about to 1.5 times the design pressure. The pressure is then remaining for a limited time at the peak to examine the system from any leaks. Visual inspection can be carried out to make shore that there is no leak in the pipe system.

In the present research an examination of pressure test was carried out on a copper pipe of diameter of 40 mm and a length of 250 mm, the pipe contains weld joint situated at the middle of the pipe, the test pressure 27 bar (400 PSI), the tested specimen is shown in Fig. 6.

Allowable pressure was calculated using the hoop stress equation and found is 306.12 PSI which is equivalent of 20.82 bar. However, that the experimental test pressure was 400 PSI which is equivalent to 27 bar, that confirmed the success of the examined sample pressure despite its failure in the examination of X-ray.

RESULTS AND DISCUSSION

The welding technology of pipes is an important part in the air conditioning and refrigeration systems. It is known that all mediums of cooling are flowing inside the pipes of system for large, medium and small size. This project is represented an important need for engineer because it helps for understanding the welding technique in refrigeration pipes and it is achieved the essential knowledge for the engineers.

Hence, from this important point there is a need to get knowledge of the theory and practice for commonly ways of pipe welding, specifically that commonly called Oxyacetylene welding.

Several parts of pipes fusion zone were prepared for mechanical testing. These specimens were sent to Ministry of oil and ministry of industry for testing. Various Destructive Evaluation (DE) methods have been applied to the evaluation of the quality of the fusion weld joints. Mechanical tests include mainly the bend back test and the tensile test.

Figure 5 shows the stress strain curve for unwelded and welded pipes in welded samples fracture occurred in the fusion zone. The tensile strength and elongation of the joint produced by silver filler material were low due to the presence of defect.

CONCLUSION

From this study, it can be seen that, all welding procedures must be qualified and welding must be controlled to strict specifications. As part of the quality-assurance process, each welder must pass qualification tests to work on a particular pipeline job and each weld procedure must be approved for use on that job in accordance with welding standards.

Oxyacetylene welding processes were conducted according to welding standard that resulted in acceptable mechanical properties. The quality and integrity of the weld joints are highly dependent on the welder skill and standard welding parameters. The selection of qualified welder (6G) who performed all the welding processes and that was important step to reduce the welding defects and achieving the required mechanical properties.

X-ray was used in this project to reveal any defects in the weld and heat affected regions, the test help to make shore that the internal part of the weld is clear from any weld defects.

REFERENCES

01. AWS., 1997. American Welding Society Welding Handbook. 8th Edn., AWS., New York, USA.,.
02. ASME., 2001. ASME Boiler and Pressure Vessel Code: An International Code: Alternative Rules. American Society of Mechanical Engineers, New York, USA.,.
03. Callister, W.D., 2000. Fundamentals of Materials Science and Engineering. Wiley, London, UK.,.
04. Oates, W.R., 1998. Welding Handbook: Materials and Applications Part 2. 8th Edn., American Welding Society, Miami, Florida,.
05. AWS, 1991. Welding Handbook: Welding Processes. 9th Edn., Vol. 2, American Welding Society, Miami, FL., ISBN: 9780871717290, Pages: 720.
06. Lee, D. and S. Shin, 2015. Specimen test of large-heat-input fusion welding method for use of SM570TMCP. Adv. Mater. Sci. Eng., Vol. 2015, 10.1155/2015/264798
07. Dieter, G.E. and D. Bacon, 1988. Mechanical Metallurgy. McGraw-Hill, New York, USA., Pages: 751.
08. Copper Development Association Inc, 2014. 260 Madison avenue. Copper Development Association Inc., New York, USA.
09. Lugo, N., N. Llorca, J.M. Cabrera and Z. Horita, 2008. Microstructures and mechanical properties of pure copper deformed severely by equal-channel angular pressing and high pressure torsion. Mater. Sci. Eng. A., 477: 366-371.