NON-DESTRUCTIVE TESTING ON COMPONENT FOR REACTOR COOLING SYSTEM BY RADIOGRAPHY AND LIQUID PENETRANT METHODS

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Abstract

Non-destructive Testing has been widely used in oil and gas industries, aircraft, and especially the nuclear reactor in the period leading to the nuclear power plant. It also allows parts and materials to be inspected and measured without damaging them. These tests are very important in determining and identifying the discontinuity and defects found on a materials and parts of an object. Techniques used in this test are the radiographic and liquid penetrating testing to inspect the reactor parts in reactor cooling system to avoid the reactor to fail in operation. By using radiographic testing, x-ray source have been used in the tests conducted to determine the flaws of the internal of an object. While the test of liquid penetrating testing used dye penetrant to identify defects on the surface. These tests will reduce the harm that might occur in the future to the objects or materials.

Abstrak

Ujian Tanpa Musnah telah digunakan secara meluas dalam industri gas dan minyak, pesawat, dan terutama sekali reaktor nuklear dalam zaman menuju ke nuklear penjana elektrik. Ianya juga membenarkan bahagian-bahagian dan bahan untuk diperiksa and dibuat pengukuran tanpa memusnahkan. Ujian-ujian ini adalah sangat penting dalam menentukan dan mengenalpasti ketidakselanjaran dan kecacatan yang terdapat pada sesuatu bahan dan bahagian sesuatu objek. Teknik yang digunakan dalam ujian ini adalah radiografi dan cecair penembus untuk menyemak bahagian-bahagian reaktor dalam sistem penyejukan reaktor untuk mengelakkan daripada kegagalan dalam operasi. Dengan menggunakan ujian radiografi, sumber sinar-x digunakan dalam ujian ini digunakan untuk menentukan kecacatan dari dalaman objek. Manakala bagi ujian cecair penembus pula menggunakan penembus pewarna untuk mengenalpasti kecacatan pada permukaan objek . Dengan ujian ini ianya dapat mengurangkan keburukan pada masa akan datang yang mungkin berlaku pada objek dan bahan.

Keywords/katakunci: Radiography, liquid penetrant, reactor cooling system

INTRODUCTION

Non-destructive testing comprises five conventional methods in order to carry out the inspection without damaging the object under test. Each method has its own advantages and limitations depends on a number of factor for instant type of material the sample is made of, size and orientation. However, this paper will discuss on two methods, namely radiography and dye penetrant testing. The discontinuities found during the test is evaluated based on its nature and dimension.

Radiography testing uses ionizing radiation as a source of energy to penetrate into the test sample. The test sample is placed in between the source of radiation and a film. The object, depends on thickness and type of material, will absorb some of the radiation. Thicker and more dense part absorbs more radiation which finally makes less radiation passed through the object and react with the film. The part on the film which received less radiation will be less darken proportionately. So the film acts as a medium to capture and store the image of the test sample. In order to reveal the image, the film, after being exposed to ionizing radiation, has to be processed in a dark room.

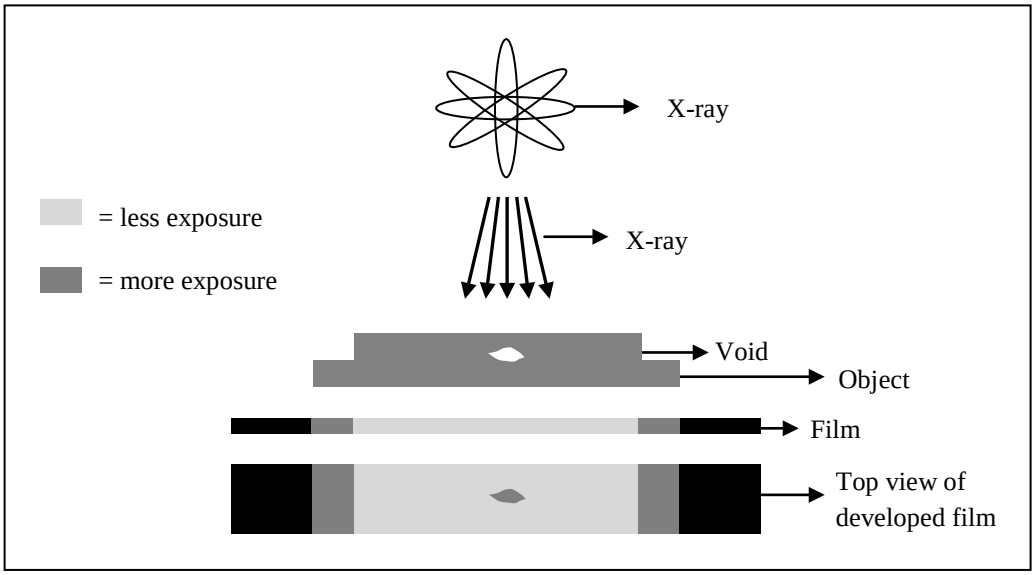


Figure 1: Schematic diagram of radiographic testing (RT)

The above figure shows a schematic diagram of a radiographic testing. Basically there are three main things we need to have in order to make the test completed. They are radiation source, object, and film.

Dye penetrant testing or in other words liquid penetrant testing is one of the methods that is widely used in non-destructive testing. The method is used especially to detect open-to-surface discontinuities in nonporous solid materials including metals and non metals. In case of metals, it is applicable for both non-ferrous and ferrous material. The reason that probably makes this method widely used in industry is because of its low cost and less equipment needed to set up the test.

METHODOLOGY

Two methods of nondestructive testing were employed in the test, namely radiography and liquid penetrant. Each method is done separately. For the first method, that is radiography, the source of radiation was generated from GE Isovolt Titan E. The machine was activated at 100kV, with 3mA tube current and the exposure time was 25s. The test sample was an aluminum 6061 pipe. The radiographic film, Agfa Structurix with speed D7 and 250mm x 100mm in size was used. The film was processed and developed in a darkroom at laboratory.

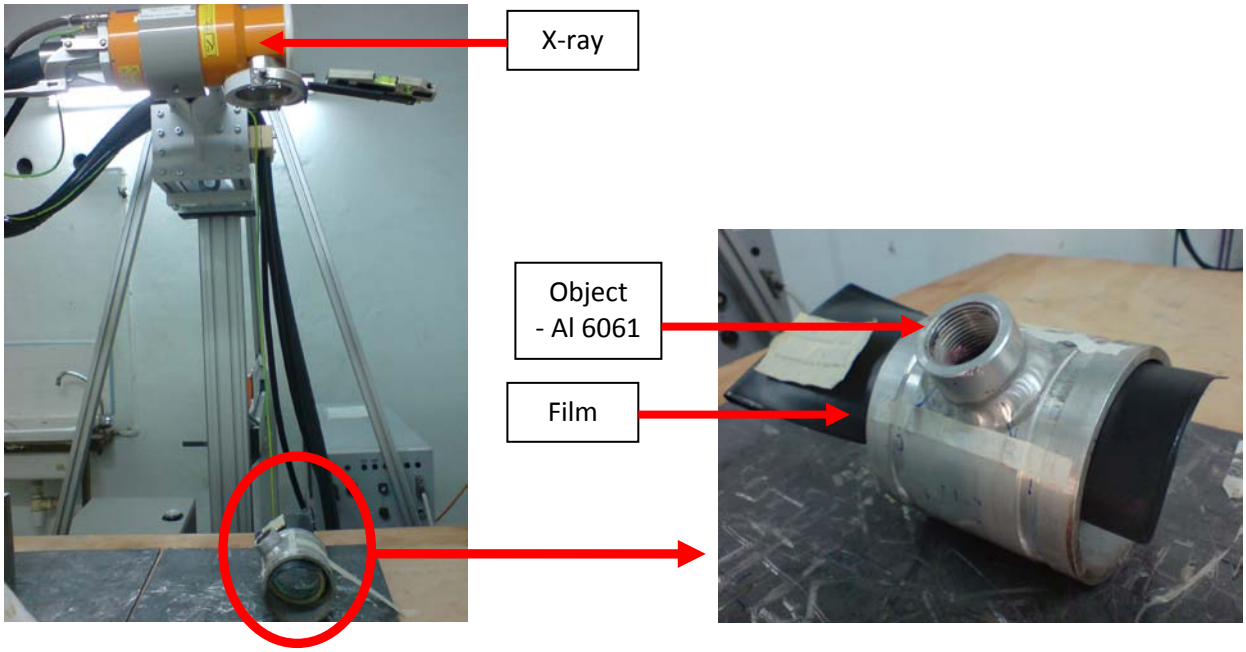
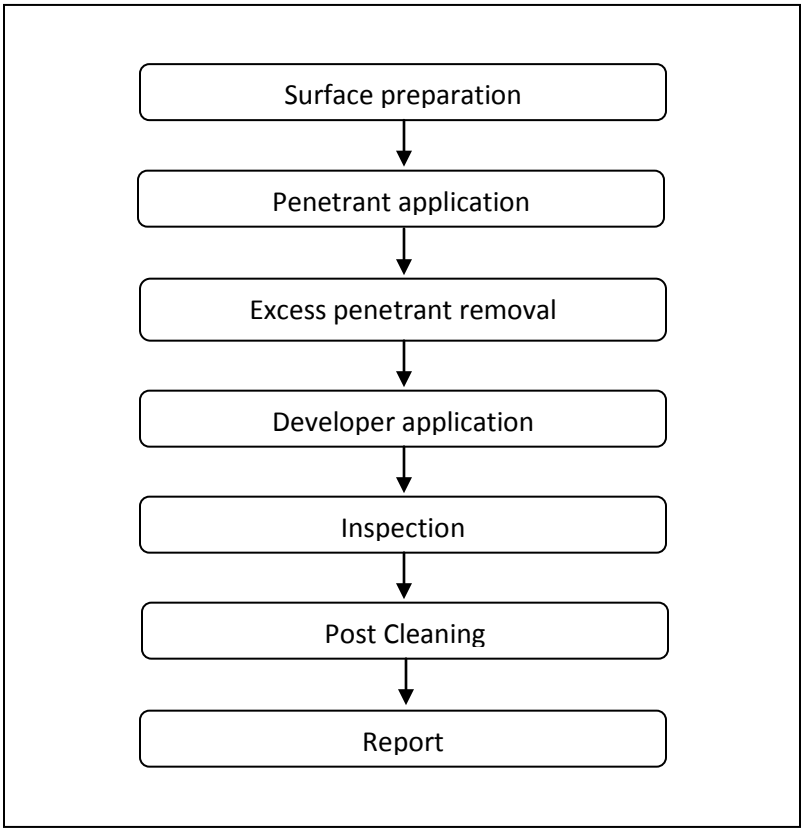


Figure 2: Experimental set up using radiographic testing (RT)

The second method in the list was dye penetrant testing. In principle, there are a several steps to consider in sequence when applying the method. The figure 2 shows the steps.



First and foremost, for surface preparation or pre cleaning stage as sometimes called, the part of test sample where the area of interest lies was physically cleaned from dirt, loose scale, welding flux or spatter by using appropriate tools. Then it was followed by applying cleaning agent on the surface to remove any other contaminant for example oily film and grease (figure 3). After few minutes, a red dyed penetrant was applied by spraying on the entire surface of area of interest (figure 4). Then test sample was left undisturbed for 10 minutes dwell time. When the dwell time completed, the excess penetrant was removed carefully in certain manner. Cotton rags slightly damped with cleaning agent were used to wipe the surface until most traces of the excess penetrant disappeared.

Next, a white color developer was sprayed on the entire surface. Certain period of time was allowed for sufficient development to happen. Immediately after the time ended a thorough inspection was carried out, normally between 5 to 10 minutes. It was observed that part which has discontinuity appeared in red spotted and the indications varied in size, length and location from the reference point. They were recorded and pictured as shown in figure 5.

Finally, the surface was cleaned using the same cleaning agent as in the beginning. The cleaning was done on the entire part until all residues of the white developer and red indication completely removed.

Figure 3: Al 6061 welded pipe

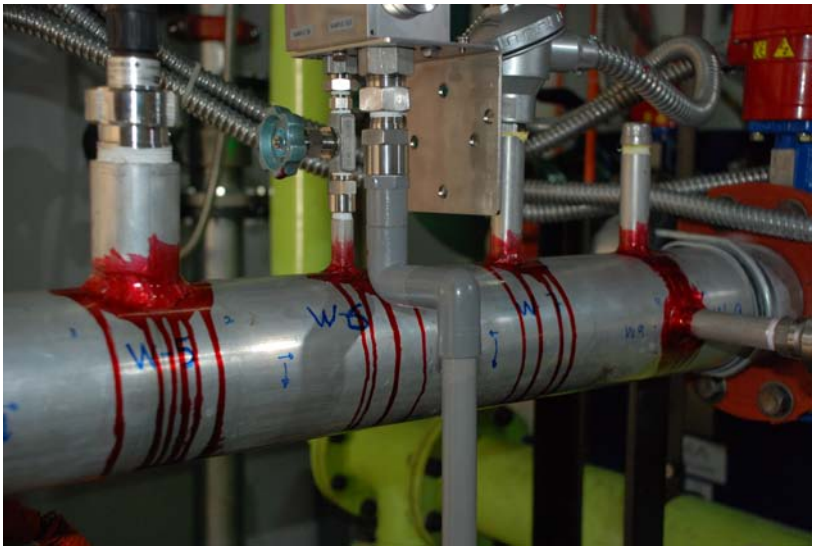


Figure 4: Dye penetrant application

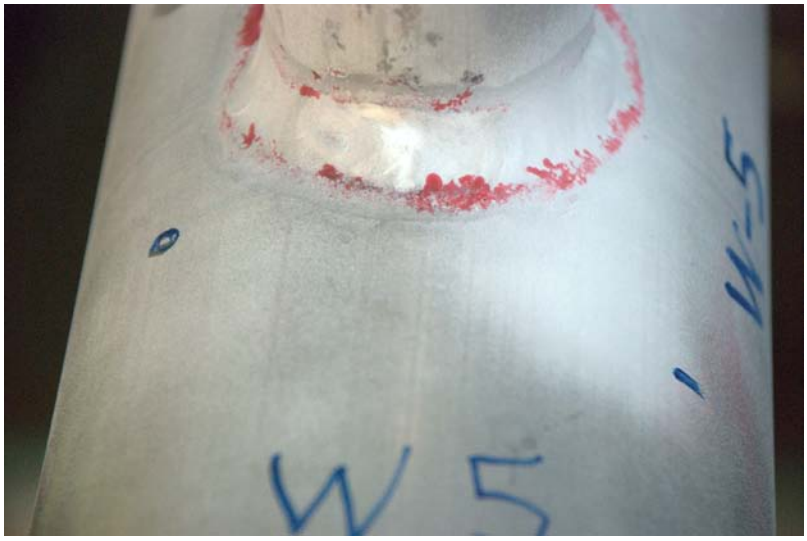


Figure 5: Developer application

RESULT AND DISCUSSION

The test samples were inspected by radiography and liquid penetrant methods. Below was the result for radiographic testing.

Part No.	Film Density	Visible IQI	Type of defects
W1(3-0-1)	2.67	Wire no 6	Lop, Lof, Scattered Porosity
W1(1-2-3)	2.72	Wire no 6	Lop, Lof, Scattered Porosity
W5 (2-3-0)	2.28	Wire no 6	Lop, Lof, Scattered Porosity
W5 (0-1-2)	2.45	Wire no 6	Lop, Lof, Scattered Porosity
W6 (2-3-0)	2.53	Wire no 6	Lop, Lof
W6 (0-1-2)	2.43	Wire no 6	Lop, Lof
W7 (0-1-2)	2.10	Wire no 6	Lop, Lof, Porosity
W7 (2-3-0)	2.14	Wire no 6	Lop, Lof, Porosity
W8 (0-1-2)	2.17	Wire no 6	Lop, Lof, Porosity
W8 (2-3-0)	2.39	Wire no 6	Lop, Lof, Porosity
W9 (0-1-2-)	2.17	Wire no 6	Lop, Lof, Porosity
W9 (2-3-0)	2.21	Wire no 6	Lop, Lof, Porosity
W10 (3-0-1)	2.40	Wire no 6	Lop, Lof, Porosity
W10 (1-2-3)	2.23	Wire no 6	Lop, Lof, Porosity
W11 (0-1-2)	2.57	Wire no 6	Lop, Lof, Porosity
W11 (2-3-0)	2.72	Wire no 6	Lop, Lof, Porosity
W12 (2-3-0)	2.85	Wire no 6	Lop, Lof, Porosity
W12 (0-1-2)	2.78	Wire no 6	Lop, Lof, Porosity

While for liquid penetrant testing it was observed that welded pipes number 1, 5, 7, 8, 9, 10, 11 and 12 have shown indications for porosity.

The inspections by radiographic and liquid penetrant methods had provided a complete coverage for they had covered inspections on surface and internal parts of the test sample. As far as area of interest is concerned both methods of inspection were done on all part of welded area.

The radiograph from radiographic and indications from liquid penetrant methods revealed lack of penetration (Lop), lack of fusion (Lof) and porosity which were the discontinuities present in the test samples. By American Welding Society Standard (AWS), test samples with Lop and Lof are rejected. It means that the parts have to be repaired.

CONCLUSION

The two nondestructive testing methods used to inspect parts of component for reactor cooling system were successfully carried out to reveal both internal and surface discontinuities. It has shown a good compliment for each of the methods has its own advantages and limitations. Therefore, a complete coverage of inspection has been done on the test samples.

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REFERENCES

1. Halmshaw, R. 1991, Non-Destructive Testing. Second Edition. Great Britain: Edward Arnold.
2. American Welding Society Standard. 2006. Structural Welding Code-Steel.
3. American Welding Society Standard. 2003. Structural Welding Code-Aluminum,
4. ASME Boiler and Pressure Vessel Code. 2010. Section VIII.
5. Abd Razak Daud. 1993. Radiografi Industri. Penerbit: Dewan Bahasa dan Pustaka.
6. Nondestructive Testing Handbook-Radiography & Radiation Testing (volume 3, second edition). 1985. Publ: American Soc. For Nondestructive Testing (ASNT).