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A review on welding inspections after welding (DT and NDT)

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Abstract

Welding connections are so common in steel structures. Weldments, designed by engineers are mostly strong enough, but the problem starts at the construction part, where welders without enough experiences do their work wrong and make defects in welds. So inspection and controls are needed to have strong enough weldments in connections. In this article the three levels of inspection is discussed respectively, according the references. Some of the common NDT and DT tests are explained with pictures. At the end this ways of inspection are compared to check which one is better for each welding.

Keywords: welding inspection, steel structures, visual test, NDT test, DT tes

1. Introduction

Welding connections designed in a structure must tolerate simple and complicated stresses of static and dynamic loads, so they are designed and executed considering this point. But you can't examine how reliable a welded connection is just by visual tests. Therefore welding inspection takes part. In order to get the best welding quality you need to do inspection during the construction, and don't let it be done at the end of the project. Many institutes are now fostering inspectors that can doo tests on welding and check the quality off weld and hazardous part [2]. The inspector should be knowledgeable concerning each of the principles and methods of examination required on a particular weldment [1].

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2. Welding inspection partition

Welding inspection is done in three phases. (1) prior to welding, (2) during welding and (3) after welding [3]. All these three are discussed here, respectively.

2.1. Prior to welding

There are many things an engineer must do before starting welding. Some of them are here below:

1. Collect information of the project and study the sensitivity of the structure
2. Study and check the drawings of the structure
3. Decide the method of welding in each part
4. Decide the material to use in each welding
5. Provide the equipment needed

2.2. While welding

1. Make sure that the welding's place is clean
2. Control the sequence of welding in structure
3. Make sure that the electrodes are clean and the coating of electrodes aren't damaged
4. The welder must be experienced enough
5. Pick up the welding slag between each welding sequence
6. Provide the pre-heating needed for welding and check the enough temperature between sequences

2.3. After welding

Inspection in this part is divided in to two categories. First is nondestructive tests (NDT) and the second is destructive tests (DT) [2]. Each of which is discussed below.

2.3.1. NDT

The whole area of nondestructive testing (NDT) of welded structures is currently undergoing a period of rapid change brought about by a combination of technological, regulatory and economic factors worldwide. The purpose of this kind of tests is to check the defects of welding in both surface and depth of the weld. in some cases you can pick up the damaged weld and do the welding progress again. None of the welded tested in this methods can be accepted totally. The most common NDT tests are (1) visual test (2) radiographic test (3) ultrasonic test (4) magnetic particle test (5) liquid penetrate test.

2.3.1.1. Visual test

Visual test is one of the fastest and cheapest ways to inspect and control the welding defects like surface cracks (fig.1) and bruise of weld. Visual inspection is probably the most widely used NDT technique but it does not generally involve the purchase of dedicated NDT instrumentation so it does not appear in market estimates [6]. In some cases some inspectors use magnifier to get better view.

Figure 1. surface cracks

2.3.1.2. Radiographic test

Radiographic test is very common in structure welding. It uses Gama and X electromagnetic rays to show the porosity of welded zone. Radiography relies on detecting a change in transmitted intensity of a Gamma-ray or X-ray beam arising from differences in the absorption coefficient of a defect and the surrounding metal [4]. These rays are projected (fig.2) move through the weld, and then part of it absorbed by weld and the rest of it get out from next part of weld which means these parts are spongy. Inspectors get the rays exited from the weld on some special film (fig.3) and check the porosity of the welding.

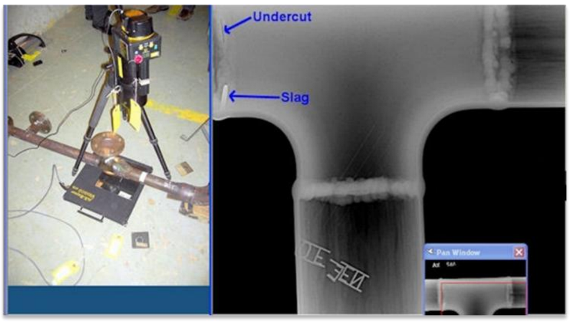

Figure 2. Radiographic test

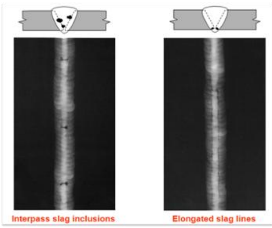

Figure 3. the rays exited from the weld on some special film

2.3.1.3. Ultrasonic test

Ultrasonic test uses waves with 20MHz-500MHz frequencies to show the defects location and size, porosity and cracks [3]. It also shows the incomplete penetration and the total depth of weld (fig.4). It is possible to use for both metal and none metal weldments. Ultrasonic waves are scattered by planar and volumetric defects, making the ultrasonic technique useful for detecting and sizing both types of defects. Even closed cracks are detectable by ultrasonic, provided that appropriate procedures are used [5]. Ultrasonic test is faster and more sensitive than radiographic test and it's simple to use, (fig.5&6).

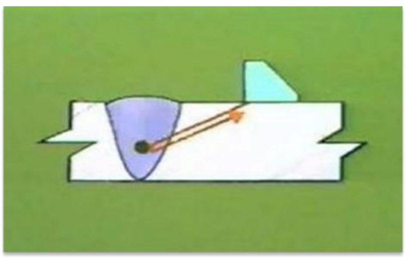

Figure 4. Total depth of weld

Figure 5. radiographic test

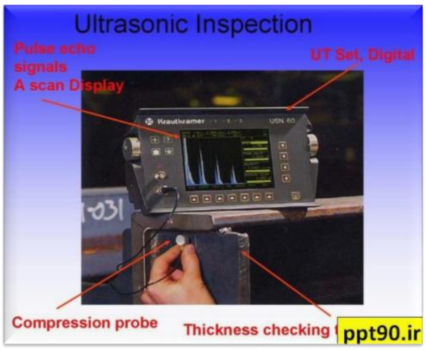

Figure 6. ultrasonic inspection

2.3.1.4. Magnetic particle test

This method is used almost exclusively for crack sizing [4]. The inspector first makes a magnetic area at the welded zone, then sprinkle the magnetic able powder on the welded zone (fig.7). After that the places which have effects of porosity, the magnetic powder will have centralized around the porosities and defects (fig.8) [2]. Unusable for none metal welding is the problem of this method.

Figure 7. welded zone

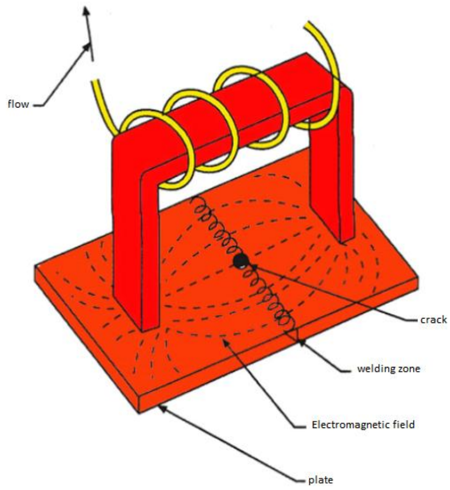

Figure 8. welding porosities and defects

2.3.1.5. *Liquid penetration test*

Colorful material floating in the liquid can penetrate in cracks on the welding [3]. First this liquid is poured on the welded zone. After that, when it gets dried, the developer powder is sprinkled on it, which make the cracks visible (fig.9). The spray-can used in this test is special as you see in (fig10). This method is totally used for surface defects of the welding and it's cheap. It can be used for both metal and none metal materials. It is also useable for none metallic weldments [2].

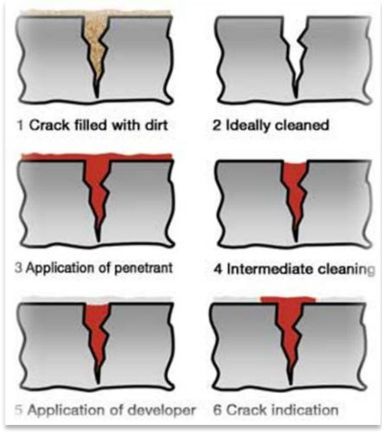

Figure 9. cracks

Figure 10. Using spray in welding test

2.3.2. *DT*

In this kind of tests, the tested weld after the test won't be able to operate. It is mostly used in experimental studies [3]. In practice it means, for example, finding out if the quality of a weld is good enough to withstand extreme pressure or to verify the properties of a material [7].The results of tests can be both quantity and quality amounts in special tests. The area and number and procedure of the test is based on special standards. The most common standard is American Welding Society (AWS) [2].

Benefits of Destructive Testing (DT): [7]

- Verifies properties of a material
- Determines quality of welds
- Helps you to reduce failures, accidents and costs
- Ensures compliance with regulations

Now we would discuss some of the methods below.

2.3.2.1. Tensile testing

This test is used to obtain the tensile strength and flexibility of welded metal to observe the mechanical specifications of it. From this test it's available to get inform about the tensile strength, yield point, modulus of elasticity and flexibility of the welded metal. This test is done in two ways [3]:

First is called Transverse Tensile Test in which the welded metal plates are stretched to rupture (fig.11). In this test the plate must not be rupture from the welded zone, instead it must rupture from the steel [2].

Second is called Longitudinal Tensile Test in which the purpose is to control the electrode and welding equipment. The procedure is simple. First a sample is made from the welded metal. Then effective length is marked (punch marks). After that the sample gets fixed to the tensile machine and started to stretch till the effective part starts to necking, meanwhile the force and elastic/plastic deformation graph should be drawn. After the rapture, the amount of elongation in effective part and the minimum cross section would be noted to check them with standard tables and determine the test's results.

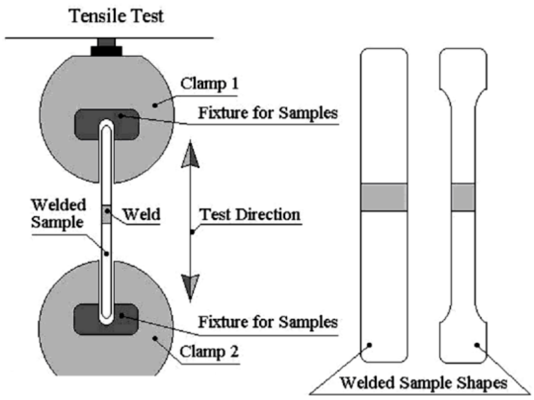

Figure 11. Tensile Test

2.3.2.2. Shear strength test

In this test the procedure is like the tensile test. The different is in results. At the end of the test, when the plate get ruptured, quotient of the maximum force applied to plate to length of weld would be the shear strength of welding [3].

2.3.2.3. Bending test

It's very cheap and simple and shows the flexibility of welded part, weld penetration, crystal structure, strength of weld and even sometimes some defects of weld. The effective length is measured and then the bending of welded plates starts. Bending goes on till cracks more than 1.5cm is seen. If no crack appears, the bending will be continued until the complete bend of the plate (fig.12).

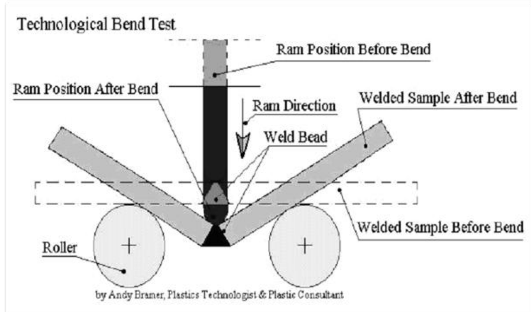

Figure 12. bending of the plate

2.3.2.4. Impact test

This is a test which shows the response of weld upon the dynamic loads (i.e. Earthquake). It shows the toughness of weld in comparison to plate. Another result that is possible to get from this test is the temperature that the ductile fracture changes to brittle fracture by testing the sample in different temperatures [3]. Two methods are available for this test: Charpy and Izod.

In Izod test just one part of the sample is fixed to clamp, and a pendulum hummer with specific potential energy hits the sample and break it, then the height that hummer goes up after breaking the sample is measured to check the amount of energy used to break the sample (fig.13).

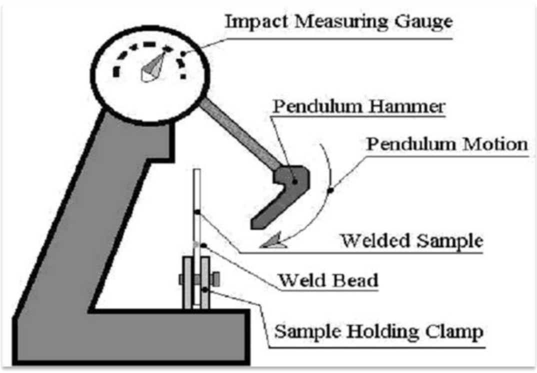

Figure 13. Izod test

Charpy impact tests are the most commonly used to determine the susceptibility of steel to brittle fracture under notched conditions in the transition region because they can provide a relatively simple, quick, and inexpensive measure of material toughness [8].In Charpy test both sides of the sample is fixed to the clamp (different to Izod), and then the hummer hit and break the sample (like the Izod one) [3]. After that the energy needed to break the sample is measured (fig.14).

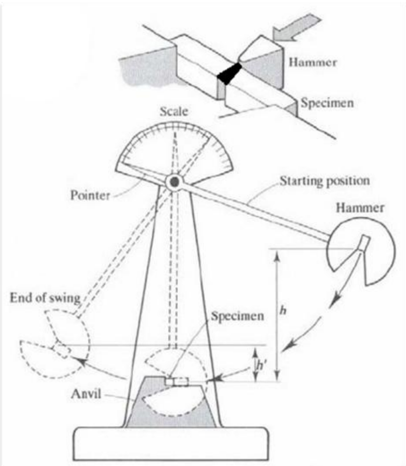

Figure 14. Charpy impact tests

2.3.2.5. Hardness test

Some references include this test in NDT tests [2]. It is used to measure the abrasion resistance and sometimes it is used instead of tensile tests to measure the resistance of welding [3]. It is based on the resistance of weld and hazard zone against inserting a hard thing (i.e. Metal ball bearings) which can show the hardness of weld and susceptibility to cracking (fig.15).

Figure 15: *Hardness test*

3. Conclusion

In recent years some exciting developments have occurred in NDT techniques for weld inspection. Major advances have been made in several fields, particularly in ultrasonic, electromagnetic methods for both crack sizing and residual stress measurement, and in on-line monitoring of the welding process. With a general look on this paper, you would recognize the ultrasonic gives you the best answer to welding inspection but isn’t the cheapest. Cost effectiveness is linked to factors such as reliability, sensitivity, speed and coverage of NDT techniques. So for each weldment you need to check which kind of NDT or DT gives you the best and economical answer.

References

[1] AWS, "Guide for the Visual Inspection of Welds",USA, 1988.
[2] Shapour Tahouni, ‘welding guidance and welding connections in steel structures’2001
[3] Mohammad Hossein Rafiee, ‘Quality Control & Inspection in Welding Industry’
[4] R. J. Ditchburn, S. K. Burke and C. M. Scala,NDT of welds: state of the art, Elsevier Science, NDT&E International, Vol. 29, 1996.
[5] Deuster, G. Int. J. Pres. ies. kPiping 35 (1988) pp 173-188

[6] P Cawley, Non-destructive testing—current capabilities and future directions, SAGE Journals, 2001.
[7] Destructive Testing (DT) – Inspecta http://www.inspecta.com/en/Our-Services/Testing/Destructive-Testing/
[8] S.H. Kim, Y.W. Park *, S.S. Kang, H.D. Chung, Estimation of fracture toughness transition curves of RPVsteels from Charpy impact test data, Nuclear Engineering and Design, 2002