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# Detection of Welding Defects by Non-Destructive Testing Methods

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***Abstract –*** One of the most used joining methods in the manufacturing industry is welded joints. Welded joints are non-removable types of joints and good mechanical properties are expected from the weld seam after joining. For this reason, it is extremely important that there are no errors, defects or gaps in the weld area. This study is about the detection of defects existing in the welding regions of various machine elements with welded joints by non-destructive testing methods. The advantages and disadvantages of the non-destructive testing methods used in the study are presented.

*Keywords – NDT, Ultrasonic Test, PAUT, Radiographic Test,*

## I. INTRODUCTION

Non-destructive testing (NDT) methods are basically divided into two as methods used to detect defects on the sample surface and sample interior (Volumetric methods). Penetrant inspection, magnetic inspection and visual inspection can be given as examples to the methods used for detecting sample surface defects. With these methods, work can be done to detect defects up to 2-3 mm deep in the material. Volumetric methods are much more advanced. They are very successful methods in identifying defects not only on the surface of the material, but also everywhere. Examples of these methods are ultrasonic and radiographic methods [1].

## II. MATERIALS AND METHOD

### A. *Visual Test*

Welding visual inspections, which can be performed by personnel qualified in accordance with EN 9712, are the most basic inspection method that gives the first idea for the weld, which is requested to be performed 100% in almost every production. In addition, Visual Inspections are also performed according to EN17637 or ASME Part V. With this method, only visible surface defects can be noticed (Fig.1) [2].

These defects are;

- Surface Cracks
- Surface pores
- Spatter and Slag
- Overlap
- Linear and Angular Misalignments
- Insufficient Filler and Excess Weld Metal
- Arc strikes
- Corrupt welding forms

Fig.1 Welding Slags

Application:

ISO 17637 states that the minimum light will be 350 lux, but recommends 500 lux (normal workshop or office lighting). Testing personnel should not have any problems with near vision [2].

Advantages

- It is done easily and quickly.
- The cost is quite low.

Disadvantages

- Only surface defects can be detected.

### *B. Penetrant Test*

The penetrant method is used to determine the discontinuities open to the material surface. It is widely used due to the ease of its application being visible and its adaptability to various inspection problems. The method is used for inspection of almost any material whose surface is not excessively rough or dirty. In Figure 2, an example of a sample subjected to the penetrant test is given [3].

Application:

- The area to be examined is cleaned by squeezing cleaner liquid.
- Penetrant liquid is sprayed on the area to be examined.
- After waiting for 15 minutes, the examination area is cleaned with a cloth that is squeezed cleaner.
- After the developer is sprayed on the cleaned area and waited for 10 minutes, the examination is started.
- After the examination, the area is cleaned by squeezing cleaner liquid.

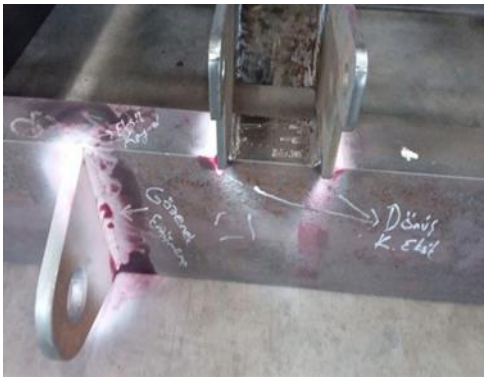

Fig.2 Penetrant Test Application

Advantages

- Defects can be detected in more detail than by visual inspection.
- Defects are easier to identify.
- It is inexpensive compared to radiographic and ultrasonic examination [4].

Disadvantages

- It takes longer than a visual inspection.
- If appropriate personal protective equipment is not used in use, it may harm human health.
- It cannot be used in fire hazardous working environments [4].

### *C. Magnetic Particle Test*

The magnetic particle test method is a method that can be applied to ferromagnetic materials. This method is based on the principle of leaving the iron powders sprayed on the white painted weld seam in the magnetic field with the help of a special device. [5] It is the detection of welding faults as a result of monitoring the movements of iron powders with the magnetic field created with the help of the Magnetic Yoke device (Fig. 3).

Application:

- White background paint is applied on the weld.
- Magnetic field is created with magnetic yoke.
- Observation is done by squeezing the black iron particle.

Fig. 3 Magnetic Test Application

Advantages

- It is faster than penetrating examination.
- There is no waiting period.
- It is cheaper than ultrasonic and radiographic examination methods [4].

Disadvantages

- It can only be used to detect surface errors.
- Can only be used on magnetic materials [4].

### D. *Ultrasonic Test*

Ultrasonic testing is one of the non-destructive testing techniques that sends ultrasonic waves into the material. These high-frequency sound waves are transmitted to the materials for the detection of defects, especially in the internal structure of the materials.

The lack of records in traditional ultrasonic testing was a major problem. For this reason, radiographic testing had been preferred. However, with the development of methods such as Time of Flight Diffraction (TOFD) and Phased Array Ultrasonic Testing (PAUT), this problem was prevented and recordable devices were developed [6]. An image of the PAUT application is given in Figure 4.

Application:

A fusing gel is applied on the material to reduce friction and prevent probe damage. Then, sound waves are sent to the material through the probes of the ultrasonic test device and the graphics on the screen of the test device are interpreted [7].


Fig.4 PAUT application

Advantages

- It can also detect defects below the surface.
- Defects can be recorded with methods such as PAUT.
- There is no harm to human health.
- Results can be obtained quickly [4].

Disadvantages

- Superior operator ability required [4].

### E. *Radiographic Test*

It is the transfer of the image to a screen by sending X-ray or Gamma rays on the material. It has the same principle as the x-ray used in hospitals [8].

Application:

- It involves passing a penetrating beam through the test object.
- The transmitted beam is collected by some type of sensor.
- This sensor is capable of measuring the relative intensities of penetrating rays striking it. In most cases this sensor is a radiographic film [9].

Fig. 5 Radiographic Test Result Evaluation

Advantages

- It is used in the control of damages in all types of materials.
- It reveals invisible discontinuities and manufacturing errors.
- It is possible to visibly protect and archive the images on the film whenever desired [10].

Disadvantages

- It is more expensive than other non-destructive testing methods.
- It is harmful to human health because it emits radiation.
- The density and thickness of the material affect the measurement values.
- It is difficult to apply in parts with different geometric shapes [10].

## III. RESULTS

Non-destructive testing methods are heavily preferred in industrial applications. This situation has made it necessary to develop test methods that give faster and better results. Technology is developing rapidly in the field of NDT as it develops in every field. Today, PAUT tests are preferred in some applications where radiography tests were performed before.

## IV. DISCUSSION

As it can be seen, each method has its own advantages and disadvantages. The important thing is to determine the most accurate and cheapest method for the product to be manufactured. NDT methods give fast, mostly accurate and inexpensive results. It is essential to use volumetric methods in critical productions that require high durability.

## V. CONCLUSION

The biggest reason why radiographic examinations are preferred over traditional ultrasonic examinations is that test results can be recorded and stored. However, with the development of methods such as paut where the results can be recorded, the reason for preference for radiographic testing has disappeared. However, many companies do not prefer new ultrasonic methods because they do not trust the method and do not follow the technology. This situation, which we encounter due to unawareness, causes deterioration of operator health, unnecessary cost increase and increase in project completion time.

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