

THE THERMOGRAPHIC ANALYSIS OF THE WELDING BY TIG

M.Sc., Eng. Maś K., M.Sc. Woźny M., PhD. Marchewka M., PhD. Ploch D. and Prof. Dr. Sheregii E.M.

Centre for Microelectronics and Nanotechnology, University of Rzeszow, Poland

kinga04@interia.pl

Abstract: Thermography measurements allow to detect the defects that may appear on a joint at welding of components. Energy pulse generated by a xenon lamp with adequate power in a short period of time is sufficient for thermal excitation and enables to register the temperature distribution using the thermography high resolution camera FLIR SC7000. The impulse with 6kJ energy and 6ms time generate sufficient power to measure the temperature distribution on the surface of the weld tested. During cooling the temperature of the area with defect changes more slowly than in the areas without defects, because of the less intense heat dissipation. This allows the registration of defects in welds "on-line" at the production process. Material used for analysis detection of defects in the welded joints is Inconel 718, stainless steel 410 and stainless steel 321. The peak energy which flow through the samples with defects in the welded joints is completely or partially blocked. It causes different temperature distribution on the surface in the places where the connection discontinuity takes place.

Keywords: THERMOGRAPHY, DEFECTS, WELDING, NDT

1. Introduction

Welded joints and padding layers are subjected to control processes through the use of non-destructive testing methods to ensure a high quality semi-finished and finished products [1-3]. Depending on liability and class of structure an individual and single method or a complex of few (usually two independent parallel testing methods), are chosen. Radiographic and fluorescent weld inspection are used as two most common nondestructive testing (NDT) methods to detect discontinuities within the internal structure of welds. The obvious advantage of both of these testing methods is their ability to establish the weld's internal integrity without destroying the welded component. These methods have been used widely in industry due to provide information about the test object without reducing its functional properties: they are used to detect defects that can cause damage or destruction of the item [4]. Thermography and thermal imaging include research methods involving remote and contactless evaluation of temperature distribution on the surface of a body [5-7]. This method is based on observation and recording the distribution of infrared radiation emitted by each body, whose temperature is above the absolute zero. If an external source of heat (thermal excitation pulse) is applied the thermography is called as active [8].

In this contribution the active pulse thermography is used for control of welds and results of control are comprised with traditional methods as radiographic and fluorescent methods of testing.

2. Materials and methods

The tests were performed on the samples of number 8, 19 and 23 made from the following materials: Inconel 718, stainless steel 410 and stainless steel 321, respectively.

The fluorescent method of testing includes the observation of defects (discontinuities) present on the surface of welds. Surface cracks and pinholes that are not visible to the naked eye can be located by the liquid penetrant inspection. It is widely used to locate leaks in welds and can be applied with austenitic steels and nonferrous materials. Assessment and indications of defects on the test surfaces occur in the ultraviolet lamp light after all stages of penetration testing. The presence of discontinuities (such as cracks, craters) indicate a shining by yellow-green color under the influence of the UV rays.

The radiography (X-ray) is one of the most important, versatile and widely accepted nondestructive method of examination. X-ray method is used to determine internal quality of the welds. Radiography is based on the ability of X-rays and gamma rays to pass through metal and other materials opaque to ordinary light, and produce photographic records of the transmitted radiant energy. All materials will absorb known amounts of this radiant energy and,

therefore, X-rays and gamma rays can be used to show discontinuities and inclusions within the opaque material. The permanent film record of the internal conditions will show the basic information by which the weld reliability and credibility could be determined.

The thermography method shows thermograms recorded directly by the IR camera during the measurement or after the computer programme (IrNDT) treatment. Due to this it is possible to trace "step by step" the temperature distribution during of the 100ms time after pulse heat excitation of the sample. The IR camera is registering how the different areas of the sample are conducting the heat because the temperature distribution on the tested surfaces is recording during the heating of sample. The places brighter in the thermograms represent a higher temperature, while the darker – lower temperature.

3. Results of testing

3.1 Results of penetration method



Fig. 1 Sample No. 8 made by Inconel 718 alloy.

In Fig. 1 is shown the results obtained for the penetration method of the sample 8, where two shining areas are observed marked as "a" and "b". In the place marked as "a" shining is lighter what means a deeper discontinuity, with the greater amount of penetrant than the place marked as "b", where shining has a point character.



Fig.2 Sample No. 19 made by stainless steel 321

In Fig.2 is shown the sample with a crater at the end of the pad welding on the left side. The purple color on the surface is coming from a pollution.

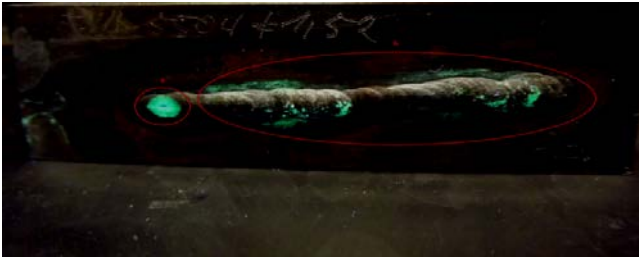


Fig.3 Sample No. 23 made by stainless steel 410

On the surface of the pad welding of the sample 23, shown in Fig.3, the crater is observed also on the left side of sample, which is evidenced by the green-yellow shining of the round shape (area "a"). Others shining places have an irregular shape. They are originated by an inequality and by the roughness of the surface.

3.2 The results of radiographic method

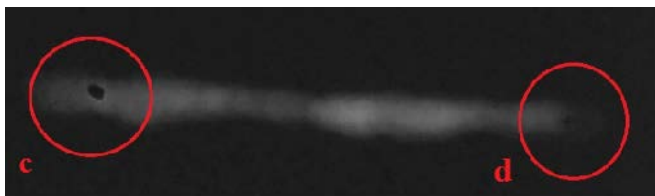
The radiographic testing of the same samples is presented in Figs. 4,5 and 6. It is seen that the dark faults take place on the pictures obtained by the X-ray.



Fig. 4 Radiogram of weld sample No. 8



Figs.5. Radiogram of weld sample No. 19



Figs.6 Radiogram of weld sample No.23

Analysis of the shown in Figs. 4-6 results allows to observe the following particulars:

- in the sample 8 the area "a" indicates that in the place of crater observed by the penetration method (Fig.1) the crack occurs inside the sample;
- the same situation takes place with the sample.
- in the sample 23 are observed not only the cracks inside the sample but a gas bladder exists inside the weld.

So, the faults belong to the internal defects invisible on the surface when the fluorescent method is used, could be observed by X-ray.

3.3 The results of thermographic method

In Figs. 7, 8 and 9 are shown the thermograms for the same samples 8, 19 and 23 with welds. Fig.7a show the IR picture obtained for the sample 8 during the heat pulse of the 30 ms time. From the 7a thermographic image, obtained directly by IR camera it couldn't be possible to identify the region of the defects. It is only possible to observe the surface roughness of the weld.

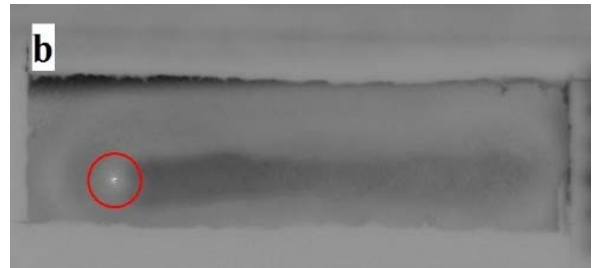
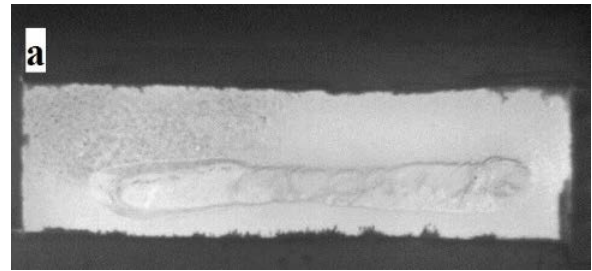


Fig.7. Thermograms of weld sample no. 8, a-thermogram directly registered by IR camera, b - thermogram obtained after computer treatment in IrNDT program.

However, the thermogram 7b, obtained after treatment by the IrNDT computer program, enables to find the bright spot (in the area marked with a red circle). Comparing with the radiological and penetration results confirms that this is the crater observed in Figs. 1 and the crack visible in Fig. 4.

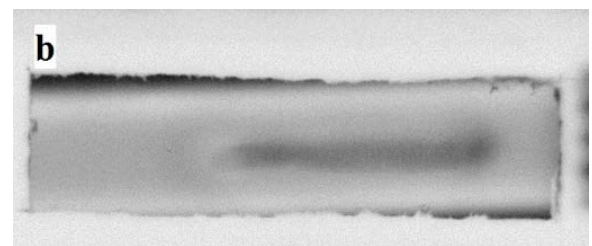
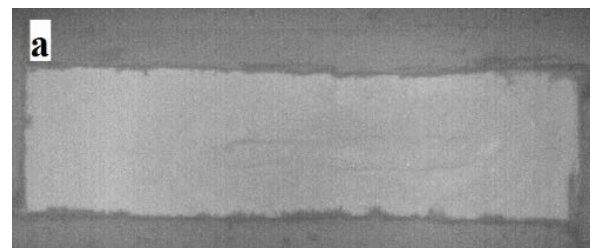


Fig.8. Thermograms of weld sample no. 19, a-thermogram directly registered by IR camera, b - thermogram obtained after computer treatment in IrNDT program.

Analogously, in the case of sample 19 shown in Figure 8a, the picture is obtained directly by IR camera, doesn't indicates the defects in the weld. On the thermogram recorded at 50 ms heat pulse and depicted in Fig. 8b the defect observed by penetration (Fig.2) and radiographic (Fig.5) methods, is located at the end of the right side of the weld.

Fig. 9 a,b shows the thermograms of the sample 23 obtained during the 70 millisecond pulse heating. Thermogram in Fig. 9a shows a recess at the end of the weld surface in the right side of sample.

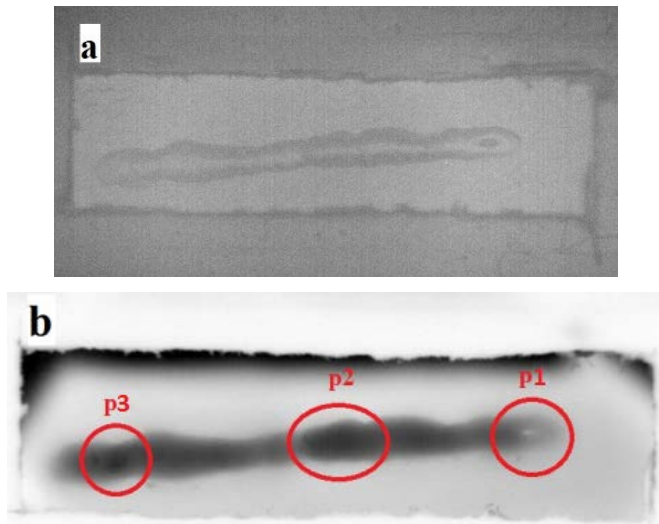


Fig. 9 Thermograms of weld sample no. 23, a-thermogram directly registered by IR camera, b - thermogram obtained after computer treatment in IrNDT program.

Fig. 9b shows the thermogram after treatment in IrNDT program. Temperature distribution shows clearly the presence of defects in the weld:

- area "p1" is a place of higher temperature in comparison with surrounding areas. A thickness of the weld material in the area of "p1" have to be smaller because of the presence of a defect. Heat pulse heats the material at this point faster, hence the higher temperature is achieved (brighter gray level or light spot).
- area of "p2" is a place where the temperature is lower than the temperature at the point "p1". After the visual observation the surface of the sample of the weld, have a larger thickness than that of "p1", because in this point the material was slower heating.
- area "p3" is also a colder place on the weld (darker gray level), in which the temperature was lower than in the area "p1". It has been observed contour defect with circular form.

4. Discusson

The fluorescent method allow to detect the areas where surface discontinuities occur. Evidence of the defects presence is green-yellow glowing of penetrating substance appearing under the influence of UV rays. The pictures in Figs 1-3 clearly are indicating the presence of surface defects on the welds tested.

Radiographic examination confirms the presence of surface defects detected by the fluorescent method but radiographs revealed the presence of internal defects in the sample 23 (Fig.6) where was observed air bladder. Besides that, the Figs. 5 and 5 registered place of incomplete joint penetration at the ends of joints: the cracks inside the craters, which are not recorded using fluorescent method.

The thermography method enables also to reveal the defects inside the welds. In the region of the defect where crater was observed by fluorescent method (Fig. 1) the bright point is detected in Fig. 7b on a darker background of the rest of the pad welding (lower grades of gray-lower temperature) indicating on the inner defect – crack registered by the radiograph (Fig. 4). Also in the thermogram (Fig.9b) is observed the contours of the bladder registered by radiographic method (Fig.6), where the blackout was greater than in the rest of the pad welding. The reason for this is presence of a gas, which acted as an insulator passing also were heat impulse. On the right side of the sample in Fig 9b internal defect is appeared as a light point. The layer thickness at this point was less due to the presence of the crack in the crater. The area was warmed faster than the rest of the weld.

5. Summary

The comparative analyses is performed using three methods of the weld testing: radiographic method, fluorescent one and thermographic one. Combination of first two method enables to reveal the surface defects on the welded joints and verify possibility of the inner discontinuity presences using radiographs. Thermograms, which are results of the thermographic measurement, allow to visualize location of the defects and determine their type. With the correct preparation the thermography method can replace the above two methods: fluorescent and radiographic. Thermography, based on the detection of infrared radiation with aim to detect defects, is a relatively new field of science, giving new opportunities for development and control of welded joints and other structures and elements to eliminate defective products.

Additional information

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