SHORT COMMUNICATION

UTILIZATION OF HOLOGRAPHY LASER TECHNIQUE FOR ARC- WELDING FAULTS DETECTION

By

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ABSTRACT

Plates of mild steel, welded by arc-welding, had been tested using laser holography technique for inspecting the welding defects like: cracks, porosity and inclusions in these plates.

He-Ne laser with wavelength of 632.8nm and output power of 10mw was used to produce a double-exposure holographic interferometry, which was recorded by the film PFG-01for Butt-welding joints. Thermal stress has been used for nano defects formation at the joints. The same joints were investigated using X–ray technique in order to compare between the two techniques.

The double-exposure holographic interferometry showed fringes that indicate the position of the welding defects by using the thermal stress. The results showed good agreement with that deduced by X–ray.

الملخص:

في هذا العمل تم فحص جودة لحام صفائح من الفولاذ المطاوع ملحومة بلحام القوس الكهربي وتم الكشف عن عيوب اللحام باستخدام تقنية الهولوغرافي بالليزر كعيوب الفجوات الغازية والتشقق ووجود الشوائب في وصلات اللحام هذه. استخدم ليزر الهليوم نيون ذو الطول الموجي 632.8 نانو متر وقدرة 10 ملي واط لإنتاج هولوغرام ثنائي التعريض حيث سجلت أهداب التداخل على فلم نوع PFG-01 وتم تحميضها بواسطة المظهر التقليدي. استخدم الإجهاد الحراري من اجل إحداث تشوه مجهري في الوصلات وذلك من اجل إظهار عيوب اللحام. تم فحص نفس العينات بالأشعة السينية لأغراض المقارنة.

أظهرت طريقة تداخل الهولوغرام ثنائي التعريض أهداب تداخل تدل على وجود عيوب في اللحام وكانت النتائج المتحصل عليها متفقة بشكل جيد مع تلك المتحصل عليها من الفحص بالأشعة السينية.

THEORY

A hologram can be considered as a device that stores a wavefront representing an image of some object. The stored wavefront is released by the reconstruction of the hologram. In holographic interferometry, the wavefront is released and used to interfere with some other wavefront, so as to bright and dark fringes regions of constructive and destructive interference. The two wavefronts can represent an object at different instants of time, one at rest and the other under stress [1,2].

The double-exposure method compares the object in two different conditions. Two separated holographic images are obtained when the hologram is reconstructed. There is interference between the wavefronts representing the two holographic images. The double exposure method avoids the problem of realignment of the hologram, because both images are stored in the hologram. The image may be reconstructed without taking any particular pains for exact repositioning and realignment. Distortion due to emulsion shrinkage is minimized, because emulsion shrinkage is identical for both exposures [3,4].

Nondestructive testing is one of the most important application fields of coherent-optical measurement techniques. It's main objective is the qualitative evaluation of the behaviour of investigated objects under load, especially for damage prevention. The qualitative inspection is based on an analysis of the resulting interference patterns where characteristic irregularities are related to object faults by experience. Despite of the great variety of appearing fringe patterns an experienced human interpreter very often is able to detect material faults on the basis of fringe irregularities, which are caused by a non homogenous deformation of the surface. Both extended practical testing and systematic numerical investigations lead to the hypothesis that the appearance of faults in holographic interferograms can be reduced to a finite set of typical fringe irregularities [5].

Five different partial patterns are considered, as shown in (Fig. 1). Two of them are characterized by topological changes of the regular fringes pattern whereas the others show rather quantitative geometrical variations. The first partial pattern, which is known as 'bull eye', can be observed very often. It is marked by concentric fringes. The second one is the so-called 'groove'. It typically shows systematic distortions or neighbored fringes, which is connected with a local change of fringe curvature. A 'bend' is defined by a local, sudden change of fringe direction of some fringes. Locally ending and laterally displaced fringes are called 'displacement'. The 'compression' is characterized by a change of spatial frequency of fringes [5] .

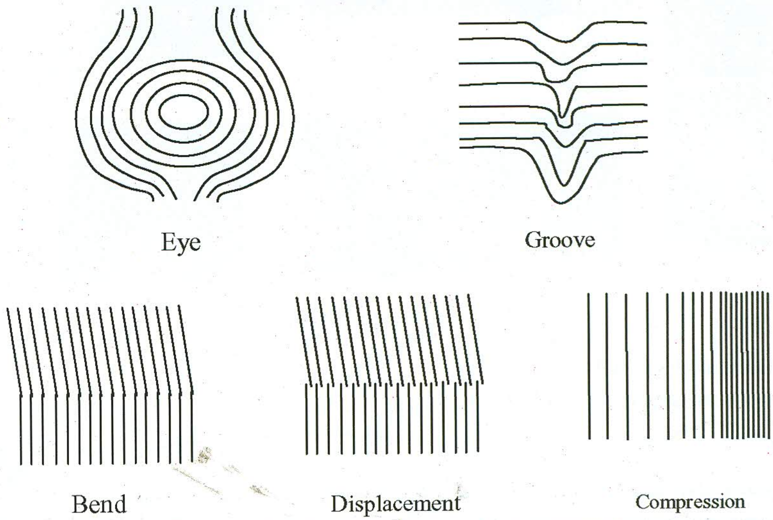


Fig. (1): Fault indicating partial patterns

Experimental Equipments and Tools

Many joints arc-welded were tested by holography using He-Ne laser (632.8nm) with output power of 10mW as a light source. The fringes, which indicate the type of welding defects, were recorded by PFG-01 plate manufactured by Slavish Company in Lithuania.

Mild steel plates 5x2.5x0.5cm, 5x4x0.2cm and 10x2x0.2cm have been jointed, with arc-welding technique, using mild steel, 10 and 12, electrode. Each pair jointed together as a butt joint. The welding joints are performed so as to have defects in the joint region, sometimes the current has been increased or decreased much more or less than it should be, and sometime the electrode is scratched, and sometimes the welding is quenched in a water, and others a second pass is used without removing the slag from the first pass, and always the welding area is not pre-cleaned [6] .

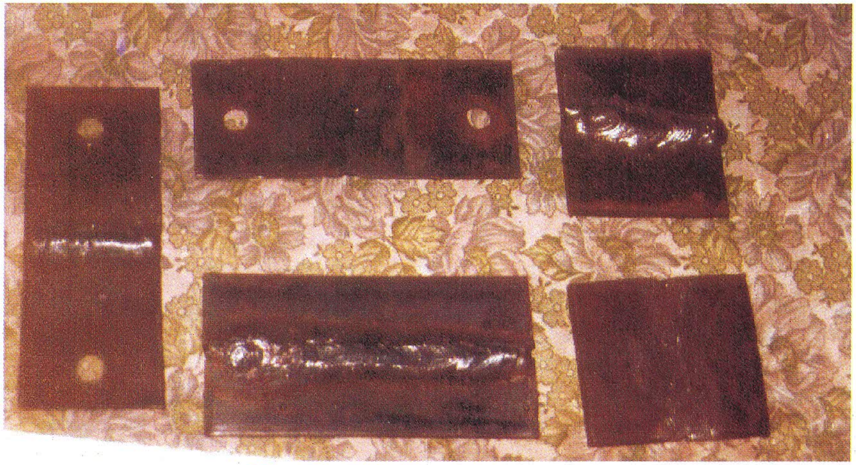


Fig. (2): Welding joints samples

Experimental procedure:

The setup was arranged as shown in (Fig. 3).

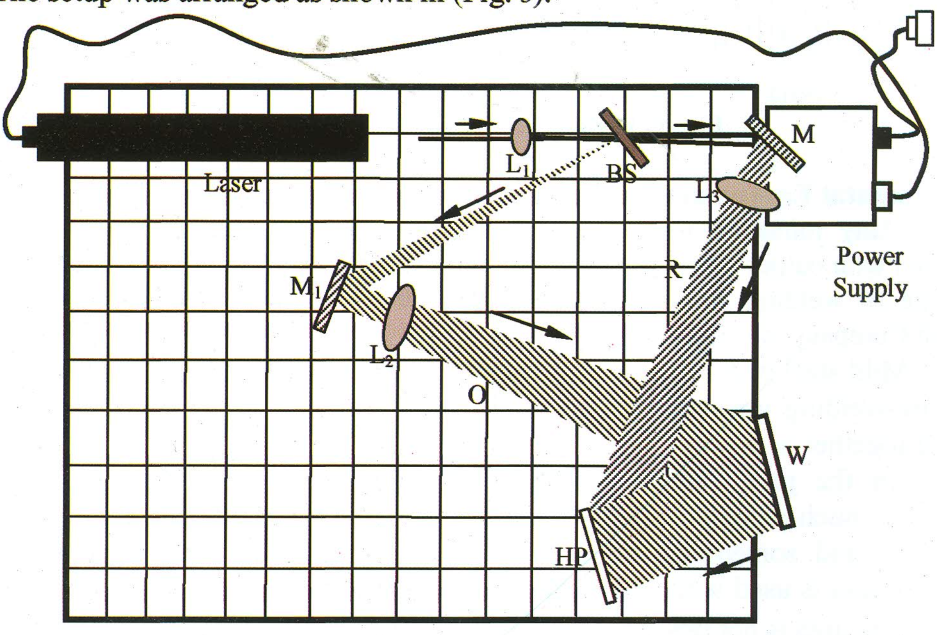


Fig. (3): Holographic interferometer setup

To expose the film for double-exposure the laser beam has been blocked off with a piece of black card board. All lights off, except the green safe light. The bad plate had been replaced carefully with a good unused holographic plate (glass or sheet). The emulsion had been adjusted to face the welding joint, and left for 1-2minutes until the vibration damped and the temperature equilibrium taken place. Then the card board had been removed for 1 second and blocked again. The welding joint had been warmed using a flame for temperature difference ΔT (before and after warming), and the card board had been removed a gain for 1 second to expose the same holographic plate. Then the holographic plate removed for developing. This procedure was repeated for all the welding joints. The same joints were tested by X- ray for comparison purposes.

RESULTS AND DISCUSSION

In the first exposure the welding joint was at the room temperature and before the second exposure the arc-welding joint temperature raised, by using aflame, between 2 and 7C°. When the temperature difference was below 2C° there are no interference fringes appeared as shown in (Fig. 4). That is because the deformation made the path difference between the interfere wave fronts less than the quarter of the He-Ne laser wavelength (632.8nm).

Also at the second exposure, when the arc-welding joint temperature difference was higher than 7C°, the interference fringes did not appear, as in (Fig. 5e). That means the deformation is more than it should be and the interference fringes are exist but they are too many to be seen, out of the eye resolution, without aided lens or microscope[4].

The images in (Fig.5), show that the fringes increase and become smaller by increasing the temperature until they disappeared as in (e).

At the second exposure, when the temperature difference is between 2-7C° of the arc-welding joint, the fringes appear, but without fringes anomalies, (Fig. 5).

For using the heat source at this test the welding joint was heated through a certain direction. Then the heat propagated at this direction, laterally or through the welding joint thickness, forcing the joint parts to deform at the same direction, and the fringes anomalies has been obtained[5].

For the known surface defects, cracks, the joint was tested and fringes curvature and discontinuity were appeared at the cracks regions as shown in (Fig. 6a) and (Fig. 6b), respectively. In (Fig. 7a), internal flaws are detected at the fringes anomalies, noncontinuouty.

The same defects has been detected by the x-rays test as shown in (Fig.7b).

In (Fig.8a), half of coincident circular fringes has been obtained due to the porosity defects inside the welding joint.

Also the x-rays test showed a porous area at the welding joint, as shown in (Fig.8b).

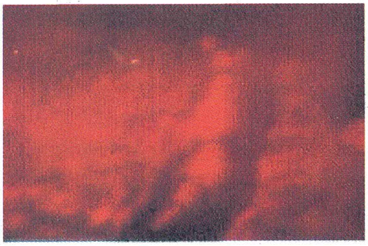
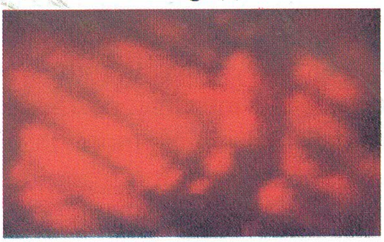
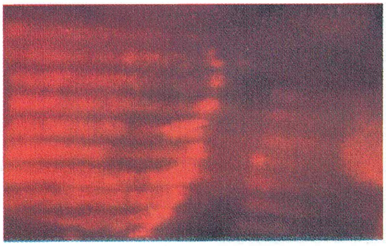


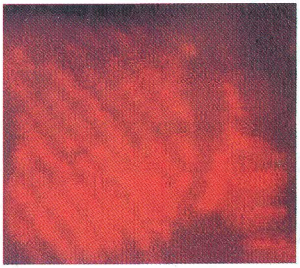
Fig. (4)



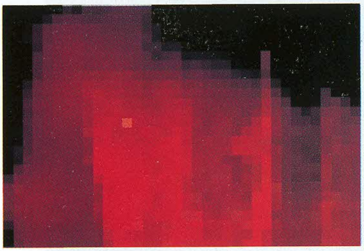
(a)



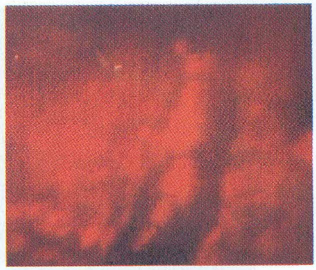
(b)



(c)

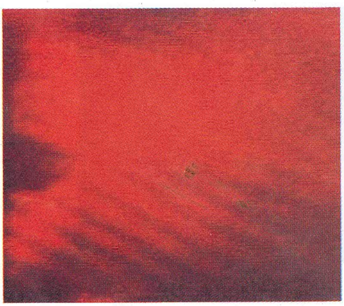


(d)

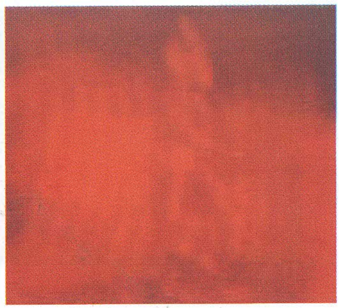


(e)

Fig. (5): The fringes size decrease with increasing temperature at (a), (b), (c), (d) and (e) for double exposure hologram of arc-welding joint (plate5x5x0.5cm).



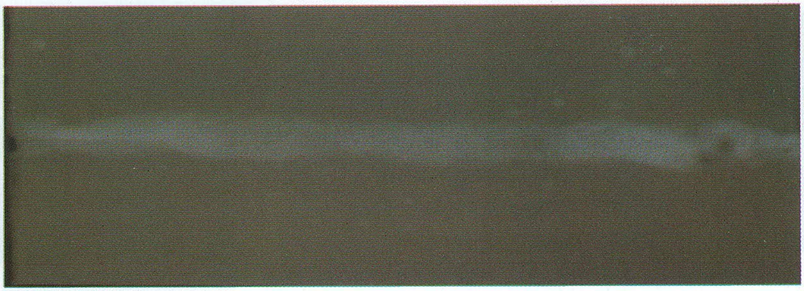
(a)



(b)

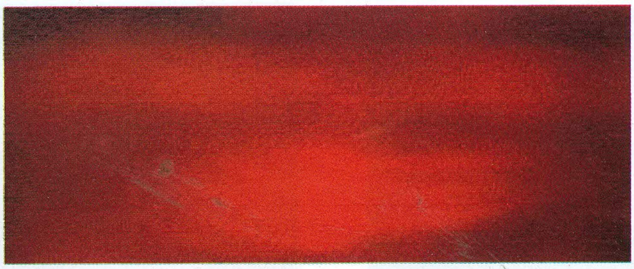
Fig. (6): Double exposure hologram of two different arc-welding joints (plate5x5x0.5cm), 2seconds exposure time

(a)

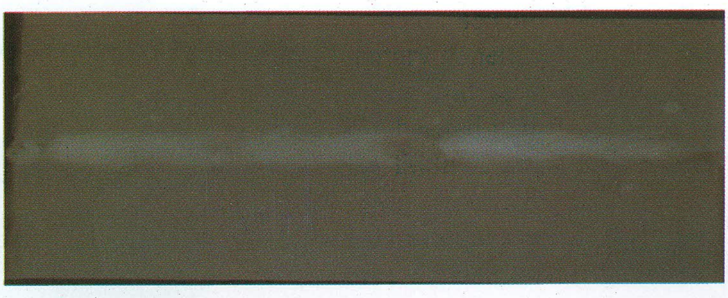


(b)

Fig. (7): (a) Double exposure hologram of arc-welding joint (plate10x5x0.2cm) (b) X-rays image of the same joint in (a)



(a)



(b)

Fig. (8): (a) Double exposure hologram of arc-welding joint (plate10x5x0.2cm) (b) X-rays image of the same joint in (a)

CONCLUSION

Nondestructive testing technique using holography, double-exposure technique has been performed for arc-welding joints. Cracks and porosities have been detected. Furthermore, holographic interferometry is relatively new and unexplored approach suggesting more intensive development work to determine the extent of its full potential.

From all the results obtained in this work one can concludes that:

(I) Small size of the holographic film can be used to record the tested object.

(II) Complete three dimensions object, welding joint, can be tested at one shoot.

(III) Quantitative data about the arc-welding faults can be found by applying the suitable load, so holography can be used to detect surface and inside faults to certain depth depending on the load value.

(IV) Holographic image magnification easily can be done.

(V) The holographic technique is a safe technique.

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