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Thermosonic Inspection of a Welded SUS Plate

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1. Introduction

The technique of bringing a sample to vibration in the near ultrasound regime (20 kHz and above) and to look at the thermal signal of the surface with an infrared camera has been used for several years as a nondestructive evaluation tool to detect defects such as cracks within materials [1,5]. The basic idea of this technique is to excite the part with a short (~ 280 ms duration) pulse of ultrasonic power (~ 2 kW, ~ 20 kHz). The relative motion of defect faces causes the ultrasound energy to dissipate locally at the defect. In turn, this energy acts as a localized heat source (hot spot). The resulting surface temperature change in the vicinity of the defect is imaged by means of a thermal infrared camera. The sequence of images, taken before, during, and after the application of the ultrasonic pulse, reveals the presence of the defect. In this paper we show results of our investigations regarding the hot spot generation at defects in the welded SUS plate. The effect of ambient temperature is discussed based on the experimental data.

2. Experiment

A photograph of a typical experimental set up for ultrasound pulse thermography is shown in Fig. 1. The object being inspected is a welded SUS plate.

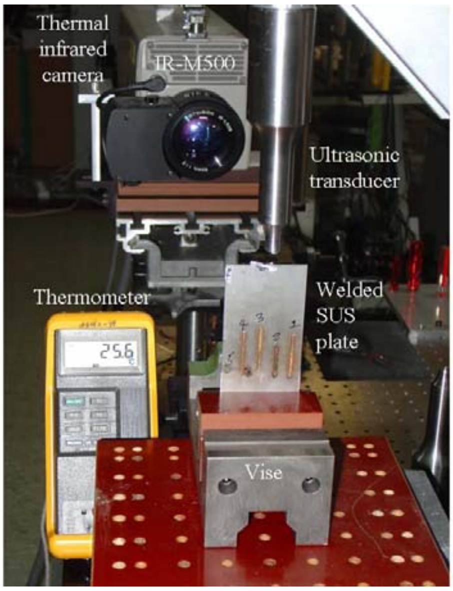

Fig. 1 Photograph of a typical experimental setup for ultrasound thermography

The tip of the ultrasonic horn is placed against the top edge of the SUS plate, which was mechanically fastened in this experiment. The ultrasonic source had a frequency of 20 kHz, and was pulsed for 280 ms in this inspection. Also seen in the photograph of Fig.1 is the IR lens (50 mm/f1.2) and front of the thermal infrared camera. The camera is a Mitsuibishi IR-M500 camera(3~5 micron, NETD 0.15°C), which acquires images at a 60Hz field rate with a 512x512 PtSi focal plane array. The output of the camera is a NTSC analog signal, which is digitized and recorded as sequence of image frames at a frame rate of 30 Hz before, during and following the application of the ultrasonic pulse. The SUS plate had been welded by Nd:YAG laser. The large defect (~ 1mm hole) was visible at the origin of the seam line, but tiny defects were not seen by the naked eye. The thermometer as shown in Fig. 1 measures the ambient temperature in the experimental environment.

Two ultrasonic IR images are shown in Fig. 2. The left image (a) is a single frame selected from the sequence at a time during which the ultrasonic excitation was active. The defects as represented in solid contours (④, ⑤ and ⑥) show dimly as bright patterns.

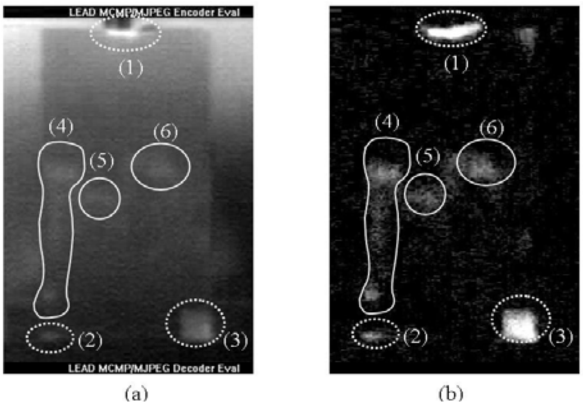

Fig. 2. Ultrasonic IR images of the welded SUS plate

The right image (b) was formed by subtracting a frame taken prior to the ultrasonic excitation from one taken during the excitation. The hot spots as represented in dotted ellipse (①, ② and ③) are also visible at the contact between the ultrasonic transducer tip and test specimen and at the contact between the sample and fastening tool. The ultrasonic IR image as shown in Fig. 2(a) is a frame taken at room temperature (~ 30°C). In Fig. 3 we show a real image of the welded SUS plate and another ultrasonic IR image taken at cool ambient (~ 20.4°C).

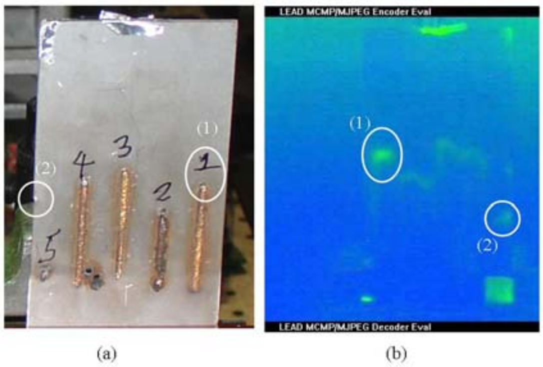

Fig. 3. Real and thermosonic images of the welded SUS plate

The solid ellipse (1) in the left image corresponds to the solid one (1) in the right thermosonic image. As compared to room temperature measurement (Fig. 2), the thermosonic inspection image (Fig. 3(b)) taken at the cool environment had superior contrast. It is evident from Fig. 3 that the welding defect is readily imaged by ultrasound pulse thermography. An interesting additional feature in Fig. 3(b) as compared to Fig. 2(a) is that the measurement in cool environment has the higher sensitivity than the one in room temperature.

3. Conclusion

The thermosonic inspection method based on an ultrasonic excitation has the potential to facilitate extremely sensitive and fast detection of small, tightly-closed defects that are undetectable using other thermographic methods. When the vibration energy generated at the ultrasonic transducer is transferred to the material, it is converted into thermal energy by a friction at the defect. In turn, this energy acts as a localized heat source (hot spot). The resulting surface temperature change in the vicinity of the defect is imaged by means of a thermal infrared camera.

In this paper we show the feasibility of the thermosonic inspection technique using ultrasonic excitation for a defect detection of welded SUS material. To enhance the contrast of thermosonic image, it is necessary to measure in the cool environment. In the case of warm ambient environment, thermosonic image contrast at the defect area was low. On the contrary, the thermosonic image taken in cool environment contrasted well with the background (intact area). From the results of this study, it is concluded that the thermosonic inspection using ultrasonic excitation is a versatile and potential NDT technique that has a real-time detection capability of a defect in a seam line of the welded material.

Acknowledgements

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