Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 177 (2017) 562 – 567

Procedia Engineering

www.elsevier.com/locate/procedia

XXI International Polish-Slovak Conference "Machine Modeling and Simulations 2016"

Nondestructive testing of metal parts by using infrared camera

Zuzana Stankovičová[a]*, Vladimír Dekýš[a], František Nový[b], Pavol Novák[a]

[a]Department of Applied Mechanics, Faculty of Mechanical Engineering, University of Žilina, Univerzitná 1, 010 01 Žilina, Slovak Rep.
[b]Department of Material Engineering, Faculty of Mechanical Engineering, University of Žilina, Univerzitná 1, 010 01 Žilina, Slovak Rep.

Abstract

The paper deals with non-destructive testing of metal parts excited by ultrasound. Material response to this excitation is detected by infrared camera. Damages in the material, such as crakes and cavities are identified based on temperature changes detected by infrared camera. The paper presents detection of cracks on the real steel form used in the production of aluminium castings when cracks resulting from thermal fatigue. There are also discussed some problems associated with the using of this technology.

Peer-review under responsibility of the organizing committee of MMS 2016
Keywords: NDT; metal; IR camera; defect;

1. Introduction

Nondestructive testing (NDT) is the process of inspecting, testing or evaluating materials or components for discontinuities without deconstruction or damage of the system. This definition of nondestructive testing includes thermal evaluation using infrared camera. Thermal nondestructive evaluation is divided into two different approaches: passive and active thermography. Passive thermography is steady-state displaying surface thermal fields of electrical and mechanical parts. The temperature of the object is recorded without the need of external stimulation, as in the active thermography.

Active thermography evaluates dynamic temperature changes. An energy source is required to produce a thermal contrast between the material and the background. The way how the heat spreads object is also reflected on the surface temperature. Therefore, it is possible to examine the materials below the surface. It is evaluated the response and evolution of the temperature field to the heat excitation. If a defect in a material absorbs the injected waves, it will locally heat up. The resulting temperature gradient on the material surface is measured by infrared camera.

* Corresponding author. Tel.: +421-41-513-2965; fax: +421-41 -5940.
E-mail address: zuzana.stankovicova@fstroj.uniza.sk

Peer-review under responsibility of the organizing committee of MMS 2016
doi:10.1016/j.proeng.2017.02.261

Active thermography can be divided into several parts depending on the stimulation method. One of the most popular methods of active thermography is lock-in thermography [1].

2. Lock-in thermography

Lock-in thermography is also known as thermal wave imaging. It is described by theory of oscillating waves. Heat performance occurs periodically with a lock-in frequency. Local surface temperature is evaluated and averaged over a number of periods. The advantage of this method is that due to averaging the sensitivity of the measurement can be improved. Because of averaging it needs a long measure time, but on the other hand the statistical noise is extracted.

Lock in method can be described as a multiplication of detected signal *F(t)* by a weighting factor *K(t)*. Usually this process is called lock-in correlation procedure. Output signal *S* for synchronous correlation is obtained by linear averaging over an integration time t_{int} [2]:

$$S = \frac{1}{t_{int}} \int_0^{t_{int}} F(t)K(t)dt. \tag{1}$$

The correlation function optimum to achieve the best signal to noise ratio is the harmonic function. When we use sine wave with amplitude A and its phase Φ we get [2]:

$$F(t) = Asin(2\pi f_{lock-in} t + \Phi) = Asin(2\pi f_{lock-in} t)cos\Phi + Acos(2\pi f_{lock-in} t)sin\Phi. \tag{2}$$

Using weight correlation functions:

$$K_j^{0^\circ} = 2sin\left(\frac{2\pi(j-1)}{n}\right), \tag{3}$$

$$K_j^{90^\circ} = 2cos\left(\frac{2\pi(j-1)}{n}\right). \tag{4}$$

We get two correlations S^{0° (real component) and S^{90° (imaginary component):

$$S^{0^\circ} = Acos(\Phi), \tag{5}$$

$$S^{90^\circ} = Asin(\Phi), \tag{6}$$

The (3) and (4) are used to calculate amplitude A and phase ϕ:

$$A = \sqrt{(S^0)^2 + (S^{90})^2}, \tag{7}$$

And phase ϕ:

$$\Phi = arctan\left(\frac{S^{90}}{S^0}\right). \tag{8}$$