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Combining heating and forced cooling: a new technique in active thermal NDT

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Abstract

The theoretical and experimental results of applying a new method of infrared (IR) thermography nondestructive testing (NDT) based on the combination of optical heating and forced convection cooling are described. A properly chosen combination of two types of thermal stimulation has allowed to increase temperature contrasts in defect areas and reduce thermal loading on the samples. The 3D model of a scanning thermal flaw detector implementing the proposed inspection technique is presented.

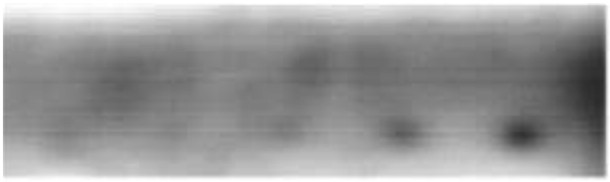
1. Introduction

Improving the efficiency of defect detection can be achieved by enhancing heating power or using periodic heating. Increasing heating power in practice is limited by the temperature of destruction of a test material. The use of periodic heating involves a long duration of test procedures and necessity of using specific data processing algorithms. In this study, a new method of thermal NDT is proposed being based on using pulsed convection cooling, which is turned on after a certain time after the main heat pulse [1]. The method can be implemented in a scanning procedure of thermal NDT, providing a high inspection performance [2, 3]. The effectiveness of the proposed method has been proven by the results of numerical simulation and experimentation, which have demonstrated a significant increase in signal-to-noise ratio (SNR), as well as improvement in the visual recognition of temperature anomalies in defect areas. The method has been especially effective in testing composite materials, particularly, in the cases with a high level of surface noise.

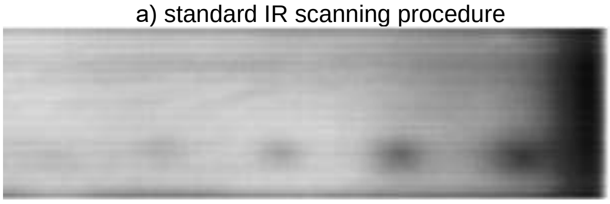
2. Theoretical and experimental results

The simulation was carried out using the ThermoCalc-3D program (Tomsk Polytechnic University). The simulation parameters corresponded to the standard one-sided testing procedure: heating with a duration of 2 seconds and a power of 10 kW/m^2, the power of the forced cooling pulse was 3.5 kW/m^2. Several test cases were investigated by changing parameters of forced cooling. It was found that the optimal moment for applying forced cooling is the time of the maximum temperature signal in defect areas, while the cooling power should be selected in such a way that the temperature of the sample surface decays down to the initial temperature of the sample.

Experimental data was obtained for the inspection of a CFRP sample with flat bottom holes by using a scanning procedure of thermal NDT. The sample was moved using a robotic arm, and the linear heat source (halogen lamp), as well as the convective cooling device, were located in such a way that the strip-like flow of cold air affected the tested surface at a time close to the time of maximum differential signals appearing in defect areas (see test results in figure 1).



a) standard IR scanning procedure

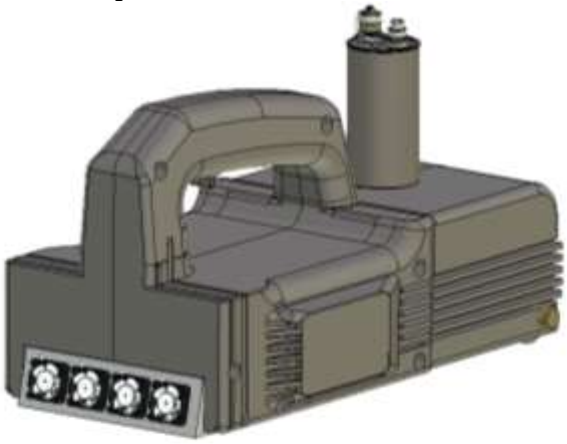


b) IR scanning involving forced cooling

Fig. 1. *Thermal NDT results*

2.1. A device for implementing a new method of TNDT

The practical application of the proposed method was realized in the device shown in figure 2. The flaw detector is a hand-held mobile device that is moved by the operator across a tested surface thus implementing the method of IR scanning. The device can be equipped with an optical or contact heat source (in the case of materials which are transparent to optical radiation), as well as a linear cooling source and an IR camera.



a) thermal NDT scanning device

b) thermal NDT scanning device (details)

Fig. 2. *3D model of thermal NDT scanning device implementing forced cooling*

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REFERENCES

[1] Chulkov A.O., Vavilov V.P., Shagdyrov B.I., Kladov D. Yu., Stasevskiy V.I., The novel procedure of active thermal ndt: combining heating and forced cooling, Russian Journal of nondestructive testing (in press).

[2] Chulkov A.O., Tuschl C., Nesteruk D.A., Oswald-Tranta B., Vavilov V.P., Kuimova M.V., The Detection and Characterization of Defects in Metal/Non-metal Sandwich Structures by Thermal NDT, and a Comparison of Areal Heating and Scanned Linear Heating by Optical and Inductive Methods, Journal of Nondestructive Evaluation. 2021, 40(2), 44 DOI: 10.1007/s10921-021-00772-y

[3] Chulkov A.O., Vavilov V.P., Nesteruk D.A., Burleigh D., Moskovchenko A.I. A method and apparatus for characterizing defects in large flat composite structures by Line Scan Thermography and neural network techniques // Frattura ed Integrita Strutturale. 2023. 17(63), pp. 110–121.