



Quantitative detection of defects based on Markov–PCA–BP algorithm using pulsed infrared thermography technology



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HIGHLIGHTS

- Quantitative detection of defects has been carried out using pulsed IRT.
- Markov–PCA–BP algorithm was proposed.
- The predictive results proved the effectiveness of the proposed method for quantitative detection of defects.

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ABSTRACT

Quantitative detection of debonding defects' diameter and depth in TBCs has been carried out using pulsed infrared thermography technology. By combining principal component analysis with neural network theory, the Markov–PCA–BP algorithm was proposed. The principle and realization process of the proposed algorithm was described. In the prediction model, the principal components which can reflect most characteristics of the thermal wave signal were set as the input, and the defect depth and diameter was set as the output. The experimental data from pulsed infrared thermography tests of TBCs with flat bottom hole defects was selected as the training and testing sample. Markov–PCA–BP predictive system was arrived, based on which both the defect depth and diameter were identified accurately, which proved the effectiveness of the proposed method for quantitative detection of debonding defects in TBCs.

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1. Introduction

Infrared thermography as a new nondestructive testing technology, has many advantages such as non-contact, large area, fast response and easy operation [1–3]. In recent years, it has got extensive attention of scholars, and a great deal of theoretical and experimental studies has been done. Thermal Barrier Coatings (TBCs) is one of the most advanced high-temperature protective coating, which use a ceramic coating to protect the metal substrate. TBCs can not only improve the corrosion resistance and thus enhance the purpose of the engine temperature, but also reduce fuel consumption and extend engine life, so it has been used broadly in aviation, aerospace, automotive and large-scale thermal power and many other fields [4–6]. The integrity of TBCs is an important security for normal work of structural components, so

it is necessary to detect and assess the condition of TBCs using non-destructive testing (NDT) techniques.

This paper focuses on quantitative detection of debonding defects' diameter and depth in TBCs using pulsed infrared thermography technology. Combining Markov and principal component analysis algorithm with neural network theory, Markov–PCA–BP algorithm was proposed to realize quantitative detection of defects was proposed. The paper was organized as follows: the principle of quantitative detection of defects depth and diameter was described in Section 2; the implementation steps of quantitative detection of defects based on Markov–PCA–BP algorithm was given in Section 3; the predictive results and analysis were discussed in Section 4; and the conclusion was arrived in Section 5.

2. The principle of quantitative detection of defects

The pulsed infrared image sequence has a strong defect detection capability after being processed by Markov–PCA algorithm, as known in Ref. [7], which was published by the authors (note:

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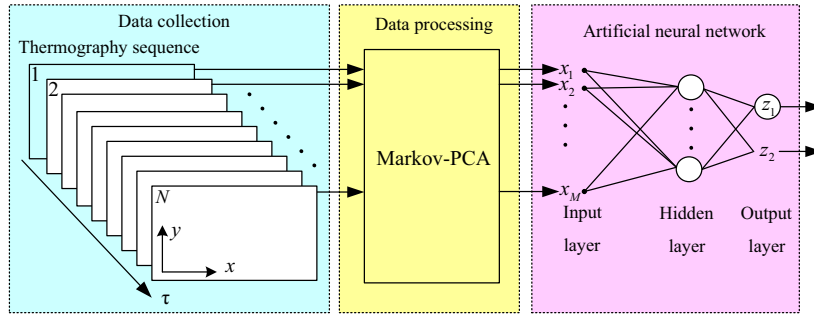


Fig. 1. Quantitative detection principle of defects depth and flat size.

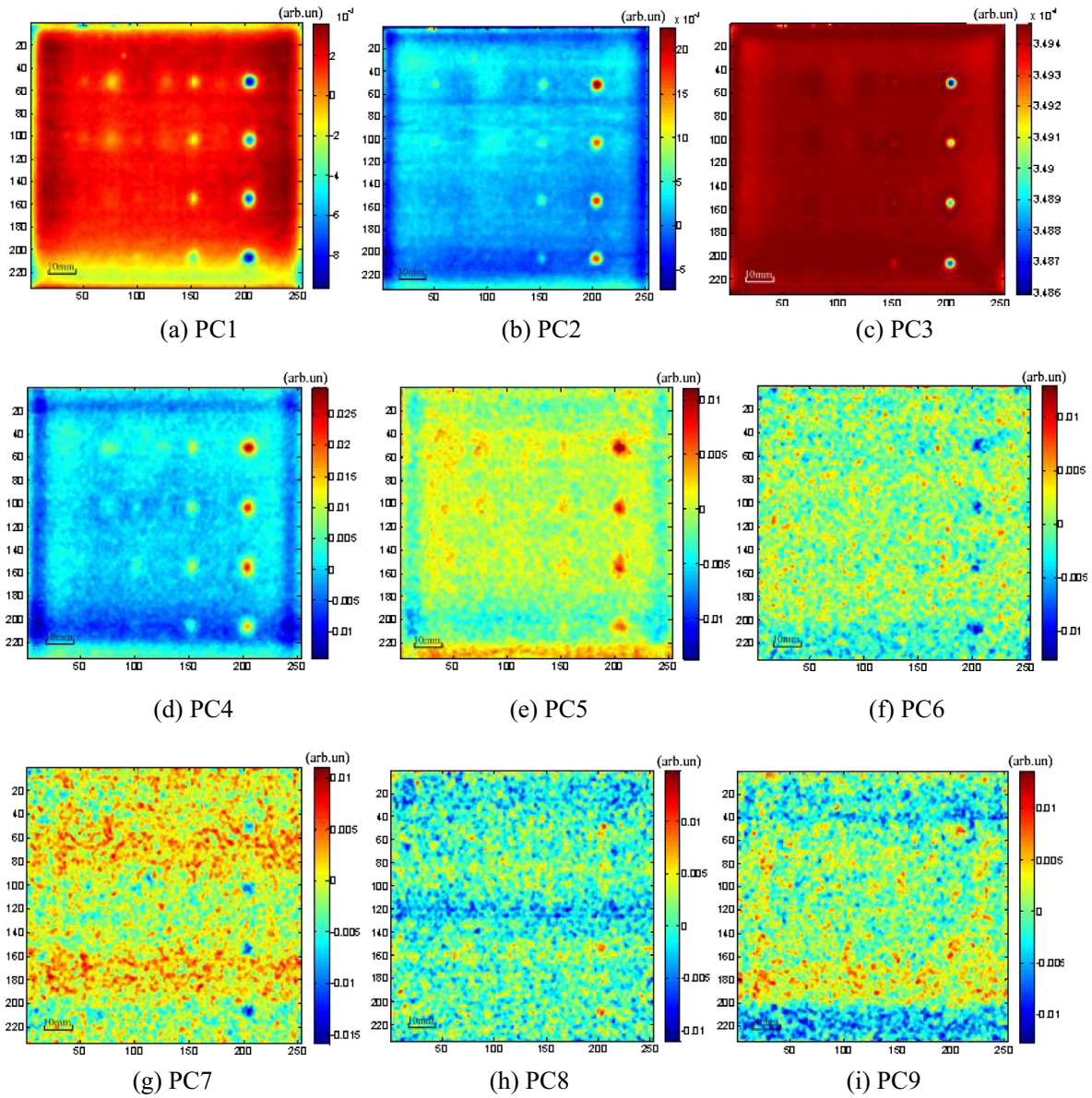


Fig. 2. Characterized images of principal component PC1–PC9.

this paper is about the further research of Ref. [7]). The artificial neural network has the ability of high degree of nonlinearity, and stronger ability of self-learning, storage function and searching

for the optimized solution quickly, and it can implement complex logic operation and nonlinear relation [8,9]. BP (Back Propagation) is one of the most common artificial neural networks. In this paper,

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