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Defect estimation of aircraft and aerospace components based on Neural Network using Lock-in thermography

by Liu Junyan*, Li Huijuan** , Wang Yang* and Dai Jingmin***

* School of Mechantronic Engineering, Harbin Institute of Technology, (Harbin), P.R.China,150001, ljywlj@hit.edu.cn and wyyh@hit.edu.cn
** CHINA AERO-POLYTECHNOLOGY ESTABLISHMENT,(Beijing), P.R.China,100028, lhj1900@126.com
*** School of Electronic Engineering and Automation, Harbin Institute of Technology, (Harbin), P.R.China,150001, ljywljhit@yahoo.com.cn

Abstract

Inspection of aircraft and aerospace components has always been a challenge. Lock-in thermography is an active technique which is popularly being used for the non-destructive evaluation of subsurface defects in composite materials such as carbon-fiber-reinforced-polymer (CFRP) in aircraft structures. CFRP-foam layered structure composite is often used for anti-heat and adiabatic material in aerospace components. In this paper, the finite element analysis (FEA) of 3D heat conduction is developed in order to investigate the behaviour of thermal waves in the honeycomb structure, CFRP and CFRP-foam layered structure plates with finite thickness under convective and radiate conditions. The FEA simulation is then utilized to predict the magnitude and phase differences produced by the subsurface defects and obtain the optimum inspection parameters. The simulation results are compared with the experimental data. The optimum inspection parameters of lock-in thermography are used to detect subsurface modeling defects is also presented in this paper. The defect estimation of artificial neural network model is proposed and simulation and experimental results are used to train the ANN model. The results show that the ANN model can be applied to detect the subsurface defect and estimate the defect depth.

Keywords: thermal analysis, FEA, CFRP, Layered structures, non-destructive testing.

Results:

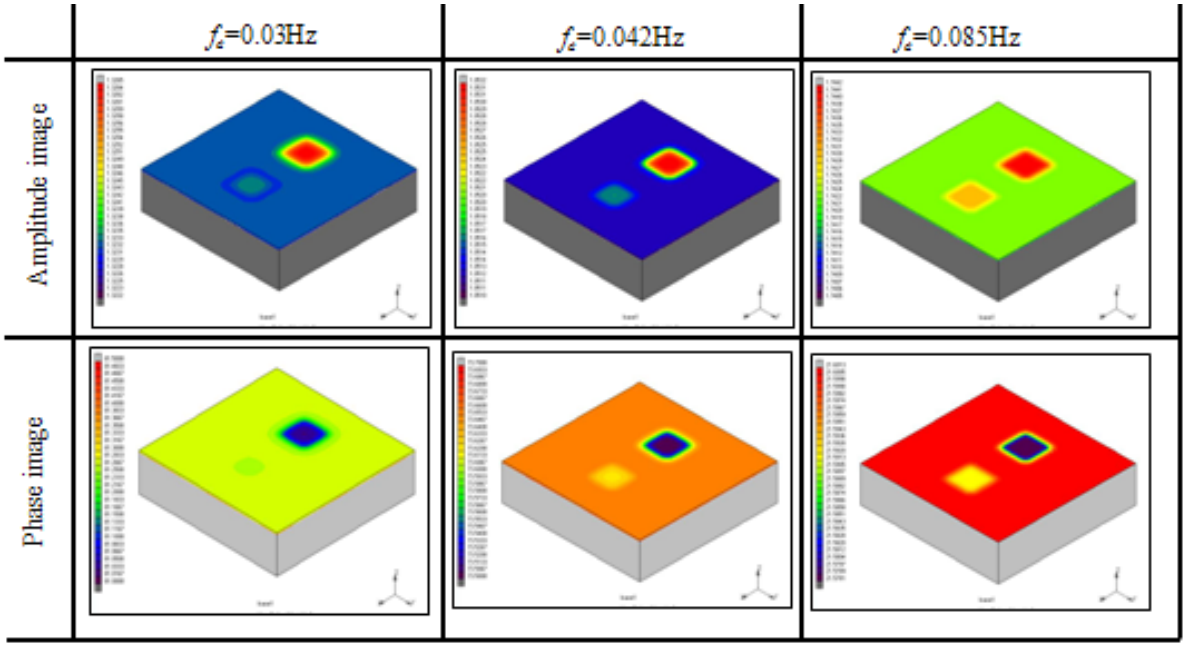

Fig.1 Amplitude and phase distribution of simulation results

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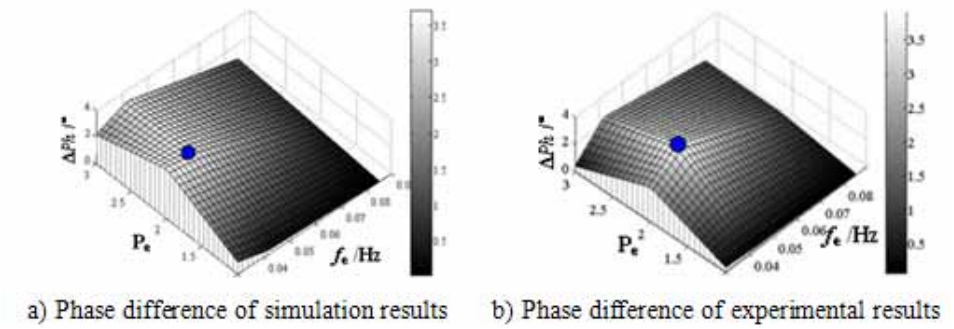
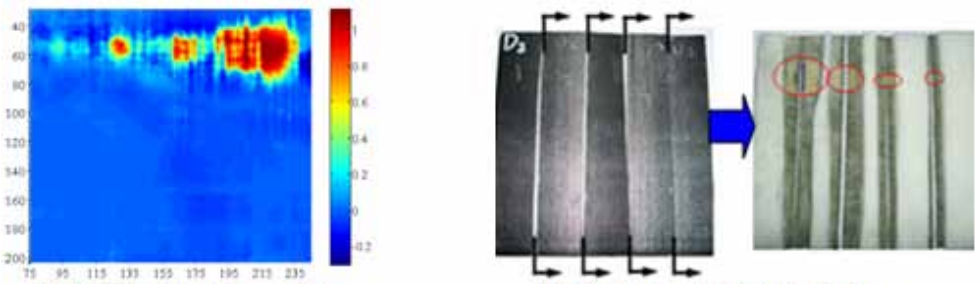


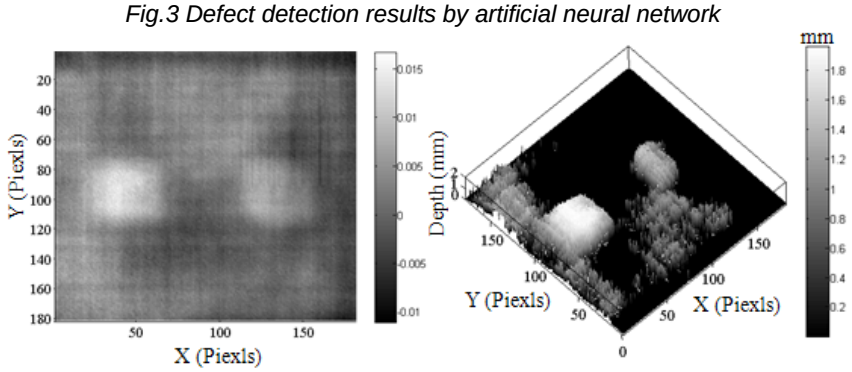
a) Phase difference of simulation results b) Phase difference of experimental results

Fig.2 The optimum inspection parameters obtained

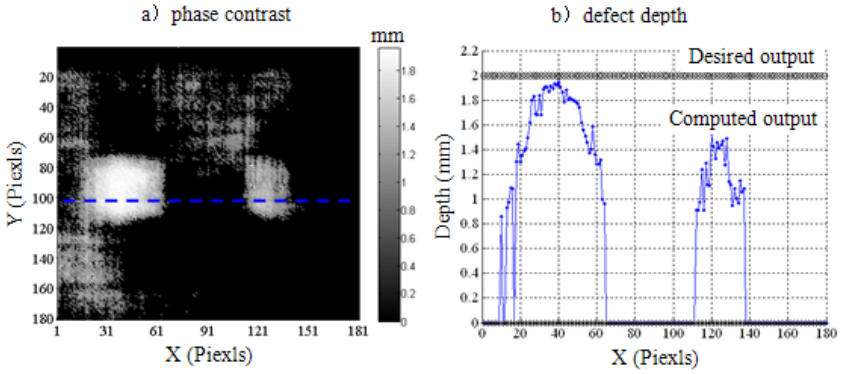


(a) Defect detection result (b) Modeling defect distribution

Fig.3 Defect detection results by artificial neural network



a) phase contrast b) defect depth



c) defect distribution

Fig.4 Defect detector results of modeling defect specimen

The figures show that lock-in thermography is very useful to detect subsurface defects of layered structure, the small size defects shape and location are satisfied to be identified under condition of given optimum inspection parameters by using lock-in thermography. IR Lock in thermography is an effective technique for layered composite non-destructive testing and evaluation.