Development and Evaluation of a New Transient Diverging Thermal Wave Technique

MM Moksin, ZA Wahab and AR Hamzah[2]

Physics Department
Faculty of science and Environmental Studies
Universiti Putra Malaysia
43400 UPM, Serdang, Selangor
Malaysia

E-mail of Corresponding Author: maarof@fsas.upm.edu.my

Key words: diverging, thermal wave, technique.

Introduction

Fiber composites, in which fibers are oriented parallel to the surface, usually exhibit anisotropic electrical and thermal conductivity values. Inglehart et al [1] used a photothermal beam deflection method to measure the thermal diffusivity parallel to the fiber axis. But as with other methods, which are based on 'mirage effect', it suffered badly from the perturbation of the sample surface by excitation beam, mechanical vibration, the weak temperature dependence of gas medium, and also air currents above the sample surface. Bertolotti et al [2] have improved the technique [1] by introducing 'transverse geometry' arrangement of probing beam. However, probe beam approach limits its application to sufficiently flat sample surface. In addition to that, the technique is also vulnerable to vibrations, misalignment and geometric variability, which are always present in on-line monitoring in industrial environment.

Materials and Methods

The transient diverging technique uses the transverse geometry arrangement described earlier [3] but with major improvement and simplification on thermal wave generation and detection. It makes use of the information contents of the thermal wave observed by an infrared detector, laterally displaced from the heat source, following optical pulse excitation of the sample. This is in contrast to the converging technique described by Enguehard et al [4]. The former can be used to characterize materials for their radial anisotropy while the latter has the advantage for detecting weak signals.

Tightly focused optical pulses from a flashlamp will be used for the excitation to illuminate an area of diameter of ~20μm on the sample. The thermal waves are allowed to diverge radially from the illuminated spot to cooler region of the sample at rate determines by its thermal diffusivity before they are detected. Optical property is also plays a part in determining initial temperature gradient within the sample subsurface and the way the detected spot emits thermal infrared radiation. Therefore, thermal wave as detected by change in the emitted gray body radiation can be analyzed to study the surface and subsurface properties of the materials.

The infrared signals are collected by an off-axis ellipsoidal mirror at several distances from the illuminated spot and measured by using a room temperature infrared detector.

Results and Discussion

The apparent thermal diffusivity measured from the standard sample was found very much lower than that was reported earlier This is mainly due to the followings:

It is impossible to get very fine spot of about 20μm from the flashlamp that emit a diverging wide-band radiation.

Radial thermal wave generation is extremely difficult and highly damped due to problem in (1).

Long and large beam spot of light pulse leads to erroneous consideration on heat loss beside complexity in the theoretical calculation although it was initially thought would substantially reduce cost by doing away with laser source.

Conclusions

The project was not very successful due to inefficient thermal wave generation method. It should perform very well by replacing flashlamp with a laser source.

Benefits from the study

Expertise development in the area of thermal wave generation, propagation and interaction, and detection.

Literature cited in the text

Inglehart LJ, Lipoutre F and Charbonnier F, 1986, *J. Appl. Phys.* 59: 234.

Bertolotti M, Ferrari A, Liakhou GL, Voti LI, Marras A, Ezquerra TA and Balta-Calleja FJ, 1995, *J. Appl. Phys.* 78(9): 5706.

Moksin MM, Yunus WMM, Talib ZA, 1994, *Pertanika J. Sci. Technol.*, 2(2): 175.

Enguehard E, Boscher D, Deom A and Balageas D, 1990, *Mat. Sci. Eng.* B(5): 127.

Toloukian YS, Powel RW, Ho CY and Nocolaou MC, 1973, *Thermophysical Properties of Matter-Thermal Diffusivity*, TRPC Data Series, Vol 10.

Project Publications in Refereed Journals

Moksin, M.M., Yunus, W.M.M., Talib, Z.A. 1994. *Pertanika J. Sci. Technol.* 2(2): 175.

Project Publications in Conference Proceedings

None.

Graduate Research

Teh Seng Guan. (Ongoing). Thermal wave NDE [M.Sc.]. Universiti Putra Malaysia.

I·R·P·A
INTENSIFICATION OF RESEARCH IN PRIORITY AREAS

Research funded by the Intensification of Research in Priority areas (IRPA) - Supported by IRPA RM-7 (1996-2000), Cycle 1997, Grant 09-02-04-0064.