1.5.14. A COMPACT, PORTABLE WET PAINT THERMAL WAVE THICKNESS MONITOR

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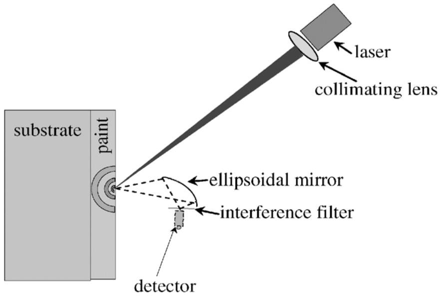
Introduction. The precise control of paint film thickness is important for aircraft in order to control their weight. Of particular interest to the study reported here was the measurement of wet paint film thickness, rather than dry paint film thickness. This distinction between measurements on wet paint, as opposed to dry paint, arose, because in order to give a final dry paint film with the necessary thickness, it is necessary to control spraying parameters in real time and measure paint thickness as the wet paint is applied, and before the paint dries. To accomplish this, the method used must be both non-contact and rapid, and there must also be an understanding of the relationship between the measured wet paint film thickness and the final thickness after the paint had dried.

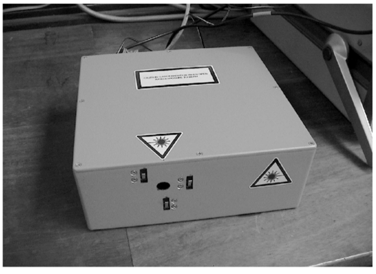
The design and construction of a prototype, wet paint thickness measurement system based on thermal wave phase measurements is described here. This system is based on the established methodology for dry films and coatings, whereby measurements of thermal phase at the coating surface can be related to layer thickness via thermal wave propagation within the layer. The technique is non-contact, and is potentially fast and accurate. Measurements of the thermal wave phase relationships are also described for the drying of a wet paint coating applied to an aluminium substrate.

Results. The optical arrangement for the prototype compact portable system suitable for measuring wet paint film thickness is shown schematically in Figure 1a. This was based on the use of a semiconductor laser to periodically heat the surface, and a pyroelectric detector, ellipsoidal mirror and phase sensitive lock-in amplifier for measuring the phase of the thermal waves. Figure 1b shows the practical device with the optical components mounted inside a self-contained unit.

The thermal phase/thickness relationships for a primer paint layer on an aluminium substrate in its wet, dry, curing and cured state are also reported. This was undertaken by first calibrating the thermal wave measurements by measuring changes in thickness as the



(a)



(b)

Fig. 1:
(a) – schematic diagram showing optical arrangement for the thermal wave measurement system; (b) – the compact unit with the optical components mounted inside the unit

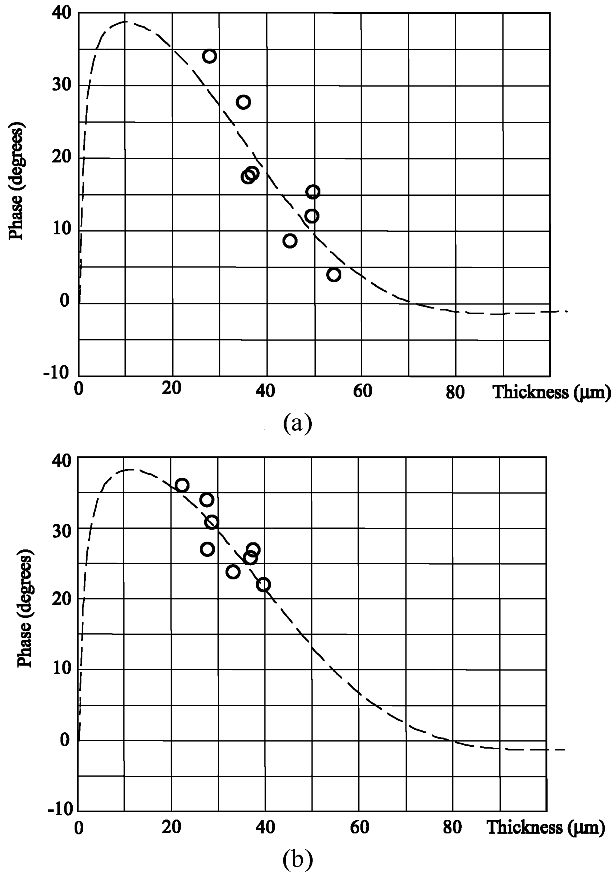


Fig. 2:
(a) – phase thickness relationship at 20 Hz for wet paint layers on an aluminium substrate approximately 1minute after paint application; (b) – phase/ thickness relationship for the same paint layers as shown in (a), but after drying

paint dried using a differential focussing technique on an optical microscope. Drying of the paint was assumed to be primarily controlled by diffusion and the release of solvent from the paint, and modelled by fitting a functional form based on this process. Figure 2 shows an example of the thermal wave phase/thickness relationship obtained for paint films of different thickness on an aluminium substrate, (a) approximately 1 minute after application of the wet paint, and (b) after drying.

Summary. It was concluded that a final cured paint thickness could be made with an accuracy of approximately of ± 2 μm, and that the errors in predicting cured film thickness from a wet film thermal phase measurement arose principally from uncertainty over the solvent content of the wet paint film, the state of cure, and the consequent uncertainty over the paint density and thermal properties.