Infrared thermography

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1. INTRODUCTION

The non-destructive use of infrared cameras to determine the heat loss behaviour of buildings is well-known. Here, the thermal properties of the object are examined. Another possibility is the localisation of inner heat sources, for instance in electronic components, during fatigue tests or the determination of the crack growth of certain materials.

With active thermography, the object is heated and the distribution and/or the development of the temperature on the surface is determined. The different thermal diffusion behaviour allows conclusions of the inner structure of the object. Typical flaws that may be found are delaminations, missing material or inclusions. To a certain degree, thermographic results may be compared with the ultrasonic C-scan inspection. The penetration depth, however, is much smaller: usually some millimetres to a few centimetres. Due to their thermal properties, plastics and their composites are quite suitable for this method.

2. TECHNIQUES

With transmission thermography the object is heated from one side and inspected from the other side. The heating may be continuous. Analogously to through-transmission ultrasonic inspection, this technique allows no statements on the depth of inner structures.

Another possibility is pulse thermography, often also called transient thermography. Here, the object is heated for a short period by a set of flashlights or a laser and the surface temperature is inspected from the same side. The temporal development of the temperature allows statements on the depth of possible heat bank-ups or heat sinks. For most of the materials such inspections are done in less than one minute (Fig. 1).

With lock-in thermography [1] the object is heated sinusoidally. The length of a period is typically five to twenty seconds. The range of the maximum thermal con-

trast is dependent on the excitation frequency. The recorded pictures are calculated to an amplitude and a phase image. Dependent on their depths, flaws have a better contrast in one or the other representation. The phase image, however, is much less susceptible to surface effects.

These two methods can be combined with pulse phase thermography [2]. The data are taken in the same way as in pulse thermography and then transformed into the frequency domain. This allows to calculate the phase information, however, of not only one frequency but of all of them. It is often easier to produce a short pulse that contains enough energy than to excite the object with a sinusoidal heating.

3. LIMITATIONS

As a heat bank-up or a heat sink leads to lateral thermal diffusion, the detectability of flaws is dependent on their position. As a rule of thumb, the lateral dimension of a flaw must be at least three to four times its depth.

The application possibilities of thermography are furthermore restricted by the surface quality and the thermal properties of the involved materials. In some cases it is necessary to treat the surface with a removable coating showing a high emissivity.

Some thermal developments are so quick that the duration of the heat pulse, compared to the heat input, is too long or the recording frequency of the camera is too slow.

4. APPLICATIONS

Infrared cameras and the necessary accessories usually are mobile and allow operations in the field. If liquid nitrogen is used for the cooling, however, the possibilities of the camera positions are restricted.

Composite structures used for space applications are often not airtight. In this case, a normal ultrasonic inspection using couplant is not possible. Thermography

Fig. 1 – Thermogram of a disbond in the adhesive of a CFRP sheet used for external reinforcement (width 50 mm).

Fig. 2 – Thermogram of a section of the front heat shield of the Cassini-Huygens probe that was sent to the Saturn moon Titan in late 1997 (diameter of the structure about 2.5 m).

can be used to investigate bondings and other inner structures (Fig. 2).

Buildings, bridges and metallic structures can be externally reinforced using CFRP-sheets. The quality of the bonding, especially at the anchors, can be inspected with thermography. Here, the advantage of this method is the fact that images are created automatically. They can be compared to earlier conditions and allow statements on the long term behaviour of the bonding or of the sheet itself.

A further application is the quality control of coatings [3]. If the base material shows different thermal proper-

ties, the cooling behaviour gives information not only about flaws but also on the thickness of the coating.

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