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Aircraft Production

IM on-destructive testing-1

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ROM FAIRLY PERFUNCTORY BEGINNINGS,

quality-control in engineering has advanced immeasurably and is likely to become a technology in its own right. Quality control is now essential to the acceptability of many products. It is also expensive and may account for some 5 to 20 per cent of the manufacturing cost. But neglect of such control, in terms of damaged reputation, repairs, replacements and compensation, can have far more damaging results.

Nevertheless, it is necessary to achieve and maintain a balance be-tween effectiveness of control and cost; to provide the requisite degree of quality without excessive opulence of method. Obviously, there is a point beyond which no further benefit can be obtained by greater subtlety of method or complexity of equipment. This point will vary with individual products, and their functions, but if a single failure could have catas-trophic results, then quality must be proved, however expensive the method.

The spectrum of quality-control ranges from the simple application of a rule or the "mike" to, as yet, un-resolved phenomena of fracture mechanics: more and more it tends towards the detection and/or preven-tion of fault before it can have harm-ful effect.

Non-destructive inspection
Methods of non-destructive testing have been in use for many years in industry as an established part of quality-control and testing procedure, as exemplified in radiography, fluores-cent- and dye-penetrant inks and magnetic crack-detection. Non-destruc-tive methods of inspection have their possibly most valuable application in the prevention of waste, by making possible the segregation of defective material before production begins.

The aircraft industry, by virtue of the nature of its products, is a con-siderable user of NDT techniques. Ultrasonic flaw-detection of large bil-lets for integrally machined compo-nents is a typical application, and routine radiographic inspection of airframe structures is another, which has the great advantage of requiring only the minimum dismantling of a structure (perhaps none at all) and which may well be the only possible method by which a part can be in-spected without destruction.

The technology of non-destructive testing is one of rapid and con-tinuous growth and progress in paral-lel with the development of new materials and the advance of materials

science in general. In Britain, indus-try is served by the Non-Destructive Testing Centre, which was established at Harwell, Berkshire, in 1967 at the establishment of the United Kingdom Atomic Energy Authority. A northern unit was brought into being at Cul-cheth, Lancashire, in 1970.
This centre functions in a threefold capacity: information is supplied to industry on existing NDT knowledge and practice; advice is given, in the form of trouble-shooting, analysis of problems and suggested solutions; and new techniques and systems of in-spection and testing are developed over a wide field.

Wor k of Britain's ND T centre

Some of the projects undertaken by the centre are adhesion-testing; the testing of composite materials by mechanical and acoustic methods; eddy-current flaw-detection; neutron radiography; and thickness gauging by ultrasonics.
Much of the establishment's work
is directed to the solution of indus-trial problems and to meet this re-quirement, a flexible procedure has been developed. Such problems often require an independent approach and, frequently, special instrumentation to suit the individual circumstances. To treat each problem as an entirely new project would be expensive in terms of both design effort and specialised equipment. A policy has, therefore, been adopted of designing and pro-ducing a series of mutually compatible electronic modules that can be linked to constitute a specialised NDT sys-tem for a particular application.

Apart from economising in design time and effort this modular approach has the advantage that systems can be assembled (and modified) quickly, while improvements can be incor-porated readily and the systems can be serviced easily by replacement of modules.

Modules include transmitters, re-ceivers, ultrasonic micrometers, flaw-detectors, facsimile recorders and other units, which can be combined for various applications, such as eddy-current inspection systems, ultrasonic amplifiers for detection of near-surface defects, ultrasonic thickness measurement and profile-inspection equipment.
When modules have been fully de-veloped and tested, they are marketed through the instrument industry. Some preliminary, outline descrip-tions of industrial applications and new developments may be noted here. Two methods of thickness measure-ment devised by the centre and of

direct interest to the production engineer are a delayed ultrasonic pulse-echo thickness-gauge for "in-process" application (e.g., when machining or another operation is in progress). This gauging system has been applied by the Rolls-Royce Bris-tol Engine Division in the measure-ment of wall thickness in the deep grinding of high-precision bores.

Features such as automatic gain control and time-expansion circuitry permit measurement of the thickness of a workpiece while it is being machined, to a precision of 2-5 mic-rons. Outputs, both digital and ana-logue, are suitable for feedback and control of the machining process. Another method of thickness gaug-ing is suitable for automatic inspec-tion of tube walls or metal sheet. By the employment of a pulsed ultrasonic resonance technique measurement of metal thickness from 75 microns to 3mm can be made, typically to an accuracy of ±0-1 per cent.
The same technique can be applied to measure the thickness of a coat-ing of one material on another. A particular advantage is that thick-ness can be measured without the need for access to the opposite side of the material. The measured thick-ness is shown by a digital display, or an analogue output can be used for meter or chart presentation.

Acoustic emission monitoring
A more recent avenue of investiga-tion with interesting possibilities that is being explored is acoustic emission monitoring. As materials fail, some of the energy responsible for their failure is emitted as acoustic waves. These waves can indicate the extent and location of damage and, in priru ciple, should reveal the mechanism of failure. Another and related aspect of this investigation is impact testing. A different field entirely, and one
of particular interest to the aircraft industry, is illustrated by a new tech-nique in the development of integrity in gas turbines, known as high-energy radiography. The ability to see and measure clearances between rotating and static elements and the position and shape of various static compo-nents in a variety of static and dynamic engine conditions is of great benefit in engine development.
Radiography is now being used in such applications. The use of a linear accelerator, with a large output of high-energy X-rays has made possible the production of high-quality radio-graphs showing the profiles of com-ponents in the engine under static and running conditions.