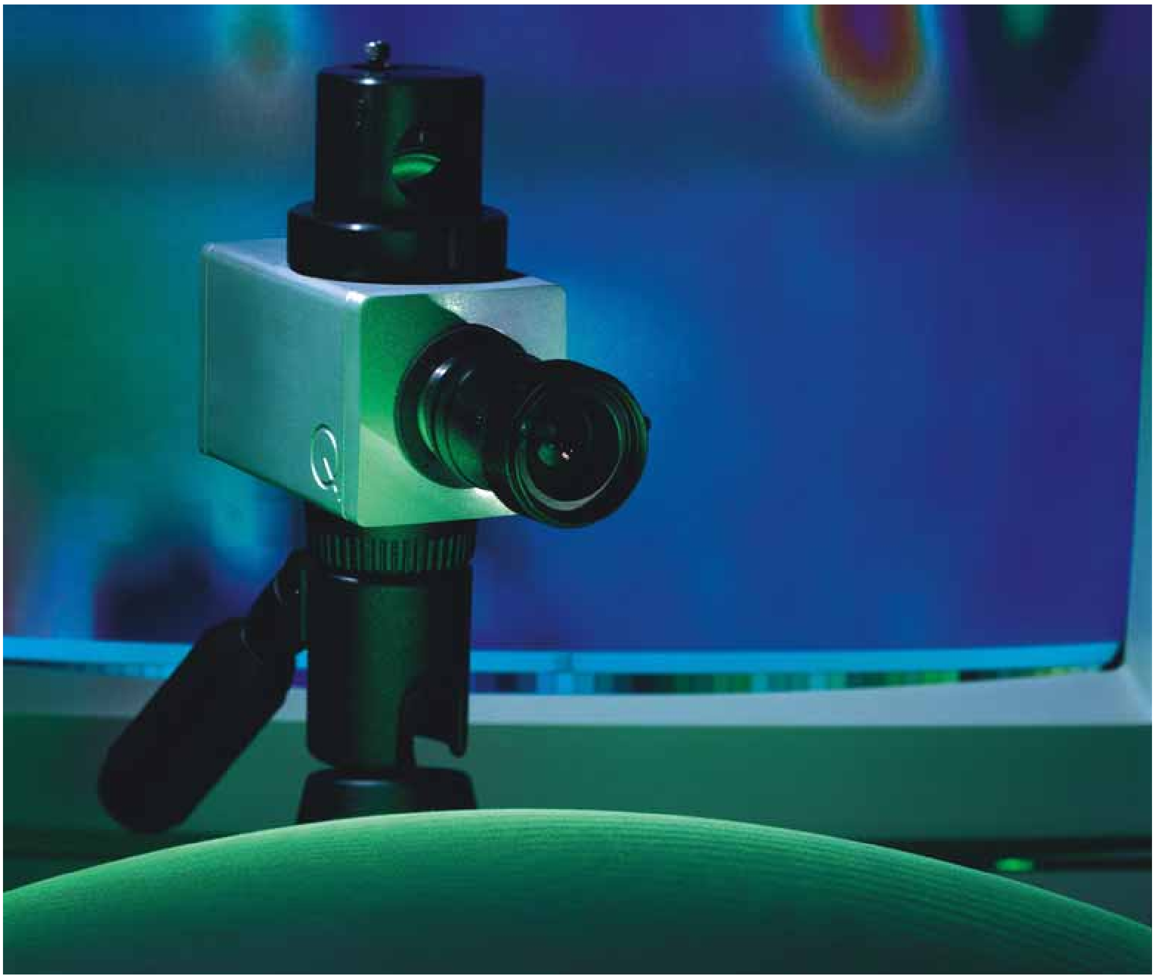
Automatic Shearography Inspection System for Helicopter Rotor Blades

Introduction

For the first time, a fully automatic inspection system for helicopter rotor blades has been installed in the aerospace industries. The system is integrated into the manufacturing line and allows 100% inspection of each manufactured rotor blade.

100%-inspection required

The production of these rotor blades follows a rather complicated and complex procedure and, consequently, a 100% inspection of the blades is required after production. The new, automatic inspection system uses laser shearography and a vacuum chamber for inspection.



Complex structures

Helicopter rotor blades are highly sophisticated products, composed of a variety of materials and composites. They are safety relevant components and, therefore, 100% quality control has to be assured. Each rotor blade is manufactured as a composite, with foam or honeycomb materials forming the core of the blade, covered with one or more layers of fibre reinforced plastics on the outside. For further reinforcement, carbon, kevlar or glass fibers are used. In highly stressed areas, such as the front edge of the blade, metallic layers provide additional reinforcement.

The main visible part of the helicopter rotor blade inspection system is the huge vacuum chamber with the dimension of 11 x 5.5 x 2 m^3, fig. 1. The rotor blade is positioned inside the vacuum chamber and loaded with slight pressure changes of less than 50 mbar. The pressure change in the vacuum chamber will produce slight deformations on the surface of the rotor blade. A laser shearography system can observe these deformations and automatically indicate defects, such as delaminations, debondings, etc., which show up by typical deformation patterns.

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Fig. 1: Automatic shearography inspection system for helicopter rotorblades.

Loading of rotor blade

A ventilation system facilitates fast pressure sequences during operation. The typical pressure difference is a few mbar. Despite the large dimensions of the vacuum chamber, the test pressure difference is realized within 5 seconds. Safety valves stop the evacuation system at the maximum allowable pressure difference of 50mbar.

Automatic clamps

The rotor blade is positioned on a sledge and fixed by automatic clamps in the centre and the sledge is driven into the chamber. Fig. 2 shows a view of the rotor blade from inside the vacuum chamber at the test position. The internal chamber dimensions are designed for inspection of large main rotor blades. Two shearing cameras are positioned on a separate guiding system on each side of the rotor blade. They allow simultaneous inspection of both sides of the rotor blade during one pressure cycle.

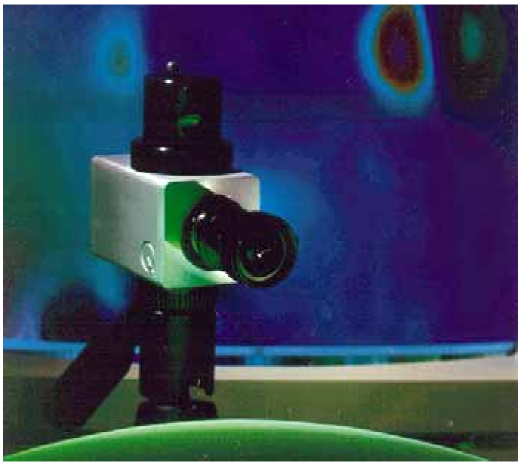

Fig. 2: Shearography camera for rotor blade inspection. The dimension of the sensor is only few inches.

Shearography camera

Two laser shearography systems measure the deformation of the rotor blade surface at slight pressure changes of 50 mbar. Fig. 3 shows a shearography camera with laser illumination, inspecting an aerospace composite component. Each camera can observe an area of 600 x 800 mm^2 (24" x 31") on each side of the rotor blade.

Fig. 3: Rotor blade, being transported into the vacuum chamber for inspection. View from inside the vacuum chamber.

Laser illumination

The inspection areas are illuminated by the green light of a 5 Watt, frequency doubled NdYAG laser. The complete laser system is integrated in the control rack of the system. No external cooling is required for laser operation. The laser light is coupled into two monomode glass fibre cables and guided to the shearography cameras. There, a diffuser system expands the laser beam, to provide homogenous laser illumination on the whole measuring field.

Easy and automatic operation

The complete system is operated by the user friendly Windows 95 software ISTRA. The software controls the exact positioning of the shearing cameras, the automatic pressurization of the vacuum chamber and automatic evaluation of the measuring results. Two monitors show the inspection results of both cameras on the control panel, fig. 4. Three different operation levels allow automatic inspection (operator level), definition of new rotor blades and teaching of "good" rotor blades (specialist level) and complete access to all data structures and free configuration of the complete system (expert level). Touch screen monitors allow operation of the system without keyboard or mouse.

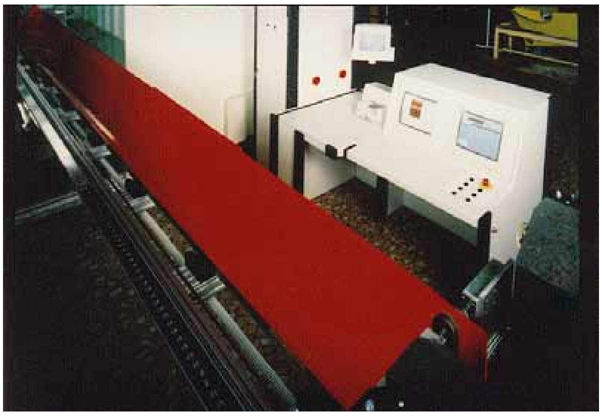

Fig. 4: Control panel of the helicopter rotor blade inspection system: two monitors show the measuring results of both sides of the rotor blade.

Comparison with master blades

For each rotor blade inspection sequences are defined and stored in a data base. These data contain all parameters for definition of the optical and mechanical properties during the inspection cycle. Using the rotor blade code, all parameters are automatically loaded and the inspection is started. If similar rotor blades have been inspected earlier, the measuring results are automatically compared with the stored master data of earlier inspections.

Deviations are automatically indicated on the monitor. The operator can decide to use these data as "good" master data, or to classify as "defect". In this way the system is being taught, learning the properties of each rotor blade by the experience of earlier measurements. Fig. 5 shows the menu, as it appears to the operator. Only limited numbers of operations are allowed. They can be started by just touching the monitor. Keyboard and mouse are not required. The expert can make use of full functionality of the system and, therefore, has a more complex menu, fig. 6

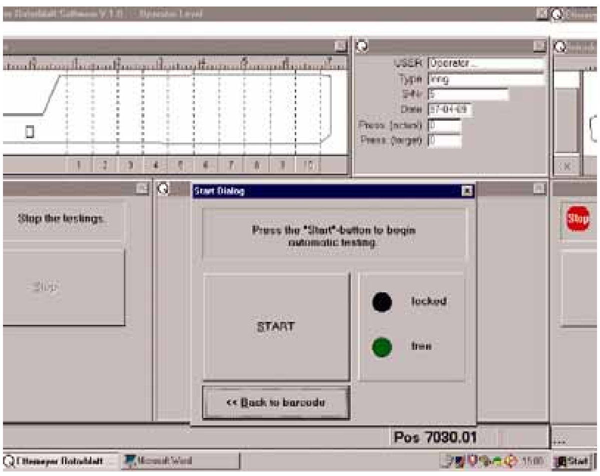

Fig. 5: Screen shot of the operator test screen: only limited numbers of functions are visible. Large buttons allow start and stop of tests just by touching the monitor.

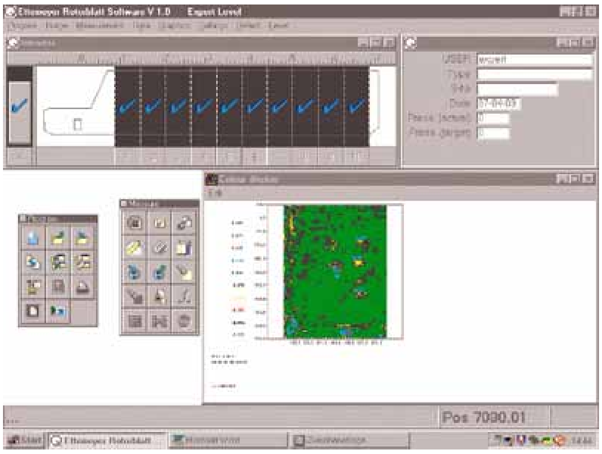

Fig. 6: Screen shot of the expert test screen: Inspected areas are marked, the live image and inspection results are shown in the lower right window. All necessary information (pressure, position, etc.) are indicated on the screen.

Defect localization

The inspection result is printed out, indicating the defect position and defect size. The accuracy of the defect position is within 5 mm, the minimum defect size is $10x10mm^2$. Fig. 7 shows some delaminations, as they show up at the inspection.

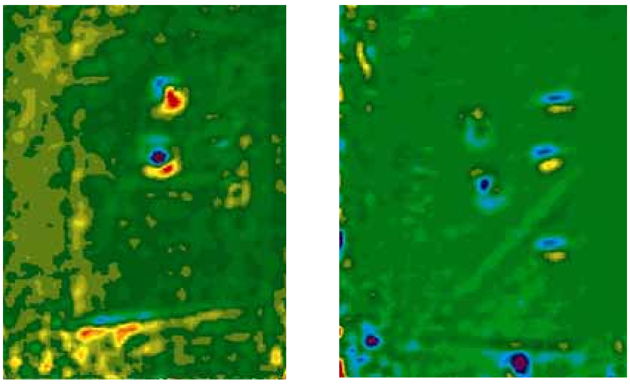

Fig. 7: Inspection results on both sides of an $800x600mm^2$ (31x24") field on the rotor blade with defects. The typical double indictations show local delaminations.

Conclusion

In comparison to the earlier manual inspection, the elapsed time for a complete inspection cycle of large, main rotor blades has been significantly reduced.

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