Crack Detection on “Used Turbine Blades”

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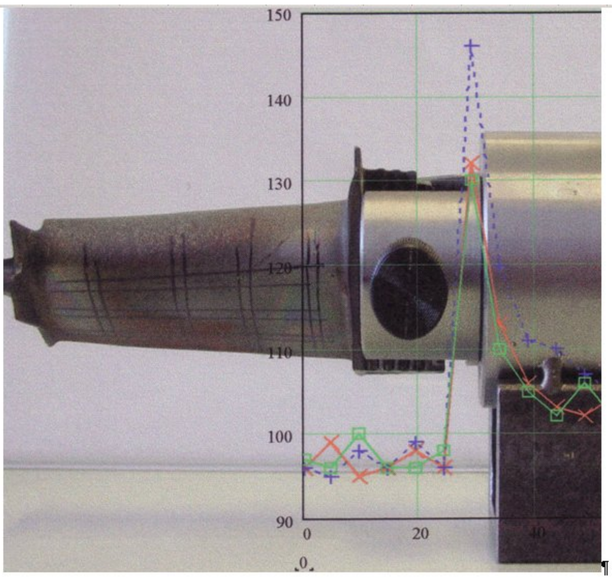


Procedure during crack detection

With malfunction of a critical mechanical engineering part the question arises whether structure alterations resulted from the excess of creep strength, from the operation, from the maintenance or already existed during material production or whether even the smallest cracks were formed.

Cracks in a component, justified in the planning or productions errors, usually develop at the beginning of the utilization period; cracks from aging develop if the life cycle is respectively exceeded.

The biggest risk of malfunction is in the spot, within which the tension and resistance distribution overlap.

The procedure and application technology depend on the question, where cracks or changes in the structure are to be determined:

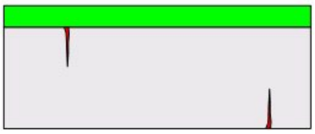
- under the coating
- at normal surfaces
- within tube surfaces

Position and orientation of cracks

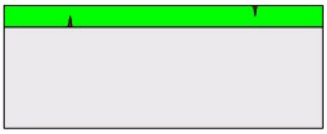
Cracks form, if tensions can no longer be diminished by the flow through the material. One knows from fracture mechanics that in this case also below the yield strength of the material the energy stores itself flexibly until the yield strength is partially exceeded and a crack develops. With the help of the PTR-technology there exists a possibility to determine the time of such situation at its early stage so that in-time measures can be seized for damage prevention.

Arrangement of cracks in components

Under the coating, non-continuous

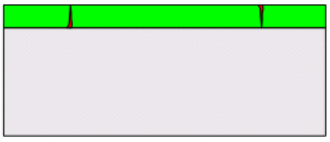


In the coating, non-continuous

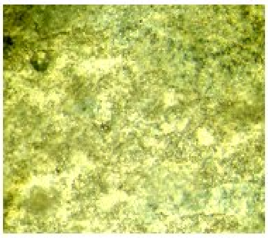


Under the coating, continuous

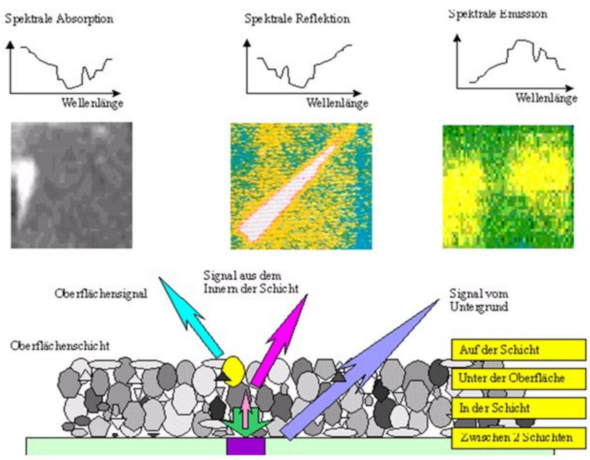
In the coating, continuous



Changes at the component's surface



Changes at the component surface are difficult to detect within the visible range of the spectrum. Recognizable structures exhibit radiation portions, which do not so easily suggest an important change of the surface function. From the pictures within the visible range, represented above, no objective statements about the condition or characteristics of the surface can be derived. Surfaces deliver peculiarities through a spectrally defined behaviour. The PTR-procedure supplies statements about the surface, the condition in or under the surface or about cracks in the component.



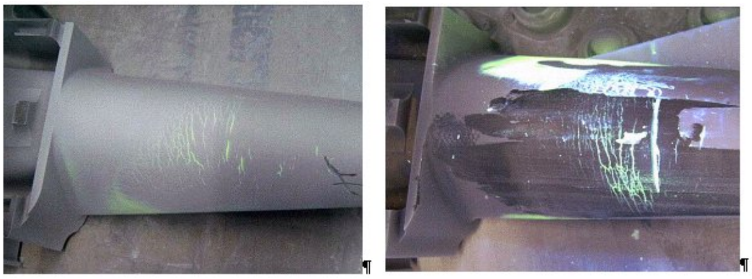
Application and process engineering depend on setting of the tasks and on the material, which should be examined. The information measured at the component surface differs temporally and spectrally, what makes the contact-free defect characterization possible.

The PTR-procedure is a non-destructive procedure for material testing, for quality control or continuous production supervision.

Practical examples:

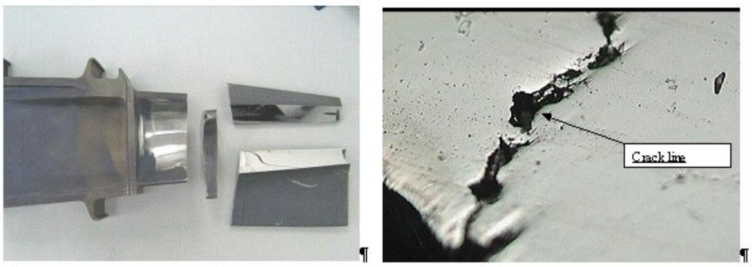
During testing and maintenance of the turbine blades the question about the wear of the applied coating and about the cracks in the blade body often arises. The two questions can be answered with employment of modern technologies, which increase profitability and substantially reduce otherwise necessary testing time.

Instead of the test with magnetic particle, which shows cracks on the surface, cracks under the intact surface of the used blades can also be reliably examined with the help of the most modern technologies within a continuous process. Before laying of a new coating the thickness of the "used" layer can also be measured whereby among other things the removal of the old layer is exactly controlled and the new coating can be made within minimum time involved.



Magnetic particle test at the turbine blade. The finest cracks at the surface can be proven with the procedure. The procedure does not enable a continuous operation.

If the cracks at the turbine blade are detected, ultrasonic or destructive tests take place and microscope investigation techniques are used, because the magnetic powder test does not supply the data about the crack depth and their type at the subsurface.



Microscope photograph (picture right) and the cut of the turbine blade (picture left). Often the components are checked with destruction test in order to identify the type of the defect.

Cutting and grinding

At selected turbine blades the critical spots become so polished that the detected cracks are clearly identified and their type can be determined. The types of the crack, its direction as well as the crack's depth are of interest by specifying and arrangement of the repair.

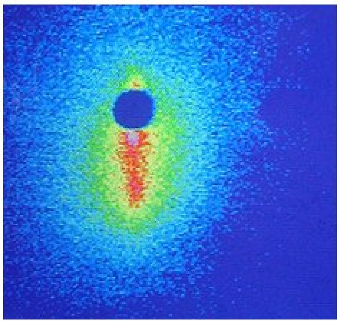
 

If the crack's depth is larger than 0.75 mm the turbine blade must be replaced. Methods which do not involve destruction tests are used for reliable, accurate and quick determination forof the crack, its direction and depth.

PTR- Technology

Tests at the turbine blades with the PTR-technology supply the statements about the thickness of the exhausted coating, about the cracks and their depth as well as about the remaining wall thickness of the body. The PTR-procedure is multi-leveled and is based on the data from different spectral areas. For clear error identification auxiliary procedures are applied.

Crack in a drill hole

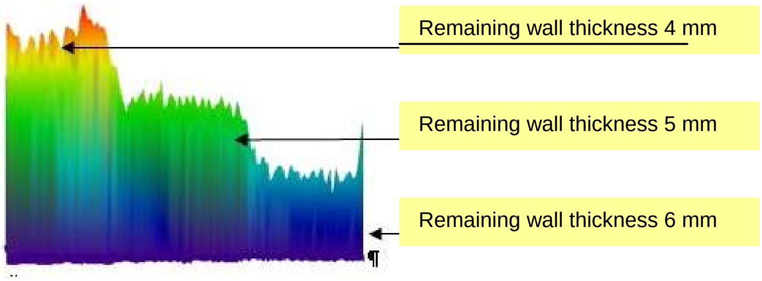


Thermoelastic effect from the impulse with high frequency mechanical oscillations results at the crack's edges. Thus locally increased temperature, dependent on the oscillation and the e-module develops. Temperature registration in the course of the time, synchronized with the oscillation, supplies the data on the type of the crack and its geometry.

For the crack characterization with the PTR-technology the multi-spectral signal registration and exact synchronization between the impulse and the signal registration are of high importance.

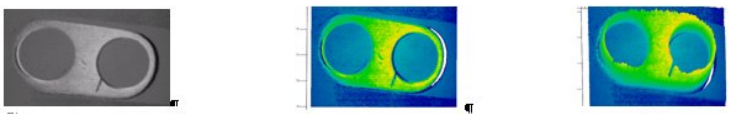
Measuring the remaining wall thickness

If corrosion arises in the inside of the tube, material dismantling leads to attenuation of the tube walls thickness. The following result shows the outcome of the IR-measuring of the tube, intact from the outside. The tube displays the remaining wall thickness of 4 mm, 5 mm and 6 mm. The result clearly demonstrates that the energy in the thin-walled tube leads to a faster and higher rise of the thermal signal than within the thicker tube area.



Determination of the crack's depth

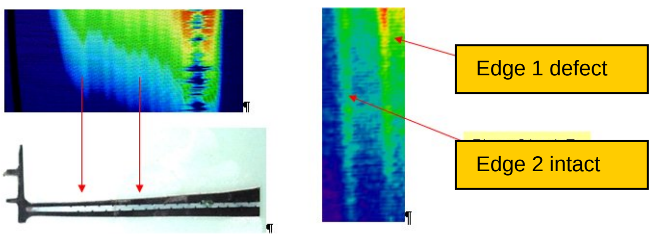
For determination of the crack's depth at the first stage the crack is identified and the crack's depth - at the second stage. The detection of the crack takes place by means of the PTR-procedure in another time period than determination of the crack's depth.



The controlled detail (picture left) with determined crack characteristics. The three-dimensional structure of the crack becomes recognizable during the further signals processing (Picture in the center and picture on the right).

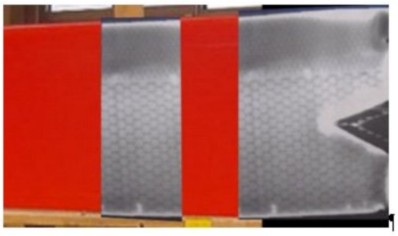
Measuring of the remaining wall thickness of the aircraft turbine blade

Via sulphate formation in the inside of the engine blade the removal of material place, which is to be proven from the outside. If the thermal behaviour of energy pulse is registered temporally fast, the remaining wall thickness of the blade wall can be derived from the data.



Adhesion defects and Delamination

The separation of the layers on the subsurface, humidity, material defects or layer thickness at components cannot be detected from the outside with the naked eye. If the PTR-technology is used, the internal structures can be visualized quickly and reliably.

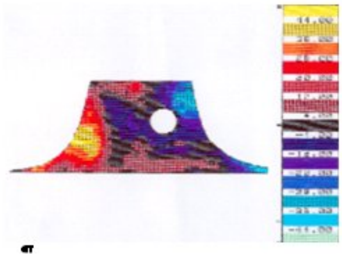


The adhesion of the core in the inside of the wing and the transition between the different honeycomb types can be examined with the speed of 25 cm/s. With the PTR-procedure the layer thickness and variation of the layer thickness can also be determined contact-free, quickly and reliably

The main advantage of the PTR-procedure is that no contact with the component is necessary and the test runs quickly and completely contact-free.

Measuring the tension distribution

Measuring the tension distribution at the complicated component (right side) as well as the result of the crack test (small picture left) with the PTR technology. The thermal particle develops from the elastic work, implemented at the test specimen.



Distribution of the total tension measured with the PTR-procedure at the complicated machine part.

The highest tension (σ_x und σ_y) is exactly at the spot of the largest thermal load.

It is shown at the example on the left side in the yellow field.

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