Evaluation of Turbine Blades Using Computed Tomography

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Abstract

Turbine blades are high value castings having complex internal geometry. Computed Tomography has been employed on Turbine blades for finding out defects and internal details. The wall thickness, rib thickness and radius of curvature are measured from the CT slices. The discontinuities including blockages of cooling passages in the cast material can be detected. 3D visualization of the turbine blade provides in extracting its internal features including inaccessible areas non-destructively, which is not possible through conventional NDE methods. The salient features for evaluation of turbine blades using Tomography are brought out.

Keywords: *Industrial computed tomography, Turbine blade, Digital radiography*

1. Introduction

Turbine blades are high value castings having complex internal geometry widely used in aircraft engines. Computed Tomography (CT) is generally used for inspection of turbine blades for detection of defects and for precise dimensional measurements of internal features such as wall thickness, rib thickness etc. X-ray film radiography cannot evaluate the internal cross-sectional configuration of the blade. CT with its extremely high contrast resolution (ability to measure small density differences) and high spatial resolution (ability to resolve fine structural details) make more attractive for critical inspection requirements of turbine blades, where failure would result in extremely high costs and possibly lives.

CT generates Digital radiography (DR) and cross-sectional images (slices) of the object. In DR, data is collected by moving the X-ray source and detector array linearly along the entire length of the object. Narrow lines of X-ray attenuation data are collected at brief time intervals. The X-ray measurements are then digitized and displayed as a two- dimensional image. DR image is also similar to a real-time radiography (RTR) image, although it has much higher contrast resolution. This is because of the detectors used are of high dynamic range. Also, the digital format of DR images permits a wide range of image enhancement functions.

In this paper, the turbine blades have been inspected by Computed Tomography (CT) for finding out defects and internal details. The usefulness and effectiveness in evaluating the Turbine blades by CT is discussed and the salient features are brought out.

Studies on Turbine blades using Computed Tomography were reported elsewhere [1, 2]. L. D. Harris et al. [1] discussed the effect of beam width on the spatial resolution of the CT system by placing the Turbine blade between the source and detector. J. F. Moore [2] used features such as Edge enhancement for enhancing the details in Turbine blade using Computed Tomography and 3D images obtained were rotated in space and milled in near real-time for even greater visualization.

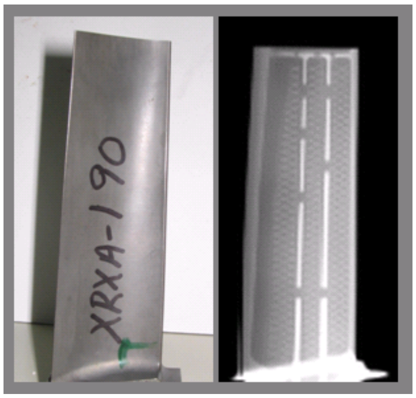

Fig. 1: Photo and Digital Radiograph (DR) of Turbine blade

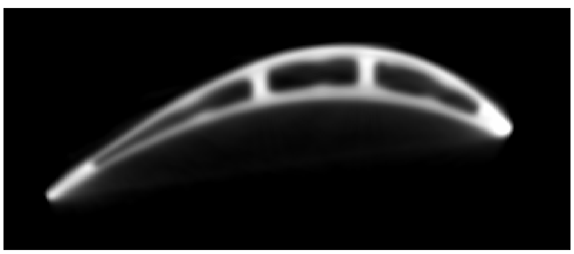

Fig. 2: Tomogram showing the cross-sectional image of the turbine blade

2. Experimental Details

Turbine blades were inspected using Industrial Computed Tomography (ICT) system. This system consists of 450 KV X-ray source, 256 channel detector array with 18 bit dynamic range and a 6-axes mechanical manipulator. The resolution of the system was 500 µm and slice thickness used was 1 mm.

Initially, a DR of the turbine blade was obtained and then CT slices were taken at selected locations from the DR image. 3D view of the blade was generated by stacking the slices one over the other and its cut-out view helps in revealing and analyzing the internal features of the Turbine blade.

3. Results and Discussion

Figure 1 shows the photo and Digital Radiograph (DR) of Turbine blade. Fig. 2 shows the cross-sectional image (slice) of the turbine blade. Fig. 3 shows the cross-sectional images (slices) at selected locations from DR image of the blade. The wall thickness, rib thickness and radius of curvature are measured from the CT slices at different locations. The discontinuities including blockages of cooling passages in the cast material can be detected from the slices, however, there are no such discontinuities and blockages are seen from Fig. 3. The results from several slices at different positions on the blade are analyzed to yield overall distortions such as twist and other shape information, however, there are no such distortions seen from fig. 3. The accuracy of the above measurements is 500 µm.

Figure 4 shows the 3D visualization of the turbine blade by stacking the slices one over the other and its cut-out view at an angle of choice to assess the internal features of the blade. The features are very clear and their measurements are possible from the images, as these images are free from overlying and underlying areas of the blade, which is seen from fig. 4. Such type of information is difficult to obtain by conventional NDE methods including the data from the inaccessible areas of the blade through nondestructively. Thus CT has emerged as a powerful tool in evaluating the intricacies involved in the inspection of turbine blades.

4. Conclusion

Tomographic inspection of the turbine blade using ICT system provided highly useful and valuable information regarding the defects, internal details and dimensions. CT made possible in extracting internal features of blade including inaccessible areas non-destructively, which is not possible through conventional NDE methods.

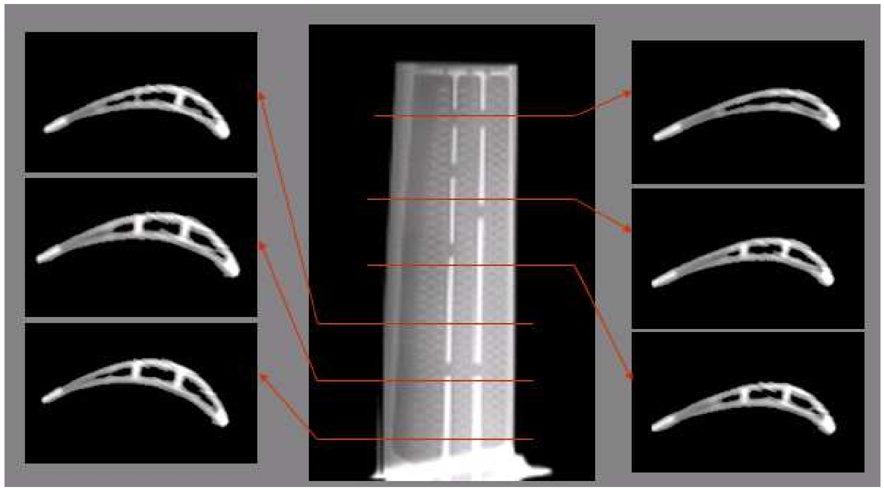

Fig. 3: Tomograms of Turbine blade at different locations selected from DR

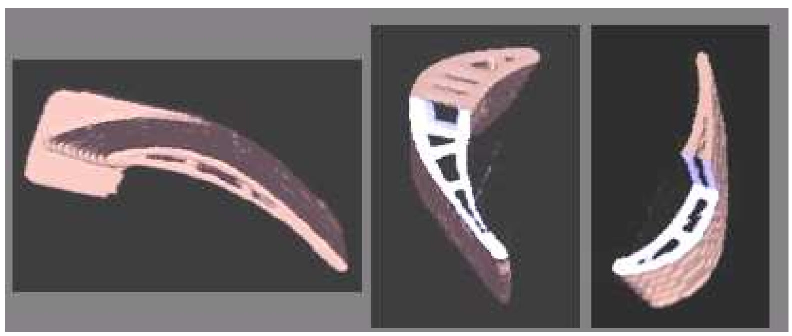

Fig. 4: 3D visualization and its cut-out views of Turbine blade

5. References

1. Lowell. D. Harris et al. 'Optimizing Spatial resolution with the mechanical design of an X-ray Computed tomography scanner' Review of progress in Quantitative Nondestructive evaluation, Vol. 9, 423-430 (Ed. D.O. Thompson and D.E. Chimenti), Plenum Press, New York, 1990.
2. John F. Moore, 'Evolution of Computed Tomography' Materials Evaluation, 48, 630-640, 1990.