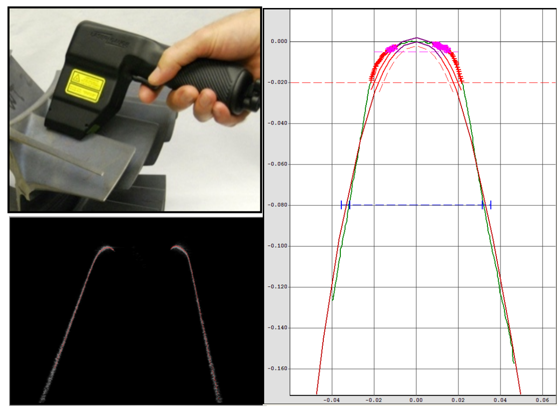
How to Inspect Leading Edges of Engine Compressor/Turbine Blades

Understanding the Impact of Leading Edge Degradation on Engine Performance

The contour of the leading edge of a jet engine compressor or turbine blade has a very significant impact on engine performance. Improper leading edge contours can degrade power and fuel efficiency, thereby increasing the cost for operating the engine. In 2016, the global airline industry's fuel bill is estimated to total $124 billion (IATA Economics 12/2016), so any improvement in fuel efficiency directly translates into cost savings. Whether manufacturing new blades or maintaining in-service blades that have been worn by heat, moisture or airborne particles, accurate measurement techniques to analyze the leading edge contour is of paramount importance.

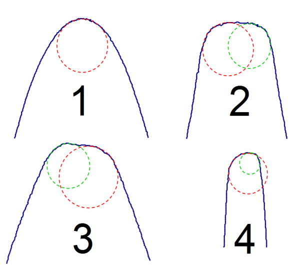


There are basically three different leading edge analysis methodologies used to determine acceptability of leading edge shape:

1. Radius at tip
2. Thickness of blade at different setback positions
3. Contour compared to a nominal template

Radius Method

The first "go-to" measurement methodology for leading edge is quite often the calculated, best-fit radius of the edge. At first glance, this method seems rather straightforward: simply take the points on the edge; fit a circle to the points, and an accurate radius reading is acquired. While this may work for a perfect blade with an edge which falls into a true circular arc (really doesn't need to be inspected), it is not very reliable for the more common case of blades which deviate from this ideal. Because of this unreliability, the radius alone isn't enough to determine leading edge quality.

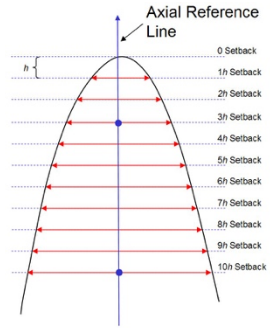


To the left are 4 different examples to illustrate the point. For #1, the tangent points of the radius can be found, and the radius value radius can be fairly easily calculated. However, for #2-4, the radius calculated depends on the "tangent" points that are used to bound the points used for the radius calculation. All three of these blade cross-sections show 2 distinct radii (three, if you include the overall top edge of the contour). Since there is not a true "circular arc" in these scans, the radius calculation is unreliable.

HOW TO GUIDE

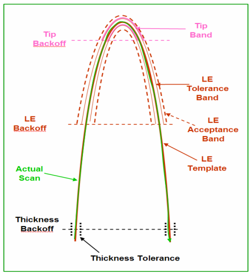
How to Inspect Leading Edges of Engine Compressor/Turbine Blades

Blade Thickness Method



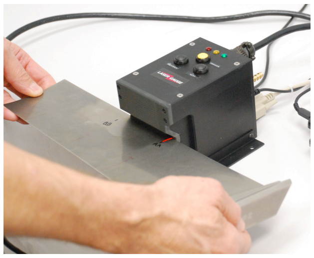
Another method that is more reliable than the radius method is the Blade Thickness method. With this method, the thickness of the blade is calculated at predefined setback positions in the scan. The blade orientation for the thickness method is defined by using an axial line along the centerline of the blade, defined using the midpoints of two transverse lines through the blade, indicated by the blue circle in the accompanying illustration. The thickness measurements are then compared to the nominal template thickness as determined from the original engineering drawings of the blade.

Template Matching Method



The final leading edge methodology utilizes Template Matching and tolerance bands to determine whether the leading edge shape is within tolerance. The illustration to the right shows a template and the tolerance bands. Typically, the tolerance bands are very narrow (as small as +/-0.002”) but have been increased for clarity in the illustration. Any points that lie outside of the tolerance band, either smaller or larger, are identified and the out-of-spec measurement is calculated and logged.

Conclusion



Since none of the 3 leading edge measurement methodologies provide the complete analysis of the blade alone, some combination of the three is ideal for optimum leading edge inspection. The portable, hand-held LaserGauge Leading Edge Scanning system provides the capability to perform all of the methods for a wide variety and sizes of blades, from blade thicknesses of as much as 0.350” down to an edge radius of as small as 0.005”. Complete data sets, including template matching, blade thickness and radius, are archived along with all of the raw scans and raw sensor images. Available as either handheld portable or benchtop system, a model exists for most any blade inspection application.