REMAINING LIFE ANALYSIS HIGHLIGHTS

By Christopher Sykora

One of the most in-depth projects for the analytical design team at RMS is the Remaining Life Assessment (RLA). An RLA is used to find out if parts (rotor disk, blades, etc.) can be operated for an extended period of time beyond the originally estimated lifespan. It consists of visual inspections, non-destructive testing, metallurgical evaluations, and a thermal/stress analysis of the part in question. The RLA does not "extend" the life of the component, but rather calculates an updated life expectancy of the equipment given the actual operating conditions and utilizing the most modern analysis techniques. The new techniques are often more precise and thus can usually afford to be less conservative than the original analysis that may have been completed before the advent of finite elements. The intention of this article is to highlight the stress analyses from the RLA's performed at RMS in 2015.

An RLA was performed on a CrMoV alloy steel GT-51 power turbine disk. Although the end user of this disk was unable to provide much operating data on their rotor, RMS was able to perform this analysis based on typical GT-51 operating information from our archives. Although not usually the case for most legacy disks designed with the conservative techniques from several decades ago, the results for this particular disk showed a very low calculated number of cycles to crack initiation. In fact the calculation (including typical safety factors) was a few hundred stop-start cycles short of the estimate of cycles already run. The non-destructive testing did not find any detectable crack indications, so the extra step of a fracture mechanics analysis was taken for this disk. This provided an estimate of the minimum inspection intervals required to detect cracks using a red dye inspection in the field, before those cracks grow to a critical size where fracture would be imminent. This rotor has already been placed back into service is expected to operate for several more years.

Another RLA example was performed on the first two of five stages from an E-526 nitric acid expander. Disks made of both A-286 and 422 stainless steel were analyzed. Results for this project were more typical in that the minimum cycles to crack initiation were estimated at several thousand, significantly longer than the operation anticipated in the future. Time to creep rupture was also calculated, but was not limiting either. This job demonstrated our ability to analyze multi-stage systems with multiple sources of cooling flow.

An RLA was performed on a RT-65 power turbine disk

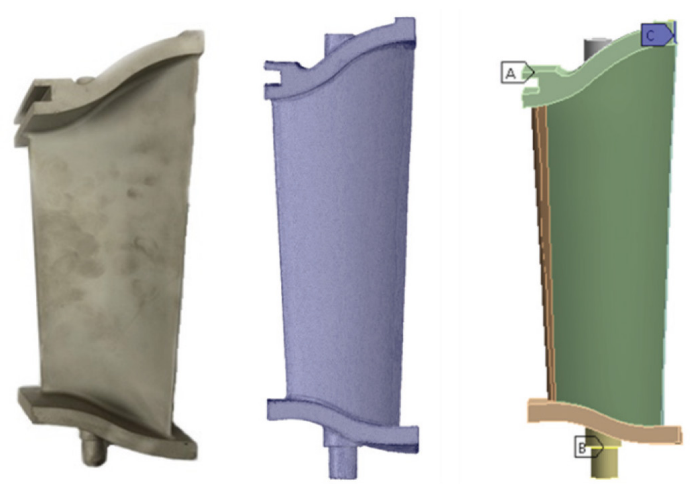

Figure 1: RT-65 Stator Vane Laser Scan vs. Analysis Model

made of 422 stainless steel and the accompanying stator vane made of cast 310 stainless steel. The disk, rotor blade, and stator vane were all provided for reverse engineering since RMS did not have any geometry of this particular rotor. All three components were turned into 3-D solid models for analysis utilizing our in-house digital measurement systems (including laser scans) and 3-D solid modeling capabilities (see image). The analysis at existing operating conditions of these component also showed significant remaining life and opportunity for extended run time even though this rotor had already been in operation for approximately 180,000 hours. This particular user also requested additional analysis beyond the typical RLA, to explore the possibility of running at hotter operating conditions in order to increase horsepower output.

This required multiple analyses at hotter conditions & techniques to calculate life expectancy including cyclic damage already incurred from past operations. RMS was up to the challenge!

The final RLA we are highlighting was for an FCC hot gas expander Waspaloy disk and 347 stainless steel nosecone/inlet struts. RMS was able to very quickly turn around the analysis on this disk since we have established a significant database of prior FCC hot gas expander models that can be quickly leveraged for future RLA's. The analysis models were updated for the particular flowpath and operating conditions of this customer and life expectancies for the disk were rapidly estimated. This was another example of significant extended life calculated with LCF life exceeding 10,000 cycles. This job also provided an opportunity for RMS to leverage our new capabilities for in-house metallurgical replica creation, which is a key part of the metallurgical evaluation. This topic will be explored in a future article. This rotor is planned for re-installation and additional service in an upcoming operating campaign given the results of this RLA.

For further discussion on the mechanics of the stress analysis involved in an RLA, the prior two articles titled "Remaining Life Assessment" by William Sullivan, PE can be found using the newsletter index on the RMS website. RMS can provide an RLA on almost any rotor if the proper information can be provided or estimated. Typical operating speeds, pressures, and temperatures and cooling system information must be estimated (usually from instruction book data). It should be noted that even if an RLA is requested only for the rotor disk, that the rotor blades are also required for reverse engineering. This is because the blade geometry must be modeled as accurately as possible since the mass and CG of the blade is the highest contribution stress on the disk from centrifugal forces.

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