Material Integrity Solutions, Inc.

PROJECT BULLETIN

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Effect of Power Increase on the Remaining Life of a Generator Rotor Shaft in a Hydro Plant

Background

A hydro power plant was considering increasing its output by about 28% utilizing the existing shrunk-on generator rotor (*Fig. 1*). The rotor shaft had experienced cracking in its keyway areas which had been attributed to corrosion fatigue. Client was concerned that additional stresses caused by increasing power output (due to additional torque) could affect the integrity of the shaft. MIS was hired to evaluate this condition and provide guidance on the operation of the rotor.

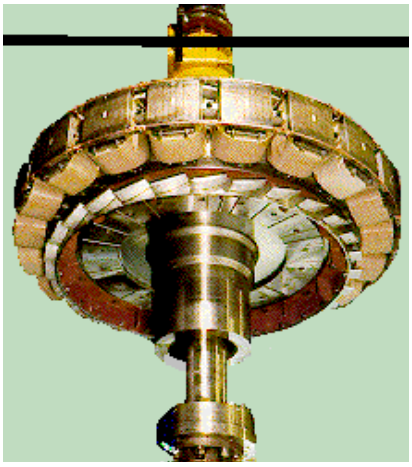

Figure 1: A typical hydro-plant generator

Discussion

MIS started this evaluation by reviewing geometry of the rotor, its material, inspection history of the rotor, its operation, and stress analyses performed by client. The rotor consisted of a long shaft (over 25') and a number of shrunk-on disks. Its material was A-293 Class-1. Past inspections found cracking on the shaft under the disks. These cracks were initiated at bottom of corrosion pits. Although a metallurgical analysis of the shaft cracking was not conducted, nevertheless, they were attributed to corrosion fatigue. The plant was using an operating practice based on daily cycling of the unit. Stress analyses, using both hand calculations and finite element methods, were performed considering all loading conditions, including centrifugal, bending, and torsional forces.

To evaluate the effect of the 28% increase in power output from this plant, remaining lives of the shaft under both output conditions were estimated. For this purpose, the following tasks were performed:

- Torsional stresses in the critical area of the shaft under both operating conditions were calculated.
- Using fracture mechanics analysis, critical crack size under operating loads was calculated.
- Fatigue crack growth analyses were conducted to calculate remaining life for a variety of initial crack sizes for a daily operating cycle.
- Threshold stress intensity factor for initiation of fatigue cracks was estimated.
- Maximum flaw size for initiation of fatigue crack under both operating modes were estimated.

The above information was then used to evaluate the effect of increase in load on shaft's integrity and remaining life (*Fig. 2*).

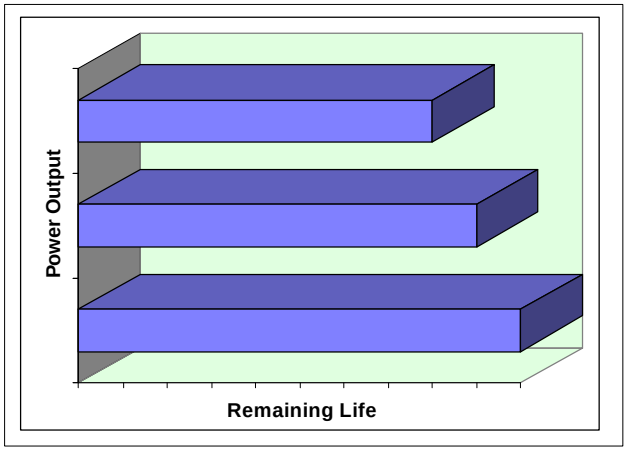

Figure 2: Effect of power output on life

Conclusion

This analysis found that the increase in stresses due to additional power output has a minor impact on fatigue crack initiation and growth life of the shaft. Therefore it was concluded that operating the rotor at either of two power outputs has an insignificant impact on it integrity and life. This meant that the load can be increased without any additional adverse effect on the rotor.