"Cost Effective Overhaul of Critical Turbine Components Using Prognosis".

by

Ashok K Koul
Life Prediction Technologies Inc.,
23-1010 Polytek street, Ottawa K1J 9J1

GE has recently released its technical information letter (TIL 1576) to large frame users informing them about the retirement criteria for rotors that have either exceeded 200,000 hours of service or accumulated more than 5000 starts. A number of users are assessing their options and considering various replacement or life extension possibilities. In LPTi's experience, it is possible to defer the replacement of the rotors of an aged or a design life expired engine by using prognostics (predictive maintenance) concepts and by implementing MIL-STD-1783 based damage tolerance or retirement for cause (RFC) methodology to maintain the engines. LPTi possesses ten years of experience with successful implementation of this methodology for maintaining a fleet of 42 W101 land based engines in Venezuela where the customer (PDVSA) has doubled the usage life from 150,000 hours to 300,000 hours and saved over $40 Million by deferring disc replacement costs and accrued additional savings on overhaul costs. The discs are currently being replaced, in a phased manner, as a result of excessive wear rather than cracking. The presentation will focus on the results of this W101 study where physics based prognostics was successfully used to quantify non-destructive inspection (NDI) requirements at overhaul and to predict a safe inspection interval (SII) for the fleet to deal with the uncertainty of potential disc failures. Probabilistic calculations were performed to quantify the reliability of the engine fleet and assess the risk of future failures.

The location of the most fracture prone rotor and the useful life limit of rotors is governed by off design engine operating environment in terms of ambient temperatures and pressures and the usage conditions in terms of operational speeds and start-up and shut down cycles. These are bound to vary from one user to another and slapping a single usable life limit on all rotors of a particular engine design is not logical, at least from a users perspective. Ideally, a usable life limit or residual life should be assessed for each engine and a SII including NDI requirements should also be established for each engine. Accurate determination of these limits is governed by accurate rotor temperature profile determination for a given engine operational envelope because thermal gradients strongly influence the stresses that the rotors are exposed to during service. A combination of operational stresses and temperatures in turn governs the location of the most fracture prone rotor in a given engine and the primary as well as secondary fracture critical locations of the fracture prone rotor. Particular attention must therefore be paid to the inspection of these fracture prone rotors and their fracture critical locations during overhaul.

Up-front prognostics analysis of rotors is essential. It is required for the residual life assessment (RLA) of the fracture prone rotors, SII determination of the design life expired engines and defining NDI sensitivity requirements for continued safe operation. Currently used and promoted metallurgical analysis such as hardness testing and replica based microstructural assessment and inspection of rotors for cracks are not sufficient to ensure safety and reliability of the engine. The uncertainly of all engine variables must be considered in detail prior to returning the engine to service.