

Improvements in the ReGENco Condition Assessment Software

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For high temperature components made of low alloy steel (1%Cr-1%Mo-0.2 to 1%V) and operating above a temperature of about 800°F, the growth of any possible crack can be due to both creep and fatigue. Fatigue crack propagation depends upon the frequency of start-stop cycles on a unit which can cause high thermal and centrifugal stresses (if rotating component). Unlike fatigue, creep crack growth depends on the number of operating hours accumulated at certain temperatures and stresses.

Until recently, ReGENco used to calculate the fatigue crack growth based on the commercially available software and for creep impact, certain safety factors were used which emerged with time and experience. There was no program/software available to accurately and collectively record the creep-fatigue crack growth behavior.

Therefore, an in-house condition assessment program was developed for life prediction analysis of turbine-generator components (especially high temperature) which captures the creep-fatigue crack growth phenomenon. Based on the published technical literature the program can record the complex creep-fatigue crack growth per start-stop cycle both depthwise and lengthwise. Hence, it can work for two degrees of freedom as compared to one degree of freedom, (depthwise), used in most commercial software (Exponent-NASCRCAC-TM, EPRI-SAFER PC etc.) for creep-fatigue. The unique feature of the program is that it uses the stress gradients from the bore surface and can also work with flaws of any shapes and location (surface/ buried). Commonly, a semi-elliptical type bore surface flaw (0.125" deep x 0.250" long) is considered to be the worst and default flaw in most cases. The program can use an elastic-cyclic plastic-primary creep-secondary creep material behavior based on its input. To account for cases of large scale plasticity or high yielding, J-integral parameter (as opposed to K-parameter) can be used.

The program is capable of calculating component probability of failure for a given number of starts-stop cycles per year. It uses Monte-Carlo probability of failure criteria for a given number of simulations or trials (normally one million simulations are used). It takes into account relevant distributions for crack depths and lengths, start-up and steady state stresses and fatigue-creep parameters to evaluate stress intensity factor for a given flaw. Also, weibully distributed fracture toughness versus excess temperature (T-FATT) curve can be used (besides normally distributed-less accurate) based on the critical temperature and material properties of the rotor. The total probability of failure is the ratio number of times the stress intensity factor exceeds the randomly selected fracture toughness value (from curve) to the total number of trials.

Since the program is capable of taking all relevant inputs and generating desired output according to ReGENco's final reports, it is relatively faster compared to multiple sets of programs used for a report in the past.

Though the program was primarily made for improvement in condition assessments of high temperature rotors (HP & IP Rotors), it works well for the other high temperature components. For example, the program has been presented (EPRI T G technical conference-Aug 2005, Denver) for life analysis of inlet sleeves (Westinghouse Building Block 44 type). These BB44 inlet sleeves with about an inch thick cross-section (P22 type material) generally has high thermal stresses and bending stresses (due to misalignment), which can possibly yield the material and can propagate potential circumferential-radial types of cracks (covered in the last newsletter). Hence the subject program was used to estimate the residual life under the high section yielding condition. Moreover, the program can work for low pressure and generator rotors/components when creep part is excluded and only fatigue is considered. The program output matches closely with commercial software and examples in the published literature.

Overall, the program aims to reduce excessive conservatism adopted in most of the commercially available software and accurate condition assessment of the turbine-generator components.