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Effect of laser shock peening on fatigue life at stress raiser regions of a high-speed micro gas turbine shaft: A simulation based study

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Abstract

Fatigue failure due to stress raiser regions on critical rotating components in gas turbine engines, such as the shaft, is a crucial aspect. Methods to reduce these stresses and improve fatigue life are a source of ongoing research. Laser shock peening is a method where compressive residual stresses are imparted on the stress raisers of such components. However, numerical based studies on multiple laser shock peening applied to stress raisers is under-researched. Hence, this study will attempt to predict the fatigue life at fillet radii step induced stress raiser regions on a high-speed gas turbine engine shaft by utilization of laser shock peening. The objective of this study was achieved by developing a more computational efficient finite element model to mimic the laser shock peening process on the fillet radii step induced stress raiser regions of a shaft. A modified laser shock peening simulation method for effective prediction of the residual stress field was introduced. Furthermore, the fatigue life improvement due to laser shock peening was predicted by employing Fe-safe fatigue software. From the results, the modified laser shock peening simulation method provided accurate prediction of the residual stress field with a reduced computational time of over 68% compared to conventional methods. The fatigue life revealed an improvement of 553% due to laser shock peening, which is comparable to similar findings in the literature. Hence, from the findings and results achieved, the developed finite element model can be an appropriate tool to assist in the fatigue life estimation of laser shock peening applied to stress raisers.