INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Evaluate fretting fatigue damage in simple and complex geometries like diesel engine head gasket

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SHORT ABSTRACT

Fretting is a surface damage phenomenon and is observed at the contact interfaces like bolted, gasketed joints etc. Fretting related failures are observed in multiple components of an internal combustion engine. Such failures can cause partial/complete break-down of the engine and can result in a significant warranty cost. In this work, fretting fatigue evaluation is carried out first for a simple geometry of a flat-flat, complete contact pair and then for a complex geometry of actual head gasket joint. Since the head gasket is a type of flat-flat, complete contact pair, equivalent analogy is assumed between the two problems. A new approach based on deviatoric strain amplitude-based parameter combined with Ding's parameter, D_{fret2} is proposed and explored in this work.

In the initial verification through two-dimensional (2D) finite element analysis (FEA) of a flat-flat contact pair, experimental correlation is carried out using the deviatoric strain amplitude-based method and traditional critical plane-based methods like Smith-Watson-Topper (SWT) and Fatemi-Socie (FS). Observing the high load-factor values, different non-linear material models like BKIN, MKIN and Chaboche are considered to evaluate the resultant fretting fatigue life results. Overall good experimental correlation, within a $\pm$ 3N scatter band, is observed for the considered flat-flat complete contact problem. The deviatoric strain amplitude-based parameter does not require critical plane-based calculations and hence, is computationally more efficient as compared to SWT and FS parameters. The effect of wear on fretting fatigue is also studied through Archard's progressive wear model and Ding's parameter, D_{fret2}. Compared to the Archard's wear model, better correlation is observed with the Ding's parameter. Further, the effect of different parameters like varying coefficient of friction (COF), frictional heat and fretting loads like normal, tangential and axial loads on the fretting fatigue damage are also explored in the current work.

Finally, the learnings from 2D FEA are considered in the fretting fatigue damage evaluation of actual head gasket using three-dimensional (3D) FEA. Corresponding fretting damage results are compared with the traditional approach based on the Ruiz's parameter F1. To evaluate the consistency in the predicted results, correlation is carried out for three head gaskets of three different high horse-power engines. Further, an alternative approach based on the 'Fretting limit line' is also proposed for simpler absolute and comparative fretting fatigue damage evaluation. It is shown that this approach is found to be more effective as compared to the current parameter based on Ruiz's parameter F1.