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# Model-Based Diagnostics of Multiple Tooth Cracks in Spur Gears

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**Abstract :** Gears are important machine components that are widely used to transmit power and change speed in many rotating machines. Any breakdown of these vital components may cause severe disturbance to production and incur heavy financial losses. One of the most common causes of gear failure is the tooth fatigue crack. Early detection of teeth cracks is still a challenging task for engineers and maintenance personnel. So far, to analyze the vibration behavior of gears, different approaches have been tried based on theoretical developments, numerical simulations, or experimental investigations. The objective of this study was to develop a numerical model that could be used to simulate the effect of teeth cracks on the resulting vibrations and hence to permit early fault detection for gear transmission systems. Unlike the majority of published papers, where only one single crack has been considered, this work is more realistic, since it incorporates the possibility of multiple simultaneous cracks with different lengths. As cracks significantly alter the gear mesh stiffness, we performed a finite element analysis using SolidWorks software to determine the stiffness variation with respect to the angular position for different combinations of crack lengths. A simplified six degrees of freedom non-linear lumped parameter model of a one-stage gear system is proposed to study the vibration of a pair of spur gears, with and without tooth cracks. The model takes several physical properties into account, including variable gear mesh stiffness and the effect of friction, but ignores the lubrication effect. The vibration simulation results of the gearbox were obtained via Matlab and Simulink. The results were found to be consistent with the results from previously published works. The effect of one crack with different levels was studied and very similar changes in the total mesh stiffness and the vibration response, both were observed and compared to what has been found in previous studies. The effect of the crack length on various statistical time domain parameters was considered and the results show that these parameters were not equally sensitive to the crack percentage. Multiple cracks are introduced at different locations and the vibration response and the statistical parameters were obtained.

**Keywords :** dynamic simulation, gear mesh stiffness, simultaneous tooth cracks, spur gear, vibration-based fault detection
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