Role of the friction-induced vibration in tuning the dynamic response of cracked gearbox

Omran Abdallah*, and **Sadok Sassi***

Department of Mechanical and Industrial Engineering, Qatar University, QATAR

Abstract. From the literature review of vibration feature-based gear wear monitoring, it was noticed that most current research works focus on tracking the impulsive response generated from the periodic variation of gear-mesh stiffness. However, this research work demonstrates that friction-induced vibration cannot be ignored anymore.

Introduction

Gear crack is a common fault that occurs in a gear transmission system. It degrades the operating efficiency and may cause other catastrophic failures such as tooth breakage and fatigue. From the literature review of vibration feature-based gear wear and damage monitoring, it was noticed that most current research works focus on tracking the impulsive response generated from the periodic variation of gear-mesh stiffness [1]. Such variation, which mainly depends on the size and geometry of mating teeth, is usually the primary source of excitation for the gearbox and the neighboring systems. On the contrary, friction-induced vibration has received less attention mainly due to the domination of the impulsive response in the case of heavily loaded mechanisms and the low contribution of the noisy-based vibration in the presence of lubrication. On the other hand, the friction-induced vibration could not be ignored in dry or poor lubrication. To fill this gap, a numerical study was put forward to investigate the effect of interactions between mating gear teeth when dry surfaces are simultaneously rolling and sliding on each other.

This research proposes a comprehensive model (Fig 1-a) to study the dynamic behavior of a one-stage spur gearbox with cracked teeth in the condition of dry friction [2]. The inter-teeth state combines rolling and sliding when the contact point moves along its line of action. The sliding arises because of the difference in curvature radii of both mating teeth and also the variation of their mutual area of elastic deformation. Hertz's theory of contact is used to estimate the dimensions of that deformed area.

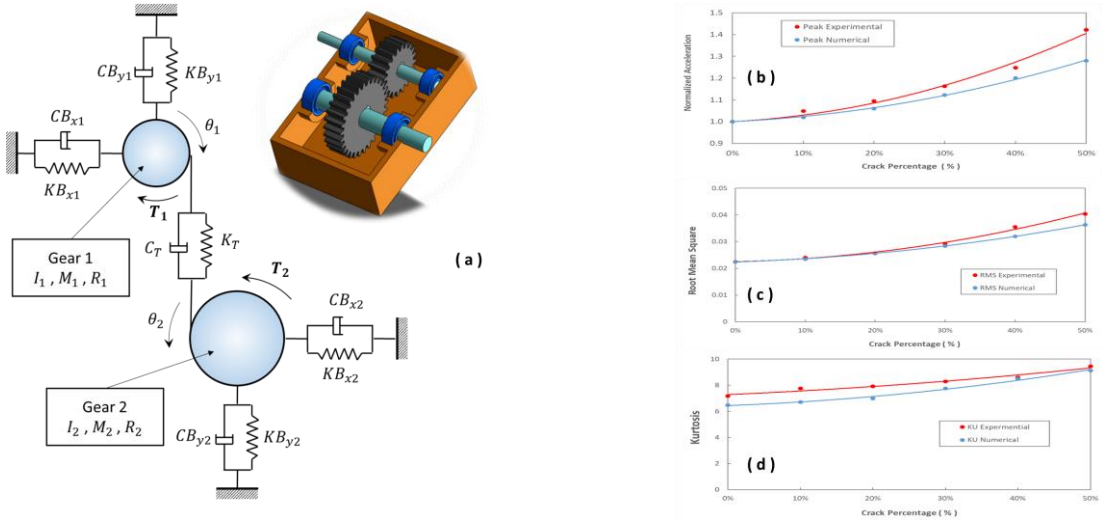

Figure 1: Model and main results. (a) Six DOF gearbox model; (b) Peak amplitudes; (c) RMS amplitudes; (d) Kurtosis amplitudes.

Results and Discussion

The variable rubbing phenomenon between sliding surfaces generates a combination of modulated and constant amplitudes noises. Adding this friction-induced noisy vibration to the primary impulsive periodic response realistically mimics the actual behavior experimentally measured on a test rig specially developed for this investigation [3]. Based on time-domain statistical indicators (Fig.1-b to 1-d), the investigation concluded that the combination of both components of friction-induced noise with the primary impacting response was found to accurately and realistically simulate the dynamic behavior of the gearbox.

References

[1] O.D. Mohammed, M. Rantatalo, Gear fault models and dynamics-based modelling for gear fault detection - A review, Eng. Fail. Anal. 117 (2020), 104798.

[2] A.S. Mohamed , S. Sassi , and M.R. Paurobally. Model-Based Analysis of Spur Gears' Dynamic Behavior in the Presence of Multiple Cracks. Hindawi Shock and Vibration Volume 2018, Article ID 1913289, 20 pages **https://doi.org/10.1155/2018/1913289**

[3] O.K. Abdallah. Towards a more efficient health condition monitoring strategy applied for gearing mechanical systems. Master Thesis. Qatar University, Qatar. January 2023.