Time-Dependent Kinematic Reliability Analysis of Gear Mechanism Based on Saddle-Point Approximation

***Junhua Chen[1], †Longmiao Chen[1]**

[1] College of Mechanical Engineering, Nanjing University of Science and Technology, China.

*Presenting author: swat_cjh@163.com
†Corresponding author: 13913870745@139.com

Abstract

Gear mechanism is widely used in various mechanical transmission systems. With the development of modern machinery in the direction of high stability, precision, and reliability, the requirements for the reliability of gear transmission systems are constantly improving. Therefore, accurate and efficient reliability evaluation is critical to ensure the safety of gear mechanism. The past few decades have witnessed substantial developments on reliability analyses of gear mechanism, especially for structural reliability. Contrastingly, less attention has been paid to the kinematic reliability analysis of gear mechanism. This work aims to develop an effective and practical method for time-dependent kinematic reliability (TKR) of gear mechanism. Firstly, dynamic model of gear mechanism is established, and a surrogate model of kinematic error is obtained based on BP neural network. After that, we employ a sequential decoupling strategy of efficient global optimization (EGO) to transform the time-dependent reliability problem into a time-independent one, with which the second-order information of the extreme limit-state function can be then obtained. Finally, the saddle-point approximation (SPA) method is applied to estimate the time-dependent kinematic reliability of the gear mechanism. The accuracy and efficiency of the proposed method are verified by several engineering problems. The reliability analysis results are compared with the reliability methods of Monte Carlo Simulation (MCS), First-Order Reliability Method (FORM) and Second-Order Reliability Method (SORM). Results of the engineering cases show that the proposed method can effectively reduce the limit-state function call numbers while reaching the same accuracy as MCS.

Keywords: time-dependent kinematic reliability, gear mechanism, sequence decoupling strategy, saddle-point approximation.