Abstract

The railway track is an essential part of the railway system. It supports the vehicle's weight and guides it in the desired direction. The railway track is a multilayered structure. It contains a large number of components including rail, railpad, sleeper, ballast, sub-ballast, and subgrade. These components lose their functionality with time. An increase in axle load and vehicle speed amplifies the process of deterioration of the track components. The loss of functionality of these track components can accelerate the formation of the track defects. Some of the common track defects are loss of track stiffness, rail discontinuity, crossing wear, corrugation, squats, and rail geometrical irregularities. To maintain smooth and uninterrupted service of the railway system, these defects must be located and rectified. Manual inspection and track recording cars are conventionally used to locate these track defects. However, manual inspection is prone to human error and running track-recording cars is expensive. Hence, non-conventional techniques are required to locate and monitor the tracks defects.

This thesis proposes non-conventional methods to locate and estimate the severity of the track defects by analysing the axle-box acceleration. Loss of stiffness defects, rail discontinuity, and crossing wear have been studied in this work. Firstly, an experimentally validated multibody dynamics vehicle-track model is developed using the commercial software SIMPACK. The experiments were performed on the newly built East-West Kolkata metro track. In these experiments, axle-box acceleration, spring compression of the primary suspension, and vehicle velocity were measured. The track defects were introduced in the model. For the defective track, axle-box acceleration is generated from the simulation. Studies were performed on different defects. In the first study, the location of the fastener assembly defect, resulting in loss of track stiffness, is found using the template-based squared correlation coefficient method. Defect severity is estimated using the normalized continuous wavelet transform method. In the second study, a rail discontinuity is located using the K-means clustering algorithm, and its severity is estimated using the continuous wavelet transform method. In the third study, both loss of stiffness defect and rail discontinuity are added to the track. The location of both defects is found by using the density-based clustering (DBSCAN) algorithm. In the fourth study, the location of the crossing is found by using the DBSCAN clustering algorithm. After locating the railway crossing, its structural health is estimated using the continuous wavelet transform method and a 2D CNN model. The effect of different process parameters such as vehicle speed, axle load, level of irregularity, and direction of motion is considered to test the performance of each of the methods.

Keywords: Track defects, multibody dynamics, axle-box acceleration, continuous wavelet transform, clustering algorithm.