Dynamic Analysis of Draft Gear and Draft Pad of Freight Wagon due to Localized Defects using FEM

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The present work investigates the effect of a crack on the modal frequency of a draft pad. Initially, the first five mode shapes of a healthy draft pad and the first seven mode shapes of healthy draft gear considering compressed draft pads are determined using the finite element approach. A mathematical model of the draft pad is formulated to predict the effect of the crack on its modal frequency. A semi-elliptical shaped crack is modelled in the lateral and longitudinal direction of the draft pad. It is observed that if the crack lies in the zone of minimum modal displacement, then the frequency drop is minimal, and if the crack lies in the zone of maximum modal displacement, then the frequency drop is significant. Various damage scenarios are simulated by varying the width and aspect ratio of the crack in order to identify its effect on the modal frequency. It is seen that if the aspect ratio is varied while the crack's width is maintained constant, then the frequency drop is linear, whereas if the crack's width is varied while the aspect ratio is maintained constant, then the frequency drop is parabolic. This study provides a tool for monitoring exciting frequencies of draft gear and shows how each modal frequency is affected by the crack due to parameters like aspect ratio, crack width, and crack location/orientation.

1. INTRODUCTION

The longitudinal dynamics of freight wagons largely depends on the dynamics of draft gear and consequently the draft pad(s). Draft gear is a key part of autocouplers in freight wagons, as they function like a cushioning device absorbing shocks in the form longitudinal forces arising due to train operations like accelerating or braking. The draft gear (RF-361) under consideration is manufactured by Miner Enterprises Inc., USA. It is normally used in open hopper/coal wagons and bulk commodity wagons. Freight wagons in Indian Railways are loaded with RF-361 draft gear. The various components of the draft gear illustrated in Fig. 1a are six draft pads with a top follower, three shoes, and a wedge. The draft pad shown in Fig. 1b consists of a rubber compound sandwiched between two steel plates and is perfectly bonded to them. All these components are assembled in housing with the three shoes arranged circumferentially around the wedge. The wedge and shoes operate between the top follower and the draft gear housing. The applied forces reach the draft pads through the wedge and shoes. Each pad has an ultra-high capacity natural rubber spring package to absorb the high longitudinal forces arising due to operations like acceleration and/or braking and also due to changes in track topography. These forces, being repetitive in nature, accelerate the damage to the draft pads in the presence of defects. These draft pads, when used in damaged conditions, cause the longitudinal forces to be transmitted to the wagon, which compromises the safety of the laden goods.

A review shows that the longitudinal in-train forces are responsible for several problems including broken draft gear and even causing freight wagons to be pulled off the inside of curves.[1] Initial efforts by researchers were aimed at reducing longitudinal oscillations in passenger trains. Measurements and simulations of in-train forces were carried out by Duncan and Webb to achieve reduction in longitudinal oscillations.[2] Work by Chen was aimed at developing a mathematical model to calculate transient responses of a coupler and to identify the coupling speed.[3] Experimental efforts by McClanachan et al. helped determine the occurrences of coupler impacts combined with pitching motions in the wagon body.[4] The impacts were simulated using the train-wagon interaction model in NUCARS and ADAMS/Rail. The fatigue life of three different wagon connection coupling systems that had draft gear with and without self-locking features was evaluated by Cole

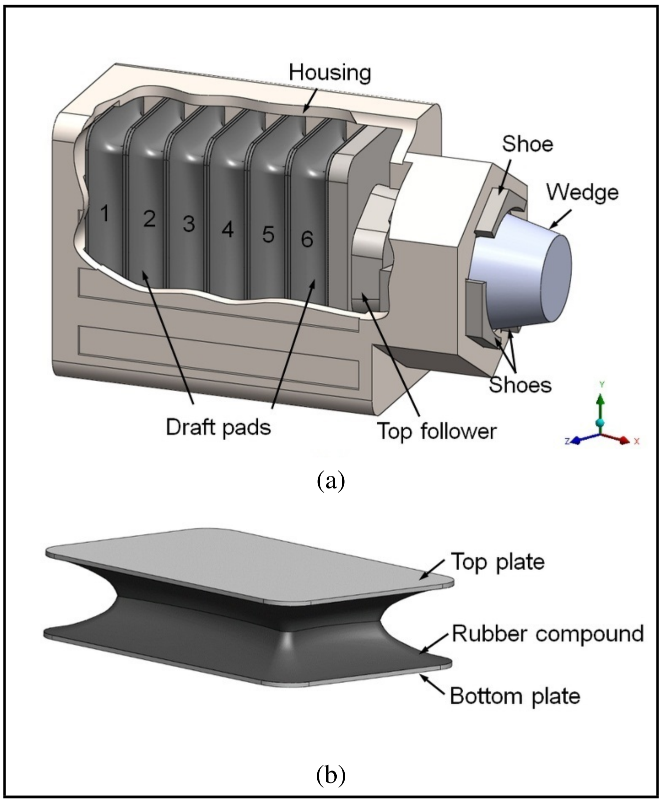

Figure 1. (a) A cross-sectional view of draft gear unit (RF-361) and (b) a typical draft pad (RF-8).