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Gauge widening of passenger coach wheel sets in Indian Railways: Observed statistics and failure analysis

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Abstract

Several hundreds of gauge widening cases have been reported in coaching stock wheel sets of Indian Railways over last two years. This work investigates the effect of non-uniformity in braking, brake load, braking frequency, wheel profile, and braking cycles on wheel gauge evolution in coach wheel sets with an aim to identify root cause of the problem. A validated finite element model considering heat generation at brake-wheel interface, heat partitioning at wheel-brake block and wheel-rail interfaces, and convective, radiative heat loss to ambient air is used to estimate wheel temperatures, stresses, and gauge change. Residual stresses generated during wheel manufacturing and fitment of wheel onto axle are considered in the study. It is found that wheel gauge reduces during braking and increases as wheels subsequently cool down. Magnitude of temporary gauge reduction and permanent gauge widening increases with increasing heat input. Thus, higher non-uniformity in braking - leading to overheating of some wheels - can cause wheel gauge widening. Interestingly, reduction in brake load reduces permanent gauge widening but increases temporary gauge reduction during braking. Nature of gauge change and effect of wheel profile, seen from gauge widening statistics, correlate well with findings from simulations.

Key words: Finite element analysis, Railway engineering, plastic deformation.

1. Introduction

Majority of passenger trains in India use ICF (Integral Coach Factory) coaches. Axle tonnage of these coaches is 13 tonnes for non-AC (non air-conditioned) and 16 tonnes for AC (air-conditioned) coaches. Acceptable diameter range of wheels used in these coaches is 915-837 mm. These coaches are used in broad gauge tracks of Indian railways where nominal wheel gauge is 1600 mm and track gauge is 1676 mm. Wheel gauge is the distance between inner flanges of wheels on an axle. In ICF coaches, wheel gauge is set at 1600 ± 1 mm during fitment of wheel onto axle. During service, allowable wheel gauge is $1600 + 2/-1$ mm. Wheel set is said to have failed from “wheel gauge widening” when its gauge is more than 1602 mm, at which time it has to be removed from service. If the wheel gauge becomes less than 1599 mm, this is referred as “wheel gauge condemning”. Gauge widened wheel sets have adverse effect on train operation on several fronts. Flanges of such wheels can hit the nose of crossing, they can cause undue strain on the track fastenings, cause more wear on wheel tread as well as on rail, and these wheel sets tend to run at the flange slope increasing derailment possibility [1]. Gauge condemned wheel sets can hit the tongue rail, damage the rail, and increase possibility of derailment at curves. Incidentally, as per records [1], around 80% of derailment accidents in Central and Northern railways in India occurred on curved tracks.

Several earlier works investigate gauge change and temperature rise in railway wheels albeit for synchronized braking. Teimourimanesh [2] considered various stop and drag braking scenarios with different

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