Abstract

Indian Railways has one of the world's largest rail networks with over 100,000 track kilometers. It operates over 20,000 trains daily with over 9,500 locomotives, 46,000 coaches and 240,000 wagons. All locomotives, coaches and wagons operated by Indian Railways, except a few, employ tread braking and operate on broad gauge track. Until 2004, there were essentially no reported cases of wheel failure from gauge widening or condemning in Indian Railways. However, from 2004 onwards, when majority of the cast-iron brake blocks were replaced with composite brake blocks, there have been hundreds of incidences of gauge widening in locomotive wheels. The number of reported gauge widening cases had dropped significantly from 2011 onwards with reduction in peak brake cylinder pressure, use of low friction cast-iron or composite brake blocks in locomotives and with bypassing of locomotive brakes in majority of braking events. Nonetheless, the problem still persists.

This work aims to identify root cause of failures and prevent occurrence of same in future. To this end, the following work is carried out in this thesis: (i) Development of a train running model to estimate heat generated at brake pad-wheel and rail-wheel interfaces for locomotive and wagon wheels using brake block characteristics, wheel-rail traction slip characteristics and train running resistance characteristics for given operating and braking conditions, (ii) Estimation of heat partitioning at rail-wheel and wheel-brake pad interfaces in locomotive and wagon wheels and estimation of wheel running temperatures for different wheel profiles for different train running conditions, (iii) Development of a finite element model to estimate residual stresses induced during heat treatment and axle-wheel assembly of locomotive wheels, (iv) Identification of the underlying mechanism of locomotive wheel failure from gauge widening and condemning, and (v) Investigation of the effect of wheel profile, brake block type, and braking conditions on locomotive wheel failure from gauge widening and condemning. It is found that high friction coefficient composite brake blocks result in higher wheel temperatures and cause large gauge changes, particularly for independent braking. Further, S-shaped wheels are found to be better suited for avoiding excessive gauge reduction or gauge increase.

Keywords: Tread braking, brake blocks, friction, heat partition, residual stresses, wheel gauge widening.