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Material and Stress Analysis of Railroad Vehicle Suspension: A Failure Investigation

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Abstract

Suspensions are the important machine element of rail road vehicle which absorb the shocks and vibration during tracking, curving and also protect the axle movement. The helical compression type of spring is used to allow axial deformation and also provide some lateral deformation at curvature. A freight rail vehicle has the frequent failure of primary suspension with major emphasis on the failure of composite spring of central axle of both frames. The failure investigation starts with the material analysis by experimentation for chemical composition for different failed specimen of springs using spectrometer. It is continued to the stress analysis with respect to the mechanical properties of material by analytical and finite element analysis at various loading conditions. The material and stress analysis revealed that the failure occurs due to design incompetency by increase of stresses at curvature and at maximum tractive efforts at various speed.

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1. Introduction

Railroad vehicles are among the most widely used methods of transporting passengers and goods [Shabana et al., 2008]. The helical suspension spring system has a significant importance on the operation of rail road vehicle, considering the effect of curving/tracking. A rail road vehicle consists of helical type of suspension spring categorize as primary and secondary spring. The complete structure is divided in tow frames and each frame contains three axles. Two sets of primary springs are mounted on each axle box near each wheel but only the composite assembly of inner and outer primary springs is mounted on central axle box of both frames. The failure investigation process relies on collecting failed inner primary spring components for subsequent examination of the cause of frequent failure using a wide array of methods. The spring material is chromium vanadium (50CrV4) emphasizes chemical contents of chromium (0.9-1.2) and vanadium (0.1-0.2). The analysis involves chemical composition of failed specimens of spring obtained by spectrometer, is an instrument used in spectroscopic analysis to identify materials and stress analysis to find the stresses to check the failure criteria by comparing it with the mechanical properties of material in different track condition.

Nomenclature

τ	shear stress
K_s	shear stress correction factor
K_w	Wahl's factor
U	strain energy
y	deflection of spring
k	stiffness of spring
V	speed
R	radius of curvature
ϕ	track angle
R_A	reaction on wheel A
G	track guage distance
h	track super-elevation
FE	finite element

2. Experimental Spectroscopy Analysis

The failure investigation starts with the chemical composition of the material of failed spring specimens using spectrometer. Total five spring specimens are collected for experimentation which has been failed in the gap of some instances. The surface of specimens polished using emery paper and place on flat base of spectrometer. The omitted ray from spectrometer sparks on spring specimen which provides the results in the form of chemical composition in percentage is shown in table 1. From table1, it is observed that the percentage of vanadium are

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