AN ASSESSMENT OF RAILWAY COACH BOGIE STRESSES UNDER THE INFLUENCE OF RAIL CONSTRUCTION

By

Mohamed Gaber Mohamed Mohamed Ismail

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Mechanical Design and Production Engineering

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Title of Thesis:

AN ASSESSMENT OF RAILWAY COACH BOGIE STRESSES UNDER THE INFLUENCE OF RAIL CONSTRUCTION

Key Words:

Bogie, railway wheel suspension, float frame of reference, multi-body system, ADAMS Analyses.

Summary:

The present work represents an investigation of the dynamic stresses on a bogie frame using multi-body system (MBS) by applying float frame of reference (FFR) technique. The Dynamic analysis of the railway bogie is applied to study the stresses per time on bogie mainframe using Finite Element Analysis (FEA). The weight load of the railway vehicle, the railway track and the vehicles suspension system are considered to be the major influencing members in dictating the dynamic forces on the bogie frame during running. This dynamic force is expected to be due to the shape of possible irregularities of the track rails and/or rails connection.

Results concluded that the stiffness of the suspension system is of a prime importance in dictating the final stresses in bogie frame structure.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Mohamed Gaber Mohamed Date: / / 2019

Signature:

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Nomenclature

F_{max} : Maximum force at the end of the deformation (N)

$f(x)$: Driving force on the bogie

K : Stiffness matrix

k : Spring constant

L: Rail gap width

M : Mass matrix

q_c : Constraint Jacobian matrix

q_e : Vector of externally applied forces

q_v : Quadratic velocity vector includes the gyroscopic and Coriolis force components

R_{iP} : Position of the point P in the non-deformed state

r_i : Non-linear motion of the reference frame Ki

r_P : Position vector of the point P

2R : Wheel's diameter

s : Deformation distance (m)

u_P : Superposed linear elastic deformation

V : Running speed

V_0 : Impact velocity

V_{ss} : Steady State speed (taken to be in the range of 10m/s – 40 m/s)

V_z : Velocity acting in the longitudinal direction parallel to the rail

W : Work done (J)

Abstract

The present work represents a theoretical analysis of the dynamic stresses on a bogie frame using multi-body system (MBS) by applying float frame of reference (FFR) technique. The Dynamic analysis of the railway bogie is applied to study the stresses per time on bogie mainframe using Finite Element Analysis (FEA). Besides the acting weight load of the railway vehicle, the railway track is considered to be the major influencing members in dictating the dynamic forces on the bogie frame of the railway vehicle during running. This dynamic force is expected to be due to the shape of possible irregularities of the track rails or rail. The rails connection is the source of irregularities in this study.

The present thesis is composed of six chapters. These chapters cover a survey of previous work in this area of research work and the sequence of application of the analytical and numerical studies. The following chapters showed the stages, methods of solution and results.

The bogie model was investigated with several values of stiffness for suspension springs in order to study the effect of suspension stiffness on bogie stresses. In addition, the effect of change of bogie working speed on the maximum stresses in the mainframe was also considered in the analysis. The study concluded that the stiffness for the suspension springs plays the major role in dictating maximum induced stresses in the bogie frame under dynamic load.

Chapter 1

Introduction and Literature Review

1.1. Introduction

Railway vehicles are transport systems designed to run safely and efficiently on railways. Railway vehicles must satisfy equally conflicting requirements: rectilinear stability on straight-line tracks (running stability) and turning performance on curved tracks. In addition, it is important for them to maintain high ride quality or being safe to withstand vibrations when passing through irregular track portions or switching points [1,2].

A railway vehicle is supported on railway by bogies, which in turn are supported by wheel-sets. The bogie frame rigidity and damping characteristics in addition to, stiffness of the suspension springs significantly affect the running performance of the railway vehicle [1,2]. It is necessary therefore to specify the characteristics and properties of the springs.

A Bogie is defined as the structure below the railway vehicle (wagon, coach or locomotive) to which axle boxes, wheels and suspension components are connected through bearings. The bogie is one of the important dynamic component which affect the dynamic stresses for the whole train. Bogie model assembly divided into Mainframe containing Main transom (bolster and sideframe), Wheel-set, Axle box, Center pivot and Suspension components which contain (the primary and the secondary suspensions, dampers and rubber spring [1,2]. Full description of the bogie construction and its main components are given in Appendix (A).

Nowadays, the bogie frame is fabricated by welding together two side beams and bolster into an H-shaped frame [3]. Bogie performs the following roles:

- Support railcar body.
- Run stably on both longitudinal and curved track
- Make good ride comfort by absorbing vibration generated by railway irregularities.
- Minimize generation of dynamic forces due to track and/or wheel irregularities and rail abrasion.

All examples and bogie dimensions are extracted from previous work on dynamic behavior of railway behavior [4].