A STUDY ON INDEPENDENT WHEEL RAILWAY BOGIE

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This thesis is submitted to fulfill part of the requirement for the entitlement of Bachelor Degree in Mechanical Engineering (Automotive)

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SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of
Bachelor of Mechanical Engineering (Automotive)"

Signature: ……..
Supervisor: ……..
Date: …….

DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature: ……..

Author: ……..

Date: …….

Specially dedicated to supervisor and beloved family who has guided me throughout the final year project

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ABSTRACT

Independent wheel railway bogie is one of the railway bogies that have been used wisely in the world. Many researches and developments have been done on independent wheel railway bogie instead of fixed wheel railway bogie. The active steering bogie could provide smoother riding compared with the fixed wheel railway bogie. The project has been introduced to design an independent wheel railway bogie in order to improve the performance during high speed cornering, and provide the stability movement to the railway bogie. CATIA V5R16 is the computer aided design software that is used in the designing step. The reliability of the independent wheel railway bogie is clarified through the result of the safety factor. The safety factor is justified through theoretical and analysis. The static analysis of the independent wheel railway bogie is done by the structural analysis of CATIA by comparing with two materials, steel, and cast iron. The simulation of the railway bogie is performed by using Universal Mechanism software in order to accomplish the project.

ABSTRAK

Bogie keretapi roda bebas merupakan salah satu jenis bogie yang telah digunakan dalam dunia ini. Banyak penyelidikan dan perkembangan telah dilakukan ke atas bogie keretapi roda bebas berbanding dengan bogie keretapi roda tetap. Bogie keretapi roda bebas boleh memberi penunggangan yang selesa berbanding dengan bogie keretapi roda tetap. Projek ini telah diperkenalkan untuk mereka bentuk satu bogie keretapi roda bebas bagi menigkatkan dan memperbaiki prestasi semasa membelok pada halaju tinggi, serta menyediakan kestabilan bogie keretapi tersebut. CATIA V5R16 merupakan perisian lukisan berbantu computer yang digunakan dalam lukisan reka bentuk. Kekuatan bogie keretapi roda bebas adalah diukur dengan faktor keselamatan. Faktor keselamatan diperolehi melalui secara teori dan analisis. Analisis statik pada bogie keretapi roda bebas dapat dilakukan dengan menggunakan analisis struktur perisian CATIA dengan membandingkan dua bahan, iaitu keluli dan besi tuang. Simulasi bogie keretapi dilakukan dengan menggunakan perisian Universal Mechanism bagi menjayakan projek ini.

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CHAPTER 1

INTRODUCTION

1.1 Overview

Railway vehicle is common vehicle that had been used wisely in many countries since the heavy industries began. Generally, railway vehicle consists of carriage, bogie frame, wheel set, and suspension system in a railway construction. Bogie is placed at the bottom of carriage, and the wheel sets are connected together with bearing attachment. Figure 1.1 shows one of the examples SF300 for railway bogie manufactured by company of Siemens Transportation Systems [1]. Railway bogie is not only considered as a chassis to support the rail vehicle body, yet it is created to ensure the stability of the train on either straight track or curve track. Besides that, railway bogie provides ride comfort to the passengers through absorption of vibration and reducing the centrifugal forces especially when train is running at high speed corner.

The types of railway bogies can be categorized into two features, articulated and non-articulated which is shown in Figure 1.2 [2]. For the part of the railway bogie axles, generally it contains one or two axles; Figure 1.3 shows the types of different number axle bogies [2]. At the part of the axle, there will be axle box suspensions, also named as primary suspension systems which are attached between the wheel sets and the bogie frame. The axle box suspension allows the vertical movement between bogie frame and wheel sets to provide smoother ride. Besides the primary suspension system, there is a secondary suspension to absorb the vibration between bogie frame and the railway body,

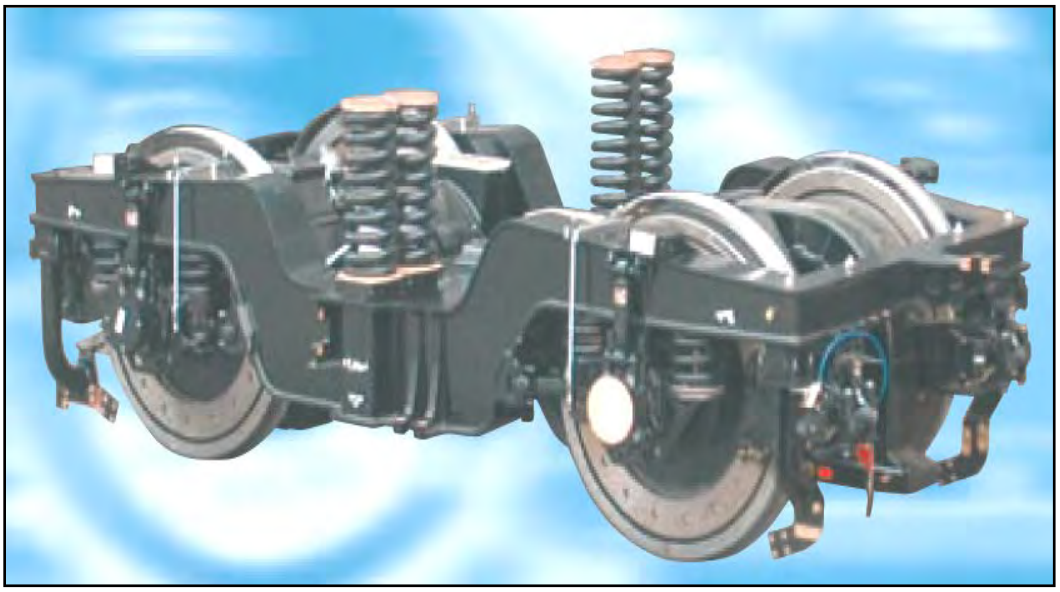

Figure 1.1: Railway bogie SF300 [1]

mostly coil springs is the main components in the suspension system. The bogie frame design of conventional railway vehicle is based on fixed wheel railway bogie system. Fixed wheel railway bogie could ensure the running stability on straight track; however, the curving performance is relatively low since the steering motion of wheel set is constrained by single rigid solid axle, this bring uncomfortable along the travel journey during the harsh interaction between wheel set and the track.

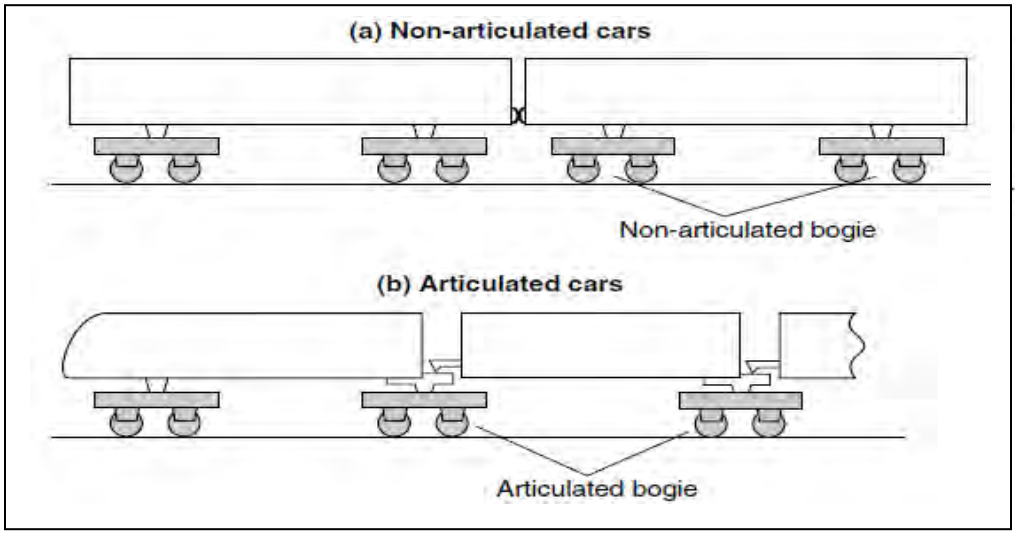

Figure 1.2: Non-articulated bogie and articulated bogie [2]

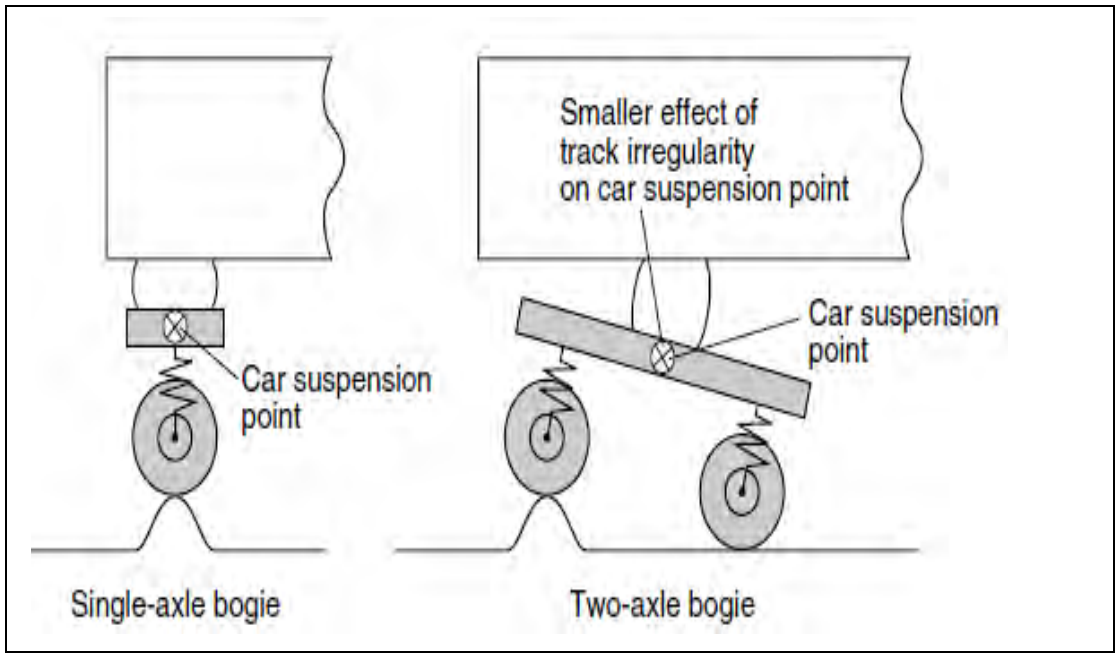

Figure 1.3: Single axle bogie and two axle bogie [2]

In order to overcome the bad curving performance faced by the fixed wheel railway bogie, independent wheel railway bogie is introduced since it has an active element to control the wheel set motion according to track condition. A lot of experiments and simulation have been done to show the effectiveness of independent wheel railway bogie to bring smoothness and stability during high speed cornering on track, and better yaw motion of the railway vehicle. From the work of Bombardier transportation, it stated that the independent wheel set has the ability to run steadily even in high speed and also smooth track cornering [3].

With the invention of this bogie system, curving performance is considered upgraded without sacrificed the running stability of railway vehicle, the vibration of wheels and rail is also reduced to ensure the driving comfort. The independent wheel railway bogie has a simple linkage between wheel set and the bogie, by applying forces to the leverage to actuate the link for desired movement of wheel set. The independent wheel railway bogie includes wheel sets which are mounted separately near the end of side frame by connecting with a connector. Besides that, there are four solid bars joined with the bottom middle bar, this is a main bar to ensure the movement of wheel sets.

1.2 Objective

The first step of objectives for this thesis is to design an independent wheel railway bogie. Secondly, safety factor is needed to be analyzed and justified via two different materials to clarify the reliability of the railway bogie. Thirdly, simulation would be done on the railway bogie to clarify the motion of behavior.

1.3 Scope

In order to accomplish the objectives of the thesis, the first scope of work for this project is to design the independent wheel railway bogie by using the CAD software. Subsequently, the railway bogie would be applied by different types of materials and a static test would be done on it. The simulation software would be used to simulate this railway bogie model.

1.4 Problem statement

The design of fixed wheel railway bogie had been widely used in the world, however due to the design with solid rigid axle of each wheel sets, it tends to lead damages not only on wheel and also the track in every high speed cornering since it has poor cornering behavior. Figure 1.4 shows the behavior of curving motion of railway bogie during the cornering pathway [4]. The harsh track impact will cause the passengers feel uncomfortable during their journey due to decreasing of stability. Besides that, maintenance is always needed due to the frequent damage of the wheel and the track and increase the cost of it. Independent wheel railway bogie could reduce the wear of the wheel and the track, thus increase the lifetime usage. Tilt is another important issue to provide smoother riding experience to the passengers.

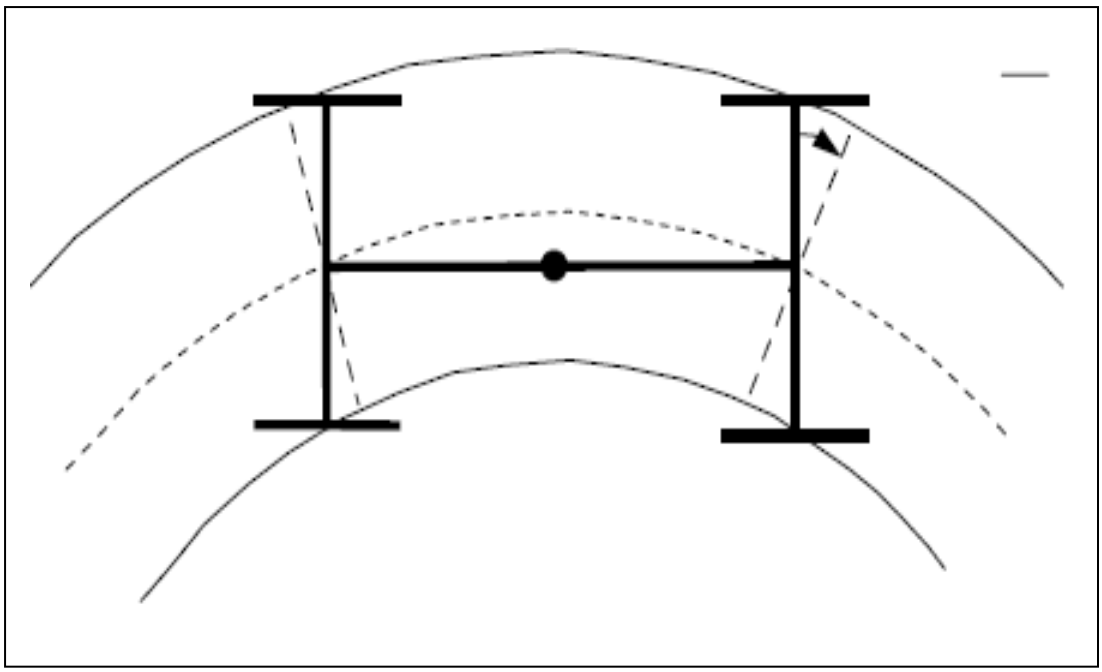

Figure 1.4: Curving motion of railway bogie [4]

CHAPTER II

LITERATURE REVIEW

This chapter is a review of the related researches based on independent wheel railway bogie that have been done previously by different researchers. The previous researches would be used as references to give advantages and more complete information for this new project. All the researched could be found from reference books, internet, journal, news and etc. However, the originality of this project is assured with proof of references.

2.1 Background

Researchers had invented a twin-axle steerable rail-bogie. Figure 2.1 showed the model of the twin-axle steerable rail bogie [5]. The rail bogie had steerable one or both of the axles with respected to the rotation of the supported frame structure, hence, the wheel assemblies was also to be proportionally respect to the vertical axis of the frame degree rotation of the frame where it was placed above the chassis. There was a slidably mounting on the end of the axle, hence it could be longitudinal slidable by achieving the steering purpose. One of the end axles was connected to pivot forward or rearward out of its normal transverse position, and it was transversally opposite supporting which acted as a pivot by holding another end of the axle. At the frame near the supporting assembly, one operating arm was joined for the purpose of moving. Through the linking

mechanism of the supporting assembly, one axle held by this supporting assembly to pivot could move in the same direction. However, the angle was smaller with respected to the frame of the rail-bogie. The steering motion where the rail bogie was turned to the left was shown in Figure 2.2 [5].

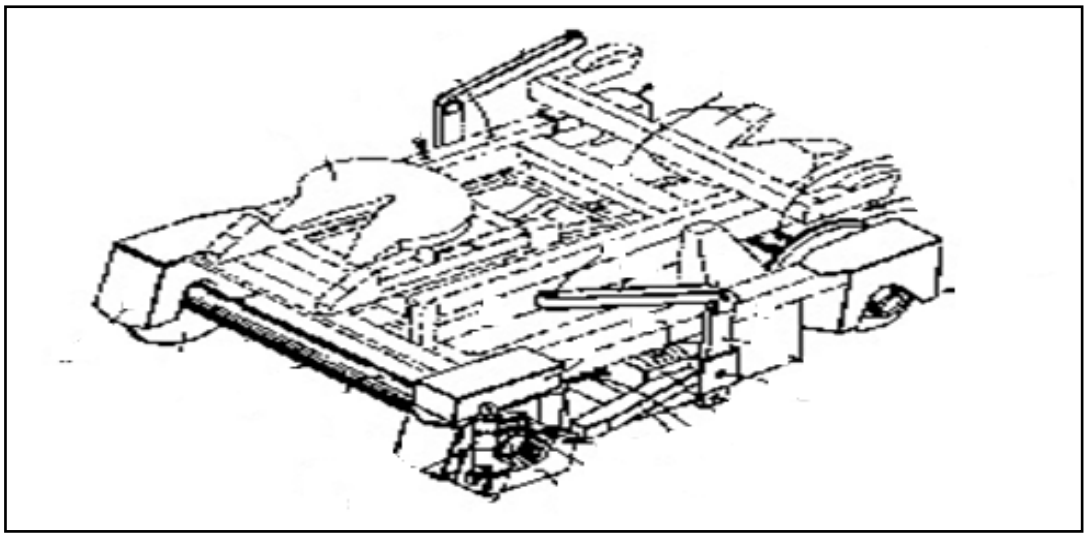

Figure 2.1: Perspective view of twin-axle rail-bogie [5]

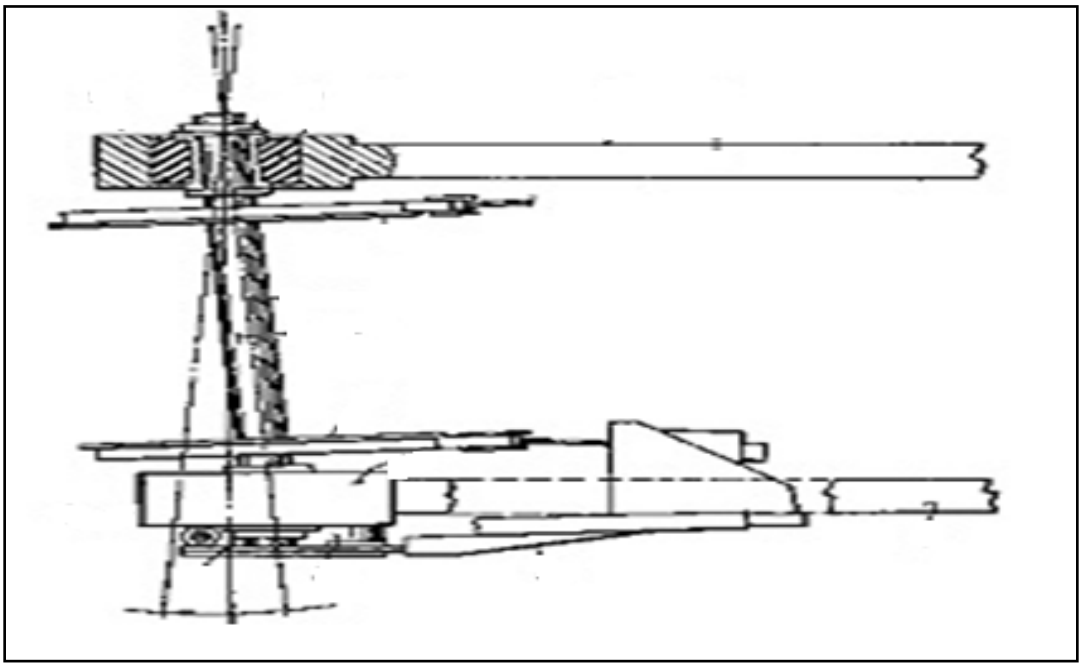

Figure 2.2: Front wheel assemblies steered to the left [5]

Researchers had introduced a driven running gear with steerable a individual unit which was shown Figure 2.3 [6]. Basically it was specially designed for low-platform rail vehicles and it must contain at least two articulated body parts. There were two separate running gears mounted with steering mean. The pivot was interrelated horizontally under the axial center of the wheels with the running gears through a connecting member. Both supported arms were directly joined at the end of the connecting member, and it acted as a body support. At least one motor with the brake would be fastened on each side. Through the telescopic universal shafts and the bevel gearings which were placed outside of the wheel, it could drive and brake the running gears. During a cornering section, it would form a bending angle between a leading body part. The trailing body part that supported on axle would transmit to the steerable individual running gears, and the pairs of wheels will turn into desired curve-radial position in the direction of travel.

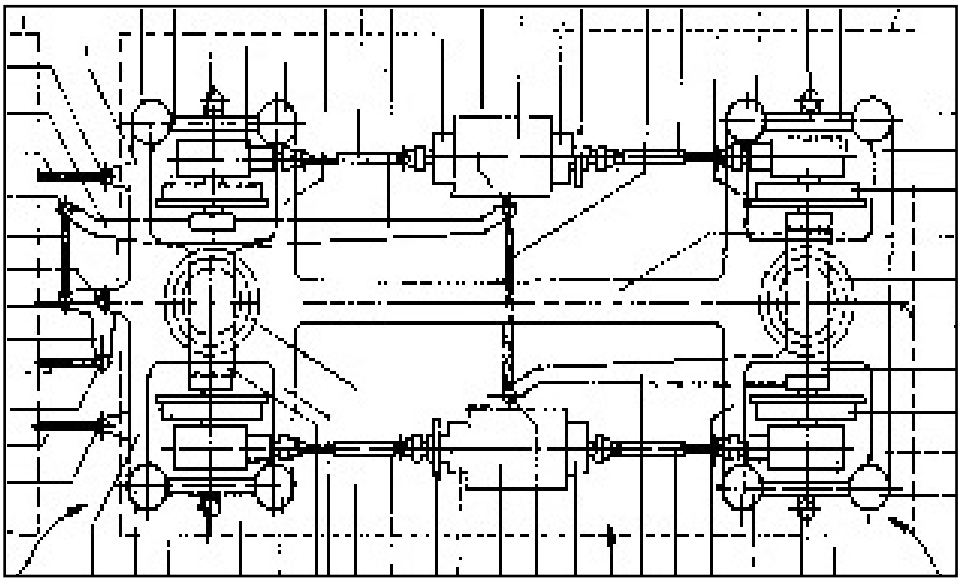

Figure 2.3: Top view of driven running gear [6]

Researchers had invented a bogie frame that consist a coupling device with two wheel sets in the year of 1996. The Figure 2.4 showed the bogie model and the Figure 2.5 showed the skeletal view of the bogie [7]. The two wheel sets were steerable through the connection with the coupling device. The adjustment forces were transmitted