THEORETICAL ANALYSIS OF TRAIN BOGIE SUSPENSION SYSTEM

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ABSTRACT

This project involves a detailed study on the" TRAIN BOGIE SUSPENSION SYSTEM" It involves a list of information on the various parts of a conventional type bogie and also the various advantages of different types of suspension and damping systems installed. In this methodology to find the optimized, with respect to safety and comfort, lateral damping of both the primary and secondary suspensions of a bogie system for a train. Under competition from other forms of transport, railway operators are seeking to offer their passengers ever-increasing train speed and comfort. It is known that considerable improvements to train speed and passenger comfort could be obtained by the use of full-active suspensions, in which the energy flow in the suspension is controlled and augmented by an external source, using a technology similar to the one developed in the automotive world.

Keyword: - *Bogie suspension, Damping, g-force, centrifugal force, Tilting Train Mechanism*

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1. INTRODUCTION

Transportation is the basic need of daily life due to which all the services are easily and on a systematic way. One of the most considerable examples of the transportation is the train. People use to refer the train as a regular transport and travel option. In our project we are working on the suspension system of the train bogies so that travelling could become more smooth and comfortable without any disturbance of roughness and discomfort.

A Tilting train is a train that has a mechanism enabling increased speed on regular rail tracks. As a train (or other vehicle) rounds a curve at speed, objects inside the train experience inertia. This can cause packages to slide about or seated passengers to fill provided squashed by the out board armrest due to its centripetal force, and standing passengers to lose their balance. Tilting trains are designed to counteract this discomfort. In a curve to the left the train tilts to the left to compensate for the g-force push to the right, and vice versa. The train may be constructed such that inertial forces cause the tilting (passive tilt), or it may have a computer controlled power mechanism (active tilt).

The first tilting train in regular public service was the 381 series electric multiple unit train operated by Japanese National Railways (JNR), which entered revenue service from 10 July 1973 on the Shinano limited express between Nagoya and Nagano on the Chūō Main Line. This technology was not fully implemented worldwide, as the marginally increased curve speeds did not justify the extra expense and technology in many cases. The British Advanced Passenger Train (being operational from 1984 to 1985) was the first to successfully implement active tilt, enabling significantly increased speeds on tight rail curves. Active tilting is the mechanism most widely used today.

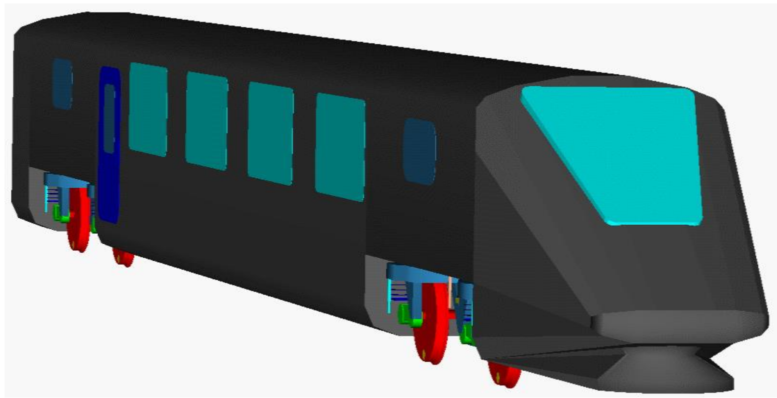

Figure 1: CAD Model of Train Bogie Suspension

1.1 Problem Identification

• Train bogies gives too much fluctuation on the speed running.

• The second disadvantage that is felt during run of the bogies that it is needed to be slow down when takes a sharp curve on track.

• This is due to centrifugal force on the bogie on its center of gravity.

• This curvy track creates loss of traction on the opposite wheels of the train bogie which can be dangerous.

1.2 Tilting Train Mechanism

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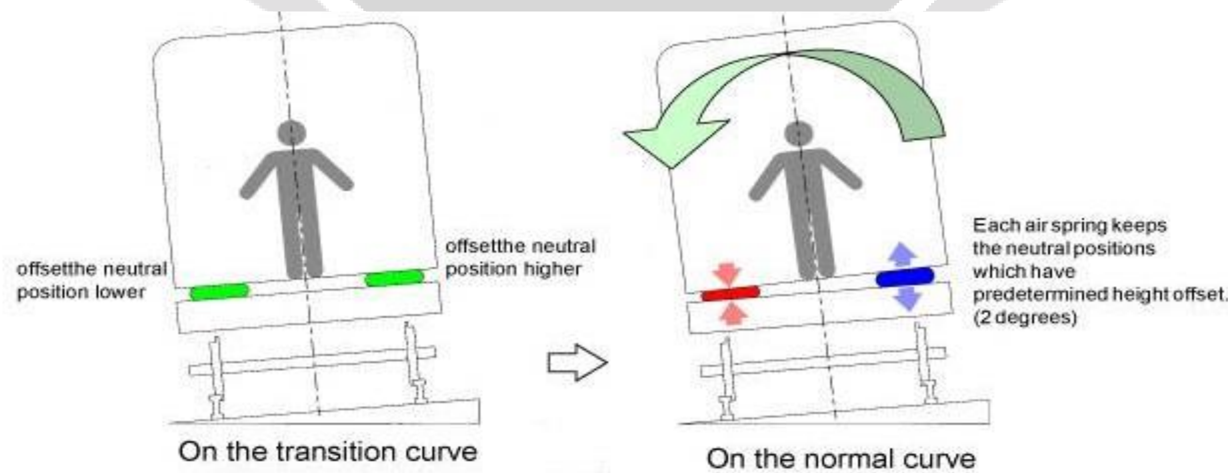

Figure 2: Tilting Train Mechanism

2. METHODOLOGY

2.1 Introduction

The methodologies of these attachments are explained in few sub- headings.

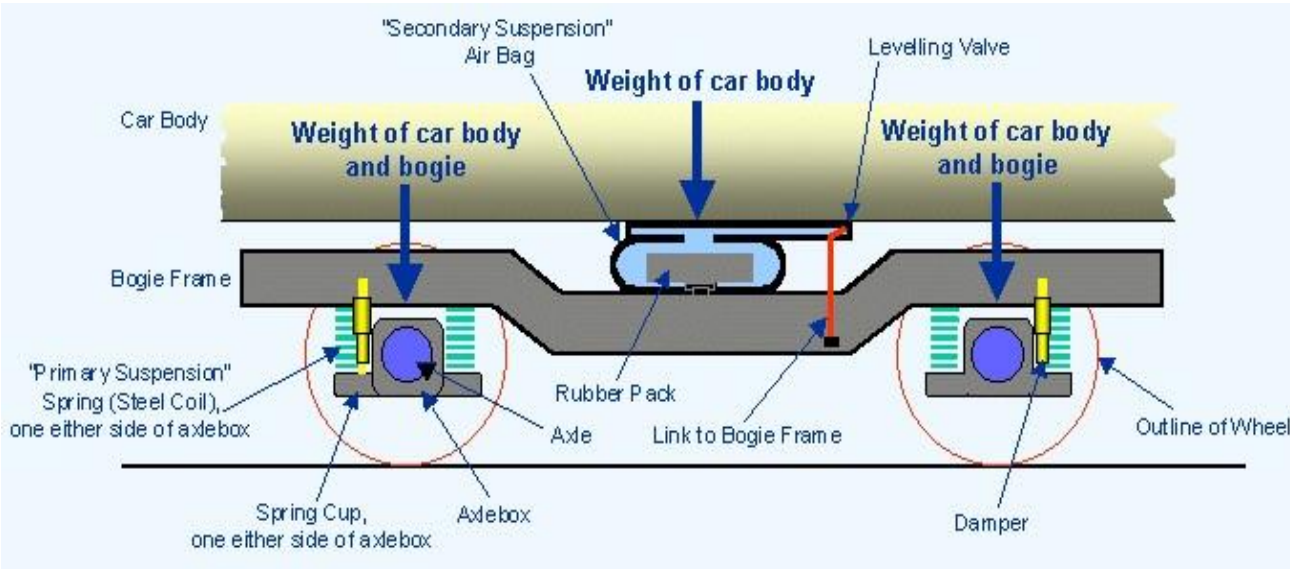

Figure 3: Diagram of bogie with steel primary and air bag secondary suspension

2.2 Damping System

The concept of damping within a structural system can have different meanings to the various engineering disciplines. To the civil engineer, damping may mean only a reference note on a seismic or wind spectral plot, "5% damped spectra" being the most common notation [1]. To the structural engineer, damping means changes in overall stress within a structure subject to shock and vibration, with frequent arguments whether a structure will have "2%, 3%, 4%, but not more than 5%" structural damping. On the other hand, mechanical engineers do not necessarily view damping as a benevolent feature, since machines, by definition, are supposed to transmit forces and motions efficiently, without energy losses. Thus the need for damping in a machine often signifies that an engineering design error has been made. The most convenient and common functional output equation for a damper comes from classical systems theory, and is that of the so-called "linear" or "viscous" damping element.

Figure 4: Train Bogie Damping System

2.3 Bogie Suspension

Bogie Frame and Bolster: The bogie frame and bogie bolster of FLEXICOIL bogie Mark-I are of steel casting box type construction manufactures as per the standard laid down by RDSO. The Locomotive body weight is transferred to the bolster through a center pivot. The steel cast H type bolster is supported on the steel - cast bogie frame at four corners, by pair of helical springs placed in spring pockets of main longitudinal member of the bogie frame. The bolsteris located w.r.t bogie frame by upright pedestals which are integral part of the bogie frame [2]. This arrangement serves to transmit force from bolster to bogie frame and vice-versa. Spring loaded sunbeam piston 2 nos. per bogie made of phenolic material to have high friction between bolster and bogie frame for damping in both vertical and lateral modes of oscillation are also provided in the above pedestal arrangement. Lateral stop are also provided on the bolster as well as on the bogie frame to limit the side movement by flexible action of the spring which is of the order of 32 mm. The bogie frame is in turn supported on the axles by another set of springs resting on the axle boxes .The load of the locomotive superstructure rest on the center pivot bowl of the bogies. The bowl is fitted with vertical and horizontal liners made of fluon (Vx2) which provides rotational freedom between body and bogie in operation. Two lifting links located diagonally opposite provides the easier accessibility as well as reduce the number of mechanisms to engage or disengage the bogie when installing or removing. Bogie Frame Bolster of WAP 4 Locos this flexi coil bogie Mark-I has two stages of vertical suspension in which helical spring have been used at primary and secondary stages. Primary, between axle box and bogie frame and secondary, between bogie frame and bolster. The transverse flexibility between the body and the bogie has been achieved by the flexi coil action of the helical spring at the secondary stage. The support of the bolster springs have been placed on the wider arm to give better stability in rolling.

Figure 5: Train Bogie Spring Suspension

3. Characteristics of spring suspension:

3.1 Principle of a spring:

In distinction to a rigid beam, a spring, regardless of its form or shape, will exert a changing force as it deflects its horn block. This relationship is linear, with maximum force being applied when the spring is fully compressed (to take the example of a compression spring), and zero force being applied when the spring is in its fully relaxed state. The actual deflection of the spring is directly proportional to a property, the 'spring rate' (or 'spring constant') of the particular spring [3] . If a spring relaxes to depress a wheel onto the rail, the reduction in the force applied to the horn block will be counterbalanced by a distributed increase in the force the loco applies to its other suspension points. Springs absorb and discharge potential energy, and decouple the vertical forces between the wheels and the body. Thus in a sprung loco traversing uneven track, there is a continuously changing set of forces applying between the wheel tire and the rail, although the sum of those forces at the railhead is constant. The action of a spring in a prototype loco is related to the weight borne by the particular axle involved, and on the prototype each spring is designed to bear and operate on a specific load. If the spring is too strong, the weight of the loco will not cause it to operate properly over irregularities in the track, while if the spring is too weak the loco is likely to show dynamic instability. Figure Force v deflection for a spring Viability of springs in small-scale models. A prototype loco is suspended, being held up by the strength of the springs. It is generally accepted as being difficult to reproduce the characteristics of prototype springs in small-scale models because:

1. The mass to momentum relationships in the prototype do not scale linearly to models.

2. With the exception of the use of commercial music wire strings as beam springs, it can be difficult to provide the range of model springs appropriate for all the different weights of model locomotives.

3. It can be difficult to adjust the springs so that the loco is both level and at the correct buffer height.

4. It is difficult to assess what the design value of the deflection of a spring.

5. Model rail does not deflect under the weight of a model loco like prototype rail does.

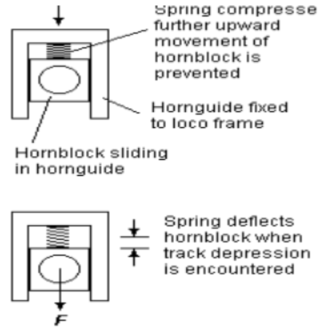

Figure 6: Principle of Spring

3.2 Spring-assisted horn blocks

A spring-assisted horn block is one traditionally containing a coil spring between a horn block and its horn guide. Under the weight of the loco, the spring compresses either fully (to bind the coils together) or until the horn block is restrained from further upward movement by some limiter device fitted to the horn guide or the frames of the loco see figure 7. The spring in such a horn block therefore depresses its axle into depressions of the track, and the deflection is in proportion to the spring rate of the particular spring [4] . The downward force of the spring will diminish the greater the depression of the track.

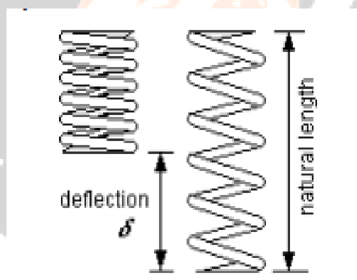

Figure 7: Spring Deflection

Spring-assisted horn blocks do not provide the equalizing advantages of beams, nor (when in their fully compressed state) the shock-absorbing advantage of properly suspended springs any upward projection of the track will transmit itself directly and abruptly to a loco chassis fitted with spring-assisted hornblocks. Moreover, if the spring rating is not chosen to match the weight being supported, a loco fitted with spring-assisted hornblocks may show non-optimal haulage, depending on the state of the track.

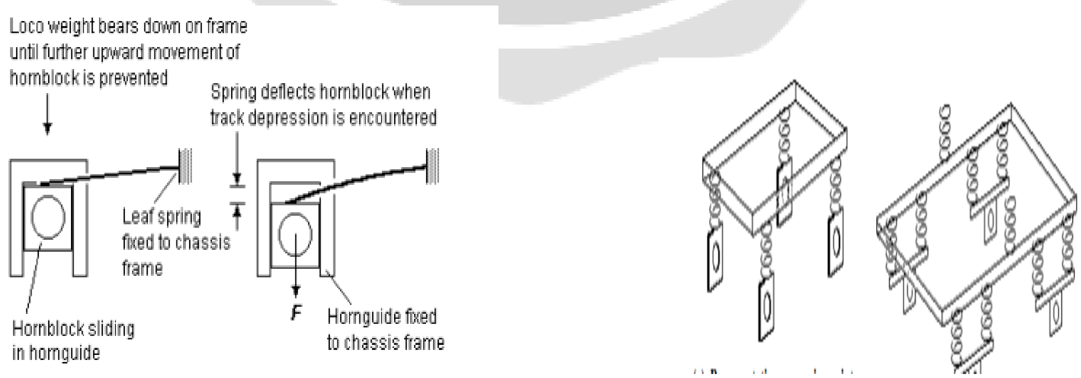

Figure 8: Hornblock Mechanism

4. LITERATURE REVIEW

4.1 A Study on Ride Improvement of a High Speed Train using Skyhook Control.

K.S.Sim, T.W. Park, W.H.Kim, and J. H. Lee ,January 4-5,2013

This paper presents a semi-active suspension control system of a high speed railway vehicle with an observer-based skyhook control for ride comfort improvement. A semi-active suspension model can be represented as a quarter-car for observer design. An observer is formulated in order to provide the estimated state that contains the lateral velocities of a car body and a bogie which are calculated using some measured accelerations. The estimated states are used to compute the gains in skyhook control. A full scale railway vehicle is developed by an MBS (Multi-body system) tool. Also, to verify the developed model before running the simulation, lateral accelerations of a car body and a bogie are compared with results from an experimental roller rig test. In the dynamic analysis, the lateral behavior of a railway vehicle using skyhook control shows more stability than when using a passive system on the irregular track.

4.2 Model validation and experimentally driven hydraulic damper model refinement

B.Titurus, N.A.J. Lievenin

The paper presents study of the issues related to modeling of hydraulic damper with mechanical relief valves. This structural component plays essential role in helicopter applications where it provides damping augmentation against vibration instabilities. Previous research has established baseline damper model, which is based on the concepts from hydraulic system theory. The parametric dynamic model of a damper is used along with set of validation experiments to analyze the quality of a baseline model and its potential for improvement. Concurrent use of damper response data taken from a mathematical model and an experiment enables closer inspection of the physical mechanisms previously not included in a given reference model, as well as detailed analysis related to uncertain aspects of the model. A set of experiments is performed on the two nominally identical dampers and the data originating from these experiments are compared with corresponding responses of the mathematical model of the damper.

5. CONCLUSIONS

Preliminary analyses carried out with ideal (without actuation-delay) continuous and discrete semi active systems have given good results, if compared with the performance of a traditional passive secondary suspension. While a qualitative description provides some understanding of the phenomenon, deeper understanding inevitably requires a mathematical analysis of the vehicle dynamics. Even then, the results may be only approximate. A kinematic description deals with the geometry of motion, without reference to the forces causing it, so the analysis begins with a description of the geometry of a wheel set running on a straight track. Since Newton's Second Law relates forces to accelerations of bodies, the forces acting may then be derived from the kinematics by calculating the accelerations of the components. However if these forces change the kinematic description (as they do in this case) then the results may only be approximately correct.

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