A Comparative Study on Improving the Riding Comfort of Indian Railway Coaches: Review on Literature

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Abstract: *The aim of this project is to study analyze the existing system of suspension used by Indian railway (IR) thoroughly and understand its lacunae to suggest further improvement in riding comfort by adapting the modern methods by incorporating the technical advancements duly considering various characteristics such as, wheel track interaction, lateral stability, curving, car body parameters, etc.*

Key Words: *Wheel track interaction, Lateral stability, Curving, Car body parameters, Indian railways, Suspension system.*

1. INTRODUCTION:

Indian Railways (IR) is undoubtedly one of the massive rail systems in the world. Major areas of future development proposed by Indian Railways Ministry, a big focus would get on track improvement, environmental sustainability, network extension of railway, capacity creation, train safety, dropping carbon footprint, high-speed train introduction and technological excellence. With other developed countries already reaching operating speed of more than 500 kmph, India is trying to cross that 200 kmph mark with its Vande Bharat express popularly known as Train-18 is the best in class semi high-speed self-propelled train set under the Make in India policy.

A combination of increased vehicle speed and non-improved railway tracks affect the riding comfort. The ride quality is deeply affected due to vibrations which directly affect the passengers. However, with competitive higher speed transportation requirement, obtaining running stability and riding quality becomes a major task. For this purpose, research work is carried out in various fields of the suspension system. This paper focuses on those aspects which will improve the ride quality and comfort of the passengers with increased efficiency and reliability.

2. LITERATURE REVIEW:

***Rakesh Sharma (2012)**[1]* has evaluated the state of the art of railway vehicle dynamics. Detailed analysis is presented on segments like comfort and ride quality. This paper relates to the various performance characteristics that are essential for increased performance i.e. lateral stability, curving, multibody simulation, wheel to track interaction, ride quality and comfort.

***Sunil Kumar Sharma et al. (2015)**[2]* have investigated the challenges in rail vehicle- track modelling and simulation to get an overview of the current features and applications for components of wheel-track dynamic modelling and few hurdles while simulating these applications.

***EwaKardas -Cinal (2009)**[3]* has examined the running safety and the ride comfort of a railway vehicle. It presents methods used for investigation of those essential ingredients within the assessment of the vehicle running behavior. conclusion that with increasing ride velocity there's an increasing risk of derailment and a decrease of the comfort.

***Yucheng Liu (2008)**[4]* has found out the various parameters which enhance the performance of suspension system, such as stability, controllability, and other capabilities. This paper briefly outlines the features and advantages of these inventions.

***Luo et al. (2014)**[5]* studied a finite element model of the car body, to investigate the effects of the suspension position, the mass of the suspension equipment, and the suspension frequency on the mode of the car body.

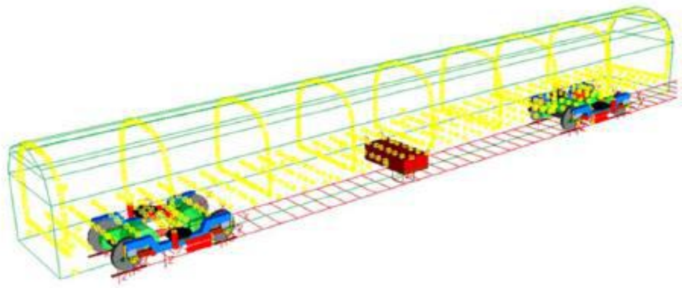

Fig. 1: A dynamical model of rail system [6]

***Sunil Kumar Sharma and Anil Kumar (2017)**[6]* have evaluated the effect of vibrations on the ride quality and comfort of a passenger vehicle. The study was aimed to evaluate the effect of introducing a semi-active suspension system on the ride quality and ride comfort of a running rail vehicle in comparison to an existing passive suspension system. the same model was developed for the semi- active suspension system with MR dampers and the performance indices were evaluated at different running speeds, i.e. 50 kmph, 100 kmph, 150 kmph, 200 kmph, 250 kmph by application of numerical simulation in MATLAB SIMULINK environment. The outcomes point out the influence of the suspension parameters and velocity on the vertical dynamics of the vehicle.

Yu-Jeong Shin et al. (2014) *[7]*have studied that the ride quality became a very important factor in the performance of railway vehicles according to the expansion of high-speed railways and speedup of velocity of railway vehicles. This research was conducted to reduce vibration of the car body of railway vehicles and described the result of applying MR dampers laterally to secondary suspension.

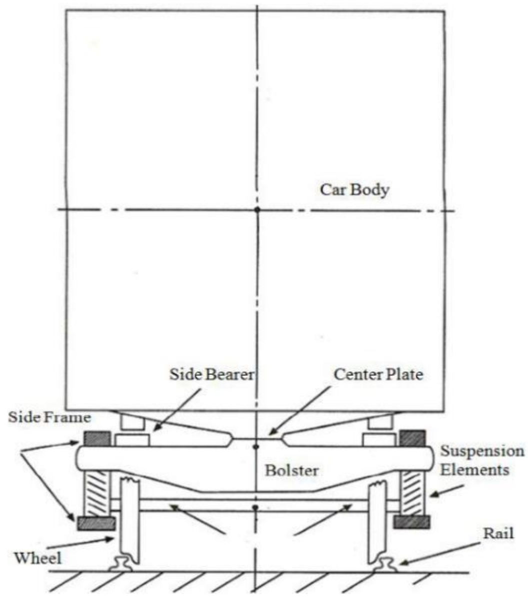

Fig. 2: A conventional freight car in lateral plane [1]

***M Dumitriu (2017)**[8]*has examined the issue of reduction in the vertical bending vibrations of the railway vehicle car body and the ride comfort enhancement at high velocities, starting from the prospect of isolating the vibrations by the best possible selection of the passive suspension damping in the vehicle. The ride comfort can be increased by raising the primary suspension damping ratio.

***Dao Gong et al.(2012)**[9]* analyzed the model showing geometric filtering phenomenon consisting of 'wheelbase filtering' and 'bogie spacing filtering' effects. The dynamic vibration absorber shows very good performance and robustness in suppression of the car body resonant vibration.

***Karim H. Ali Abood et al. (2011)**[10]* have presented a mathematical dynamic model of railway conventional vehicle with 12 degrees of freedom equation of motion. The railway truck mathematical equations of motion are solved using Rung- Kutta method. This paper presents the dynamic responses of the rail truck to lateral, vertical, yaw and roll motion at different speed of rail vehicle.

***Paul Eade (1999)**[11]*has studied the issues related to railway noises and vibrations.

Sebastian Stichet et al. (2010) [12] have studied the active suspension system and focused on the benefits of using a so- called Hold OFF- Device (HOD) function in the lateral secondary suspension system, and found that in order to center the car body above the bogies in curves and thus to avoid bump stop contact, a HOD function can be implemented.

Jorge A.C. Ambrósio et al. (2005) [13] have proposed a methodology based on the use of flexible multibody models for the ride and stability optimization of vehicles. For ride optimization is achieved by finding the optimum ride index that is the outcome of a metric that accounts for the acceleration measure in several key points of the vehicle.

D. Younesian and A. Nankali. (2009) [14] have analyzed objective functions of the ride comfort and the fatigue life of the suspension system. The design parameters are seen through like, damping properties of the secondary and primary suspension system as well as the wire diameter of the coil spring suspension is also considered.

Sanjay Shukla et al. (2009) [15] have presented the dynamic behavior of a vehicle depends on the primary and secondary suspension elements. The effects on vertical acceleration and ride index have been studied for vehicle speeds up to 110 kmph.

Palli et al. (2015) [16] have analyzed the primary and secondary suspension system and found out that locations at the left and right are more vulnerable than at the center of gravity of the bogie.

Jong-Seok Oh et al. (2016) [17] have presented the vibration control performances of a semi-active railway vehicle suspension system using a magneto-rheological damper tested on the roller rig. They have determined the design parameters that is compatible with dynamic performances of conventional (existing) passive railway suspension system.

3. CONCLUSION:

The results of the analysis presented in this paper enabled us to consider the effects of various factors affecting ride comfort and the ride quality of passengers in the Indian Railway coaches. The semi-active controlled suspension system has improved performance in reducing vibrations for acceleration at the centre of car body as compared to the passive suspension system. Considering the cost effectiveness of a train in Indian conditions the existing active suspension can be improved by following design alterations:

i. The ground-borne vibrations and the vibrations felt by the passenger at normal running speed under unsuitable soil type, rock layers and soil layering can be considerably reduced by ballast less tracks (slab track) or elevated tracks other than the traditional sleepers and ballast.

ii. The design parameters effectively consider the c.g height for the car body as low as possible with respect to ground level for better and stable steering at curves at high speed and also the weight distribution, to minimize the difference between centre of gravity and the centre of mass of the car body for a stable performance.

iii. The unsprung mass majorly depends on the bogie type, if it is a trailer bogie or a motor bogie. The major parts which comprises the unsprung mass are the wheel and axle. The weight of the unsprung mass needs to be reduced so that the wear and tear of the track and wheel reduces considerably and will also reduce the noise and vibration. It can be effectively carried out by optimization of geometry, material and production process.

4. FUTURE SCOPE:

The changes in the car body, primary suspension, and secondary suspension and wheelbase parameters have the following effect:

i. Higher value of car body mass than the existing values are preferred near the centre of gravity of the coaches which will considerably reduce the vertical and lateral PSD acceleration.

ii. Increasing the primary stiffness reduces the displacement quotient at the car cg and the bogie cg considerably at all the speeds. Marginal reduction in the response amplitudes at the car cg and bogie cg are shown due to minor increase in the primary damping.

iii. Reducing secondary suspension vertical stiffness value from existing value is preferred. An increase in the secondary damping reduces the response amplitude at greater speeds.

iv. Reducing the wheelbase from the existing value reduces the vertical PSD acceleration in lower and middle frequency regions.

v. The car body centring HOD function of the active suspension has shown to significantly improve ride comfort, since bump stop contact can be avoided.

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