A Review on Primary Suspension of ICF Bogie

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ABSTRACT
Dynamic response of railway coach is a key aspect in the design of coach. Improving the dynamic behavior focus on optimization of primary passive suspension of coach. This paper provides a comparative analysis of different research conducted on primary suspension of railway coaches.

KEY WORDS
Primary suspension, comparative analysis, oil spillage, magnetorheological fluid.

INTRODUCTION

ICF Bogie is a conventional railway bogie used on the majority of Indian Railway main line passenger coaches. The design of the bogie was developed by ICF (Integral Coach Factory), Perambur, Chennai, India in collaboration with the Swiss Car & Elevator Manufacturing Co., Schlieren, Switzerland in the 1950s. The design is also called the Schlieren design based on the location of the Swiss company [1].

The bogie can be divided into various subsections for easy understanding as follows:

a. Bogie Frame
b. Bogie Bolster
c. Centre pivot pin
d. Wheel set assembly
e. Roller bearing assembly
f. Brake beam assembly
g. Brake levers
h. Brake cylinder
i. Secondary Suspension
j. Primary Suspension
k. Brake blocks
l. Brake head

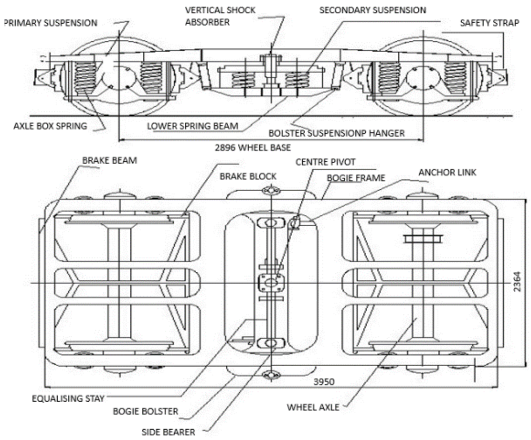

Fig. 1: ICF Bogie [2]

The primary suspension in an ICF Bogie is through a dashpot arrangement. The dashpot arrangement consists of a cylinder (lower spring seat) and the piston (axle box guide). Axle box springs are placed on the lower spring seat placed on the axle box wing of the axle box housing assembly. A rubber or a Hytrel washer is placed below the lower spring seat for cushioning effect. The axle box guide is welded to the bogie frame. The axle box guide acts as a piston. A homopolymer acetyl washer is placed on the lower end of the axle box guide. The end portion of the axle box guide is covered with a guide cap, which has holes in it. A sealing ring is placed near the washer and performs the function of a piston ring. The axle box guide moves in the lower spring seat filled with dashpot oil. This arrangement provides the dampening effect during the running of the coach Bush Helical Spring Dust Shield. Circlip. Dust Shield Spring. Protective Tube Upper Rubber Washer. Axle Box Guide Screw with sealing washer the axle box guide (piston) is welded to the bottom flange of the bogie side frame. Similarly, the lower spring seat (cylinder) is placed on the axle box housing wings forms a complete dashpot guide arrangement of the ICF design coaches. The axle box guide, which is welded to the bogie frame has a polymer washer (homopolymer acetyl guide) bush fixed at the head. A polymer packing ring and a guide ring is attached with the Acetyl guide bush. These two components act as piston rings for the axle box guide. In order to ensure that the packing ring and the guide ring retain their respective place, a dashpot spring is fixed which applies continuous pressure on the piston ring [3].

Axle box guides are of cylindrical type welded to the bottom flanges of the bogie side frame with close dimensional accuracy. These guides together with lower spring seats located over the axle box wings house the axle box springs and also serve as shock absorbers. These guides are fitted with guide caps having nine holes of diameter 5 mm equidistant through which oil in the lower spring seat passes under pressure during dynamic oscillation of coach and provide necessary damping to primary suspension to enhance riding quality of coach. This type of rigid axle box guide arrangement eliminates any longitudinal or transverse relative movement between the axles and the bogie frame. The quantity of oil required for maintaining 40 mm oil level above the guide cap in modified arrangement is approximately 1.6 liters and in unmodified arrangement is approximately 1.4 liters. As it is not possible in open line to distinguish between modified and unmodified arrangements, 40 mm oil level is standardized for both [3].

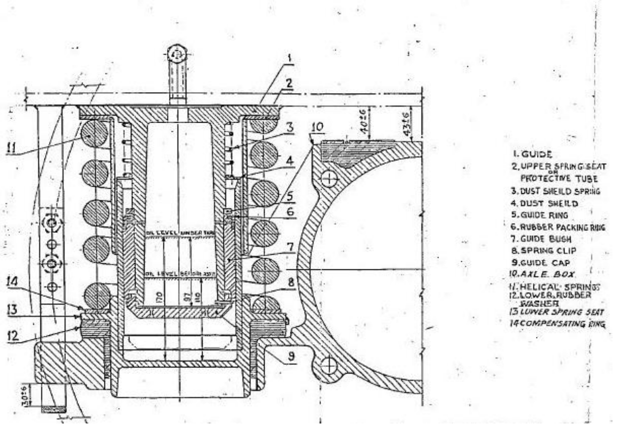

Fig. 2: Axle Box Guide Arrangement [2]

LITERATURE REVIEW

Study carried out by R. Burdzik et. al [4] presents results of the modern vehicle shock absorbers' researches on indicator test stand. On this stand can be determined the diagrams of force versus displacement and force vers:s velocity. These diagrams can be determined for changeable strokes and constant velocities or the opposite way round. In research the modern hydraulic twin-tube vehicle shock absorber was modified and the changes of oil volume were possible. There was determined the influence of oil volume changes on force versus displacement and force versus velocity diagrams. On the basis of force versus velocity diagrams, the dumping characteristics were determined (value of force for maximum velocity on this diagram). The influence of oil volume changes on dumping characteristics was determined too. The results of this investigation can be used in simulation researches of vehicle suspension dynamic.

Study carried out by A. Herrero [5] is focused on the optimization of the primary passive suspension of a high speed train with the aim of improving the dynamics behavior in terms of ride comfort and wheel-rail wear objective functions, while safety is considered as a threshold.

The work carried out by S. Palli et. al [6] is, vehicle dynamic response in terms of Eigen frequency modal analysis and harmonic analysis of an Indian Railway 6Ton ICF bogie, using Finite Element Method.

The work of R.C. Sharma et. al [7] details a coupled vertical-lateral 37 degrees of freedom mathematical model of an Indian Railway general sleeper ICF coach is formulated using Lagrangian dynamics. In this analysis, the vertical and lateral irregularities of railway track are incorporated as a random function of time.

B. R. Kumar and S. Ranganatha [8] studied smart fluid technology as an emerging field of research that leads to the introduction of Electro-rheological (ER) fluids. ER fluids are such smart materials whose rheological properties (viscosity, yield stress, shear modulus etc.) can be readily controlled upon external electric field. The use of ER fluids introduces a new philosophy on the fact that the stiffness and damping can be changed by applying high electric field and thus minimizing the vibration of the structure during normal operation. Here an improved expression is developed for the dynamic characteristic in terms of Reynolds's number for a particular electro-rheological fluid. Bingham model has been used to describe the behavior of the electro-rheological fluids.

The work carried out by R.C. Sharma et. al [9] presents the influence of rail vehicle parameters on vertical and lateral ride behavior. The analysis considers coupled vertical-lateral 37 degrees of freedom mathematical model of an Indian Railway General Sleeper ICF coach formulated using Largangian dynamics. Both vertical and lateral irregularities of the railway track, considered as random function of time are incorporated in analysis. The ride analysis of the mathematical model suggests that discomfort frequency range lies from 4 to10.5 Hz and improvements in the design of rail vehicle coach are required for better ride comfort. It is seen from parametric analysis that car body mass, secondary suspension vertical damping, primary suspension vertical damping and wheel base are the most sensitive parameters influencing vertical ride. While lateral ride is significantly influenced by car body mass, roll &yaw mass moment of inertia and secondary suspension lateral stiffness.

The research papers fail to discuss the existing flaw in the design that causes the problem of oil spillage. All the calculations for the efficiency of the dashpot is done assuming no loss of oil during operation i.e. completely sealed arrangement, but it is empirically not possible to achieve completely sealed arrangement. There is no study related to affect due to aeration in oil/viscous fluid due to overheating. Electrorheological fluid requires electronic stimulation of 1 KV but such an arrangement requires more space than available in the existing assembly. The magnetorheological fluid is not yet experimented as damper fluid for trains.

CONCLUSION

The following aspects could be concluded : -

1) The problem of spilling of oil from the dashpot is as old as the design itself. Numerous design changes have been implemented in the last many years however, the problem of oil spillage is still a challenge.
2) The cylinder piston arrangement of the dashpot, i.e. the Lower Spring seat and the axle box guide is not fully sealed due to the limitation of the design and practical applicability.
3) There are holes in the guide cap, the oil passes through these holes into the hollow body of the axle box guide. This helps in dampening the vertical vibrations.
4) The axle box guide displaces the oil in the lower spring seat and pushes it upwards. Since, only part quantity of oil is able to move up in the hollow portion of the axle box guide, the balance displaced oil moves up and spill.
5) It is to be ensured that the hole in the guide are in alignment with corresponding holes in the guide

bush. However, this is practically difficult to maintain in the shop floor of bogie shop.

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