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A Survey on Railway Freight Wagon

Praveen[a] & Dr. S Shankar[b]

[a]*P G Scholar, Department of Mechanical Engineering, Cambridge Institute of Technology, Karnataka, India.*
[b]*Prof, Department of Mechanical Engineering, Cambridge Institute of Technology, Karnataka, India.*

ABSTRACT

The tremendous growth towards the Indian economy has necessitates various aspects in the freight traffic management, the long age study towards Indian Railways system suggests that the routes of railways are large in extent but of speed enough. Thus, wagons are used to bring better cart system in all the transport systems like roadways, railways, seaways etc. But wagon requires suspension under certain dynamic loads, more capacity against volume and it has got some issues like failures of walls. This paper addresses some of the important aspects of wagon in railways, types of load, and necessary aspects of wagon. Also, a survey is discussed about the existing researches in wagon of railway. Later, an existing research gap is illustrated with a futuristic line of research of research to overcome the research gaps.

Keywords *- Freight Wagon, Design, Economy.*

1. INTRODUCTION

The Indian Railways contributes to India's economic development, accounting for about one per cent of the GNP and the backbone of freight needs of the core sector. The Indian Railways, with nearly 63,000 route kilometres fulfils the country's transport needs, particularly, in respect of long-distance passenger and goods traffic. Freight trains carry nearly 1.2 million tons of originating goods [1]. Most rail container traffic in India is handled by CONCOR (the Container Corporation of India) which until recently was the only such organization. Freight trains bring two thirds of the Indian Railway revenues and are referred to as the bread earners for the Railways [2]. CONCOR is a public-sector concern, but it maintains its own fleet of wagons. Indian Railways (IR) carries nearly 1012 Million Tons of Freight in a year as reported from Freight Operations Information System (FOIS) in Year 2013-14 [3].

Railway wagons are unpowered railway vehicles that are used for the carriage of goods. A variety of wagon types are in use to handle different types of goods, but all goods wagons in a regional network typically have standardized couplers and other fittings, such as hoses for air brakes, allowing different wagon types to be assembled into trains [4]. Wagon, covered – Wagon of a watertight nature by virtue of the construction of the vehicle (completely covered on roof and sides), also characterized by the security of transport (possibility of locking and/or sealing the wagon). Wagon, open – Wagon not fitted with a roof. It may be either high sided, low sided or without side. Freight systems are normally profitable goods normally transported in bulk over larger distances and are economical. Energy costs lower than road [1, 2, 3].

Freight trains are formed in classification yards where wagons are sorted destination-wise, Wagons loaded / unloaded at terminals /warehouses. The major commodities carried by Indian Railways are Coal, Iron Ore, Food grains, Iron & Steel, Cement, Petroleum products, Fertilizer and Containerized Traffic [5]. Based on this information managers make allocation decisions continually to dynamically Optimize Utilization of resources like wagons, locomotives, crew and paths on the network. Real time information allows good decision making and thus ensures high levels of mobility within the system. This realization has led to the development of FOIS [6].

When considered in terms of ton-miles or ton-kilometers hauled per unit of energy consumed, rail transport can be more efficient than other means of transportation. Maximum economies are typically realized with bulk commodities. Rail freight uses many types of goods wagon for heavy or bulky loads. Advantages of rail freight wagons for transporting bulk material, such as minerals and coal, and for transporting liquids and gases.

Environmental benefits because rail transport is very energy efficient compared to road transport. Low cost of transport [7].

Major disadvantage of freight wagon is its lack of flexibility. Time consuming for creations of tracks and more investment in initial setups. Low gross to tare ratios and high cost maintenance regimes have contributed to the loss of competitiveness of rail freight. The improvements to freight train braking systems will be required not only in order to provide greater margins of safety, but also to allow less restricted access to available freight train paths through congested metropolitan lines [7, 8].

This paper presents an exhaustive survey over the railway freight wagons along with future line of researches. This paper is organized as below. The section II discusses the background of the study. Section III idealizes the existing issues in freight wagons while section IV discusses the most recent/ existing research towards the freight wagon design, suspension etc. Section V describes the shortfalls of the existing researches i.e., research gap while section VI illustrates the futuristic line of research in wagon system. Finally the section VII concludes the conclusion of the paper.

2. BACKGROUND OF THE STUDY

Wagons are immediately distinguished from carts, used to carry goods from one place to other. Freight wagons are designed for carrying bulk loads. Wagons play a vital role in ground transport and it is the most economical transport compare to air transport or sea transport.

A. Freight Wagon:

Freight wagons are being carrying with railway; it transports the major goods like foods, industrial raw materials and automobiles etc. There are general and special wagons used to carry goods, general wagons are normally open or covered box shaped. Freight wagons are broadly classified either according to under gear or according to utility. The under gear based freight wagons can be classified as four wheelers and bogie wagons. Currently, brake vans are using for service while the four-wheeler wagons like CRT wagons and tank wagons are not in service. The bogie wagons can be again classified as cast steel, CASNUB, UIC fabricated and diamond frame bogie wagons [1-8]. Similarly, the freight wagons can be classified [9, 10, 11] based on utility as below:

1. Open wagons:

These are wagons are used for transportation of coal, ore, limestone's etc. which does not require protection from rain. The wagons are provided with flap doors for ease of loading/unloading of consignment.

2. Covered wagons:

The consignments which required to be protected from rain etc. are transported in covered wagons. These wagons generally carry food grains, cement, fertilizers, fruits &vegetables etc. For Example: Four-axle covered wagon (F-aCW) (with metal front wall) shown in fig 1, has got Loading capacity of 66 ton, Tare weight of 23 ton and Volume of 120 m^3. Also, four-axle covered wagon with broadened doorways shown in fig 2, has got loading capacity of 68 ton, Tare weight of 24 ton and Volume of 120 m^3.

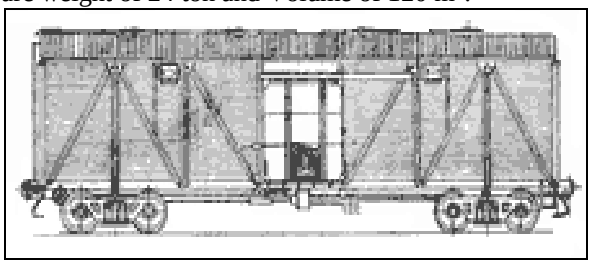

Fig 1: F-aCW with Metal Front Wall.

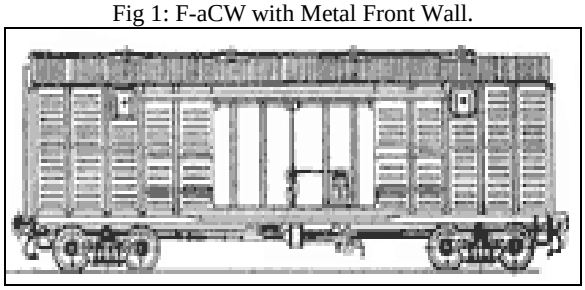

Fig 2: F-aCW with Broadened Doors.

3. Flat wagons:

These wagons are without side walls and are generally used for carrying steel coils, billets, rails sleepers etc.

4. Hopper wagons:

These are special wagons designed for Rapid discharge from bottom. These are used for transporting coal and ballast. These are classified as cereals hoppers and cement coppers for transportation of corresponding items. This has got loading capacity of 68 ton and Volume of 120 m^3.

Fig 3: Hoppers wagon

5. Well wagons:

These wagons have well shaped under frame and are used for larger consignments like military tanks, heavy equipment's etc.

6. Container wagons:

These are special flat wagons designed for handling containers.

7. Tank wagons:

These are wagons designed to carry liquid consignment like petroleum products, milk, edible oils, etc. This wagon shown in Figure.4, has got Loading capacity of 66 ton and Volume of 73 m3

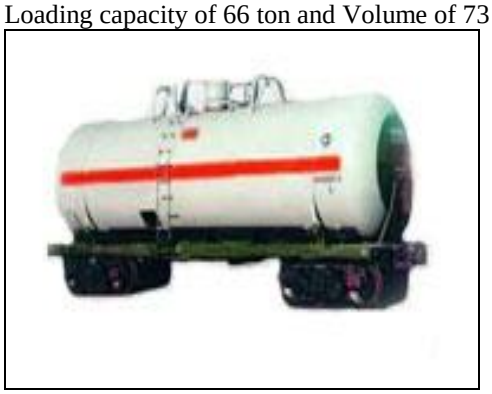

Fig 4: Tank Wagon.

8. Brake vans:

These are guards van used with freight trains as last vehicles.

Fig 5: Freight Wagon.

B. Damages during loading and unloading of Wagon

Increase in market demand for goods transport and competition aides the engineering of freight wagon system. Increasing the capacity of wagons and optimizing the design with better analysis. Some of the issues related to wagon loading and unloading and unloading [12] are listed below.

- ***Wagon damage due to Pay loaders:***

The fact that damages are being caused by pay-loader, JCBs, clam shalls, grabbers, mechanized showells, etc. during loading and un-loading of commodities such as coal, iron ore, clinkers, lime stone, etc. is well known.

There are large number of sidings where loading (coal, ore, etc.) is being done by pay loaders. During the process wagons are getting damaged due to following action of the equipments.

- Wagon doors being closed with JCB/Pay loaders grab.
- Unloading of coal from wagons by scooping with pay loader buckets.
- Hammering of top coping of wagons by pay loader bucket or arm during loading or withdrawal of bucket after loading.
- Shunting and positioning of wagons at material heap by pay loaders.
- Pressing of stanchions by wheels of Pay-loaders.
- Hitting of bucket against the side wall of wagons to drop the sticky coal during loading operation. This has the effect of side wall being pulled outwards and welding cracking open.
- Sometimes due to mis-operation by driver, the bucket hits the side wall leading to tearing/perforations in side walls.
- Floor is damaged because of hitting of floor plates by buckets especially when buckets have teeth, these tend to pull out the floor plates.

- ***Effect of wagon damages on safety of Rolling stock***
  - Damage of wagon doors caused by hitting of grab of JCB/Pay loader ultimately leads to bending of wagon doors. Such bent doors are difficult to close and when partially closed, open out on run and cause hitting of wagon doors with OHE mast.
  - Similarly, hammering of top coping of wagons by pay loader bucket or arm and pressing of stanchions by wheels of pay loader leads to bulging of wagon side walls beyond safety limits.
  - Excessive Pressure of pay loader bucket from top for wagon commodity adjustment and side wall bulged wagons can cause excess loading of commodity beyond permissible limit.

3. EXISTING ISSUES IN WAGON MANAGEMENT

The liberalization in railway sector, the introduction of new wagon ownership regimes and the technological evolution in GPS, computing, mobile communication and Internet offer new potentialities but also impose higher productivity targets for the wagon management. It is investigated that technological and organizational requirements for the operation of a system that offers real-time wagon monitoring and management functionalities. The relevant research concluded that the essential components of such a system are: (a) a user/wagon reservation scheme, on-board track-and-trace equipment with autonomous battery and advanced energy-saver apparatus and a loading/unloading sensor.

(b) a suitable software platform that include a prediction mechanism for the time of the wagon arrival at destination station and wagon asset management (to allow for the wagon bid and offer, the dispatching operations and to facilitate the wagon delay management). In addition, certain wagon management issues have been further investigated, namely:

- The adequacy of the classic Transportation Problem formulation to solve the wagon dispatching process and the requirements to tackle the imbalance between wagon offer and wagon demand as well as to allow for the fair allocation of benefits among the users of the system. The implementation of a data recording system for the non-satisfied wagon dispatching cases in order to compensate in a similar future case, has been foreseen as a potential solution to this problem.
- The benefits that can be achieved thanks to ETA information. An appropriate wagon dispatching strategy has been proposed that can improve the performance of the system, in terms of wagon-km. An order of magnitude of these saving has been identified through model-based investigation of hypothetical wagon offer and demand scenarios.

The trade-off between wagon availability (in terms of reliable wagon arrival at demand nodes) and system's performance (in terms of total travel time of wagons). An optimization framework based on hybrid GAs has been developed and applied in a hypothetical network for addressing the reliable optimal empty wagons allocation problem. The results revealed that reliability considerations may significantly alter the system's performance.

4. RESEARCH ANALYSIS

This section discusses the most prominent research works performed in Freight wagon, performance analysis. The analysis is performed by collecting the useful, recent transaction paper from well-known publications.

The important design aspects for freight design are found in Williams et al. [14]. The authors have mentioned that how the freight system is important in today's transportation. They have studied some of the recent designs of freight system and described how the modern mechanisms can be utilized in freight wagon design to get the

required results, efficiency, reliability etc. Author have also discussed the techniques like finite element analysis, modal analysis, dynamic performance simulation etc.

Later, the author Sun and Dhanasekar [15] have introduced the concept of vertical interaction between wagon system and rail track and is considered as "dynamic model". In this author have considered the various aspects of rail track and vehicle interaction researches for their dynamic model. This model is designed to examine the rail track and wagon system. In this, wagon with two wheelsets are modelled which represented with two bogies as ten degree of freedom subsystem while the track was designed as four-layer subsystem and two subsystems were coupled with each other by Hertz contact technique. The designed model was passed through various test data.

By observing the recent study analysis, Petrovic and Bizic [16], have given the suspension system improvement for Fbd wagons for transportation applications like coal transportation. The author has introduced a rubber elastic element in the existing system wagons, between underframe and the laminated spring buckle. Later, they have performed the analysis on suspension behavior in with and without elastic element. The proposed wagon design helps with reduced wagon maintenance cost and enhanced efficiency of the coal transportation from mining area to thermal power plant.

The study of Milovanovic et al. [17] represents the methodology to detect the causes of cracking near to the welded joints of the wagon underframe to provide the transportation of swap bodies and container. This research aims to find and calculate the residual stresses which appear after the underframe mounting. Finally, they have acquired the results for maximum vertical load.

Author Harak et al. [18] have described a virtual wagon vehicle design by using computer tools such as "virtual prototyping tools". In this, they have considered the open type wagon as freight wagon. The freight wagon is consisting of car body structure and other two solid works bogies for modelling the freight wagon. The wagon geometry is exported to the ANSYS tool. The significance of this work is that it offers better stability and comfort level for vibration modes.

The analysis towards the nonlinear dynamics of 2axle freight wagon in curves was explained in Gialleonardo et al. [19]. In this, authors have considered the assembly of three wagons or one isolated wagon together. The dependency of vehicle speed and curve radius was found by considering the 2axle freight car with larger amplitude periodic oscillations at higher speed values lying at operating speed range. They have performed investigation on the interaction among the adjacent vehicles too and indicates the forces will exchanged via coupling elements affects the 2axle freight wagons dynamics.

The study towards the variable costs from a analysis and management prospective of modeling influence of technical parameter of wagon was found in Dolinayova et al. [20]. The costs were calculated through the conversion calculation method by using standards and norms for rail transport. They have also performed calculation of the real-time transport utilization on the basis of wagon utilization.

Author Saviz [21] have presented a design mechanism for wagon springs having two stage suspension scheme to meet the requirements like static, strength and dynamics along with standard preferences. The process s precisely explained in good manner for modelling of the suspension elements for dynamic simulations. The designed spring was subjected to simulations and performed the comparative analysis with standard permissible values.

The study of Shukla and Bharthi [22] indicates the analysis of BSNHL wagons doors. In this, authors have considered the various aspects of the Indian rail freight wagon. Also, they have suggested improvement od reliability and availability factors in the transport system throughput enhancement.

A most recent study of Rezvani and Mazraeh [23] have discussed the stability and dynamics analysis of the freight wagon subjected to the railway track and operational conditions of the wheelset. The authors investigated the effect of axle box clearance, track curve radius, variation of the wheel rail friction coefficients etc., on nonlinear critical speed. The outcomes of the study were analyzed and found that the proposed mechanism yields vehicle dynamic performance improvement.

5. EXISTING RESEARCH GAP

After reviewing the existing techniques towards freight wagon, it has been seen that there are various forms of the techniques that has been introduced till date in order to enhance the rail freight wagon throughput. Still, there are certain pitfalls that have not been found to be addressed and hence they broaden the scope of further research work towards such unaddressed problems. The brief highlights of the open research issues are as follows:

a) Less Focus towards freight wagon optimized design: There are lesser studies carried out towards optimized freight design. None of the studies till date has used standard design aspects of Freight wagon. For this reason, the existing techniques could show superior outcomes from simulation viewpoint but it doesn't guarantee its applicability in real-world implementation.

b)Few research on throughout enhancement: The existing techniques are more focused on quality-of-service. However, there is no focus on throughput enhancement.

c)Less benchmarked techniques on Routing: At present, there is no standard or benchmarked modeling of any research work where optimal performance of freight wagon is reported. Studies towards benchmarking will require extensive test-environment to implement the train track, suspension which is yet to be explored in future.

6. FUTURISTIC RESEARCH

The future research towards the freight wagon design, improvement in the throughput can be obtained by following the following steps.

- An exhaustive existing research survey need to be performed to understand the design aspects of the freight wagon.
- After analyzing the research survey, a common unresolved problem will be formulated
- A novel design is need to be implemented with proper parameter consideration which can help to overcome the existing issues.
- After successful execution of the research, the results will be compared for the performance analysis with recent works.

7. CONCLUSION

This paper highlights the various concepts of the freight wagon and its types. In this, the existing issues of wagons are also mentioned. The paper discussed the significant research survey section, which provided the various research works towards freight wagon design, influence parameters of wagon etc. With the help of survey analysis a research gap is formulated. Based on the research gap a futuristic line of research is illustrated.

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