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Optimisation of Bogie Springs for Higher Axle Load Wagons

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Abstract- **Railway freight stock (wagons) are used for carrying goods in bagged form or in bulk form, machines, ores etc. from one place to other place. It is very important because for a strong economy an efficient transportation system is necessary. Major portion of the revenue of railway comes from freight operation. Currently Indian railway uses less capacity wagons in comparison to other players in international market.**

Over the last decade, Indian railway adopted various measures to improve the operational and commercial performance of its rail freight operations. These include an increase in the permissible axle loading for major commodities, improvement in wagon utilization by improving wagon turn-round times together with incentives to customers. Although all these measures are, effective but did not fulfil the desired demand. Importantance of new and improved design of wagon was felt which could transport maximum volume of goods from one place to other in time. Heavy haul freight trains are demand of time. Indian railway has taken an ambitious project of optimization of existing bogie to suit heavy haul wagon for the operation of heavy haul freight train on dedicated freight corridor.

Upgraded technology for transportation, preparedness for increase in productivity and minimization of unit transport costs remained the guiding principles for formulating this ambitious project, which will be transforming the entire rail transport infrastructure of India. Particularly in freight operation for achieving these targets Indian railways has decided to increase axle load capacity of freight trains from 22.9t load to 25t, which will further be enhanced to 32.5t.

Key Words- Bogie, Nucars, simulation, suspension, Wagon.

1. INTODUCTION

Rail freight uses many types of goods wagon. these include covered wagons for general merchandise, flat wagons for heavy or bulky loads, well wagons for transporting road vehicles; there are refrigerator vans for transporting food, simple types of open-topped wagons for transporting bulk material and tankers for transporting liquids and gases. Most coal and aggregates are moved in hopper wagons or open wagons that can be filled and discharged rapidly. Importantance of new and improved design of wagon was felt which could transport maximum volume of goods from one place to other in time. Heavy haul freight trains are demand of time. Existing bogies of wagon require optimization to suit wagons of heavy haul freight train on dedicated freight corridor.

A universally agreed definition of heavy-haul train is that it has transportation capacity of at least 5000 metric ton, hauls revenue freight of at least 20 million metric tons (gross) per year, and operates with axle loads of 25t or more. Yet another characteristic of such a train is that it consists of wagons that are uniformly of the same type, carry a single commodity, and move uninterruptedly from a single origin, say a mine head, to a single destination, say a seaport. Trains are typically loaded in only one direction and return empty for fresh loading.

2. OBJECTIVE AND RELEVANCE OF THE PROJECT

Considering the need for quantum augmentation in rail capacity for meeting transport demand of the country, in 2007, GOI established the dedicated freight corridors corporation of India (DFCCIL) under the company's act of 1956, as a special purpose vehicle, wholly owned by ministry of railways (MOR). The dedicated freight corridors entails construction of railway tracks capable of handling 25t axle load initially and 32.5t axle load in future.

The vast railway network of Indian railways spread over 65000 route kilometers handles more than 1050 million tons freight traffic and is poised to increase its business due to the significant traffic potential related to industrial production and other components of GDP.

3. BOGIE

Rolling stock can be divided into two main parts, one is car body and other is truck or bogie. Bogie played very important role in rolling stock dynamics. Bogie have two cast steel side frames connected together by a cross member called spring plank to maintain bogie squares. There is also one floating member called bolster. Bogie design requires following parameters

- Number of axles
- Axle load

- Speed potential
- Wheel diameter(new & condemning)
- Wheel base
- Journal centers
- Suspension characteristics
- Damping or snubbing force
- Type of center pivot
- Type of side bearers
- Side bearer centers
- Type of construction
- Position of side bearer from rail level
- Type of bearing
- Brake rigging

Bogies used in Indian railways are 2-axles, 3-axles, 5-axles depends on the consignment to be transported within the limitation of axle load.

3.1 Axle Load

Axle load depends on maximum pay load to be carried. It is calculated gross load of wagon divided by number of axle. Magnitude axle load depends on type of track on which vehicle will run. Designer should utilize maximum axle load permitted by civil directorate of Research Design Standard Organization. (Ministry of railway). Indian railway uses 16.25t, 20.32t, and 22.9 t. Axle load of 25t & 32.5t are projected for future use.

3.2 Speed Potential

Speed of rolling stock depends on track conditions such as Rajdhani track, maim line track and ordinary track. Higher speed increases throughput reduces down time.

3.3 Wheel Diameter (New & Condemning)

Diameter of wheel plays important role to achieve required bogie height, speed of vehicle and axle load.

3.4 Wheel Base

Wheelbase should not be lower than 1830 mm as per schedule of moving dimension on Indian railways. Conventionally wheelbase considers twice the wheel diameter in case of BG wagons.

3.5 Journal Centres

Journal centers limited to 2240mm and 2260mm as per schedule of moving dimension on Indian railways for BG.

3.6 Suspension Characteristics

Wagons during movement on track are subjected to disturbing forces in various directions at rail-wheel interaction points, due to surface defects, misalignment and geometrical inaccuracies at rail wheel interaction points. Vertical disturbances are most dominant out of all the disturbances. If these forces are allowed to pass throughout wagon structure without any cushioning effect provided at some stage, wagon structure along with commodity would be subjected to a lot of damage and would need heavy maintenance. To prevent this occurrence some sort of cushion in form of spring element with or without damper is provided at appropriate stage of suspension in a wagon. Bogie suspension system is divided in to two parts such as primary and secondary. Primary suspension is limited to elastomeric pad only, provided between side frame and adopter. Secondary suspension consists of nest of coil spring provided between side frame and bolster. Coil spring nest consists of outer, inner and snubbed spring. Number of springs depends on bogie stiffness and speed potential required for particular wagon. A softer suspension is suitable for higher speed operation. Maximum deflection between empty wagon and loaded wagon should be 75mm maximum.

3.7 Coil Spring

A coil spring, also known as a helical spring, is a mechanical device, which is typically used to store energy due to resilience and subsequently release it, to absorb shock, or to maintain a force between contacting surfaces. These are made of inelastic material formed into the shape of a helix which returns to its natural length when unloaded.

One type of coil spring is a torsion spring .The material of the spring acts in torsion when the spring is compressed or extended. The quality of spring is judged by the energy it can absorb. Those springs which are capable of absorbing the greatest amount of energy for the given stress is the best one. Metal coil springs are made by winding a wire around a shaped former - a cylinder is used to form cylindrical coil springs.

4. NUCARS (New and Untried Car Analysis Regime Simulation)

There are many types of multi body dynamics simulation software for railroads. NUCARS is a general- purpose program modelling for rail vehicle transient and steady state responses developed by TTCI, USA. RDSO has latest NUCARS version. NUCARS has made significant advances over existing models in providing a single means to predict vehicle response. NUCARS simulates the dynamic response of vehicle to input track conditions. It is capable of predicting the response of any type of rail vehicle; locomotive, passenger and freight car on any type of track geometry.

4.1 Development of Vehicle Model

The process of modelling is to prepare a set of mathematical equations that represents the vehicle dynamics. These are prepared automatically by the computer package through user interface requiring the vehicle parameter by entering a set of co-ordinates describing all the important aspects of the suspension and the required outcomes.

A network of bodies connected to each other by the flexible elements and connections models the vehicle. The bodies are usually taken as rigid but can be flexible with a given value of stiffness. Masses, moment of inertia, and center of gravity are specified

The NUCARS modelling of a railway vehicle comprises of the following steps:

- Identification of heavy and light bodies

- Deciding degrees of freedom of the various heavy body
- Providing spaces coordinates of the center of gravities of the various heavy bodies
- Providing space coordinates of the various inter connection of the bodies
- Masses and moment of inertias of the heavy bodies
- Type of connection between the heavy bodies out of a wide variety of connections provided by NUCARS software.
- Properties of the various types of connections in the form of piece wise linear (PWL)
- Track inputs : track geometry and irregularities
- Track inputs to the model are usually made at each wheel-set in space curve format.
- Following raw data channels are required:
- Distance along track
- Curvature super elevation
- Cross level
- Gauge
- rail/ wheel contact geometry

The wheel rail geometry file is a combination of the wheel and rail profile and is defined by specifying the lateral shifts by the following parameters:

- Roll angle
- The rolling radii of the two wheels
- The contact angle on the two wheels
- Left and right profile
- Left and right rail alignment

The system model file will be created for new 25t axle load wagon with bogie as LCCF bogie with all of the six suspensions characteristics has been defined in the model. All suspension options will be tried in simulation considering following input variables

- Track file(.trk)
- Rail wheel integration file(.wnt)
- Output parameters for analysis

5. CRITERIA & LIMITS

The criteria used during oscillation trial are vertical and lateral accelerations and their ride index, lateral force at axle box level applicable over 2m distance and derailment coefficient. As per 'third report of standing criteria committee' issued in January '2000 and amended on 10.07.2000, the present revision-1 of the report is published incorporating all the amendments made from january2000 to may2013. The limits laid down for different criteria for freight stock are given below.

- The lateral/transverse forces lasting more than 2 meters shall not exceed 0.85 (1 +p/3) tons, where p is the axle load in tons.
- Isolated peak values exceeding the above limit are permissible provided the record shows a stabilizing characteristic of the wagon subsequent to the disturbances.
- A simultaneous assessment of the lateral force exerted by the adjacent axles at a point where a high lateral force is exerted by a particular axle.
- A derailment coefficient should be worked out in the form of ratio between the lateral force (hy) and the wheel load (q) continuously over a period of 1/20tl second; the value hy/q shall not exceed 1.
- A general indication of stable running characteristics of the wagon as evidenced by the movement of the bogie on straight and curved track, and by the acceleration readings and instantaneous wheel load / spring defections.
- In the case of such wagons where measurement of forces is not possible, evaluation shall be in terms of ride index which shall not be greater than 4.5; limit of 4.25 is preferred.

6. DETAILED METHODOLOGY

A 25 T wagon has been designed jointly by RDSO and American rail industry (ARI) USA and a prototype wagon has also been manufactured by ARI for fatigue testing of the wagon on Simuloader. It was decided by railway board that bogie for this wagon would be designed indigeniously.The available bogies are of axle load 22.9t.The problem is to design bogie which will be fit for 25t axle load and enhance speed of 100kmph.it was decided that the current LCCF bogie which is running under container wagon will be optimized.

Detail methodology consists of mainly following steps as follows

- Selection of bogie (with optimized structural strength).
- Formation of suspension options considering damping force, energy dissipation & stiffness.
- Simulation runs of different options on simulation software NUCARS.
- Discussion of result according to criteria laid down in third criteria committee report of Indian railways
- Validation of result by oscillation trial.

7. SUSPENSION OPTIONS TRIED ON SIMULATION

The NUCARS simulation for 25T wagon has been done with following different suspension sets to see their riding parameters and to find out the best suitable suspension option for new 25T axle load variant.

- Original BOXN suspensions (6 outer, 3 Inner and 2 Snubbed).
- IRF-108 bogie suspension (7 outer, 7 Inner & 2 snubbed).
- AAR D5 suspension with single AAR snubbed [7-D5 Outer 4-D5 Inner and single snubbed (2-B432)].
- AAR D5 suspension with AAR double snubbed [7-D5 Outer 3-D5 Inner and Double snubbed (2-B432 Outer & 2-B433 Inner)].
- AAR EQUIVALENT MAIN COILS OF CASNUB NLB BOGIE (6 OUTER , 3 INNER) AND AAR DOUBLE SNUBBER (2-B432 OUTER & 2-B433 INNER).
- Additional suspension: IRF-108 bogie suspension (6 outer, 6 Inner) and AAR Double snubbed (2-B432 Outer & 2-B433 Inner).

8. Simulation Results

After simulation in all configuration and with each suspension type over speed ranging from 30 -130 km/h , the generated NUCAR output (.out file) analyzed for exception values of Max L/V lasting for 1/20th sec, Max lateral acceleration, Max vertical acceleration and Max lateral forces lasting 2 m in MUTIVU module by running command batch. The processed output (Exceptions of each parameter as defined in CMD file for each speed) dumped in .CSV format file, which further utilized for further analysis of results. The comparative results of each simulation run with different suspension option on straight and curve track files of DHN-MGS and Katni- Bina sections.

Suspension options	Condition	Max L/V lasting for 1/20th sec and speed	Max lateral forces lasting 2 m & speed (kg)	Max lateral acceleration & speed (g)	Max vertical acceleration & speed (g)
AAR D5 suspension with double AAR sunubber (7-D5 Outer 3-D5 Inner) and AAR Double sunubber (2-B432 Outer & 2-B433 Inner)].	Empty Straight	0.652 at 120 km/h	1897.52 at 120 km/h	0.40 at 120 km/h	0.67 at 120 km/h
	Loaded Straight	0.217 at 120 km/h	5051.6 at 120 km/h	0.43 at 120 km/h	0.349 at 120 km/h
	Empty Curve	0.56 at 60 km/h	1715.14 at 100 km/h	0.412 at at 100 km/h	0.519 at 100 km/h
	Loaded Curve	0.452 at 100 km/h	8905.68 at 100 km/h	0.415at 100 km/h	0.214 at 100 km/h
AAR Equivalent main Casnub NLB coils (6 outer, 3 Inner) and AAR Double snubber (2-B432 Outer & 2-B433 Inner).	Empty Straight	0.597 at 120 km/h	1897.52 at 120 km/h	0.37 at 120 km/h	0.67 at 120 km/h
	Loaded Straight	0.21 at 120 km/h	5316.16 at 120 km/h	0.45 at 110 km/h	0.339 at 120 km/h
	Empty Curve	0.58 100km/h	1599.99 100km/h	0.406 100km/h	0.46 100km/h
	Loaded Curve	0.43 at 100 km/h	8477.83 at 100 km/h	0.45 at 100 km/h	0.212 at 100 km/h
IRF-108 main coils (6 outer, 6 Inner) and AAR Double snubber (2-B432 Outer & 2-B433 Inner).	Empty Straight	0.476 at 120 km/h	1387.13 at 120 km/h	0.32 at 120 km/h	0.58 at 120 km/h
	Loaded Straight	0.257 at 90 km/h	5414.15 at 100 km/h	0.452 at 110 km/h	0.366 at 120 km/h
	Empty Curve	0.63 at 70 km/h	1584.95 at 100 km/h	0.376 at 100 km/h	0.429 at 100 km/h
	Loaded Curve	0.40 at 100 km/h	7594.44 at 100 km/h	0.45 at 100 km/h	0.213 at 100 km/h

9. Conclusion

The NUCARS simulation results of new 25 T axle load open wagon fitted with LCCF bogie 840 mm diameter wheel carried out with first five suspension options (Option I to V of para 7 of report) on the track files of DHN –MGS and Katni-Bina Sections on straight and 2 degree curve in empty and loaded conditions. The maximum values of all critical parameters analyses in these simulation for max L/V lasting for 1/20th sec, max lateral acceleration, max vertical acceleration & max lateral forces lasting 2 m at the corresponding speed where these exceptions has occurred with suspension options IV, V & VI on Katni-Bina track files are shown in table above which further summarized below to draw the final conclusion-

- AAR Equivalent main CASNUB NLB coils (6 outer, 3 Inner) and AAR Double snubbed (2-B432 Outer & 2-B433 Inner).
- IRF-108 main coils (6 outer, 6 Inner) and AAR Double snubbed (2-B432 Outer & 2-B433 Inner).

It may also be noted that out of above two suspension the requisite parameters of suspension option IRF-108 main coils (6 outer, 6 Inner) and AAR Double snubbed (2-B432 Outer & 2-B433 Inner) shows better results in even in empty condition and comparable results in loaded condition.

On the basis of the oscillation trials conducted on “GONDOLA 25” Wagon to RDSO drg. No. WD-13016-S-01 fitted with the springs in each nest, 6 outer, 6 inner, 2 snubbed outer & 2 snubbed inner over CTC-PRDP section in KUR division of East Coast Railway, it is concluded that the test Wagon has satisfactory riding and stability characteristics up to the maximum test speed of 95 kmph in empty & up to 85 Kmph in loaded condition on straights, station yard, Curve (1.750-2.20)-2.10 & Curve (1.00-1.50)-1.50, on track maintained to other than C&M-1, Vol-1 Standard. The assessment of the riding & stability characteristics of Wagon is based on the criterion given in the 3rd Report of the Standing Criteria Committee.Results obtained from Detail oscillation trail, conducted by testing directorate, validates the NUCARS simulation result. This suspension may be easily modified for higher axle load (32.5t) in future by more options of suspensions may be tried on NUCARS simulation. A lot of options can be formed and tried, by making system files for different options in less time than direct oscillation trial, on simulation trial. In oscillation trial if one option fails considerable time, money and preparations will be needed for further trial. Virtual simulation saves a lot of money and

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precious time. An oscillation trial costs approximately 25 to 30 lacs depending on case and at least two to three months' time. Lots of statutory clearances required which is valid for one trial only. For fresh trial again all processes will have to be done.

This technique can also be used for calculating center of gravity of wagon in empty and running condition as well as for obtaining required kinematic profile in running condition.

REFERENCES:

[1] Technical pamphlet no G-95 (Revision-1) published by RDSO Lucknow.
[2] International standards EN 143613.
[3] Oscillation trial report MT-1383 series-I published by testing directorate RDSO Lucknow
[4] A guide on oscillation trial mt-334 published by testing directorate of RDSO Lucknow.
[5] IS-7906 helical spring.
[6] Indian railways annual reports.2011,2012..2013 &2014
[7] Indian railways technical bulletins published periodically
[8] AAR (American association of railroads) manual of standards and recommended practices section-c and section-d.
[9] Indian railway maintenance manual
[10] Oscillation trial reports MT-1384 series-II published by testing directorate of RDSO Lucknow