Chapter 21
Dynamic Analysis of Steering Bogies

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ABSTRACT

Running times of high-speed rolling stock can be reduced by increasing running speed on curved portions of the track. During curving, flange contact causes large lateral force, high frequency noises, flange wears and wheel load fluctuation at transition curves. To avoid derailment and hunting, and to improve ride comfort, i.e., to improve the curving performances at high speed, forced/active steering bogie design is studied in this chapter. The actively steered bogie is able to negotiate cant excess and deficiency. The bogie performance is studied on flexible irregular track with various levels of cant and wheel wear. The bogie and coach assembly models are developed in Adams VI-Rail software. This design can achieve operating speed up to 360 km/h on standard gauge ballasted track with 150mm super-elevation, 4km turning radius and 460m clothoid type entry curve design. The key features of the designed bogie are the graded circular wheel profiles, air-spring secondary suspension, chevron springs in the primary suspension, anti-yaw and lateral dampers, and the steering linkages.

1. INTRODUCTION

Now-a-days, railway is one of the important transportation systems in most of the countries. To increase the popularity of railway transport for further, improving speed, comfort and safety are some of the important issues. However, heavy investment in infrastructure development, design and fabrication, research, maintenance and operations, etc. is required to commission high-speed rails. When operating speed increases up to 300-350 km/h, regular maintenance requirements and related economic issues influence the decisions taken by railway operators. To minimize the wear in the wheels and rails, track quality is the essential factor. The dynamic performance as well as ride comfort can be increased in the
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straight track as well as curved track by taking care of bogie design as well as track design. To enhance the performance in the straight track, optimization of bogie parameters is sufficient whereas; in curved track, optimization of track design parameters as well as bogie parameters are necessary. Some of the major parameters that influence performance (stability, comfort, etc.) and wheel/track wear in a curved track are curve radius, cant given to the track, wheel-rail geometry, bogie parameters, axle load and the tractive force between rails and the wheel.

For high speed rolling stock, running times can be reduced by increasing running speed on curved portion of track. During curving, flange contact occurs on the gauge corner of the outer rail which causes large lateral force, high frequency noises, wear of flanges and significant change of the wheel load at transition curves. In extreme case, there is a chance of derailment. To avoid derailment and hunting, and to improve ride comfort of the passengers, in the overall, to improve the curving performances at high speed on curved path, two types of bogies have been implemented along with optimization of track parameters: they are tilting bogie and steering bogie.

Running speed can be increased without reducing the ride comfort of passengers by using tilting bogies. When a train enters a curve at high-speed, centripetal force can cause loss of balance of passengers and luggage objects. Tilting is used to compensate this. When tilting is caused due to deformation of suspensions only then it is called passive tilting. When actuators are using to force tilting, it is called active tilting. The amount of tilt including that from track super-elevation (much like banking of roads) is usually restricted 6 or 8 degrees. Beyond this, on long distance travel, passengers may suffer from a form of nausea resembling seasickness. This restriction does not allow for speed increase beyond a certain range. Therefore, tilting technology if often combined with other technologies.

With the help of steering bogie, speed increases on the curves by minimizing lateral force. Due to high speed on the curve, wheel exerts large lateral force on the rails which causes wear of wheel flanges and rails. Worn wheels or tracks affect the dynamic behavior of bogies. To reduce lateral force as well as lateral displacement, steering mechanisms can be implemented. In fact, active steering mechanism allows for a great deal of speed increase.

Primary steering of rail vehicles is achieved due to conical wheel profile. However, there is an inherent conflict between curving performance (steering) and stability. Stability and curving performance mostly depends on wheel-set guidance and bending stiffness and shear stiffness of primary suspension in the horizontal direction. Generally hunting in the straight track occurs due to self-excited vibration of wheel-sets. The critical speed of railway vehicles depends on the suspension parameters and equivalent conicity of the wheel tread. To overcome the problems of the stability and curving performance (steering), several developments have taken place in the form of implementation of passive steering, semi-active controlled steering and active controlled steering.

This chapter discusses various steering bogies in details and their dynamic behavior is analyzed. The steered bogie and its assembly (car body, front bogie and rear bogie) are modeled using multi-body dynamics framework and run on a designed measured track. The dynamic performance of steered bogie is investigated by changing the design parameters. The creep forces, wheel displacement, contact geometry, accelerations and ride comfort are estimated against standards to ensure safe operation. The input parameters are design parameters of bogie and different track irregularities in vertical as well as lateral directions. Stability, curving behavior and comfort analysis is performed at various speeds. The dynamics of the steered bogie is analyzed using multi-body system (MBS) simulation software ADAMS (VI-Rail).