MATHEMATICAL SIMULATION FOR LATERAL DYNAMICS OF CONVENTIONAL AND UNCONVENTIONAL RAILWAY TRUCKS

by

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DEDICATED

TO MY BELOVED PARENTS

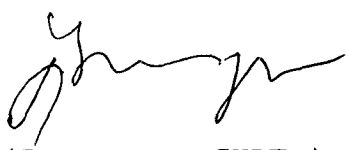
Thiru R.PONNUSWAMY

and

Thirumathi M.KAMALAM

CERTIFICATE

The thesis entitled **MATHEMATICAL SIMULATION FOR LATERAL DYNAMICS OF CONVENTIONAL AND UNCONVENTIONAL RAILWAY TRUCKS** being submitted by **Mr. P. MANNAR JAWAHAR** to the Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy, is a record of bonafide research work carried out by him. He has worked under my guidance and supervision, and has fulfilled the requirements for the submission of this thesis which has attained the standard required for the Ph.D. degree of the Institute. The results presented in this thesis have not been submitted elsewhere for the award of any degree or diploma.



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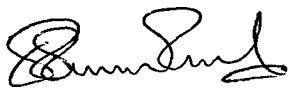

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ABSTRACT

This thesis aims at developing a methodology for modelling and analysis of Lateral Stability and Dynamic Response of a Railway Vehicle System. Since higher operating speeds and greater axle loads are due to be implemented in Indian Railways, it is absolutely essential to obtain a better understanding of the rail-vehicle system under this situation.

The lateral dynamics of rail vehicle system is strongly influenced by the interaction forces between the wheel and the rail. When a wheelset is disturbed from the central position on a tangent track, large horizontal forces called creepforces are generated at the wheel rail interface. These horizontal forces are responsible for truck hunting.

Here a linear and non-linear mathematical model has been constructed by deriving the equations of motion of a railway vehicle truck using Newton's law. For linear modelling, Kalker's creep theory is applied to evaluate the contact tangential forces acting between wheel and rail. For non-linear modelling, the non-linear formula is used to evaluate the wheel rail contact forces. The non-linear profile of wheel and rail are taken into account. Also the lateral stiffness of the track is taken into consideration.

In both linear and non-linear modelling, the equations of motion are derived for (a) truck with conventional wheelset (b) truck with unconventional wheelset (independently rotating wheels). For lateral vibration, 7 degrees of freedom are considered. The degrees of freedom represent lateral and yaw movements of both the wheelsets and lateral, yaw and roll movements of the truck.

Linear modelling is used to analyse lateral stability. Here the equations of motion are transformed into a standard eigen value problem. Eigen values are determined using similarity transformations and double QR Algorithm with shift strategy. By noting the sign change in the real part of the eigen values obtained by changing various input parameters, particularly speed, the threshold of stability is determined.

Non-linear modelling is used to analyse lateral dynamic response. Here the equations of motion are transferred into a form suitable for numerical integration by Adam's method.

To carryout all these mathematical operations, two computer softwares are developed, one for linear modelling and the other for non-linear modelling. In the interest of computing economy, certain approximations have been introduced for calculating creep forces.

Sample results are given for a model of a typical railway vehicle used by Indian Railways. The lateral stability and lateral dynamic response of the railway vehicle for both conventional and unconventional wheelset has been analysed.

Finally at the end, based on comprehensive synthesis of research reported in different chapters, it has been attempted to highlight contributions and limitations of the research pursued, and scope of further research in related areas. The thesis concludes with a detailed list of references and an appendix.

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