NAME OF THE SCHOLAR KARIM H. ALI ABOOD
NAME OF SUPERVISOR PROF. RASHEED AHMED KHAN
DEPARTMENT MECHANICAL ENGINEERING DEPARTMENT
TITLE OF THE THESIS DYNAMIC RESPONSE OF RAILWAY CARRIAGE

ABSTRACT

Three railway dynamic mathematical models are constructed in the present study to investigate the dynamic response of the complete railway carriage against the critical speed of hunting. Single and double-point contact between the wheel and the rail is considered for the railway model moving on tangent and curved tracks. Rolling contact mechanics is described using Hertzian contact theory. While the tangential forces and spin moments which are introduced at the area of contact between the wheel and the rail are calculated using nonlinear creep model. In which nonlinear creep model is constructed by linear theory of Kalker and saturated with nonlinear coefficient presented by Horak. The values of the creep coefficients calculated by Ahmadian are used in the present study to construct the nonlinear creep model. Railway single wheelset is modeled with six degrees of freedom which govern lateral, yaw, vertical and roll displacements and angles of the wheelset with lateral movement of left and right rail for the wheelset. In addition railway model of conventional bogie frame is considered with 17 degrees of freedom which govern lateral, yaw, vertical and roll dynamic responses of each wheelset while lateral, yaw, vertical, roll and pitch displacements and angles for the bogie frame with lateral movement of left and right rail for each wheelset. Complete railway carriage is modeled with 39 degrees of freedom which govern lateral, yaw, vertical and roll movement of each wheelset with lateral movement of left and right rail. In addition the complete railway carriage model describes lateral, yaw, vertical, roll and pitch dynamic response of the carbody and the bogie frames. The second order differential equations of motion of the three railway models are transformed using simple technique into first order state space

differential equations of motion in order to be easily solved by the numerical methods. Computer-aided simulation is used to present the time domain solution of the transformed differential equations of motion of the three railway dynamic models using fourth order Runge-Kutta numerical method. Railway simulation models are used to investigate the dynamic behavior of the railway models against the critical speed of hunting. The three simulation models are able to describe the dynamic movement of the railway models which are subjected to different parameters within the permissible limits of the displacements and angles. Influences of the parameters of wheel-rail contact geometry and the suspension characteristics against the critical speed of hunting are investigated by the simulation models. Principle of limit cycle and phase plane approach is adopted in the present study to describe the hunting stability of the railway model and calculate the associated critical speed of hunting. The simulation models are used to identify the most sensitive suspension parameter against the critical speed of hunting for each model in which high value of critical speed of hunting is obtained. Simulation results are compared and discussed to present the parameter with high influence against the critical speed of hunting with the associated value of the critical speed of hunting to be used as a reference value. Semi-active technique is used to control the magnitude of the parameter with most influence in order to increase the value of the critical speed of hunting and improve the hunting stability of the railway carriage. Two simulation models of semi-active suspension are performed while lateral and yaw movements are used as thresholds in the semi-active simulation model. It is observed from the simulation results that the two models of semi-active simulation accomplished equal values of critical speed of hunting according to the reference value. However the semi-active simulation model with threshold of yaw angle is considered as the best controller used to improve hunting stability of the complete railway carriage.