Low-complexity Behavioral Model for Predictive Maintenance of Railway Turnouts

Maintenance of railway infrastructures represents a major cost driver for any infrastructure manager since reliability and dependability must be guaranteed at all times. Implementation of predictive maintenance policies relies on the availability of condition monitoring systems able to assess the infrastructure health state. The core of any condition monitoring system is the a-priori knowledge about the process to be monitored, in the form of either mathematical models of different complexity or signal features characterizing the healthy/faulty behavior. This study investigates the identification of a low-complexity behavioral model of a railway turnout capable of capturing the dominant dynamics due to the ballast and railpad components. Measured rail accelerations, acquired through a receptance test carried out on the switch panel of a turnout of the Danish railway network, have been utilized together with the Eigensystem Realization Algorithm – a type of subspace identification – to identify a fourth order model of the infrastructure. The robustness and predictive capability of the low-complexity behavioral model to reproduce track responses under different types of train excitations have been successfully validated. It is anticipated that the identified model will be instrumental for the development of methods for diagnosis and prognosis of faults and degradation process in switches and crossings.
Numerical simulation of track settlement using a multibody dynamic software a holistic approach

The increase of train loads, axel loads and operational speeds, contribute to increased degradation processes of the track, particularly in critical sections such railway turnouts, leading to the initiation and development of damage mechanisms. The increased track degradation means that it is necessary to intensify the frequency and the amount of maintenance works in the critical track sections, resulting in increased costs for the infrastructure manager. The fundamental idea of this work is to create and implement a novel methodology to analyse the train/track dynamic interaction and its influence on the overall track settlement mechanism of any track section. This will be achieved by creating an iterative loop that makes possible to assess the condition of the track based on the vehicle forces. This concept enables firstly, to keep the computational advantages of multibody codes when contact behaviour between the wheel and the rail is assessed. The main contribution of this work rests on performing a track degradation analysis considering a regular stretch of railway track, in which the abovementioned methodology is implemented. In the first phase, a train/track interaction analysis is developed and assessed by evaluating the contact forces between the wheel and the rail. In a second phase, the forces at each particular support, beneath the rail, are extracted and transformed, by applying a degradation law at the ballast layer, into vertical displacements that in turn are applied as longitudinal level irregularities in the rail. The process is completed by including the updated geometry that enables the further calculations, in a loop mode, considering as many cycles as required. In light of the foregoing, this work presents an efficient and novel technique that enables a commercial MBS (Multibody Simulation Software) to iteratively predict the impact of the accumulated track settlement on the train/track interaction.

Projects:

Intelligent Quality Assessment of Railway Switches and Crossings

This project aims at significantly improving the safety, reliability and operational lifetime of the 3500 switches and crossings (S&Cs) in the Danish railway network. The project is a close cooperation between the Technical University of Denmark (DTU), the Danish rail infrastructure provider Rail Net Denmark and four affiliated European partners with significant expertise within this field. An inter-disciplinary scientific effort is employed to obtain enhanced rail transport reliability and regularity simultaneously with significant savings in S&Cs maintenance costs. The project results will make maintenance based on intelligent fault prediction tools, instead of the presently used regular planned inspections, and it will provide sophisticated tools to prevent hidden faults from developing to failure in the future. In a novel approach, the project will install state-of-the-art sensor technology in selected S&Cs and correlate dynamic parameters during train passage with static geometry data from conventional measurement vehicles. Monitoring of the dynamic responses will provide diagnosis of patterns that indicate when components or ballast begin to deviate from fully functional conditions. Modelling of dynamics will identify root causes to signs of degradation. Damage assessment of components identified by anomalous readings will be done by metallurgical examinations. Data and results will be processed by a holistic model that can produce Maintenance Performance Indicators (MPI) for the S&C condition. The correlation of sensor data to measuring vehicle data will allow existing data to be used reliably as input for the MPI model. It is expected that this project will enable optimisation of maintenance procedures, by which appropriate maintenance can be predicted in advance, thus avoiding unscheduled repairs and delays in the railway traffic.

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