

Politecnico di Milano
Department of Mechanical Engineering
Applied Mechanics Group

Proposed MSc thesis topics

(for more information please contact the underlined professor)

RAIL VEHICLES

1. Effect of wheel-rail contact point position on the accuracy of dynamometric wheelsets (Ing. Bionda)

numerical - experimental thesis

The dynamometric wheelset is one of the most used instrument for the measurement of the contact forces. By means of the measure of the deformations of the wheelset, it is possible to infer the forces that caused them. The relations between forces and deformations are obtained through a calibration process. Unfortunately, there are many parameters that affect the deformation distribution. One of the most relevant one is the effect of the contact point position. The present thesis proposal aims at investigating the effect of the contact point position on the measured deformation field.

2. Alternative wheelset calibration processes (Ing. Bionda)

numerical - experimental thesis

The measure of the contact forces is one of the most important issues in railway engineering. In the last decades, both researchers and industrial companies have carried out many attempts in order to design reliable and accurate instruments for the measurement of the loads acting at wheel-rail contact interface. One of the main instruments is the so-called dynamometric wheelset: a common wheelset is instrumented with strain gauges. Thus, starting from the measurement of deformations, the forces that cause them are inferred by means of a calibration process. A simple least square regression may lead to regression coefficients that determine a high sensitivity to measurement noises. This thesis aims at investigating the possibility of using alternative calibration methods in order to obtain a robust force reconstruction tool.

3. Numerical methodologies for assessing critical vehicle speed (Ing. Di Gialleonardo)

numerical thesis

The critical speed of a railway vehicle is characterized by the occurrence of hunting instability of wheelsets or even of the whole bogie. Assessing this limit speed through numerical simulations requires detailed vehicle and track models and various types of excitation (track irregularity, initial perturbation, ...) may lead to different limit values. The present thesis aims at defining a relation between the various excitation methods as well as between the different degrees of complexity of the models.

4. Diagnostic system for railway applications powered by energy harvester (Prof. Resta, Ing. Tomasini)

experimental-numerical thesis

Cracks in wheelsets of goods-wagons can lead to significant safety problems. The goal of the thesis is to design a diagnostic system, based on acceleration measurements, able to identify possible cracks, arising during the standard operation. Considering that the sensor node has to be located in the proximity of the wheelsets, it has to be powered by a system which recovers energy from the

mechanical vibrations (energy harvester). In the thesis, starting from the numerical models, the diagnostic system will be designed and a first prototype will be realised.

5. Limit conditions for transient derailment (Ing. Di Gialleonardo)

numerical thesis

Limit conditions for quasi static derailment are well known in the literature (the most famous limit is the so-called Nadal limit). However, this is not the only possible derailment mechanism. Although less frequent, also transient derailments are possible. Such derailments are characterized by extremely high impulsive loads that typically occur due to wheel or rail defects. For these derailments, no limit criterion is presently available.

6. Parametric analysis for assessing the limit derailment surface of freight wagons (Ing. Di Gialleonardo)

numerical thesis

It is widely accepted that derailment occurs if more than one vehicle parameter is far from its nominal values. In the present thesis work, an algorithm for assessing the limit derailment surface in the vehicle parameter space is searched for. Moreover, for setting out maintenance criteria, which is the final target of the research, also the gradient close to the limit surface is of importance and has to be precisely assessed.

7. Aerodynamic homologation tests for high speed trains (Ing. Tomasini)

experimental thesis (6-9 months)

Homologation of trains implies several different aspects, including passengers comfort when a train enters a tunnel. Due to significant pressure variations in the outer region of the vehicle, train sealing needs to be assessed by means of pressure measurements, also inside the coaches. During the present thesis the student will start working on the setup of the measuring system, followed by an experimental validation on a laboratory train.

8. CFD analysis of the wake of a high speed train (Ing. Tomasini)

numerical thesis

The work regards the study of the wake of a high speed train for assessing the effect of the wake on objects and persons located close to the track. The analysis will be conducted using the open-source framework OpenFOAM. There is the possibility for experimental laboratory/full-scale tests.

9. CFD analysis of entrance of a train in a tunnel (Ing. Tomasini)

numerical thesis

The work regards the study of the flow due to the entrance of a train in the portal of a tunnel. The effect of the portal shape on the pressure pulse experienced by the train and by the objects in the tunnel will be investigated. The analysis will be conducted using the open-source framework OpenFOAM. There is the possibility for experimental laboratory/full-scale tests.

10. Train tunnel interaction analysis (Ing. Tomasini)

numerical-experimental thesis

Pressure variations due to train passages inside tunnels need to be strictly taken into account during homologation of new rolling stock. In this thesis work the student will help instrumenting a laboratory train, carrying out tests and then comparing these data to a numeric code in order to assess its reliability.

11. Experimental evaluation of flying ballast phenomenon (Ing. Tomasini)

experimental thesis

When a high speed train is running, in its underbody region wind gusts are generated. Due to this turbulent flow, ballast stones become airborne and can cause damage to both the vehicle and the track. This phenomenon is called ballast projection or ballast lifting. During the present thesis the student work will include experimental tests on a real train by means of acoustic and optical sensors and wind tunnel tests on full scale model of the infrastructure.

12. Optimal design of partition walls for reducing derailment risk due to sloshing in tank vehicles (Ing. Di Gialleonardo)

numerical thesis

Due to the maximum acceptable axle load, tank vehicles cannot be fully filled, Thus, sloshing always occurs. It has been shown that sloshing may increase wheel unloading during curving conditions. What still has to be investigated is the coupled longitudinal – lateral dynamics that would require the co-simulation between a multibody vehicle model and a CFD model of the fluid inside the tank. Moreover, internal partition walls may significantly reduce the risk of derailment.

13. Development of a model for the evaluation of the maintenance effort of a track (Prof. Collina)

The work of thesis is carried out in the framework of a cooperation with the department of structural engineering, within a contract with Ferrovie Nord Milano.

Aim of the work is to set-up a macro-model able to estimate the maintenance effort of a trackwork for regional and suburban liens. Main parameters involved are: rolling stock typology and characteristics (axle load, bogie base, primary and secondary suspensions characteristics), plan of the line (curve, gradients, ...), track type and sub-grade and terrain characteristics, track irregularity. The considered phenomena are: track and track-bed settlement, rail wear and damage due to axle passing. The macro model combines sub modules: train-track interaction, track settlement, rail wear using referenced bibliographic source (paper and EU technical report).

Main activities are: numerical simulation, data analysis and managing, comparison with historical data series (from Ferrovie Nord), macro model set-up.

Final outcome will be an informatics tool able to perform a comparative analysis among local networks, to establish the requirements in terms of track duration, replacement intervals and required maintenance effort as a function of traffic volume, rolling stock type and operational speed profile.

14. Development of a thermo-dynamical model able to reproduce the thermal effects on the contact area during pantograph-catenary interaction. (Ing. Bucca, Prof. Collina) experimental-numerical thesis

In the operation of railway vehicles, especially at high speed, a particular care is addressed to the contact between pantograph and catenary, either because it is essential for the regular run of train or because of the wear of collector strips and contact wire. Wear phenomena related to collector-contact wire sliding interaction are object of research: the aim is to decrease wear level and, consequently, the maintenance costs. The wear phenomena are highly influenced by the thermal conditions in the contact area: a development of a thermo-dynamical model is therefore needed to create a more reliable predictive wear model. Experimental tests on the test bench BPS (Banco Prova Strisciante) of Politecnico di Milano will be carried out in order to obtain experimental results useful for the development of the numerical model.

15. Development of a smart pantograph with a fiber optic monitoring system. (Prof. Collina, Ing. Comolli)

experimental-numerical thesis

The contact force between overhead line and pantograph is fundamental for good current collection. The measurement of this dynamic force is non easy for many reasons, i.e. the high voltage, the electromagnetic disturbances, the hostile environment. Fiber optic sensors overcome these difficulties with an intrinsic electrical insulation and EMI immunity. Many different solutions has been applied in the past years in the test campaigns on high speed trains (Frecciarossa 1000) and low speed trains (underground of Milan and Madrid). New sensor design can improve the metrological performances. The candidate will be involved in designing new sensors (force, acceleration), testing them in the laboratory's test benches and in in-line test campaigns, analyze the results.

16. Design of control logics for a full scale roller rig for locomotives (Ing. Sabbioni)

numerical thesis

On a full scale roller rig for locomotives, braking tests are foreseen. For this purpose, the angular speed of the rollers has to be controlled in order to realistically reproduce the micro-slippages that occur at wheel – rail interface during these manoeuvres.