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DEVELOPMENT AND SIMULATION OF AN HIL FULL-SCALE TEST-RIG TO STUDY HIGH SPEED TRAIN DYNAMICS UNDER DEGRADED ADHESION CONDITIONS

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In recent years, the employment of high speed railway vehicle for passenger transport in the European countries is notably increased and the travelling speeds are passed the limit of 350 km/h, introducing important problems in the safety fields. Therefore, accurate testing activities on the influence between wheel-rail adhesion conditions and the safety on board subsystems (such as odometry algorithms, wheel slide protection devices (WSP) and anti-skid devices) have to be performed. Usually, the testing activities consist of complex experimental tests (required by the regulation in force on the safety on board subsystems [4]) mainly performed by means of on-track tests. Moreover, the technological improvements, the integration of different on board subsystems and their mutual interaction have to be carefully evaluated. The main problems related to the on-track tests are the high economic investments and the speed limitations (the maximum speed limit for most of the testing circuits is often limited to 200 km/h) which may negatively affect the development and the calibration of the high speed devices. Thanks to the economic investment of several national and academic institutions, a railway research and homologation center (Laboratorio Materiale Rotabile L.M.R.) has been recently inaugurated in Firenze Osmannoro (Florence, Italy). One of the most advanced testing equipment of L.M.R. is an innovative full scale roller rig with the aim of reproducing degraded adhesion conditions and testing both traction and braking equipments at high speed (over 350 km/h). Innovative features, comparing with conventional

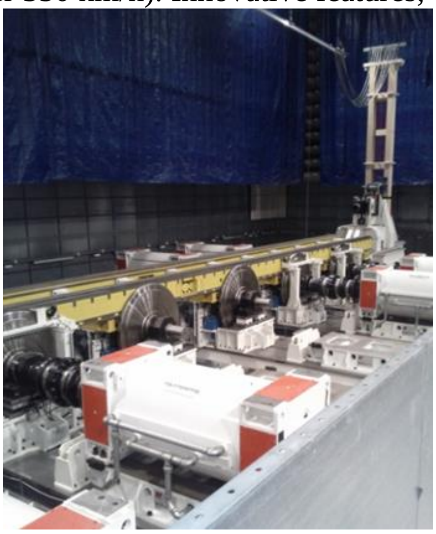

Figure 1: Osmannoro roller-rig in the semi-anechoic facility

roller rigs [1], are related both to the roller rig performances and to the degraded adhesion simulation strategies. In particular, the macro-sliding are notably reduced in order to avoid a significant wear or damage of the rolling surfaces. To reach this goal, Osmannoro roller-rig roller motors have to be controlled to reproduce the same tangential contact forces and the same wheel speed profiles arising under degraded adhesion conditions (simulated by a virtual model reproducing the real behaviour of the vehicle) and at the same time to minimize the sliding among the roller and wheels [2].

The HIL architecture of the proposed simulation model (which is highly inspired by the Osmannoro one) consists of five different sub-models which reproduce the different physical and virtual systems interacting in the roller rig:

1)**3D roller-rig model**: this part contains the 3D multibody model of the rollers with the whole actuation system (the rollers are actuated by means of Permanent Magnet Synchronous motors) and the sensors installed on the system [3].

2)**3D railway vehicle**: a complete 3D multibody model of the railway vehicle is defined including the main non-linearities that characterize the railway wagon. The electrical asynchronous motors of the locomotive are also implemented in order to evaluate several traction conditions.

3)**2D virtual vehicle model**: this part is related to the simulation of the longitudinal vehicle dynamics under degraded adhesion conditions. The dynamics of the 2D model will have to be reproduced on the 3D roller rig by means of the implemented controller.

4)**Estimation part**: this part simulates the strategy used by the system to estimate the torque applied on the wheels by the vehicle motors (because, in order to reduce the setting-up phase, the locomotive torques cannot be directly measured). The only physical quantities measured by the sensors are the tangential contact forces on the roller supports and the roller angular velocities;

5)**Controller part**: this part implements the control law used to reproduce on the roller rig the same dynamics calculated by the 2D vehicle model when degraded adhesion conditions occur.

In this work, the authors will analyze the dynamical behaviour of the roller rig in terms of Hardware In the Loop (HIL) performance, stability and controller robustness when degraded adhesion conditions occur. The reproduced tests in the HIL simulation model are both traction and braking phases. The cooperation with Italcertifer has provided geometrical and physical data concerning the main components of the L.M.R roller rig and of the sample railway vehicle, which have been used to perform some preliminary simulations (that will be validated when the preliminary results of the testing activities will be available).

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