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Pour l'obtention du grade de Docteur en sciences de l’ingénieur et technologie

« Couplage entre dynamique multicorps et méthode des éléments discrets »

qui se déroulera
le jeudi 31 janvier 2019 à 16h15
Auditoire BARB 94
Place Sainte Barbe, 1
1348 Louvain-la-Neuve

Membres du jury :
Prof. Paul Fisette (UCLouvain), supervisor
Prof. Olivier Brüls (Université de Liège), supervisor
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Many engineering applications involve a mechanical articulated system interacting with granular media: an everyday application is the passenger train which is a mechanical articulated system guided by rails that transmit the load to the ground via the ballast. The ballast, composed of crushed stones, is a granular media. To study the global dynamic behavior of a railway system, a lumped mass model of the track (i.e.: rail and ballast) may be sufficient. Contrarily, the study of maintenance operations requires methods that consider the dynamics of each grain of the ballast. Indeed, during these operations, strong dynamic interactions occur between the grains and the maintenance tools. Approaches that take each grain of the media into account are called Discrete Element Methods (DEM). In case of the ballast, the high stiffness of the stones requires the use of the so-called Non-Smooth Contact Dynamics (NSCD) method to properly model the contact phenomena.

One of the maintenance operations is the tamping process of the ballast. This operation restores the railway track geometry to improve the safety of the traffic and the passenger’s comfort. During this operation, the rail is firstly moved to its correct position, then the tamping machine vibrates the ballast in such a way that it behaves more like a fluid. This allows to squeeze the ballast with less load, reducing the stones degradation rate. To study this operation, one may use co-simulation approaches between granular media using DEM and the machine using MultiBody System dynamics (MBS). This solution faces stability problems due to the stiffness of the media. Another approach models the dynamics of the granular media using DEM, while imposing the kinematics of the machine whose dynamics is then neglected.

In this thesis, we have firstly developed a monolithic approach in which the dynamics of the DEM and of the MBS are solved simultaneously. This formalism has shown a good stability and versatility. Secondly, we have carried out a numerical benchmark that highlights the change in behavior of the granular media when vibrated, and its impact on the multibody system. An experimental version of this benchmark has also been designed and studied. Finally, we have compared our monolithic approach that includes the dynamics of both the granular media and the machine, with a model in which the machine kinematics is imposed. This has allowed us to reveal a huge difference in terms of load applied on the granular media as well as in terms of tamping process quality.