PERFORMANCE ANALYSIS OF A TRACKED VEHICLE USING MULTI-BODY SIMULATION

Francesco Mocera, Andrea Nicolini

Politecnico di Torino – Department of Mechanical and Aerospace Engineering (DIMEAS)

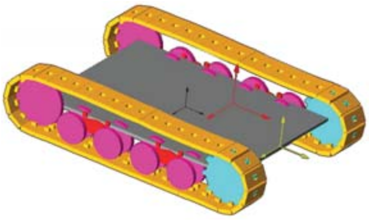
Introduction

Tracked industrial vehicles are flexible self-propelled working machines that can be found in several industrial fields: construction, agriculture, earthmoving, green maintenance. Compared with other industrial vehicles, they usually have great stability due to their lower centre of gravity that allows for better performance on unstructured fields. They can be equipped with different tools giving them great versatility as working machinery. These tools may change consistently the weight distribution of the vehicle having a strong effect on its dynamic performance and maximum tractive force.

In this work, a Multi-Body (MTB) model of a tracked vehicle is shown. Its main aim is to provide an instrument able to exploit machine's performance in case of different equipped tool and different ground characteristics.

The MTB model

- **Track Model**
- **Chassis body design**
- **Tensioning system**
- **Inertia properties**



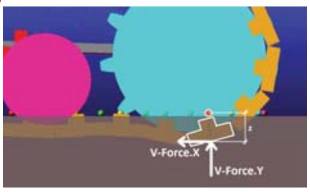
Track-ground interaction

$$\sigma = \left(\frac{k_c}{b} + k_\varphi\right) z^n$$ **Pressure-sinkage [Bekker]**

$$\tau_{res} = c + \sigma tan\varphi$$ **Maximum shear stress [Mohr - Coulumb]**

$$\tau = \tau_{res}\left(1 - e^{\frac{-ix}{K}}\right)$$ **Shear stress - displacement [Janosi-Hanamoto]**

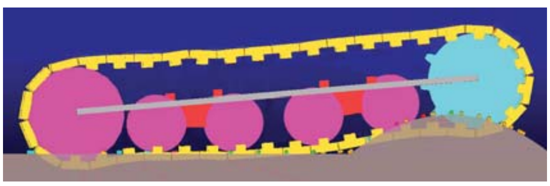
Moving ground model



The track-terrain interaction is considered implementing a moving ground model within the MTB environment. It consists of a contact model which follows each rigid link applying a force depending on the terrain characteristics and local link sinkage.

In order to know the terrain profile, a number of spheres equal to the number of links is used. Each sphere is always aligned with its link and it follows the terrain profile that may exhibits peaks and valleys. The **Bekker** equation enters in the vertical component of ***V-force*** elements applied on each link, where the *z* variable represents the *sphere/terrain - link* distance. The **Janosi-Hanamoto** equation is integrated on the link length and solved only for those already in contact with the terrain to obtain the horizontal component of the ***V-force***. It depends on the slip *i* directly related to the link speed on the terrain. The sum of the horizontal force on each track link gives the drawbar pull of the vehicle. In the **shear stress** evaluation, the real pressure distribution below each link is taken into account solving at each integration step the Bekker equation only for the links in contact with the terrain.

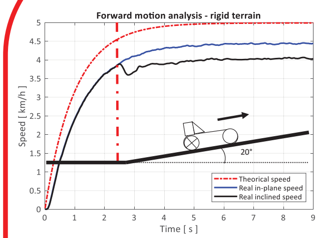
The ground is considered as a rigid body and, thanks to the moving ground model, no useless calculations are performed to take into account deformable soil. Different kinds of soil characteristics are introduced in the model simply by mean of empirical constants in the above equations.



MTB CONTACT DYNAMIC TRACTION

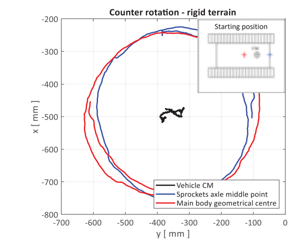
MTB modeling → **Contact models integration** → **Dynamic simulation** → **Tractive force evaluation**

Results



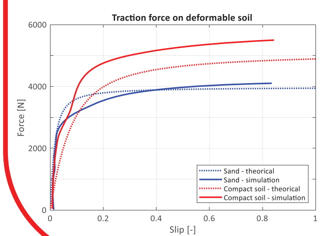
Slip effect

The difference between the real speed of the vehicle and the ideal one is shown, for forward motion on horizontal plane and on a ramp. In this test, intended to the model validation, the contact model was simplified with a Coulomb friction model.



Counter-rotation

The trajectories of several key points during counter-rotation of the tracked vehicle, with the simplified contact model, are shown. The CM trajectory lies within a 100 x 100 mm area. It acts as a pivot point because of the higher mass concentration maximizing the traction force nearby it.



Traction performance on deformable soil

The traction force – slip plot on sand and compact soil are shown. The test is performed on the MTB model applying a linear force growing with the vehicle forward motion and analyzing the *i* slip trend. The results extracted by the model are compared with the analytical one.

Reference

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