CFD Simulation of a passage of a Pirelli F1 wet tire on a puddle using Particleworks

N. Agazzi[a], **M. Merelli**[b]

[a] Polytechinc of Milan, Piazza L. Da Vinci, 20133 Milan, (nikagazzi97@gmail.com, nicholas.agazzi@mail.polimi.it)

[b] EnginSoft, Via Stezzano, 87, Kilometro Rosso Edificio A1, Bergamo (m.merelli@enginsoft.com)

Introduction

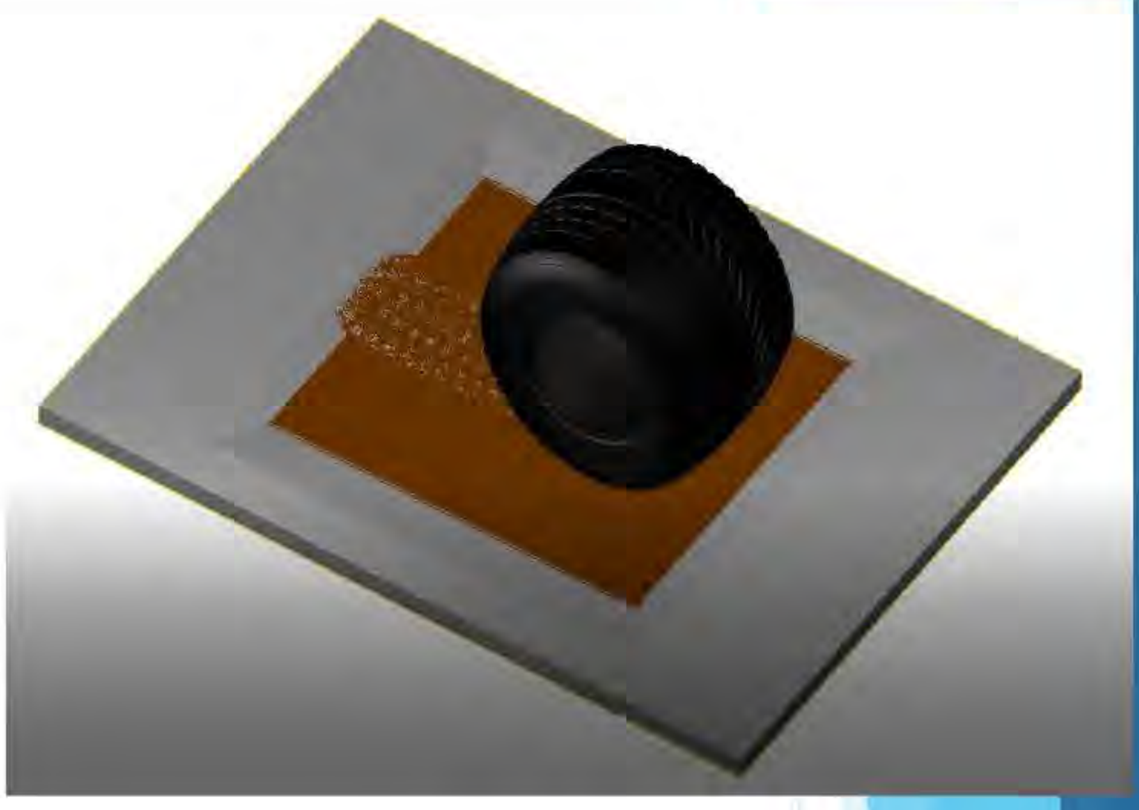
Moving Particle Simulation (**MPS**) is a CFD approach in which the **fluid** is **discretized** in particles (computational fluid volumes). On them, the Navier-Stokes equation are solved with a **Lagrangian approach**. This solver does not require any mesh-generation step, as the fluid is already discretized in the first place. This enables **fast** model preparation and does not pose any additional issue when considering moving/rotating domains or wall boundaries.

MPS is very suitable to analyze in an efficient way **free surface flows** and **large fluid deformations**, so Particleworks is widely used in the automotive industry, where gearboxes, e-axles, e-motors and transmissions are simulated in whole-simulation systems.

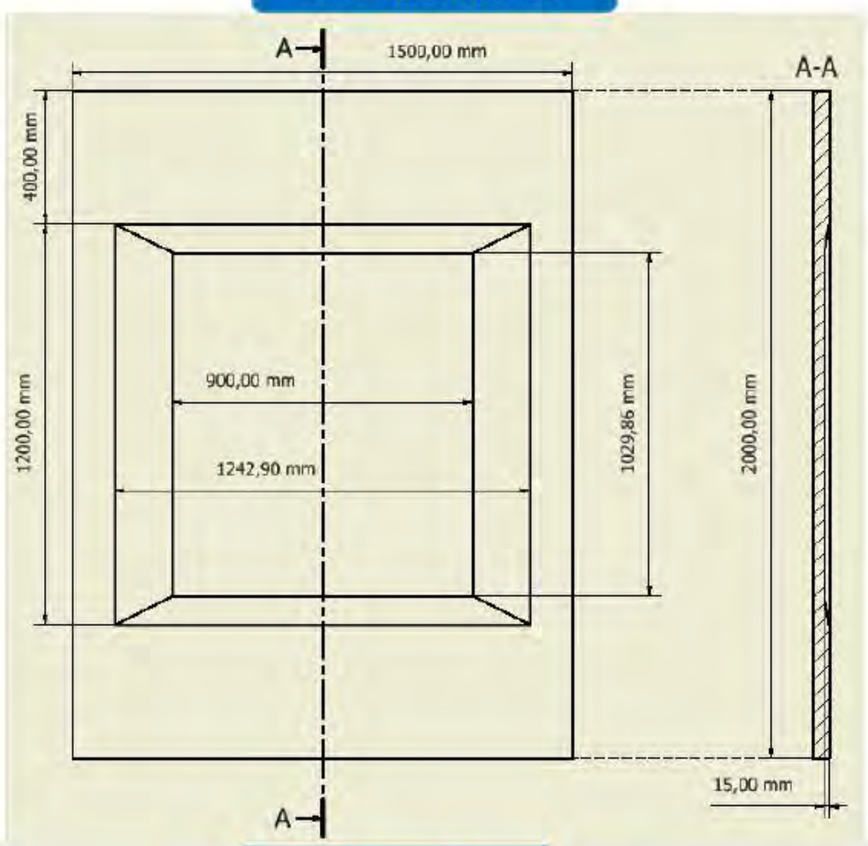
In this project, we simulated the passage of a Pirelli F1 wet tyre on a puddle.

Objectives

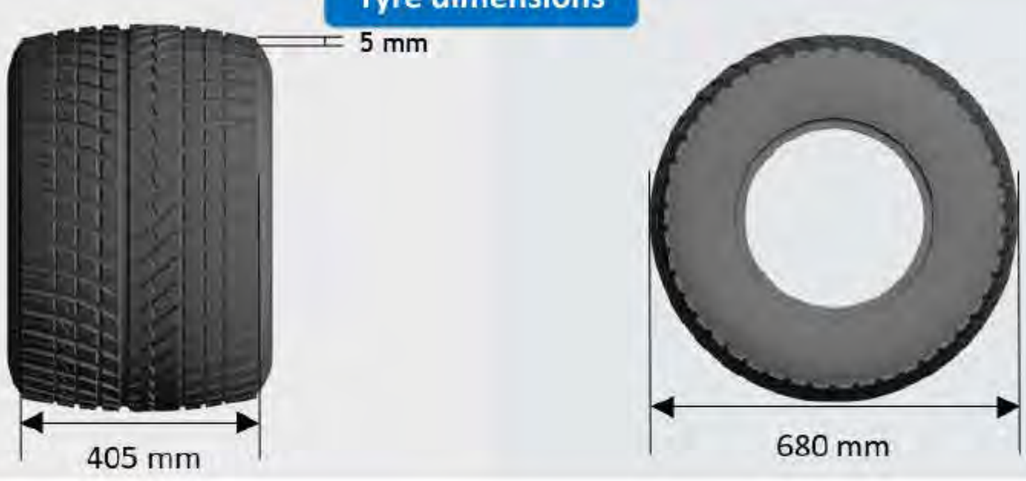
- Tyre-water puddle simulation
- Evaluation of tyre footprint
- Splashing and water evacuation through treads



Hole dimensions



Tyre dimensions

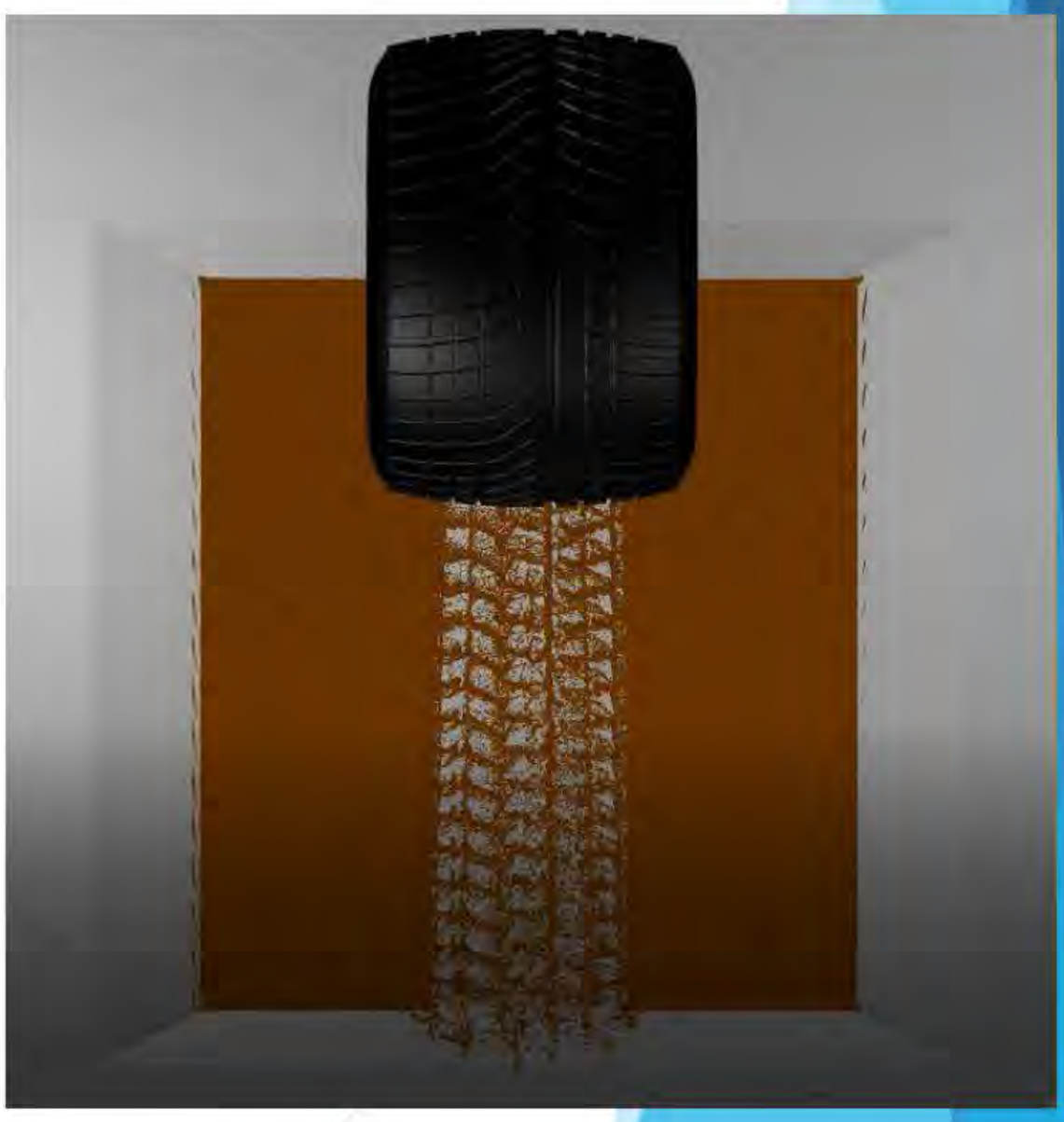


Model description

In order to simulate the worst case regarding the **aquaplaning problems**, the rear tyre was chosen because the width is higher than the front tyre.

The simulation was realized starting from the construction of CAD models (using Autodesk Inventor), through the kinematic description of the motion of the tyre with a fixed speed of **100 km/h** and **no slipping** with the road.

The fluid, a mixture of **water/mud**, was generated from a **filling plane** that was set at **7 mm** from the bottom of the puddle.



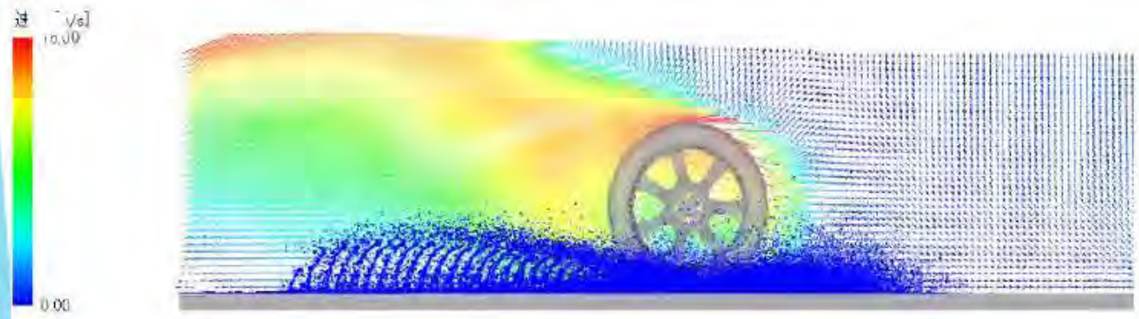
Results

With the simulation it is possible to forecast the effectiveness of the tyre in evacuating the fluid and to allow a good adhesion on the asphalt.

In the analyzed case a **good fluid evacuation capacity** is obtained, where the various contacts between the tread cleats and the road surface can be seen, represented by the gray areas left after the passage of the tire.

In the case where gray spots aren't present, we have the aquaplaning effect, so the design of the tyre must be changed to evacuate more fluid, and it can be done before starting the production in order to **save money** and **time**.

By coupling the FV **airflow solver** with the liquid MPS solver, the gas and liquid phases can be simulated simultaneously, taking into account the interaction with the atmosphere and so the **aerodynamic drag**.



Bibliography

Koshizuka, Seiichi, and Yoshiaki Oka. "Moving-particle semi-implicit method for fragmentation of incompressible fluid." *Nuclear science and engineering* 123.3 (1996): 421-434.

Koshizuka, Seiichi, Atsushi Nobe, and Yoshiaki Oka. "Numerical analysis of breaking waves using the moving particle semi-implicit method." *International journal for numerical methods in fluids* 26.7 (1998): 751-769.