Application of tire multiphysical modeling methodologies for the preliminary definition of a racing motorcycle setup

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Abstract:

Optimizing the performance of racing motorcycles is a central goal for competition teams. The necessity to ensure driver stability and a good level of grip in the widest possible range of riding conditions makes it necessary for tires to work in the right temperature window, capable of ensuring the highest interaction force between tire and road (Farroni 2022). Indeed, the magnitude of the tire-road interaction forces of the motorcycle tackling a specific dynamic maneuver is strictly influenced by the tire structure and the tire compound viscoelastic characteristics, which in turn is strongly influenced by the tire’s layers’ temperatures (Farroni 2018). Specifically, the internal temperature of the tire is a parameter that can be difficult to measure and control but has a significant impact on motorcycle performance and, also, on driver stability. For this reason, deepening the knowledge of internal tire layers temperatures in racing motorcycles, could have an important impact and provide useful information to work on performance optimization on the track and to find the right motorcycle setup. With this aim, Farroni et al. introduced a motorcycle application of their physical thermal model thermoRIDE (Farroni 2020), derived from “Thermo Racing Tyre” (TRT), able to accurately reproduce the tire thermal dynamics in all the vehicle working conditions and to provide the full temperature local distribution inside the tire’s inner rubber layers (Figure 1).

Figure 1. Example of thermoRIDE tire mesh configuration in motorcycle applications.
In this work, the introduced thermal model is adopted for an activity concerning the development of a moto-student vehicle, to predict the racing motorcycle setup allowing the tire to work in a thermal window that optimizes grip and maximizes tire life.

More in detail, a focus has been placed on the effects of the motorcycle’s wheelbase and pivot height variations on internal tire temperatures. Indeed, the stability and handling of the vehicle are highly dependent on the geometric properties of the chassis (Scappaticci 2017). Several values of such quantities have been tested in a properly implemented vehicle model developed in the “VI-BikeRealTime” environment, validated by outdoor tests, able to provide forces acting on the tires, slip indices, and speeds, needed by the thermal model as inputs (Figure 2). Since the thermoRIDE model relies on Fourier’s law of conduction related to a three-dimensional body, it has been also required to identify the thermal diffusivity of each layer of interest employing an experimentally validated procedure (Allouis 2016) to ensure that the achieved results are reliable and consistent. Finally, the model in use needs one last input, which is the extension of contact patches under various load, pressure, and camber conditions. These have been obtained through indoor testing and another experimentally validated procedure. Through the analysis of the internal temperatures calculated by the model, reached by the various layers of the tire, it has been possible to investigate which of the simulated conditions cause a too fast thermal activation of the tire and which of them is able to avoid overheating and underheating phenomena. Furthermore, since having the tires working at the right temperature in the fastest possible time is crucial in a race, various tire warm-up levels via thermal blankets have been tried, to figure out at which temperature and for how long to use them to reach an optimal inner liner and tread core temperature.

![Figure 2. Normal tires forces evaluated from slalom test in VI-BikeRealTime® environment.](image)

**References**


