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Conference Abstract

Performances of bicycle tyres - effect of vertical load and inflation pressure

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Abstract: Tyre characteristics can strongly affect bicycle dynamics, therefore the overall bicycle performances. We already know the importance of longitudinal tyre characteristics (commonly known as rolling resistance), but the lateral characteristics are mostly ignored. Proper testing machines for bicycle tyres are required to measure the lateral characteristics, in order to have a full tyre characterization. The paper presents the results from an experimental campaign on road racing bicycle tyre. Vertical load may affect a lot the tyre characteristics, as well as inflation pressure. Specifically, a variation in vertical load of 50 N may results also in 10% increase in cornering stiffness, the main parameter used to assess tyre lateral characteristics.

Keywords: bicycle dynamics, test-rig, vertical load, lateral characteristics, racing.

1. Introduction

Cycling races are often decided by a few seconds difference, especially in time trial stages. Aerodynamics has already proven to be crucial (Pogni, 2016), but tyres may also play an important role (Baldissera, 2017). Pushing races and athletes to limits requires a proper analysis of every aspect. Tyres should be considered part of the strategy (Dell'Orto, 2022). As you may notice, one never rides a bicycle following a perfect straight line. The balance is given by micro (or macro, mainly depending on the speed) adjustments of the steering (Kooijman, 2011). This is the reason why it is important to fully characterize the tyres.

In addition, we must also consider that tyres may affect bicycle dynamics (Previati, 2019), as they may cause unexpected dynamic instabilities (Bulsink, 2015), (Tomiati, 2019). In light of the growing popularity of two-wheeled vehicles, road safety concerns are also growing. Therefore, more knowledge about bicycle dynamics is needed and appropriate test-rigs are needed to obtain tyre parameters with a high level of accuracy.

In this context, at the Department of Mechanical Engineering of Politecnico di Milano, a new test bench has been designed specifically for the characterization of bicycle tyres (Dell'Orto, G., 2022). It is possible to measure lateral force and self-aligning torque at varying slip and camber angle, vertical load and inflation pressure.

The aim of this study is to have accurate measurements on bicycle tyres lateral characteristics, varying working parameters such as vertical load and inflation pressure. This may be really useful to assess tyres, and set the proper strategy for improving both performances and bicycle stability.

2. Materials and Methods

Experimental tests were performed through VeTyT, an indoor test-rig specifically designed for bicycle tyres. It is the only test-rig for bicycle tyres complying to the standard ISO 9001-2015.

VeTyT is based on a rigid frame, made from Aluminum 6060 T6, and reinforced with plates and steel rods to ensure lightness and sufficient stiffness (Figure 1). The design was focused to achieve both versatility and accuracy of the measurements. A Watt's linkage constrains the lateral motion and measures the lateral force through instrumented bars. The camber (or lean) angle can be set just rotating the whole frame around its longitudinal axis. The latter was defined so that it crosses the contact point tyre/ground. This solution allows compensating vertical vibrations of the wheel due to possible unevenness on the rolling surface. The tyre/road contact point can be displaced only in vertical direction, with in zero longitudinal slip.

The slip angle can be adjusted by rotating the steering shaft. The vertical load acting on the wheel can be varied by adding masses on the frame.

Tyres can be tested mounted both on standard commercial rims or on high-stiffness laboratory rim (six times stiffer in lateral direction with respect to commercial aluminum rim).

Figure 1. Test-rig VeTyT at Politecnico di Milano. It can be used to measure tyre lateral characteristics, as tyre parameters vary.

3. Results

Tests were performed on flat track, employing a road racing bicycle tyre mounted on high-stiffness rim (tyre size: 700x26, from premium brand; TPI: 120). Speed was kept constant during the test at 9.3 km/h, to avoid detrimental increase of temperature which may affect the results.

The effect of different loads and inflation pressure was investigated. We considered cornering stiffness [N/deg] as benchmark for lateral characteristics (Doria, 2019). It is the slope of the lateral force plotted as function of slip angles, when slip angle is equal to zero (Bulsink, 2015).

Increased vertical load for the same inflation pressure means higher cornering stiffness, therefore a quick response of the tyre when turning. This effect is crucial for handling. In addition, it is worth noting that the highest values of lateral forces were recorded for tyre subjected to high vertical loads.

The effect of pressure was then studied. Higher pressures are recommended for higher vertical loads. The challenge is to understand which is the correlation between inflation pressure and vertical load, in terms of tyre lateral performances. In Figure 2, the combined effect of vertical load and inflation pressure can be seen on the cornering stiffness. For vertical loads lower than 400 N, cornering stiffness is higher for less inflated tyres.

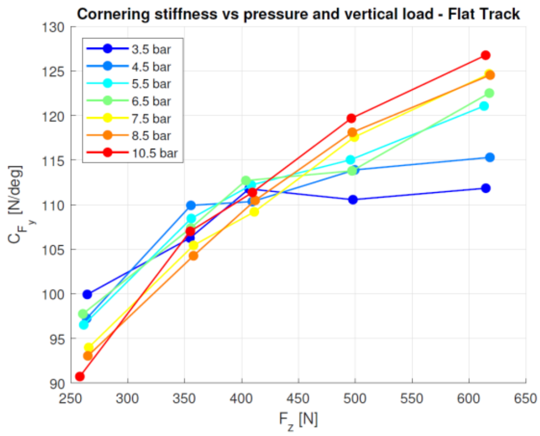

Figure 2. Cornering stiffness as function of vertical load. Lines with different colours refer to different inflation pressure.

By studying the combined effect of vertical load and inflation pressure variation, the importance of proper setting the inflation pressure according to the applied vertical load was found. For low vertical loads, cornering stiffness is higher for less inflated tires. Conversely, by increasing the vertical load, the tires must be inflated more to generate higher cornering stiffness.

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