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Methods for evaluating the radial structural behaviour of racing bicycle wheels

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Abstract

Aim of the work was the development of a test method for evaluating the radial structural behaviour of racing wheels, believed to be correlated with the riding comfort properties. Four front wheels of different shape, material and spoke disposition were equipped with the same tubular tires and tested under radial loads. The wheel/rim/tire load-displacement curves were measured in static, cyclic and bump tests. The stiffness varied with load: despite great differences in the rim behaviour, the wheel overall behaviour resulted very similar due to the tire masking effect.

Keywords: Racing bicycle; wheels; radial loads; stiffness; static; dynamic

1. Introduction

The perceived quality of a racing wheel is related to the combination of several performance parameters with the level of comfort during long cycling tracks on irregular road textures. Cruising comfort is related to the radial behaviour of the wheel assembly, intended as combination of tire and rim. Radial properties of wheels are believed to be dependent on tire pressure and construction, rim profile and materials, spoke design and disposition, hub shape and materials.

Despite the common opinion among cyclists that the wheel radial properties affect the rider's back comfort, previous studies were focusing mainly on the effects of rider's weight (Stone & Hull [1]) or on the frame materials (Hastings *et al.* [2]). Very few studies were analyzing the structural radial behaviour of wheels and their correlation with the degree of rider's comfort. The aim of the present work was the

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development of a standard test method for the quantitative analysis of racing wheels in terms of static and dynamic radial behaviour.

2. Materials

Four front racing wheels (named AF, BF, CF, DF) were selected for the study. Wheels were all equipped with the same tubular tire (Continental "Sprinter" 700x23) inflated at 8 bar, but were different for material, rim profile, spokes number and disposition as summarized in Table 1.

Table 1. Tested wheels characteristics (* mass including tire).

Wheel	Rim profile	Rim material	Hub material	Spokes Nr. Front	Spokes Pattern Front	Spokes material	Mass* Front
AF	Low H 20 mm	Composite	Composite	22	Radial	Steel	850 g
BF	High H 50 mm	Aluminium	Aluminium	18	Radial	Steel	900 g
CF	Medium H 30 mm	Composite	Composite	20	2x	Composite	760 g
DF	Medium H 30 mm	Aluminium	Aluminium	16	Radial	Steel	930 g

The wheels were rigidly supported at the hub axis as shown in Figure 1(a): A servohydraulic MTS 242 cylinder with a 15 kN load cell was used to load the wheels in the radial direction by means of a stiff aluminium plate (Figure 1(b)). The load was applied to the tire and the radial displacement of the wheel system x_W was measured by the cylinder's internal LVDT. An additional LVDT was placed internally on the rim to measure the rim radial displacement x_R: the tire radial compression x_T was calculated as the difference between the wheel and the rim displacements.

The Wheel assembly was considered as the combination of two subsystems, as shown in Figure 1(c): The Rim subsystem (composed by rim, spokes and hub) and the Tire subsystem. The Wheel system resulted to be composed by tire, rim, spokes and hub. The wheel system was modelled by a lumped parameters model (Figure 1(c)) composed by 2 subsystems in series (spring-damper parallel elements) representing respectively the 2 subsystems Rim and Tire.

3. Methods

Three types of radial tests were developed, having different maximum load levels and different loading rates: Static, Cyclic and Bump tests. In the Static radial test the maximum load of 2000 N was reached at a loading rate of 200 N/s (Figure 2(a)): the rational of this test was the simulation of a quasi-static radial overload on the wheel. The Cyclic radial test was developed in order to simulate the load acting on the wheel during its rolling over a flat and smooth surface at a speed of 30 km/h. It consisted in the repeated application at 4 Hz frequency of the load cycle shown in Figure 2(b), composed by a half sine load reaching the peak of 1000 N and a zero load plateau of the same duration. The maximum load rate was about 14800 N/s. The Bump test was introduced to simulate the case when the wheel hits a common obstacle like a road bump. The maximum load of 1500 N was linearly reached at a constant loading rate