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Characterization and Modelling of Various Sized Mountain Bike Tires and the Effect of Tire Tread Knobs and Inflation Pressure

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ABSTRACT

Mountain bikes have become and continue to be the largest segment of U.S. bicycle sales, totalling some 577.5 million USD in 2017 alone. One of the distinguishing features of the mountain bike is relatively wide tires with thick, knobby treads. Over the past two decades mountain bikes have trended from 26" to 29", then 27.5" wheel diameters in various widths with fat and plus-size niche proliferation. Although some work has been done on characterizing street and commuter bicycle tires, little or no data has been published on off-road bicycle tires. Even in the motorcycle and automotive sectors, limited treatment of highly treaded tires is offered in the literature. This work presents measurements of inflated tire profiles, tire contact patch footprints, force and moment data as well as static lateral and radial stiffness for various modern mountain bike tire sizes. Pacejka's Motorcycle Magic Formula tire model is applied and used to compare results. A basic model of the tire lateral stiffness incorporating individual tread knobs as springs in parallel with the overall tread and the inflated carcass as springs in series is derived from experimental tests. Finally, since inflation pressure is an important parameter for mountain bike setup and performance, its influence is also examined.

Keywords: bicycle, mountain bike, tire tread pattern, force and moment, e-bike, motorcycle

1 INTRODUCTION

Mountain biking is a popular recreation and fitness activity which uses a bicycle and components designed to be rugged, to withstand off-road riding, and capable, to handle unpaved surfaces, loose dirt, gravel, mud, etc. Last year 8.69 million people participated in mountain biking in the U.S. alone [1] which saw some 577.5 million USD in mountain bike sales the year prior [2].

Tire behaviour is a critical factor in bicycle performance and safety. Like road or city bicycle tires, weight must be kept low since, except for e-bikes, the rider must propel the vehicle under their own power. Tire durability is important since a flat tire can ruin a ride. Ride comfort, gleaned from the tire deflection, is a consideration even for bicycles with front and rear suspension while performance and grip become even more important when navigating up or down steep grades, dodging trees, etc. In addition to tire size options, a wide variety of tread patterns, made of up individual "knob", i.e. tread element, shapes and depths are available depending on intended use.

As with any sport, mountain biking has a large cadre of enthusiasts. There is much debate among racers, riders, and industry marketing lobbies over optimal tire size, tread pattern, inflation pressure, and, more recently, rim width. While all these things are likely to affect a tire's performance, little or no scientific study of mountain bike tire properties exists in the literature.

In this work, four modern mountain bike tire sizes are characterized through force and moment measurement via the tire test device at University of Wisconsin-Milwaukee [3]. Pacejka's