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Measuring Dynamic Properties of Bicycle Tires

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Abstract

Dynamic tire properties, specifically the forces and moments generated under different circumstances, have been found to be important to motorcycle dynamics.[1][2] A similar situation may be expected to exist for bicycles, but limited bicycle tire data and a lack of the tools necessary to measure it may contribute to its absence in bicycle dynamics analyses.[3][4] This paper describes tools developed to measure these bicycle tire properties and presents some of the findings.

Cornering stiffness, also known as sideslip and lateral slip stiffness, of either the front or rear tires, has been found to influence both the weave and wobble modes of motorcycles. Measuring this property requires holding the tire at a fixed orientation, camber and steer angles, with respect to the pavement and its direction of travel, and then measuring the lateral force generated as the tire rolls forward. Large, sophisticated, and expensive devices exist for measuring this characteristic of automobile tires. One device is known to exist for motorcycle tires, and it has been used at least once on bicycle tires, but the minimum load it can apply is approximately 200 pounds, nearly double the actual load carried by most bicycle tires.[5]

This paper presents a device assembled for less than US$1000 that measures bicycle tire cornering stiffness. It takes advantage of any sufficiently long, level, rigid, and smooth stretch of floor adjacent to a plumb, straight, rigid, and smooth wall to provide the test track. Several purpose-built tracks are also described. A flat and straight track avoids issues created by either vertical or horizontal curvature.

Figure 1. The test device and its track.

Although steer and camber angles must be measured separately, they can be precisely and finely set with rigid turnbuckles in any combination. The orientation of the tire is also enforced and wheel flex minimized by two sets of guide wheels that run on the braking surface of the rim. One is at the bottom of the wheel, near the contact patch, to prevent flexing due to the lateral force generated at the contract patch. The second is at front of the wheel to prevent rotation about the steering axis due to torques generated at the contact patch.

Nearly any sufficiently accurate force measuring system may be used to detect the generated lateral force, and this implementation uses a system from Pasco intended for classroom experiments.[6] The Pasco sensors themselves are rated for only ±50 Newtons, far less than the maximum expected lateral force from the tire, and so a simple lever mechanism, similar to the one Pasco uses on their stress-strain apparatus, is employed to scale down by five-to-one the lateral force generated by the tire, well below the 50-Newton maximum. Three force sensors are used: two to measure lateral force, and one to measure torque.

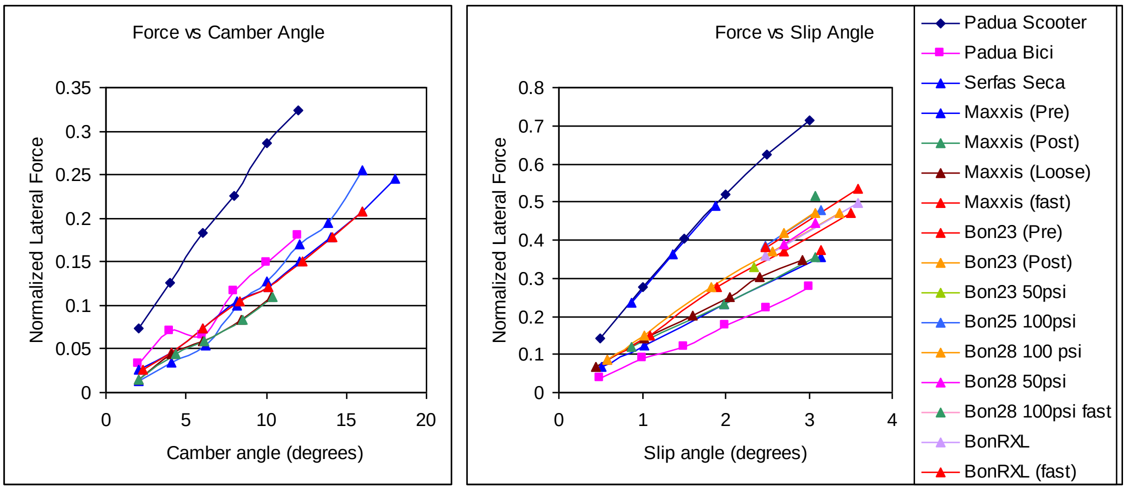

Figure 2. Test data shown along with data reported by Cossalter for a scooter and a bicycle tire.

The bicycle tires tested generate a larger lateral force for a given slip angle and a smaller lateral force for a given camber angle than the bicycle tire tested by Cossalter.

References

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