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Bicycle tyres – rolling resistance

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ABSTRACT

A new test rig for measuring the bicycle tyre rolling resistance is presented. We focus here on the rolling resistance produced by hysteresis and friction related to tyres. The final aim is to enable the assessment of tyre free rolling performance. The test rig is composed by a longitudinal beam with twin wheels. A proper mass applies the desired radial load at the two wheels. A load cell measures the longitudinal force when the wheels roll over a drum whose diameter is 2.6m. Accurate and repeatable measurements are performed.

Keywords: bicycle, tyre, rolling resistance, measurement.

1 INTRODUCTION

The measurement of rolling resistance of free rolling bicycle tyres may seem a simple task, however accurate and repeatable measurements are not easy to be obtained. To the Authors' knowledge, in the literature there is not a proper contribution dealing with the topic in an ultimate scientific way [1].

For automobile and truck tyres there are already on the market dedicated test rigs for measuring rolling resistance [2], according to known standards [3-6]. Presently no standards are available for bicycles.

The focus of the paper is just on rolling resistance of free rolling tyres. The focus is not on the energy requested by the cyclists, nor on the total drag, aerodynamic effects included.

In the literature, a number of contributions have been given on topics that are close to the one dealt with in this paper. In [8-13] rolling resistance of bicycle tyres is estimated together with other relevant parameters referring to drag. In [14,15] the rolling resistance is estimated for cycling on rollers.

In [16] the rolling resistance is estimated for different pressures and radial forces with the coast down method. Such a method requires the estimation of other drag effects that affect the accuracy of the measurement. A study similar to the one in [16] was performed in [17].

In [18] an original method has been conceived by letting eccentrically loaded wheels to oscillate backwards and forwards to highlight the tyre rolling resistance. This does not take into account the proper effect of the tread pattern which encounters the road along a direction only.

In [19,20] former studies on bicycle tyres were attempted.

2 CONCEPT DESIGN AND REALIZATION

The test rig is basically composed by a longitudinal arm which is connected via a load cell to a ground fixture (Fig.1). The arm is positioned on top of the RuotaVia test rig, located at the Laboratory for the Safety of Transport (La.S.T) of the Politecnico di Milano. The ballast on the arm is approximately 90kg. The actual vertical load for a single tyre is nearly 500 N. The load cell full scale is 10 N.

The test rig is apparently simple, but specific design solutions make it quite accurate and the results are repeatable in the long term. The positioning on top of the drum is crucial and deserves special attention.

Two tyres have been fitted to the arm to avoid applying any torque at the load cell; additionally, this arrangement doubles the sensitivity of the test rig.

The drag effects of ball bearings and aerodynamics are treated as follows.

Referring to roll bearings, the effect is measured by applying to the wheel a radial load and measuring the drag at the reference rotational speed. Referring to aerodynamic drag, we keep the one due to ventilation of the wheel but we miss the one coming from forward speed.

Proper measurement of aerodynamic drag are performed in the Wind Tunnel of the Politecnico di Milano.

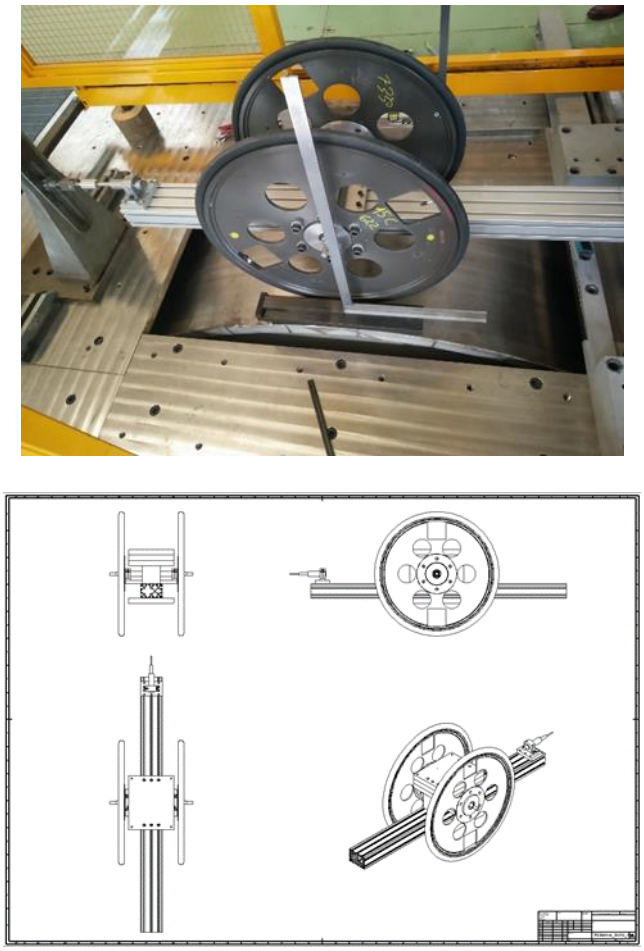

Fig. 1. Test rig (arm) for measuring the rolling resistance of bicycle tyres.

3 MEASUREMENT

Many bicycle tyres have been measured at different inflating pressures and speed, one example is reported in Fig.2.

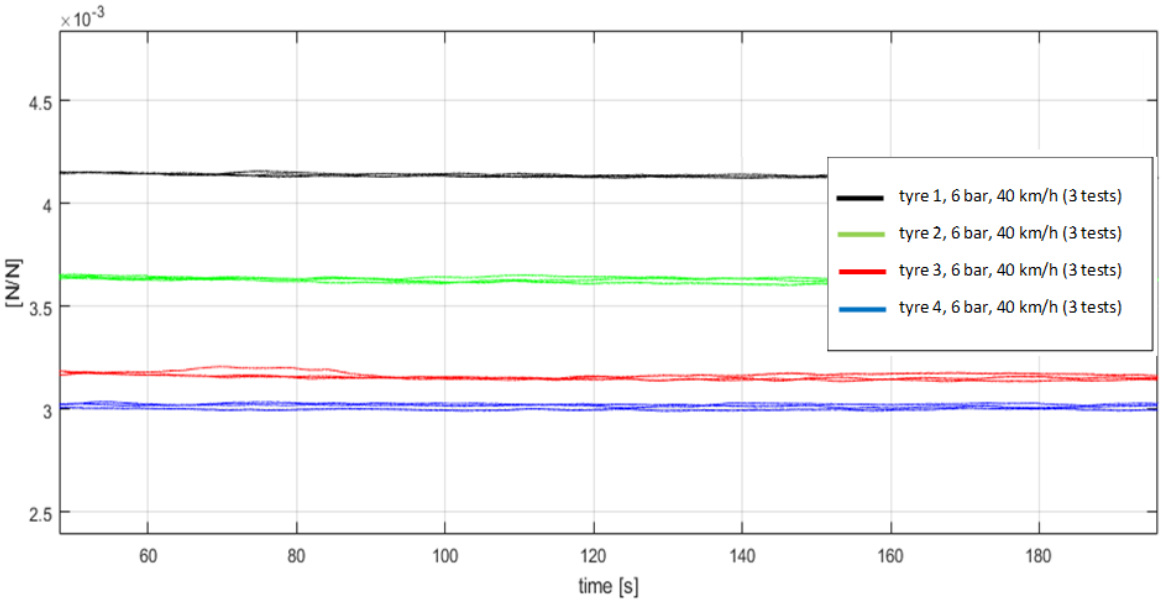

Fig.2. Ratio of the tangential force (drag force) to the vertical force on a tyre.

In Fig.2 the ratio of the tangential force (i.e. longitudinal force, drag force) to the vertical force on a single tyre is given. It can be noticed that the longitudinal force is quite low, the tangential/vertical ratio is approximately few thousandths. In Fig. 2 the longitudinal force is reported as function of time to show the influence of disturbance, mostly due to the tyre out of roundness. Each test is repeated three times. We see that the repeatability seems sufficient for accurate measurements.

4 CONCLUSIONS

In the paper a new test rig to measure accurately the rolling resistance of bicycle tyres is presented. The test rig is basically a beam with twin wheels. Despite the simple assembly, the positioning on the drum top is quite difficult since an extreme geometrical accuracy is needed. After such a problem has been solved, the measurements that have been obtained have been quite satisfactory since accuracy is within 0.1N and repeatability of the same order of magnitude.

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[3] https://www.mts.com/cs/groups/public/documents/library/dev_002230.pdf

[4] ISO 28580 Passenger Car, Truck and Bus Tires – Single Point Test

[5] ISO 18164 Passenger Car, Truck, Bus and Motorcycle Tires

[6] SAE J1269 Steady-State Procedure for Car and Truck

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