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Conference Abstract

Experimental Measurement of Transmission Performance: Sensitivities to Hardware Design and Test Implementation

George C. Barnaby [1],*, Jason M. Yon [1], Stuart C. Burgess [1], Ben J. Hicks [1], and Robert T. Wragge-Morley[1]

[1] Department of Mechanical Engineering, Queen's Building, University of Bristol. BS8 1TR. UK

* Correspondence: (GCB) george.barnaby@bristol.ac.uk

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Abstract

Introduction: The performance of bicycle transmissions is of interest to the cycling sector for both elite racers and amateur hobbyists. Significant efforts are made by professional teams and individual cyclists to maximise the performance of transmission through equipment choices, gearing selection, and choice of lubrication. Correct selection can improve the physiological efficiency of a rider, increase the power efficiency of a transmission, and better the longevity of components. Transmission performance in cycling applications can be assessed practically by different methods and reviewed in the literature [1,2]. The most common test equipment are chain dynamometers, where there are two major types: Transmitted Power Measurement (TPM) and Frictional Power Measurement (FPM) dynamometers, also known as Full Load Test and Full Tension Test respectively.

The different dynamometer types have associated loading and boundary conditions, resulting in nuanced differences in contact mechanics and lubricant behaviours in the articulating links of chains under test. Consequently, comparing results from different testing methods, and extrapolating the applicability of results to real-world circumstances, is a non-trivial task and there may be significant error associated with oversimplified comparisons of these conditions.

Materials and Methods: In this study, analytical models from the literature [3] are adapted to illustrate the effect of the different boundary and loading conditions between common dynamometer types used in both academia [3,4] and industry [5,6]. The study is extended with empirical data from a TPM dynamometer (Fig. 2). Sophisticated control of the driving electric machine is exploited to deliver a cyclist's pedalling torque profile to the driving sprocket of the transmission, and average performance determined over a shaft revolution.

Results: Tension in links around the transmission are quite different between TPM and FPM dynamometers due to the differences between the high-tension tight span and low-tension slack span (Fig. 1). Predicted friction in articulating links is also subtly different, varying by up to 4.8% in the tested envelope. Empirical results from a TPM dynamometer demonstrate the dependency of cycling specific loading conditions on the test measurand (Fig. 2), where sinusoidal torque increases losses by 7.4% on average across the tested envelope.

Conclusions: Boundary conditions and loading conditions are shown both analytically and empirically to affect the measured performance of a transmission under test where previously conditions have been assumed to be nominally alike. This demonstrates that measured performance is sensitive to the testing conditions and care should be taken in comparing similar, but not identical, test environments as well as extrapolating results to real-world use-cases.

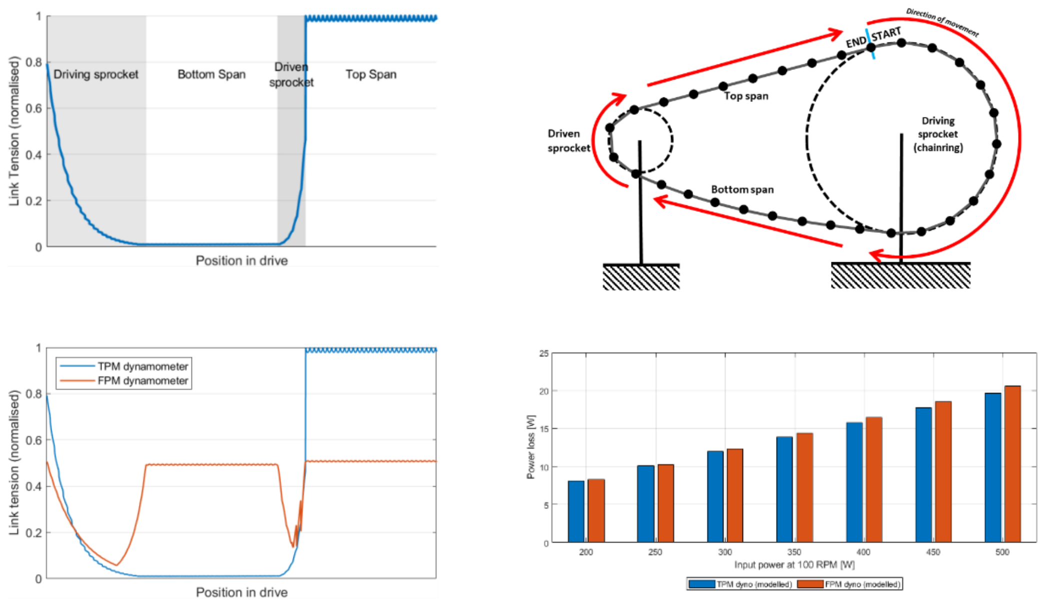

Figure 1. Modelling the effect of boundary and loading conditions on link tension around a dual sprocket drive for two dynamometer types, and frictional power loss between FPM and TPM

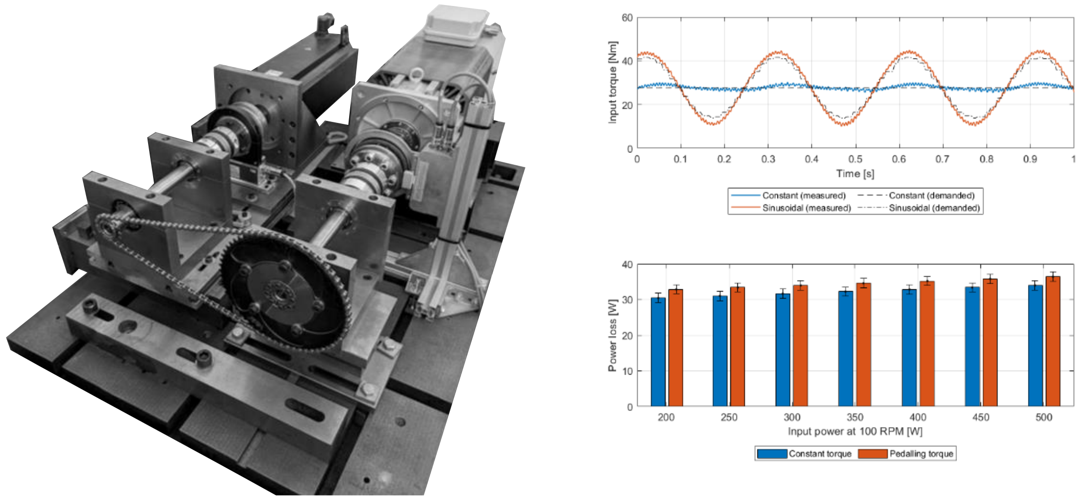

Figure 2. Sophisticated Transmitted Power Measurement (TPM) dynamometer, with measured torque input and power loss results for constant and sinusoidal pedalling torque profile.

Keywords: Transmission, Efficiency, Model, Losses, Testing, Dynamometer.

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