A Model for the Elastodynamic Analysis of the Geared Timing System of a Motorbike Engine

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Abstract
This work deals with the elastodynamic model of the geared valvetrain of a four-cylinder “L” engine of a Ducati racing motorbike. The model, which is an evolution of the author’s research, is obtained as a combination of lumped parameter and finite element parts. The model is able to inspect the dynamic behaviour of both the geartrain and the cam-valve mechanisms. The paper mainly describes the model validation process that is based on several experimental tests and it is achieved by means of different steps. The information obtained from the validation stages have been finally employed for the tuning of the combined lumped/finite element model of the geared timing system. The experimental procedures are also illustrated, together with some details on the signal treatments. The comparison between simulations and experiments shows that the effectiveness of the model is satisfactorily assessed, thus permitting the use of the model as a tool for the design optimisation of the motorbike timing system. The results obtained for the competitive motorbike engine can also be utilized for common production engines, where conformity to vibration and noise standards must be fulfilled.

1 Introduction

In the field of motorcycle industry the effort to preserve and improve durability and reliability of the motorbike engine, as well as the research to reduce engine vibration and radiated noise, have become increasingly crucial due to more stringent requirements for higher performance, increased engine power, low fuel consumption and low cost. In order to optimize the engine performance, the attention is addressed to the control of the gas exchange cycle because the mixture formation and the combustion process strongly depend on it. From this point of view, a proper functioning of the engine valvetrain is decisive to achieve high overall performance. It is therefore indispensable to assure accurate valve timing and to operate for valve vibration lowering, so as to optimise the engine combustion characteristics.

The engine valves are driven by cam mechanisms (the usual cam-valve mechanisms with springs for valve closure, the recently developed pneumatic cam-valve mechanisms, or the distinguishing desmodromic cam-valve mechanisms), whereas a geartrain is often adopted for transmitting power from the crankshaft to the camshafts, especially in the case of the high speed engines. The gear train guarantees a more precise valve timing at high engine speeds, if compared with chain or belt transmissions. However, the gear backlash seriously affects the geartrain dynamics and may cause unstable behaviour that could worsen the valve timing. In addition, an inaccurate behaviour of the geartrain results in additional dynamic forces that reduce the durability and stability of the system, and becomes a source of noise as well as other undesirable phenomena (e.g. gear rattle) [1].

Nowadays the elastodynamic analysis represents an integral tool of the design process [2, 3, 4]. In particular, the development of elastodynamic models for the vibration analysis of the engine timing system makes it possible to match durability and reliability with high-performances and lower vibrations.