Dynamic analysis of a motorbike engine timing system: Experimental and numerical investigation of the geartrain

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Abstract

The development of high-performance vehicle engines requires advanced investigations in order to provide engineers with proper analysis tools to optimize the system design. The elastodynamic behaviour of the engine powertrain may be critical at high velocities (when the flexibility of the system components can have a major role on the overall performance) with consequences on the valve timing and the transmission of dynamic loads. A thorough numerical/experimental investigation was performed on the timing system of a racing motorbike engine. The timing system included the geartrain, which transmits power from the crankshaft to the camshafts, and the valve train, formed by the camshafts and the cam-follower mechanisms for the valve actuation. An experimental campaign was designed and carried out with the purpose of inspecting the timing system behaviour for different velocities and different design parameters. A numerical model was developed in order to provide a simulation/analysis tool that permits the design optimization of the main system components. The present work focuses on the geartrain elastodynamic analysis, which is the main novelty of a long-lasting activity carried out by the authors in collaborations with Ducati Motor Holding S.p.a. (Bologna, Italy). The experimental campaign, the model development and validation, and some simulation results are reported and discussed.

1. Introduction

The efforts to reduce engine vibrations and radiated noise, while improving durability and reliability of the system, are increasingly important for the automotive industry due to more stringent requirements for higher performance, increased engine power, low fuel consumption, low noise and low maintenance cost. In order to optimize the engine performance, major attention is addressed to the control of the gas exchange cycle because of its influence on the mixture formation and the combustion process. In this perspective, a proper functioning of the engine timing system (composed of the valve train and its driving transmission chain) is crucial to reach high overall performance [1]. It is therefore essential to assure accurate valve timing and to operate for valve vibration lowering, so as to optimise the engine combustion characteristics. The limitation of vibrations and dynamic loads is also important to guarantee high durability standards of the system. These issues are particularly significant for high-power engines and for high-performance applications where requirements for a good efficiency are very stringent.

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