ABSTRACT

Cam follower mechanisms with variable lift of follower offer considerable potential to reduce fuel consumption and enhance the performance of automotive engines. Variable lift of follower is also useful in profile cutting and power transmissions. Objective of present work is to propose a variable lift cam follower system (VLCFS), for the lift variation of follower motion. Novelty of proposed system is variation of follower lift with respect to camshaft speed has been obtained mechanically, without any power driven actuators and electronic control units. VLCFS is a combined system of a cam, follower and centrifugal actuator. It comprises of a trapezoidal shape cam with varying height along the axis of camshaft, which rotates and slides in the axial direction. When camshaft speed varies, sliding motion of cam has been executed by a centrifugal actuator. Displacement profile of a cam, which is in contact with follower changes due to sliding motion of cam. Consequently, the follower lift varies with respect to cam profile in contact.

A comprehensive design procedure for synthesis and design of VLCFS elements has been presented. Special attention has been paid to synthesizing and manufacturing of cam profile. The present thesis deals with synthesis, design and analysis of VLCFS to investigate the performance characteristics. Performance characteristics at three influencing sections such as actuator, follower and cam follower interface are investigated. These include cam displacement, controlling force, radius of rotation, peak lift variation, lift profiles, acceleration, residual vibration and jump. More emphasis is given on the investigation of lift characteristics, as these represent the ultimate output of VLCFS. Lift characteristics are predicted by simulation and verified by the experimental approach. Computerized experimental setup has been developed to measure the follower lift and cam translation at different speeds. Experimental and simulation analysis are carried out using actuator springs of stiffness 320 N/m and 1750 N/m, with highest peak lift speed of 600 rpm and 1180 rpm respectively. Follower peak lift variation range of 5 mm to 11 mm is considered for this investigation.
Present investigation states that, VLCFS works satisfactorily for variation of follower lift. Centrifugal actuator is found to be useful for obtaining the sliding motion of cam. Lift variation result shows, with actuator spring stiffness of 320 N/m, peak lift is found to be 10.25 mm at 600 rpm. With actuator spring stiffness of 1750 N/m, peak lifts are found to be 6.7 mm and 10.25 mm at 600 rpm and 1180 rpm respectively. Average deviation in follower and kinematic lift is found to be 2.1 % by simulation, whereas 9 % in experimental analysis. No significant effects of actuator forces have been found on follower response and jump characteristics. At constant speed, VLCFS and CCFM (conventional cam follower mechanism) imparts same peak lift motion to follower. However, VLCFS works as CCFM at constant speed with an added advantage of lift variation with respect to speed. Good concurrence has been found between design, simulated and experimental lift characteristics.

The proposed VLCFS is a mechanical system, which has a potential to vary the follower lift continuously with respect to camshaft speed, without any power driven actuators, sensors and electronic control units. With suitable modifications, VLCFS can be used in various applications such as valve trains and cam based infinitely variable transmissions (IVT). Qualitative and quantitative information provided in this investigation that will be of great value to the designer and manufacturer in the development of new variable lift cam mechanisms.

**Key words:** VLCFS, mechanism, trapezoidal cam, variable lift, centrifugal actuator, spring stiffness, dynamic response.