REVIEW ON CRITICAL SPEED IMPROVEMENT IN SINGLE CYLINDER ENGINE VALVE TRAIN

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ABSTRACT
The purpose of valve train is to operate the inlet and outlet valves of the engine. The valve train mainly consists of rocker arm, push rod, cam, poppet valve and spring for keep the valves closed position. The Greaves G400W/G engine valve train is operated at the maximum speed of 3600 rpm. The main objective of this project is to improve the valve train speed up to safe speed limit that is up to 5000 rpm.

The valve spring parameters are optimized based on space availability, stress limit, stiffness, buckling of pushrod and natural frequency of the system. The optimized valve spring configuration is used in the push rod type valve train and the valve train dynamics for different engine speed is studied using commercially available multi-body dynamic ADAMS software. A comparative valve train dynamics analysis is also carried out with the existing and optimized valve spring combinations. It is observed that valve jump engine speed with respect to optimized valve spring is enhanced to considerable amount when compared to the existing valve spring configuration. Design improvements include detail study on following topics:
1. Valve Spring Stiffness.
2. Push rod buckling.
3. Valve closing Velocity.
4. Contact stress between cam and follower

KEYWORDS: Valve train, Computer Aided Engineering, ADAMS, Stiffness, Buckling, Valves, Valve Spring, Push rod, Valve Cam shaft.

INTRODUCTION
The function of the valve train mechanism is to use the intake and exhaust valves to control in a timely way the entry of charge and the exit of the exhaust gas in each cylinder following each cycle of engine operation. The valves must respond quickly to the valve train and they must seal against the combustion pressures and temperatures. The poppet type of valve has a low lubrication requirement, low friction, simplified sealing, easy adjustment, and low cost. Therefore, it has been the most commonly used valve in four-stroke engines.

The valve train system should be optimally designed so as to avoid an abnormal valve movement, such as valve jumping or bounce up to the maximum engine speed. In earlier valve train systems, valve lash used to be set manually during initial installation and readjusted at regular maintenance intervals by means of adjusting screws and shims. When the engine is in motion, the dynamic forces like normal reaction forces, frictional forces, Impact forces on the timing chain may cause considerable effect on the function of the valve train & hence on valve. The effect is prominent when the engine is at high speed. In this project work, the dynamic analysis of valve train system insights on design and optimization of the speed of opening and closing of valve.

Fig Valvetrain schematic and nomenclature

OBJECTIVE OF WORK
To improve the speed of engine valve train without any failure of contact between cam tappet and cam.

**LITERATURE REVIEW**

After the study of SAE paper it is found that there is Andrew J G Whitehead (1) proposed the best method to improve the critical speed of engine valve train. The valve spring parameters are varied based on an iterative logic with constraint on space availability, stress limit, stiffness and natural frequency of the system. The optimized valve spring configuration is used in the push rod type valve train and the valve train dynamics for different engine speed is studied using commercially available multi-body dynamic ADAMS software. The kinematic and dynamic properties are analyzed by using ADAMS software.

**METHODOLOGY**

The existing valve train of engine is center pivot OHV type of valve train, a flat face or roller hydraulic lifter can be used as a cam follower. It is a single cylinder engine with rated output range from 7-7.7 kw at 3600 rpm for CNG, LPG, and Gasoline. The maximum torque obtained should be 23-27 Nm at 2700 rpm. The dimensions of engine are 86 x 68 x 395 mm. The orientations of crank shaft horizontal, with liquid cooling of engine. The maximum operating speed of valve operation is 3600 rpm.

The Royal Enfield engine is considered as the bench mark for the contact stresses. The maximum value of contact stresses between cam and roller tappet should not exceed 1200 Mpa. The engine valve train operating speed i.e. the speed of cam shaft shall be improved from 3600 rpm to 5000 rpm without failure of pushrod, rocker arm, valve, and the contact stresses should be less.

By referring Phil Carden(1) paper to improve the valve train speed i.e. speed of cam shaft. The speed is changed by adjusting the valve spring stiffness, the current valve spring stiffness is 23.05 N/mm at 3600 rpm. According to the valve spring stiffness the forces comes to 7.8 mm valve lift on the pushrod, cam, cam tappet, rocker arm valve etc. should be calculated analytically and by using ADAM software speed should be calculated on different values of the spring stiffness.

The contact stresses between the cam and roller follower having cylindrical to cylindrical contact present, the pushrod and rocker arm having sphere to sphere contact present, and the rocker arm and valve head having sphere to sphere contact, the contact stresses should be calculated by using Hertz contact stresses theory. The force required to lift valve upto 7.8 mm it depends upon the stiffness value of the spring. The force come on the pushrod should be calculated by using rocker ratio. The pushrod buckling should be checked for different spring stiffness values. To find the natural frequency of the valve train the overall valve train stiffness and effective mass of the system. The effective mass of system should be depends upon the mass of valve, spring, retainer, pushrod, rocker arm, and tappet. The overall stiffness depends upon the stiffness of cam/ tappet, pushrod, rocker arm, and cylinder head pedestal fulcrum. After completing the analytical calculations the cross verification of the forces, pressure, stresses, deflection and speed should be checked by using software solution.(2-10)

**EXPERIMENTAL VALIDATION**

The experimental validation of finalized spring and other valve train components is done by replacing the old components with the modified parts. The validation includes effect on emission, valve train speed and the rated output of engine should be studied.

**RESULT AND DISCUSSION**

Flexible multi-body engine valve train dynamic analysis is carried out to predict engine speed at which the valve train components lose their contacts and optimized the valve spring design. In order to capture the dynamic behavior of the valve train system closely, each coil of the tested valve springs is modeled as separate flexible body and the contacts between coils of these flexible bodies are also established. A comparative valve train dynamics analysis is also carried out with the existing and optimized valve spring combinations. The comparative study reveals that the proposed optimized valve spring configuration works properly even beyond the engine speed of 5000 rpm where the valve train component separation will be observed in case of existing valve spring combinations.

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