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Extended Abstract

Improvement of Full-Load Performance of an Automotive Engine Using Adaptive Valve Lift and Timing Mechanism

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Abstract

This paper describes an improvement of full-load performance of an internal combustion engine using Adaptive Valve Lift and Timing Mechanism (AVLT). AVLT enables engine power improvement by increasing valve timing and lift at high engine speed and load operating regions. It utilizes engine fluids pressure difference with respect to engine speed to actuate the AVLT mechanism which will make the valve lift higher and longer duration at higher engine speed and loads. Since engine speed and load can be linearly correlated to these pressures, a mechanical sliding arm valve actuation mechanism is constructed based on their transient behavior. Therefore, a continuously dynamic valve lift profile with respect to engine speed can be achieved to increase brake power of the engine. Dynamics analysis performed using MSC Adam software showed that tappet translation increased by 32% from 9.09 mm to 12.01 mm by varying translational skate position between 0^{o} and 10^{o}.

Keywords:

Variable valve timing; Charge formation; volumetric efficiency; Brake power; BSFC

Introduction

Direct fuel injection has been used in internal combustion engines to improve volumetric efficiency of internal combustion engines which results in increased heating value of cylinder charge for specific power improvement. It also enables charge stratification and UN throttled operation which is favorable for improved thermal efficiency. Compressed natural gas spark ignition engine can significantly benefit from direct fuel injection due to the problem with displaced air in the intake manifold that reduces output power in port fuel injection system. Compressed Natural Gas Direct Injection (CNDGI) engine is fuel-efficient, environmentally friendly and offers low overall vehicle ownership cost. By understanding the behavior of CNGDI engine, changes can be made in order to improve thermal efficiency and performance including optimization of compression ratio, valve lift- timing profile, as well as design of exhaust and intake manifolds.

One of the major aspect in improving engine performance lies on the optimization of valve lift and timing of an intake valve. The intake (as well as exhaust) valve profile determine the quantity and quality of air-fuel mixture in the combustion chamber, which affects the power produced. In spark ignition engines, intake valves close during the initial part of compression stroke and the spark plug ignites the air-fuel mixture at the end of the stroke, creating a force that eventually propels the car forward. Most engines have intake and exhaust valves at the top of the cylinder. Other engines, however, may put the valves on the sides. The valves can also be in a combination with one valve on the top of the cylinder and the other located on the side.

Analysis of Adaptive Valve Lift and Timing

Analysis of adaptive valve lift and timing were made to determine the improvement of high end performance using Adaptive Valve Lift and Timing (AVLT). It includes mechanism modeling, dimension analysis and engine simulation test with chosen engine specifications. The mechanism was designed so that it can possibly be mounted on the engine head and improves valve lift and duration upon actuation. The valve lift, duration and timing were varied to determine the improvement of using AVLT.

Dimension Analysis

Dimension analysis was carried out using MSC Adams to analyze the translation of tappet. Translational skate positions were varied to determine

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the differences in tappet translation. The position of translational skate is set so that the minimum translation position is matching with the default valve lift and timing of the cam profile would have do and is set to the maximum translation of tappet the mechanism can do. Figure 3 shows the maximum translation of skater position and is set as reference angle for this analysis.

Engine simulation test

In order to determine the effect of AVLT to the engine performance, engine test simulation was done by using Lotus Engineering Software. With this software, engine parameters can be input to the engine map in various conditions. By using the results from dimension analysis, valve lift and duration data were inserted to the valve specifications thus the performance result on power, torque, mean effective pressure, specific fuel consumption and volumetric efficiency can be acquired. Figure 6 shows the engine map constructed in Lotus Engineering Software with Camaro 1.6 engine specifications.

Conclusion

This study has demonstrated that using AVLT mechanism in an engine has a potential to improve high end performance with respect to fuel efficiency, volumetric efficiency and output power. Dynamics analysis performed using MSC Adam software showed that tappet translation increased by 32% from 9.09 mm to 12.01 mm by varying translational skate position between 0° and 10°. The Lotus Engineering software simulation showed that brake power at speed between 5000 and 6500 rpm increased between 2 to 7%. Maximum torque improvement was realized at 7000 rpm while BSFC was reduced by up to 2% at 7000 rpm. The increased in brake power and torque are direct results from volumetric efficiency linear improvement between 1.5 and 6% at speed range of 5000 to 7000 rpm. AVLT mechanism design is flexible where oscillating follower can be shaped so that it can fulfill the desired valve lift and duration which can be applied to any internal combustion engine. The combination of forwarded and retarded in maximum translation of AVLT improves high end performance the most.

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