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A
PROJECT REPORT
ON

"Piezoelectric Control Hydraulic Stacks for Camless Engine"

(Project Reference No. 37S0751)

BACHELOR OF ENGINEERING
IN
MECHANICAL ENGINEERING

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ABSTRACT

Keywords: Better fuel economy 09-12% increase, Higher Torque & Power 10-15% increase, avoid NOx, Increased air motion & improved combustion by using asymmetric valve lifting, Altered firing order, Reducing noise of engine, etc.

Presented a synopsis of the advanced development, design, manufacture, and analysis of a piezoelectric controlled hydraulic actuator for the camless engine. This actuator was developed for use as a replacement for the camshaft in an internal combustion engine (IC Engine). Its development results in a new device is called cam-less engine (C. L. Engine).

Since the early 1999's, there was a fluctuating interest in the research of cam-less engines operating on without camshaft and its various technologies. Recently, cam-less engines are receiving more interest from many scientist due to many reason including (1) the national concerns of the liquid fuels limited resources, (2)the environmental issues and (3) the needs to use a reliable, durable and efficient engine., The Cam-less engines research focus on utilizing the replacing the camshaft by using cam-less engine in IC engines, while using piezoelectric device controlling hydraulic spool valves as operated inlet and outlet valves of IC engine. The Cam-less engine research gained more higher power & torque, better fuel efficiency due to the demanding of vehicles, as a cam-less engine. Produced from renewable resources with lower resources (when it burns it produces: insignificant SOx, little NOx and little amount of CO2). Furthermore, because of the high demand of two wheeler vehicles (Motorcycles), it can be used in conventional spark ignition engine with minor modifications, with comparatively high efficiencies of power, torque, ecofriendly, good fuel efficient to camless engines. The system design utilized a customized piezoelectric stack and hydraulic spool valve combined with an in-house designed hydraulic amplifier. Control is facilitated by a function generator, and feedback is monitored with an oscilloscope.

The resulting system is capable of displacing an engine valve to nearly 13 mm, and frequencies up to 500 Hz have been obtained. The proof of concept can be considered successful, as it demonstrates the ability of piezoelectric control of hydraulics for use as an IC Engine's

valve actuator. Furthermore, the device has demonstrated potential areas of improvement that can be implemented in a third generation cam-less engine.

Looking back on this project, the overall outcome of results was successful. This can be evaluated by looking at how well our objectives were met. Out of the three objectives we created, we accomplished two of them. Our first objective, to conceptual development and implement within a Rs.57000 budget was collect by spending only Rs.36000.Our next one objectives, to design, manufacture and assembly of an cam-less engine, select a hydraulic spool a/ cylinder that meets specifications and construct an poppet valve, deal with the design aspect of our project and were all achieved based on our initial performance result and running of the engine. More specifically, the electronic control unit we constructed is able to read engine speeds from 0 to 5000 rpm and vary the valve timing depending on engine speed and vehicle operator inputs. However, our final objective, to obtain gains in horsepower, torque, and fuel efficiency is 09-12%. Our engine was stable enough to withstand the weight and pull force of a dynamometer, which meant we could obtain the necessary results. We are confident though that this objective can be met if more time for testing is given by spending Rs.18000.

Initially, the boundary interface of the design had to be well defined. This is divided into three discrete components. First, the connections to the spool valve needed to be outlined. Next, the interface with the engine valve stem needed to be studied. Finally, the systems envelope needed to fit within the available space on the test stand. The provided spool valve had standard four port control valve connections as dictated by ISO 4401. These dimensions are illustrated in Figure 1 and the table below.

Following a consultation with the manufacturing group at Siemens Petrol Systems Technology (PST), Pune, MH, INDIA the final piston design was completed. This design created the basis for the development of the remaining components, including the bore plate and the cylinder block for completing this part we need some budget then cover the overall project only in Rs.5000.

The major components that make-up the cam-less engine actuator are set of ¼ hp motor Gear pump of above 10 bar pressure create, 2 cylinder block, 2 small piston, and the piezoelectric control unit on operated over the plc delta. Additional elements include the fasteners, o- rings. The control of the cam-less engine system is facilitated by a series of electrical components that ultimately supply of electronic control unit and a variable voltage to piezoelectric device.

The following are the conclusions that can be drawn from the theoretical and experimental investigations of this thesis:

1) Perception of benefits of cam-less technology compared to engine size &displacement.

2) Potential benefits of cam-less technology from the view point of fuel consumption & emission reduction.

3) Assembly issues of cam-less technology in comparison with a conventional variable valve timing valve-train.

4) Servicing benefits & issues

5) Identification of secondary benefits of cam-less valve-trains for both the OEM and the final to customer.

6) Provide a fuel economy of about 9-12% by proper & efficient controlling of the valve lifting & valve timing.

7) Reduction in the engine size & weight. Will be resulted in increased power output.

8) Cam-less engines can slash nitrogen oxide, NOx, Pollution by about 30% by trapping some of the exhaust gases in the cylinders before they can escape.

9) Market Potential. 10) Technologies affected by the possible achievement in cam-less engine system.

11) From that cam-less engine technology achieved upto 210CC capacity engine & maximum power 27.5 KW with maximum torque 67 Nm.

12) Giving maximum speed upto 3600 rpm.

13) Un-throttled part- load operation by early intake valve & closing valve.

14) Cylinder & valve deactivation.

15)2 Valves operation carried out in the project.

16) Asymmetric valve lift can be used to increase air motion & improved combustion.

17) Altered firing order. 18) 4 stroke operation.

19) Fuel consumption reduction of upto 15% & lower engine out emission in the drive cycles are possible.

20) Alternative operating cycles, such as Miller cycle and Atkinson cycle.

21) Cam-less Valve trains can enables improvement in transient response & increased engine torque can also be achieved, particularly at low engine speeds.

The author proposes future scope and work to be focused on the following areas:

1. A pressure chamber to supply disturbance pressure in the hydraulic spool valve test-bench setup is needed. It can be used to test both the proposed induced-voltage based pressure estimation and the piezoelectric control Unit controller.

2. The estimates of terminal velocity and current at the end of the approach control trajectory are rather noisy. This limits the convergence speed of cycle-adaptive controllers. Better interpolations and data smoothing schemes should be applied to improve these estimates.

3. The on off current controller utilized in the experimental section is rather crude. If more work is done in the modeling, voltage-based feedback linearization may be applied to achieve much better current tracking and subsequently improve approach controller performance.

4. Terminal ILC would be much more effective if constraints and cost functions can be easily incorporated.

5. Piezoelectric control Unit controller is not the only direct search algorithm. Despite its advantages, its theoretical convergence conditions have not yet been found. Other direct search algorithms such as Rosen rock and Pattern search should be investigated to see if they can perform better than the piezoelectric control Unit controller (PLC Delta) algorithm on hydraulic spool valve actuator control.

6. Depending on how quickly disturbances change, the cost associated with a vertex can become outdated and should be replaced. One way to prevent this problem is to associate disturbance estimation information with the simplex vertices. If any earlier simplex vertex has disturbance estimate different from the rest, it should be replaced quickly. If this scheme is successful, the ramp disturbance rejection performance of the piezoelectric control Unit controller should improve.

7. Approach controllers in this thesis are limited to using cycle-based compensation. However pressure disturbance can and does vary greatly between consecutive cycles. This design is very realistic for the future of the automotive industry as well as our education. With the recent developments in electromagnets, this technology has become more feasible with production models currently in development by BMW and Lotus. Currently, Lotus had been presenting a marketable design in 2008. This advanced technology is improving engines as we know them.