ISSN 2395-1621

Pneumatic Actuated Valve of IC Engine

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ABSTRACT

Normally, the valve is operated by a "cam" system, which controls valve opening (down-stroke), while the valve "return", i.e. the closing movement (up-stroke) is the result of the action of some kind of spring. The duration and phase of the valve timing on an internal combustion engine has a significant effect on emissions, fuel economy, and power. This effect will vary depending on the operating conditions, such as engine speed and load. Therefore, in applications where operating conditions are expected to vary significantly (such as a car), the ability to continuously and independently vary the duration and phase of the valve timing is highly desirable. Pneumatic valve systems refer to valve actuation systems that are able to change the duration and/or phase of the valve timing on an internal combustion engine.

ARTICLE INFO

Article History

Received: 9th June 2018

Received in revised form :

11th June 2018

Accepted: 13th June 2018

Published online :

13th June 2018

I. INTRODUCTION

Internal combustion engines have been the main source of propulsion for cars and trucks for over a century. The constant demand for reducing transport related emissions leads to a constant search for improvements in fuel economy. This forces manufacturers to seek new solutions where efficiency increases can be found. One of the vital focus areas on the internal combustion engine (ICE) is the gas exchange process. The inlet of induction air and outlet of exhaust gases are governed by poppet valves, and in almost all ICEs the valve operation is performed by camshafts. One of the reasons for the popularity is its inherent synchronization with the piston movement. However, this means the engine can only be optimized for a certain engine speed and load and significant efficiency increases can be gained if the valve timing could be varied. Camshaft-based variable valve timing (VVT) can be applied, but these systems are limited due to its mechanics and hence not fully variable. Furthermore, generally speaking, these systems do not allow variable valve lift, only variable valve timing. Another solution is to get rid of the camshaft altogether and use e.g. pneumatics or hydraulics to power a fully variable valve train (FVVT) that also is variable for each valve and cycle to cycle. To better optimize engine performance across the entire operating range AVL SPEAB wants to explore this through an electronically controlled pneumatic/hydraulic valve actuator (EPVA) system that allows completely variable lift, duration and timing. A functioning FVVT will be a valuable aid in the search for improvements in fuel efficiency. In addition to VVT, it also makes it possible to test various concepts – such as different combustion modes (2, 4, 6-stroke etc.), Miller cycle* and temporary valve shutdown – without the need to have costly rebuilds the between each test.

II. LITERATURE SURVEY

1. By Hazem I. Ali, Samsul Bahari B Mohd Noor (A Review of Pneumatic Actuators (Modelling and Control))

The pneumatic actuator represents the main force control operator in many industrial applications, where it's static and dynamic characteristics play an important role in the overall behaviour of the control system. Therefore improving the dynamic behaviour of the pneumatic actuator is of prime interest to control system designers. This paper is a review of literature that related of the pneumatic actuator systems. In particular, the innovations in different control strategies applied to pneumatic actuators along with the modelling, controlling and simulation techniques developed for different applications of pneumatic actuators are reviewed. The review concentrates also on the analysis, investigation, performance, practical constraints, nonlinearities, uncertainties and the new applications of the pneumatic actuators.

2. By W.K. Lai, M.F. Rahmat (Modelling and Controller Design of Pneumatic Actuator System with Control Valve)

Pneumatic actuators offer several advantages over electromechanical and hydraulic actuators for positioning applications. Nonetheless, pneumatic actuators are subject to high friction forces, dead band and dead time, which make fast and accurate position control difficult to achieve. This research paper presents the process of controller identification, design, modeling and control for pneumatic actuator system. System Identification approach is used with the purpose to estimate the mathematical model of pneumatic actuator system and for controller design. Data collection of input and output signal of the system has been performed from experiment procedure. This data is used for estimate the model by selecting Auto-Regressive Exogenous (ARX) model as a model structure. The accepted model is based validation test namely as residual correlation, Akaike Final Prediction Error and best fit percentage. Different control schemes such as PID and LQR (Linear Quadratic Regulator) have been applied for controller design.

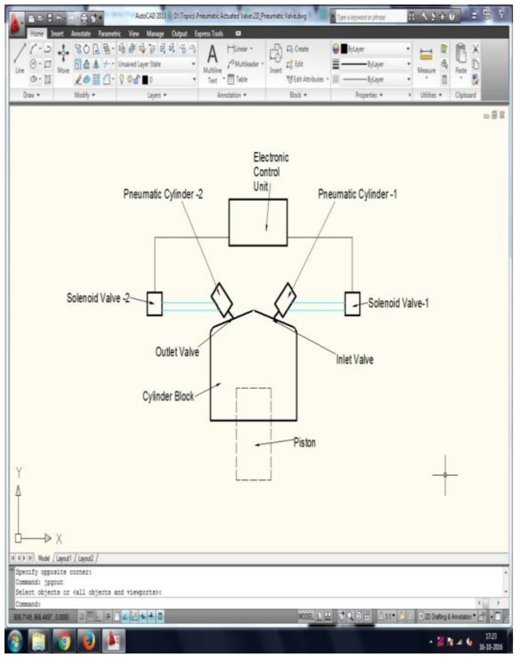
3. By T. Nguyen, J. Leavitt (Accurate Sliding-Mode Control of Pneumatic Systems Using Low-Cost Solenoid Valves)

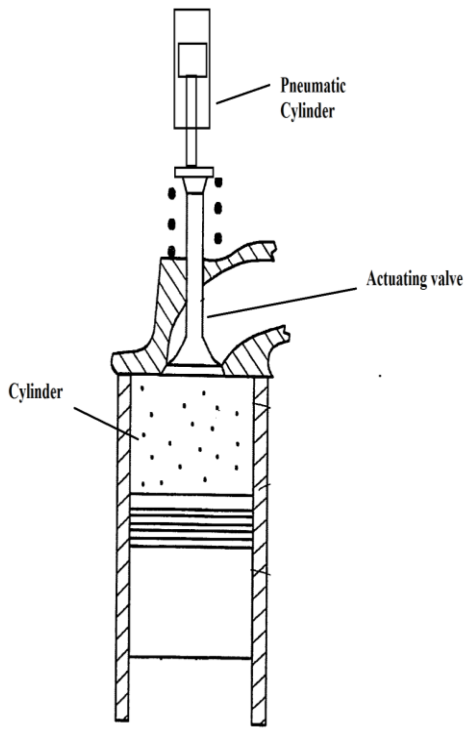
Pneumatic actuation is becoming more popular recently due to decreasing component costs and recent improvements in valve technology. Today's valves are faster, less expensive, and more accurate than valves made previously. Pneumatic actuators are known for their clean operation, high force-to-mass ratio, and easy serviceability. In most previous work, servovalves, rather than solenoid valves, have been used for pneumatic actuation applications. For example, McDonell and Bobrow, developed a hierarchical feedback linearized controller for force and position tracking of a pneumatically actuated robot. Surgenor and Vaughan used a servovalve in conjunction with a sliding mode control approach to achieve excellent performance. Other researchers have included the dynamics of the servovalve as part of the control design to achieve higher performance (see, for instance, Richer and Hurmuzlu or Richard and Scavarda). Unfortunately, servovalves like the ones used in the abovementioned research are usually expensive because of the high-precision manufacturing needed to produce them and because of the need for a built-in orifice area control circuit. With faster and more accurate valves now available, solenoid on/off valves can potentially be used to replace servovalves. One method for controlling systems with solenoid valves is to use pulsewidth modulation (PWM) to effectively approximate the flow properties of a servovalve with solenoid valves. As a result, it allows control laws derived for servovalves to be used with on/off valves. For example, Shen et al.used PWM to create a sliding mode control signal in conjunction with the so-called "equivalent control" signal, necessary to keep the system dynamics on the sliding surface. Varseveld and Bone developed several PWM schemes to effectively linearize the relationship between the modulator driving voltage and the load velocity. It was demonstrated in Noritsugu that if this linear relationship is established, the highly nonlinear pneumatic system will be easier to control with a higher level of accuracy.

Actuation Systems

Actuation systems are the elements of control systems which are responsible for transforming the output of a microprocessor or control system into a controlling action on a machine or device. For example, we may have an electrical output from the controller which has to be transformed into a linear motion to move a load. Or, we might have an electrical output from the controller which has to be transformed into an action to control the flow of liquid into a vessel.

Model diagram





Computer Aided Engineering (CAE) in Design

It is the broad usage of computer software to aid in engineering analysis tasks. It includes Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD) , Multi body dynamics (MBD), and optimization.

CAE areas covered include:
Stress analysis on components and assemblies using Finite Element Analysis (FEA)

Thermal and fluid flow analysis Computational fluid dynamics (CFD)

Multibody dynamics (MBD) and Kinematics

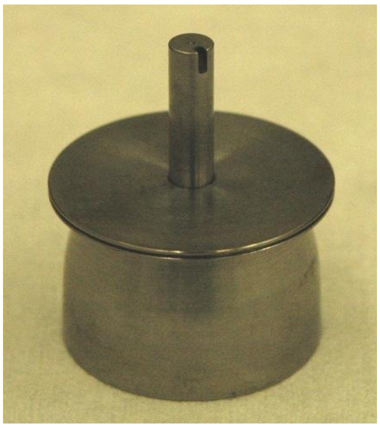
Analysis tools for process simulation for operations such as casting, molding, and die press forming.

Optimization of the product or process.

Three phases in any computer-aided engineering:
Pre-processing – defining the model and environmental factors to be applied to it. (typically a finite element model, but facet, voxel and thin sheet methods are also used)
Analysis solver (usually performed on high powered computers)
Post-processing of results (using visualization tools)

Variable valve actuation
In a camless FVVT there is an infinite flexibility in terms of varying the valve opening and closing times as well as valve lift. Each valve is controlled by an individual actuator and each valve can therefore be activated freely from each other. This presents a lot of optimization possibilities for gas exchange and combustion processes and a whole range of new concepts.

Free Valve Technology
The EPVA, called "Free Valve Technology", has been invented and developed by Swedish company Cargine Engineering AB. Each actuator‡ (see figure Free valve actuator with piston left image) controls one engine valve each and consists of an actuator piston (AP) (figure Free valve actuator with piston middle & right picture), cylinder, two solenoids, two spool valves, two port valves and a hydraulic latch. Solenoid 1, called the timing solenoid (TS), controls a spool valve and the hydraulic latch. Solenoid 2, called the lift solenoid (LS), controls another spool valve. In turn, the spool valves controls the air entering the actuator cylinder.

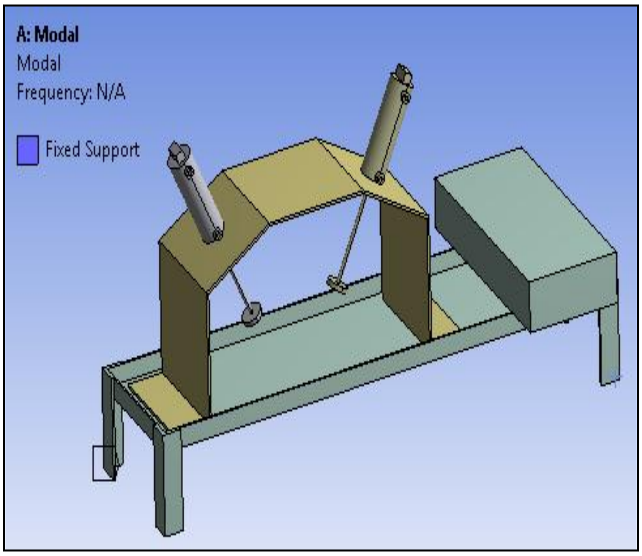


Free valve actuator with piston

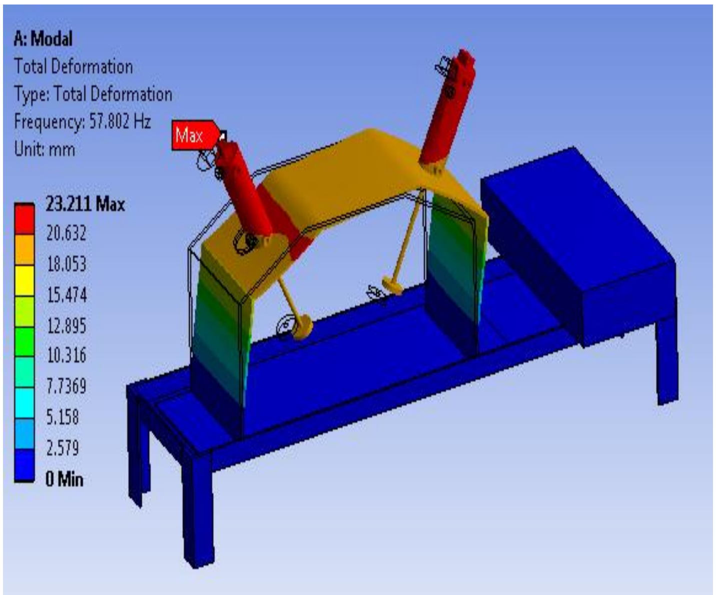
The compressed air powers the piston which presses on the engine poppet valve, causing it to open (see figure Actuator detail). To better describe the dynamics of the system

Analysis result on cylinder:-

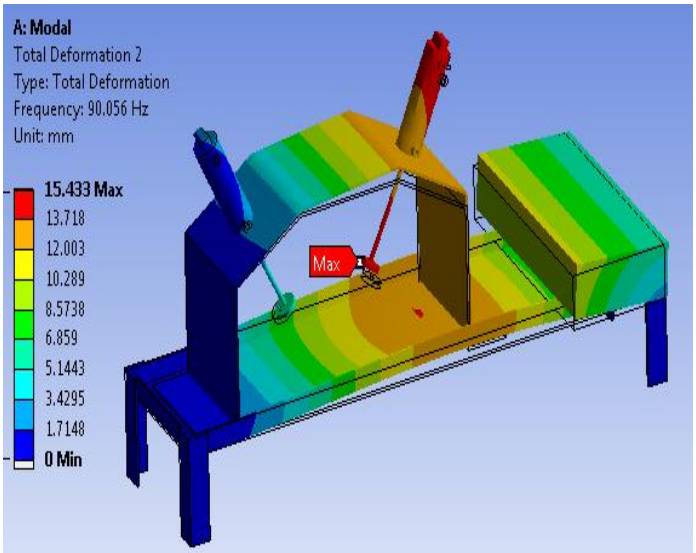
Boundary Condition



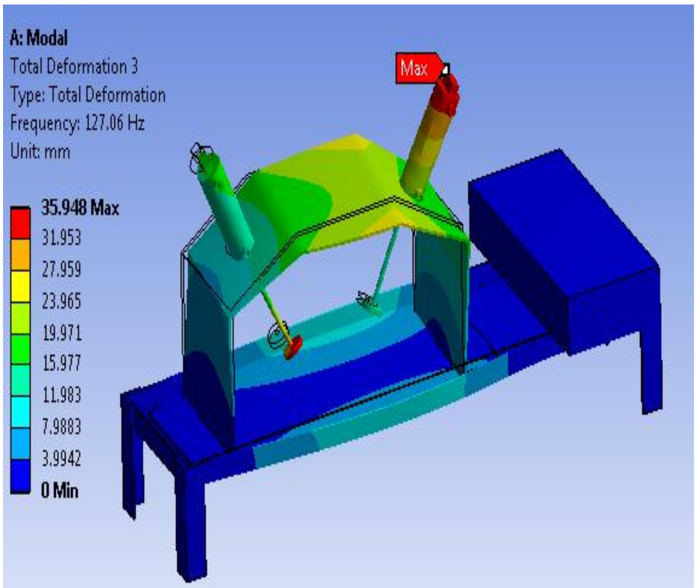
Total Deformation Result
MODE 1



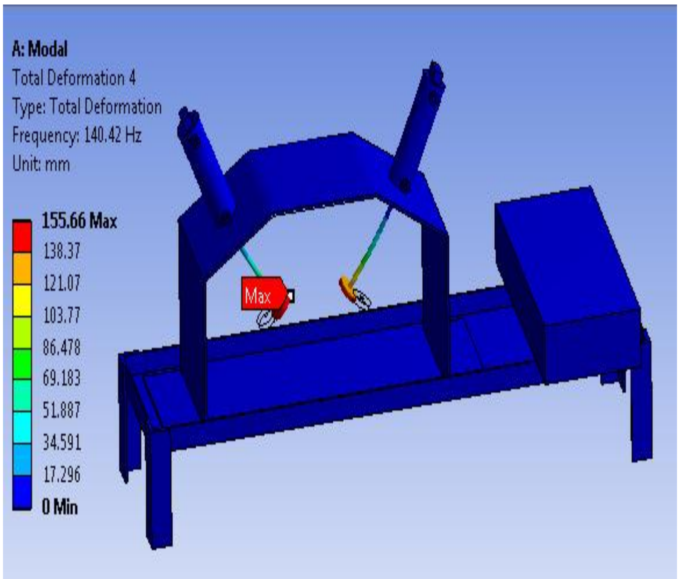
MODE 2



MODE 3



MODE 4



OBJECTIVE:

1. To reduced frictional loss.
2. To reduced mechanical losses due to Rocker arm.
3. Revised Mechanism for the working of valves of IC engine

Scope

This project aim is to provide new control system for actuation of intake and exhaust valve of engine. It replaced the present cam follower actuation system with pneumatic cylinder. Pneumatic cylinder actuated by solenoid valve. Timing for actuation is set in micro-controller. Controller passed signal to solenoid valve. In this prototype we use cylinder block, which has one inlet and one outlet for intake and exhaust of air supply. There will be two pneumatic cylinder will be placed at intake and exhaust valve respectively. The pneumatic cylinder actuation will be controlled with help of solenoid valve. Solenoid valve will be controlled by using microcontroller.ECU is used to set the timing of actuation of pneumatic cylinder.

Methodology

SEMESTER I

-We started our work with literature survey.
-Search many research papers from various articles and published journal papers.
-Reference sites:

1. http://explore.ijert.org/
2. http://www.ijetcse.com/
3. http://industrialscience.org/
4. http://www.ijist.net/

-Worked on diff. Mechanisms that can be useful for our project.
-We have done a rough 2D sketch of model in Auto-CAD.
-After getting rough model we started calculation of some components.
-We selected standard components.
-Simultaneously we have done work of report for semester I.

SEMESTER II

Actual preparation of project:

-We will complete calculations of remaining parts.
-We will purchase standard components from market.
-We will be done a rough 3D model of our project.
- Manufacturing will be done.
-Assembly will be done.
-Testing of set up will be done.

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