Variable length intake manifold for small combustion engines

Project plan

Introduction

Our goal is to build a VLIM (variable length intake manifold) for a small combustion engine. The VLIM will provide better power and torque across the power band as well as providing better fuel efficiency. The VLIM will be built on a 10 Hp Briggs & Stratton engine, which is mounted on a test rig. Once we got a working mechanism, we will compare the power and torque output from the engine with and without the VLIM.

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Starting point

We have a test rig, which consists of a 10 Hp 4-stroke combustion engine, 7.5 kW servomotor and a frequency converter. The engine is connected to the motor by belt drive.

How the variable length intake manifold will be built is decided later.

Targets

Target for this project is to build a continuously variable length intake manifold. The intake manifold length is adjusted according to engine operating speed. We also will make the intake manifold control system to upload current running parameters in the Internet, for example Twitter.

Preliminary ideas

The position of the throttle body will be kept constant. Instead we will build a U-shaped intake pipe, which consists of three parts: Two stationary pipes, one attached to throttle body and the other to the engine block and the third moving U-shaped pipe which position is adjusted by a stepper motor rotating threaded rods.

Realization

Tasks:

- Research what kind of mechanism are used in commercial products (no commercial continuously adjustable manifold available)
- Components: Two straight pipes, one moving u-shaped pipe, stepper motor, threaded rods, Arduino as a platform to control manifold length and an additional microcontroller to upload statistics to internet. RPM measurement components (already placed on the motor) and a measurement system to measure intake manifold position.
- Coding
- Building of electronics
- Assembly
- Testing

Coding, assembly and testing will be done together with another course project for which the test rig is being built.

Schedule

We will have detailed plans at the end of first period. Working VLIM at the mechatronics circus.

Documentation

Our team constructed a variable length intake manifold device shown in fig 1. The device consists of a u-shaped pipe that is connected to two straight pipes at its ends. The u-shaped pipe can be moved axially and thus the length of the piping can be varied. The two connection points of the pipes are covered with rubber boots in order to keep dust and other contamination away from the engine intake air. A stepper motor connected to a threaded rod adjust the length of the intake. The stepper motor is controlled as shown in fig. 4.

The optimal length for intake manifold can be calculated by modeling the system as a Helmholtz resonator. (http://www.ijstr.org(final-print/may2014/Analysis-Of-Change-In-Intake-Manifold-Length-And-Development-Of-Variable-Intake-System.pdf).

Length for the intake manifold was decided so that the volumetric efficiency of the cylinder could be optimized between 2600 and 3500 rpm. This gave the needed lengths for the intake manifold to be between 100cm and 60cm. It might have been possible to build an intake manifold with more adjustment capabilities, but our U-pipe solution gave quite good working range with reasonable size and manufacturing complexity.
In the figure 2 the end of the u-pipe is shown. The limit switch is connected to the end of the system and detects the end position of the manifold adjusting range. During the start-up procedure, calibration is done using the limit switch. After the start-up calibration the position of the manifold is calculated from the stepper motor control values. This proved to be accurate enough for the needs of this project.
The throttle body shown in figure 3 is controlled by Arduino Mega. The throttle body was built for the Bricks & Scrappin project and further details are available on its documentation.

For the IoT application of the machine a separate Arduino Uno with ESP8266 wifi module was used. A separate microcontroller was used because the functionality of measuring the rpm of the engine has to work fast and code related to the wifi implementation is too slow for this. Arduino Uno reads values of throttle position and lambda sensor and tweets them.

Final configuration and system explanation is given in figure 4.
The arduino codes for the intake manifold and the throttle body are available as an attachment.

codes.rar

Budget

We already have the sensors, actuators and hardware available at the Aalto Industrial Internet Campus Innovation Lab. Some minor purchases may or may not be needed.

Update: u-pipe and rubber boots were bought from a local moped tuning store.