

Cylinder Head Intake Flow Analysis

Badih Jawad

Lawrence Technological Univ

Selin Arslan

Lawrence Technological Univ.

ABSTRACT

In order to achieve optimum performance from an engine a homogeneous air fuel mixture must enter the combustion chamber. There are a number of factors that affect the mixture; this study focuses on the flow through a cylinder head port. This paper investigates the shape of a cylinder head port effects on the flow of the port and the horsepower and the torque of the engine. Two port shapes were examined, the stock port shape which is round and a modified port shape which is approximately an upside down triangle. By using computational and experimental analysis a direct relationship is demonstrated between the shape of the port and the performance characteristics of the engine.

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INTRODUCTION

Homogeneous air /fuel mixture entering the combustion chamber is the key to achieve an optimum performance from an engine. There are multiple factors that affect the homogeneity of air/fuel mixture. This study focuses the air/fuel flow through a cylinder head port. In the literature, there were studies to determine the shapes selected for the cylinder head port were a better shape than the stock port shape [1].

One of the most important characteristics of the cylinder head is how the air/fuel mixture is delivered to the combustion chamber. A cylinder head port that is mis-sized can cause the air/fuel mixture to fall out of suspension or "puddle" on the floor of the port. This will cause a loss of horsepower and torque in the operating range of the engine. Flow bench testing of the cylinder head in modified and unmodified form can give some idea of the horsepower and torque that "may" be developed in the engine. A dynamation program was used to help evaluate what the theoretical power output should be. In the car testing of the unmodified and modified cylinder head is a much better indicator of the performance of the engine. This was performed and the results are presented using the "G Tech Performance Meter" and the computer program "G PASS" to present the data.

Many of the current cylinder head port designs do not take into account where the air/fuel travels in the intake port or how to keep the fuel from falling out of suspension. This study focuses on where the air/fuel mixture travels and how

to maximize the cylinder head port design shape to improve not just the airflow through the port but the quality of the air/fuel mixture entering the combustion chamber.

Droplets of fuel, which are not in homogenized state entering the combustion chamber, will not burn. This will contribute to the loss of power and increased emissions of the engine. If too much swirl is induced to try to homogenize the mixture, the fuel can be thrown against the cylinder wall, which is detrimental to the rings and can cause oil dilution.

While the performance of the engine is dependent on the amount of air entering the combustion chamber, it is argued that the quality of the mixture is also important. The port design introduced in this paper, will try to combine increased flow and improved quality of the mixture when it enters the combustion chamber.

SYSTEM ANALYSIS

The port shapes that are available have advantages and disadvantages. The round port shape ports have been in production for a long period of time and recognized well and have more intakes that are readily available for each of them. The round port also has an advantage of years of testing and manufacture. The new port design has the advantage of increased flow with a smaller port volume and better port flow quality of the mixture that will be entering the combustion chamber [2].

With the increased demands being placed on the auto companies to increase performance and fuel economy to

reduce emissions will take a new approach to how the mixture is delivered to the engine. This is a big disadvantage for the round port shape. The disadvantage of introducing a new port shape is a limited information database, a completely new shape and thought of how the air/fuel mixture travels through the port.

Design Objectives

- Increase overall vehicle drivability through creating an increase in the quality of air/fuel delivered to combustion chamber.
- Increase power
- Increase torque
- Decrease emissions through better fuel atomization
- Enhance throttle response through improved air/fuel management

TESTING PROCEDURES

The testing procedure involves 4 steps:

1. Ideal Analytical Flow Analysis
2. Flow Bench Analysis
3. Computational Analysis
4. Experimental Testing.

Analytical work was formulated based on literature survey, books and SAE papers. This information helped arrive at a conclusion on the port shape that combines all the principles that should maximize airflow and air quality. [Figure 1](#) shows a CAD drawing of the final shape of the intake. According to the analytical results, this shape provided the best flow gradient that was necessary to achieve complete fuel atomization.

The next step is to find a suitable engine with lightweight, aluminum cylinder heads and throttle body fuel injection or carburetion. The Geo Metro engine was according to the parameters of the design. The engine was light of weight; the aluminum cylinder head had round cylinder head ports with thick walls for easier porting. The engine has throttle body fuel injection, this was chosen so that it could be shown that the fuel would not fall out of suspension but would achieve a more complete fuel atomization through superior port flow. Three cylinder heads were acquired, one was used for measurement, one cylinder head was left in stock configuration and one cylinder head was modified. The modified cylinder head and the stock cylinder head were given valve jobs.



Figure 1. CAD drawing of tri-shape port attached to bore

FLOW BENCH SETUP

After the engine was chosen two of the cylinder heads' valve were improved, then one cylinder head was modified to the shape that was determined to be optimal. The shape that was chosen was roughly an upside down triangle. From experience at the race track and the flow bench analysis done on other types of cylinder heads it was determined that the majority of the flow occurs at the roof of the port and less flow was at the floor of the port. By maximizing the area of the roof more flow could occur and by minimizing the floor of the port the smaller cross section would increase the flow velocity which would help to keep the fuel in suspension or even re-atomize the fuel that tried to fall out of suspension [3]. [Figure 2](#) shows the cylinder head with a flat roof and triangle shape floor. The roof of the port was larger in cross section than the round port for an increase in flow and the shape is so that a flow velocity gradient would be present [4].



Figure 2. Cylinder head with port modification

Both cylinder heads were then mounted on the flow bench at Lawrence Technological University, a SF 600 and the results are listed. All flow figures are at 25 inH₂O and was not corrected but taken from the readout given. [Figure 3](#) shows an SF 600 flow bench at Lawrence Technological University, cylinder head shown mounted on flow bench.