Air Intake Data Acquisition and Analysis of a four-stroke engine using FSA Bosch Engine Analyser

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Abstract *Internal combustion engine resemble an air pump, the more air that flows through it, the more the horsepower it produces. Therefore, the control of the air inlet flows investigation. To know how each flow characteristics; Air Pressure inlet, Air Temperature intake, and Theoretical Airflow rate calculation largely affect the performance of reciprocating engines. The purpose of this article published the result of an experiment. The airflow system. The experiment was conducted using FSA Bosch engine analyzer. Where air intake temperature, pressure, and theoretically calculated airflow rate is obtained. The experiment process repeated at different configuration. Air configuration measured by using additional electric air blower flow in through the intake manifold to observe and obtain any alteration in the engine performance.*

Keywords*: — intake manifold, naturally aspirated engine, air configuration, airflow, four-stroke engine*

1) INTRODUCTION

The intake and exhaust valves design significantly influence the combustion system efficiency. Power output, fuel consumption, emission (thermodynamic properties) are directly influenced by volumetric efficiency and the combustion chamber charged motion. On the other hand, if the manifold flow path is too restrictive, the desired high air velocity and turbulence are not reached, and this will consequently affect its capability in carrying fuel droplets as well as in enhancing evaporation and air-fuel mixing [1].

For all of these targets to be met, an appropriate design of the inlet ports will obtain charged motion and a high flow pattern. Horsepower will be made unless additional fuel is also added. Air fuel mixture in a combustion chamber produces energy that makes horsepower in an engine. Therefore, every two horsepower produced requires one pound of fuel per hour. The airflow pattern susceptibility is both the paths it takes and speed/flow rate into the combustion chamber and out of the engine[2]. The primary tests shall be the pressure, temperature and the theoretical calculation flow rate of the S4PH Proton Campro engine. If the tests carried out are consistent, no need for atmospheric conditions of machine variations.

2) LITERATURE REVIEW

2.1 Material of Intake Manifold

History has it that cast aluminum alloy is the commonest material used in the fabrication if intake manifold system. Specifically, cast aluminum alloy (AlSi2), polyamide composite and magnesium alloy. However, the prevailing material used in production still is the aluminum alloy.

The design of intake manifolds for internal combustion engines came into prominence when the desire to increase the engine's overall output took place at the 1940s.

2.2 An Insight to Manifolds

Detailed activities in an intake manifold during engine combustion obtained. The fluid (air) in the system is sloshing forth and back due to its inertia, bouncing against the resilient gas in the resonant cavities; there are compression and expansion waves traveling through the gas, reflecting from closed and open ends, and from changes in the area. The gas in the intake branch from the manifold to the valve subtly considered a transient mass; it is compressible. A string of minor masses associated with modest spring's wave can toss around along the branch. The waves are butt-centric in this section. A literal activity taking place in an intake manifold during combustion is obtained. The fluid (air) in the system is sloshing backward and forward due to its inertia, bouncing against the resilient gas in the resonant cavities; there are compression and expansion waves traveling through the gas, reflecting from closed and open ends, and from changes in cross-section [2].

The gas flowing through intake manifold is subtly transient. It is compressible. Tiny masses of spiral waves connected by tiny springs hence the backward and forward wave travel along the branch. These waves are analyzed methodologically. Considering the gas sees a larger area, the registered gas is the other type (Compression wave mirrors as expansion and extension wave as pressure) and if the incident wave sees a smaller area, the reflected wave is term same. The theory mentioned above is literal concerning unsealed ends. The prolog to wave displaying of a solitary barrel with one intake system framework engine.[2]

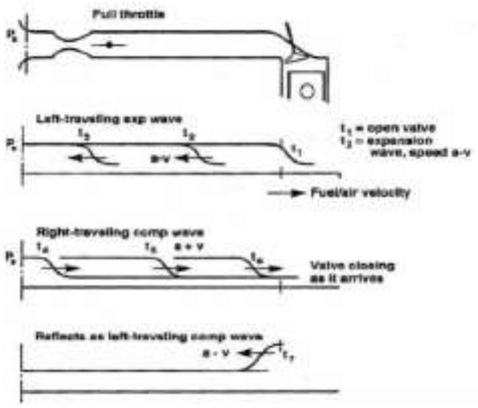

Figure1: The figure illustrates a schematic representation of wave action in the inlet manifold [2]

3) EXPERIMENTAL SET-UP

3.1 Apparatus and Instrumentation

The experiment carried out with complete apparatus and installed air configuration from a regulated electric air blower coupled to the FSA Engine analyzer.

The power system specification culled from the Proton S4PH manual, the FSA Bosch Engine analyzer, and all instruments are as follows:

A. Engine Specification

TABLE 1

Model	Proton Campro SP4H 1.6 Liter
Valve	DOHC 16 Valves
Number of Cylinders	Four (4)
Bore x Stroke	76.0mm x 88.0mm
Total displacement	1597cc
Compression ratio	10:1
Fuel System	Multi-point injection (MPI)
Cycle type	Four (4)
Max Output (KW/rpm)	82/6000
Max Torque (Nw/rpm)	148/4000

B. Engine Analyzer

TABLE 2

Make	Bosch
Model	FSA 740/720
Type	DSI

C. Electric Air-blower

TABLE 3

Make	Pensonic
Model	PSF-46A
Air flow rate	54 m^3/m

3.2 Engine Testbed set-up

The SP4H machine coupled to the engine analyzer FSA 740

Temperature, pressure and air intake flow rate at the idle, half and full input (rpm). The plugs/probes in the FSA Bosch engine 740 are placed in the MAP-Manifold Air Pressure body, in the same location with the Intake Air Temperature (IAT).

The figure below shows the device test-bed both the naturally aspirated engine test bed. Indicated also is the schematic diagram of the electric air blower used to add more air into the intake manifold.

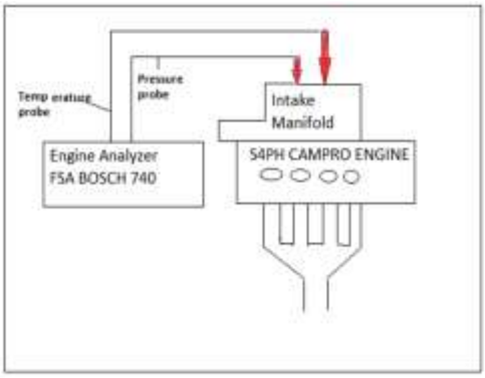

Fig 2: Schematic arrangement of the naturally aspirated engine test set-up

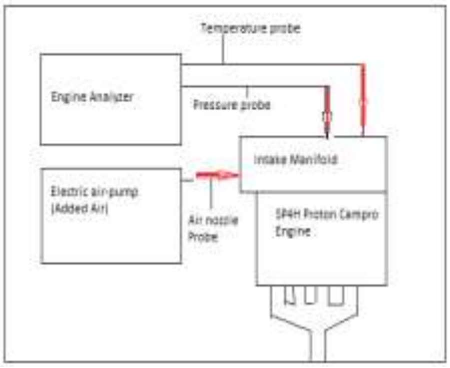

Fig 3: Schematic arrangement of the added air and the naturally aspirated engine test set-up

3.3 Design of Experiment

Design of Experiment(DOE):

Input Parameters: Engine Speed (RPM) and Air intake configuration.

Output Parameters: Frequency(Hz), Pressure(Pa) and Temperature(°C).

Input Parameter				
A	Engine Speed (RPM)	1 (Idle) 1000	2 (½) 3000	3 (Full) 6000
B	Air intake Configuration	Stationary 1	Blowed 2	

The above table 4 shows the input which will determine the flow characteristics, the output, and

Airflow rate to be discussed and verified by results obtained as trials demonstrated in the naturally aspirated and air-configuration engine system.

Using the engine analyzer, the pressure and temperature at idle, half and full throttle (WOT) known and acquired sequentially.

For the naturally aspirated engine, the experiment was conducted by plugging in all necessary probes to appropriate location on the intake manifold of the S4PH Campro engine. The engine switched-on and the ignition were initiated. Taking after fifteen minutes of running the engine, the FSA Bosch motor analyzed at various phases of the info - Idle, half, and Full throttle-WOT.

Engine switched off to cool and to be even with the ambient temperature. Three (3)consecutive trials for each parameter stated/given (Section 4) performed for 25 minutes. These particular experiments were performed nine (9) times.

For the added air engine- additional air configuration through an electric air-pump delivering air at the rate of 54m3/min into the air intake manifold. The flow characteristics fully acquired by repetitive trials just as conducted with the naturally aspirated engine.

3.4 Theoretical Airflow for the Engine

Knowing the theoretical airflow in cubic feet per minute (cfm) the car can take in at a given engine speed determines volumetric efficiency. In order for the engine to burn efficiently, the amount of air, displacement, maximum rpm and number of stroke calculated theoretically.

The equation to calculate theoretical airflow is:

$$TAF = \frac{(ED)(rpm)(VE)}{(ES)(C)}$$

Where:

rpm = maximum design rpm
TAF = Theoretical air flow (ft^3/minute)
VE = Volumetric efficiency (100% theoretical)
ED = Engine displacement (in^3)
ES = Engine stroke (2 for a four stroke engine)
C = Conversion factor from in^3 to ft^3 [3]

3.5 Theoretical Average Of Flow Characteristics

The average of trials per flow characteristic calculated theoretically to acquire the proper data to plot output against the input:

$$T_{average} = \frac{1st\ trial + 2^{nd}\ trial + 3^{rd}\ trial}{3}$$

The equation applies to all the input and output parameters- Idle, half and full throttle (WOT), when the additional air was static or in motion for input, flow rate, pressure, and the temperature respectively}.

The design of experiment tabulated, where all the trials performed for both the naturally aspirated and air configured engine test bed recorded and documented. The output characteristics that were computed culled from the FSA Bosch Engine analyzer (specifically, the pressure and temperature) while the airflow calculated theoretically.

Calculations showed beneath $T_{airflow}$ computed in the table.

$$T_{air\ flow\ rate} = \frac{ED \times RPM \times VE}{ES \times C}$$

Where:

ED, Engine displacement = 97 in^3
RPM, 6000
VE, Volumetric efficiency = 1.00
ES, Engine stroke = 2 for a four stroke engine
C, Conversion factor from in^3 to ft^3
Solving for $T_{AIR\ FLOW} = \frac{97 \times 6000 \times 1}{2 \times 1728}$

$= 168\ ft^3/\ min$

$= 4.8\ m^3/\ min$ (After conversion from ft^3 to m^3).

When in half throttle, the theoretical air flow will be 2.4 m^3/ min and in idle, it is 1.6 m^3/ min.

Table 5

INTAKE			
	Q (m^3/min)	P (bar)	Temperature (°C)
A1 B1	1.60	0.32	31.00
A1 B2	19.60	0.39	45.00
A2 B1	2.40	0.28	42.00
A2 B2	29.40	0.50	55.30
A3 B1	4.80	0.81	52.30
A3 B2	58.80	1.06	64.00

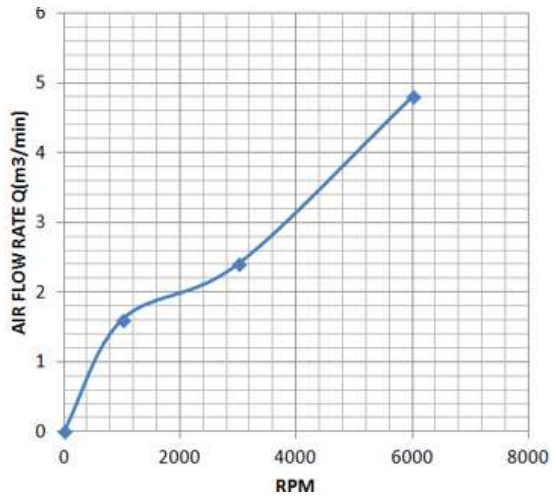

Fig. 4 Graph of Output- Theoretical Air Flow Rate Vs Rpm & Air Configuration- Stationary

At low (500 to 600 RPM) idle speeds, the air is moving very slowly in the intake manifold.
Of these, airflow estimation for the above graph may be the most elusive. There is typically no permanent installed flow meter. Pressure and temperature measured promptly . Be that as it may, precise estimations largely dependent upon the positioning of probes in right areas. Likewise, can be troublesome [4]

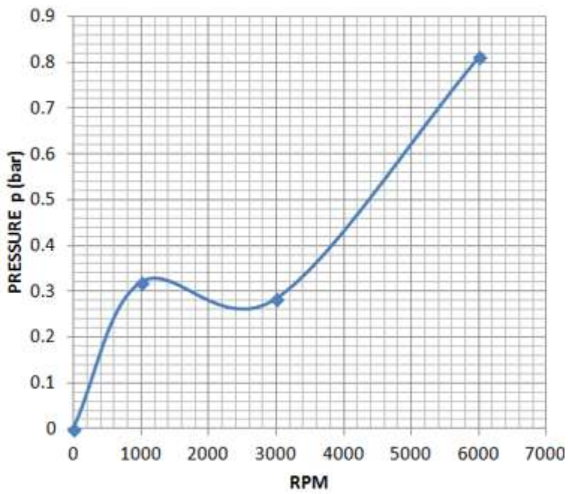

Fig. 5 Graph of Output- Pressure against the Rpm & Air Configuration- Stationary

The airway through this manifold introduces a pressure drop test to the air inlet designers. The pressure drop over the air intake system has an impact on the shown force of the ICE (Internal combustion engine). The Pressure drop in the chart (0.33 to 0.25 bars) made because of the suction created by the plummeting cylinder on account of normal suctioned engine [5].

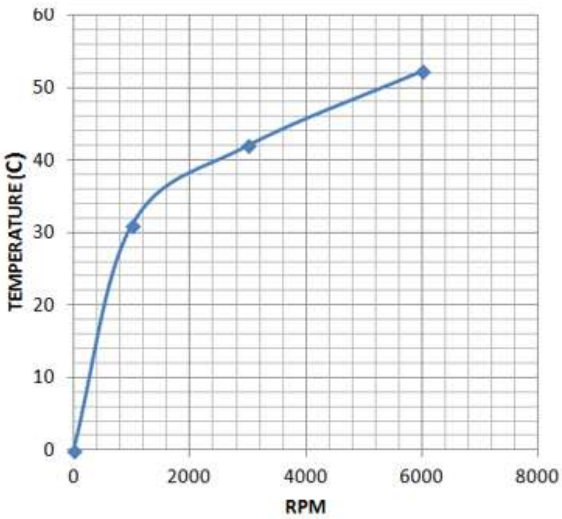

Fig. 6 Graph of Output- Temperature against Rpm & Air Configuration- Stationary

Air temperature increases as the pressure expand (Gay Lussac's law). From the above graph , high air intake temperature requires complete vaporization. High temperature decreases engine efficiency. If the intake manifold is too cold, the air-fuel mixture condenses on the surfaces. In this way, the inlet framework surface must warm-up adequately to enhance vaporization and anticipate fuel buildup in the manifold passages.

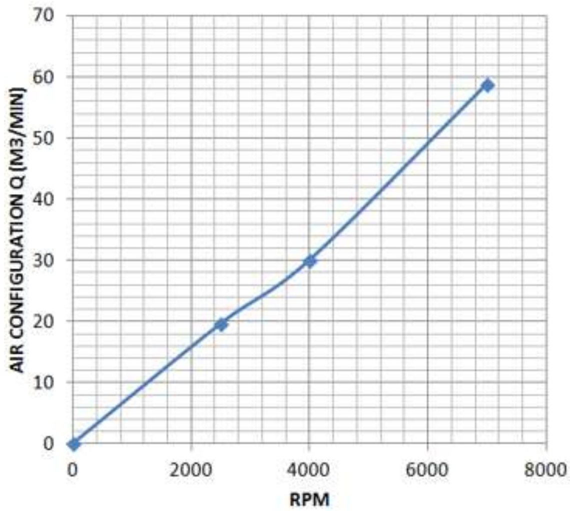

Fig. 7 Graph of Air Configuration Intake + Air Flow Rate against Rpm

Forced induction has to cause ‘a wave pressure' thereby pressure at idle increases or equals ambient pressure (1 bar). However, the material used to guard the air through into the intake manifold not in its best shape to allow the full air delivery. Hence losses of the cold air supplied from the mechanical device [6].

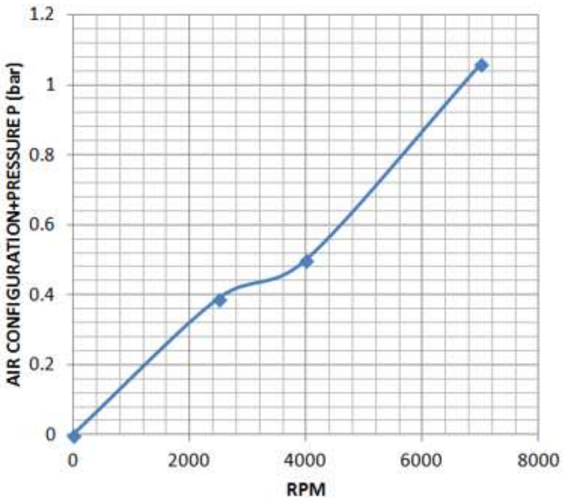

Fig. 8 Graph of Air Configuration + Pressure against Rpm

Now the interesting thing is: if the inlet valve opens again exactly when the wave pressure comes back, the force wave will help to charge the combustion chamber due to its high pressure. From the above graph , the rushing air configured to pump is more air augment the curve line and suppresses drop in pressure as against when the naturally aspirated sucked [7]

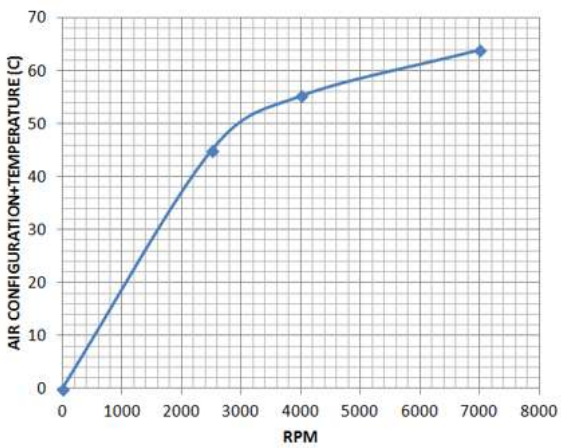

Fig.9 Graph of Air Configuration+ Temperature against Rpm

Inlet complex temperature assumes an immense part with air setup impelling applications. Pressurizing the air specifically relative to the air consumption temperature. The more boost run, the higher the air intake temperature are going to climb. To be reasonable, however, the more the run, the more air found in a given volume. What to pay special mind to is that under greater boost, circumstances air intake temperature gets +50. Surrounding and higher temperatures, which by then the air is warm, less demanding to touch off in the motor, and timing to save from explosion in the engine. In any case, the cooler the air, the denser to blend and blaze the fuel effectively. The above chart is the immediate elucidation of the last summation.

Fig. 10 Naturally aspirated engine- SP4H Proton connected to Engine Analyzer via the probes.

4. CONCLUSIONS

Final tests and graphically explained trials demonstrate that the surrounding pressure is a more applicable parameter to specifically affect the motor than the air temperature. These were normal results , as higher the air temperature as lower the air density.

Based on the examinations, minor departure from the ambient temperature and pressure effects the force yield from the motor.

Streaming gas in the intake system to the valve can't be basically seen as transient mass. It is compressible.

Faster blaze achieved by instigated charge movement. Air configuration setup impacts the execution however negligibly measured, and subsequently, they must be assessed utilizing accessible sensors as a part of the intake manifold.

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