COMPARATIVE ANALYSIS OF AIR FLOW IN A STANDARD CYLINDER AND A PREPARATION OF A GRAND VITARA 1600 CC SOHC ENGINE

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Summary. *The main purpose of this study is to be able to quantify and verify the increase in air flow that exists when oversizing the inlet and exhaust ducts of a cylinder head, in addition to knowing the advantages of carrying out this work with appropriate equipment, leaving aside the empirical form Which has always remained in our midst.*

This study is developed by comparing the air flow between a standard and a prepared cylinder head, in addition to detailing the results of power and torque of the vehicle with each cylinder head, which will be properly checked in the flow checking equipment , In the roller dynamometer and in Solidworks graphing and simulation software.

With the development of this research it is demonstrated that the flow check equipment can quantify with real and exact data the increase of air flow that exists when oversizing the inlet and exhaust ducts of the cylinder head, in the same way allows to maintain a uniform flow In all the cylinders, being this an essential equipment that allows to save costs and time when realizing an oversizing of conduits.

The objective of this investigation is to know in what percentage increase the performance of the vehicle, oversizing the intake and exhaust ducts of the cylinder head using appropriate measuring equipment that can facilitate and sustain this work, this being the most known form in which can gain power in the engine.

NOMENCLATURE

Compare, quantify, power, trick.

I INTRODUCTION

The present work is carried out with the purpose of providing practical and theoretical knowledge for the oversizing of intake and exhaust ducts of the cylinder head of the vehicle Grand Vitara 1600cc SOHC, using appropriate tools and equipment that allow us to quantify and verify if this trucking of cylinder head is Well done.

Nowadays, the problem with cylinder heads is that when the intake ducts and exhaust ducts are oversized, they are performed empirically and without knowing that this can produce an irreversible problem in not obtaining the expected results. The cylinder head being a very important element regarding the increase of power of the engine, it should be worked with tools and machines of measurement or verification that sustain their improvements.

For this reason, it is necessary to carry out a study of oversizing the intake and exhaust ducts of the cylinder head, using tools and equipment to quantify and verify the work of the cylinder head, in addition to being able to maintain a uniform flow in all Ducts, so that all cylinders work equally well and none of them generate power losses to the vehicle.

II MATERIALS AND METHODS

Automotive tools.

Appropriate tools exist that allow to realize a trick of oversizing of intake and exhaust ducts of the cylinder head in a correct way and that allow to obtain the best result.

Flow check equipment for cylinder heads.

It is an instrument of great help for an engine preparer, with this we can test the cylinder head, carburetor, intake and exhaust manifolds (Funes, 2011).

Solidworks Software.

It is a software that helps to design better products and faster. When the designer has an idea for an excellent product, he will have the tools to design it in less time and at a lower cost (Vidal & Maroño, 2015).

Solidworks Flow Simulation.

With Solidworks Flow Simulation, you can easily simulate fluid flow, heat transfer, and fluid forces critical to your design success. The SOLIDWORKS computational fluid dynamics tool, fully integrated with 3D CAD software (Corporation, 2015).

Flow test.

This is to measure the flow of air passing through a given conduit at a constant test pressure. After the measurement is made, the modifications are made in the conduit or element to be measured and the same pressure is tested again, if the flow rate improved, the work was satisfactory (Funes, 2011).

Headache.

The trick is the improvement in the behavior of the engine, and in general of the car, but in the limit in which this car does not lose its qualities of civilized vehicle. It is a question of improving performance, achieving greater acceleration, increasing engine power and in doing so within its much faster and more fulminant range than any vehicle of its own displacement (Vicente, 2003).

Automotive Dynamometer.

A Dynamometer is a test bench used to measure the power or torque produced by a machine, the dynamometer is very popular in the field of automotive mechanics, both as a diagnostic equipment and as a way of measuring the results of the modifications Of performance, is formed by two rollers in which are placed the driving wheels of the vehicle.

III RESULTS.

The following section details all the results obtained using the different equipment and suitable tools that allow to quantify the differences between a standard cylinder head and a prepared cylinder head.

TABLE I

Technical data of the grand vitara vehicle.

Datos técnicos del vehículo Grand Vitara	
Especificaciones generales	
Marca	Chevrolet Grand Vitara
N° Cilindros	4
Distribución	SOHC
Cilindrada	1590 cc
Relación de Compresión	9.5:1
Diámetro del cilindro	75mm
Volumen de la cámara de compresión	25.5 cc
Espesor del empaque de la culata	1.2mm
Diámetro Válvula de admisión	29.2mm
Diámetro Válvula de escape	25.0mm

TABLE II

Results obtained standard head vs cylinder head prepared.

Resultados obtenidos				
Equipos y herramientas utilizadas	Culata estándar		Culata preparada	
Sobredimensionamiento de conductos	Admisión 41 mm	Escape 32 mm	Admisión 43 mm	Escape 33 mm
Equipo de comprobación de flujo para culatas	82% flujo	0.4 in H2O	84% flujo	0.2 in H2O
Cálculo del volumen de conductos práctico	Admisión 95 cm3	Escape 59 cm3	Admisión 97cm3	Escape 60cm3
Cálculo del volumen de conductos Software Solidworks	Admisión 94.89 cm3	Escape 58.60 cm3	Admisión 96.93 cm3	Escape 60.20 cm3
Simulación en el Software Solidworks	26.432 m/s		26.765 m/s	
Dinamómetro	5100 RPM	57.67 Hp 59.97 ft-lb	5000 RPM	62.12 Hp 65.82 ft-lb

Standard vehicle power and torque curves.

The Grand Vitara in standard condition has a power of 57.67 (HP) and a torque of (59.97) (ft-lb), its peak is reflected at the 5100 RPM values obtained from the test in the automotive dynamometer, in addition it is observed That the mixture of air-fuel in low RPM is rich introducing to the combustion chamber less air and more gasoline, but when increasing RPM the mixture improves arriving to enter up to 12.07 kg of air to 1 kg of gasoline.

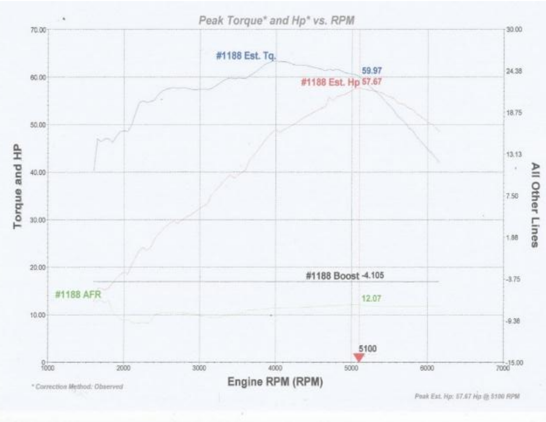
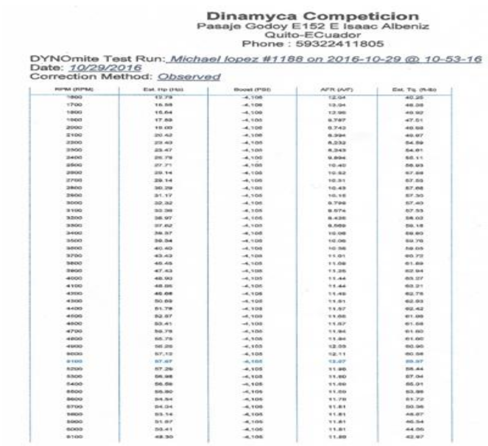


Fig. 1 Torque and power curves obtained on the dynamometer with standard cylinder head.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DYNOmite Test Run: Michael lopez #1188 on 2016-10-29 @ 10-53-16
Date: 10/29/2016
Correction Method: Observed

RPM (RPM)	Est. Hp (Hp)	Boost (PSI)	AFR (A/F)	Est. Tq (ft-lb)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Fig. 2 Detailed report of results of the roller dynamometer.

Calculation of the volume of standard ducts in a practical way.

The steps to follow for this calculation of the volume of the ducts are as follows, first place the valves in the cylinder head in their correct position to form a seal and do not allow the leakage of the liquid, then pour the liquid without spilling until filled Completely finally it is proceeded to measure it, to be sure of the result of the calculation of the volume one can realize two or more tests.

Fig. 3 Calculation of the volume of the standard intake duct.

Fig. 4 Calculation of the volume of the standard exhaust duct.

Calculation of standard duct volume in Solidworks software

In addition to allowing us to graph, the Solidworks software also allows us to calculate the volume in the cylinder heads, in this case the standard intake ducts, which helps to justify the data obtained in practice with the data Obtained in the graph, thus being an indicator that allows to affirm that the standard intake duct graphed is identical to the actual conduit of the vehicle's head.

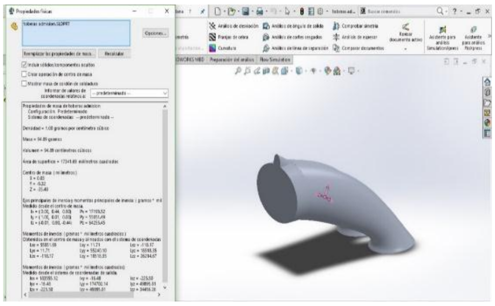


Fig. 5 Calculation of the volume of the standard intake duct.

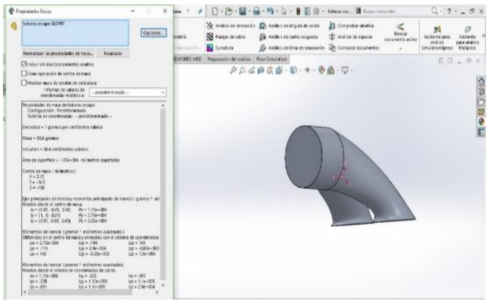


Fig. 6 Calculation of the volume of the standard exhaust duct.

Chart of the stock cylinder using the software "SOLIDWORKS"

In the following figures can be seen from different views the final graphic of the standard cylinder head, which has the measures previously taken, this cylinder head was drawn from a rectangle to facilitate the process, the software used is Solidworks 2017.

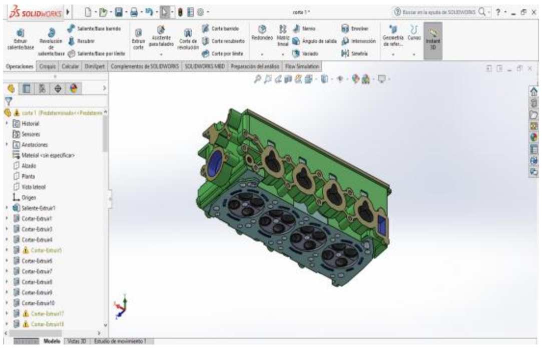


Fig. 7 Complete graphic of the standard stock in Solidworks software.

Simulation of the passage of air in the ducts of the standard cylinder head, based on the operation of a vehicle.

Simulation in the Solidworks software in the Flow Simulation module was performed to simulate the flow of air inside the standard cylinder head. Taking into account that the cylinder head is composed of 8 intake nozzles and 8 similar exhaust, the decision was made to carry out the study in 4 nozzles 2 of intake and 2 of exhaust that operate on a same section of the cylinder head, this did it To save the computational cost that is generated when performing a fluid simulation in a design software.

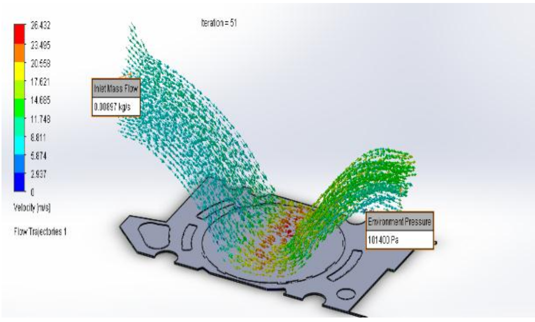


Fig. 8 Simulation of the air passage in the standard cylinder heads.

Simulation of air passage in the standard cylinder heads, based on the operation of cylinder head check equipment.

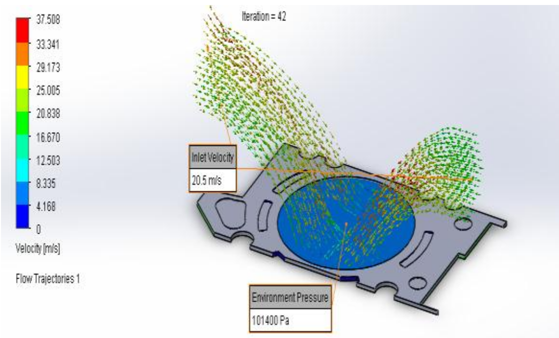


Fig. 8 Simulation of the air passage in the standard cylinder heads.

"Standard cylinder head" flow test

Fig. 9 Standard cylinder head test.

Flow tests of the standard cylinder head are performed in order to know the percentage of flow each pipe has before it is modified, a value that will serve as a basis for quantifying the flow improvement that will have after being modified.

Overdimensioning of intake and exhaust ducts.

Used materials.

Straight electric or pneumatic grinder.

Grates of sandpaper

60

80

100

120

Roughing cutters

Grain beds

160

260

400

Sponge sand

800

Special ink for marking

Fig. 10 Preparation of the cylinder head.

Calculation of the volume of the modified ducts in a practical way.

Next, a measurement of the volume of the intake duct and the exhaust duct is made in the prepared cylinder head, filling the ducts with liquid to know the increase in the volume of the cylinder head due to oversizing.

Fig. 11 Calculation of the volume of the modified exhaust duct.

Calculation of the volume of modified conduits in Solidworks software.

The same procedure that is used to calculate the volume of the standard ducts is done with the intake ducts prepared in order to justify that the volumes are the same as those obtained in practice and therefore the graph is being made of a Excellent way, also know that the measurements obtained are accurate to be able to make the graph.

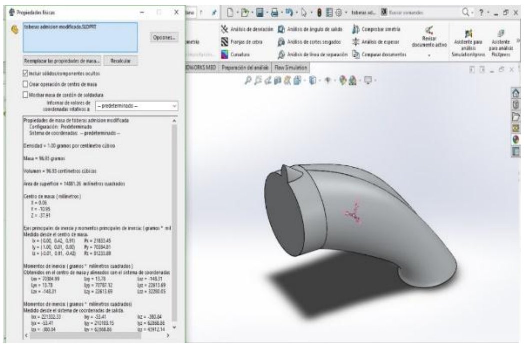


Fig. 12 Calculation of the volume of the modified intake duct in Solidworks.

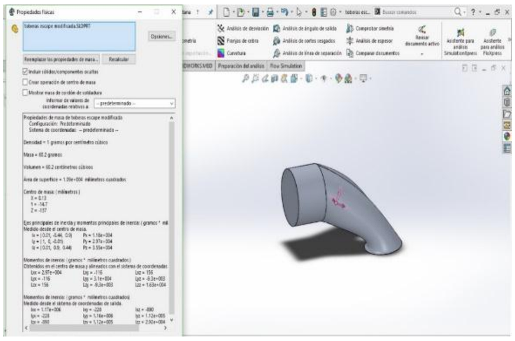


Fig. 13 Calculation of the modified exhaust duct volume in Solidworks.

Chart of the cylinder head modified using the software "SOLIDWORKS"

In the following figures, the final graph of the prepared cylinder head can be observed in different views, which has been oversized for both the intake and exhaust ducts due to the work done. Valves to allow free passage of air.

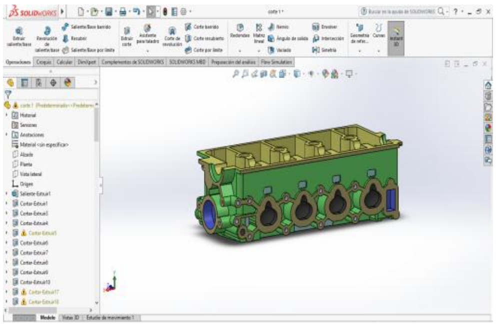


Fig. 14 Complete graphic of modified cylinder head in Solidworks.

Simulation of the passage of air in the conduits of the prepared cylinder, based on the operation of a vehicle.

Simulating the Solidworks software in the Flow Simulation module performed the proper procedure to simulate the air flow inside the cylinder head prepared using cylinder head check equipment. The parameters used for the simulation are the same as those used with the standard cylinder head, the graph clearly indicates the direction and speed of the fluid.

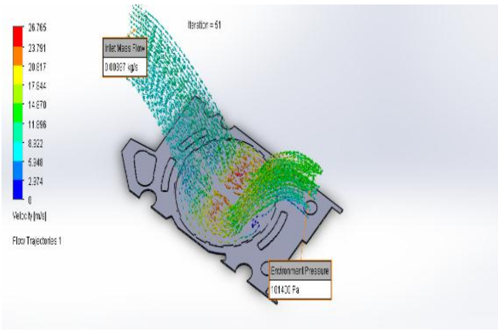


Fig. 15 Simulation of the air passage in the modified cylinder heads.

Simulation of the air passage in the prepared cylinder heads, based on the operation of the flow check equipment for cylinder heads.

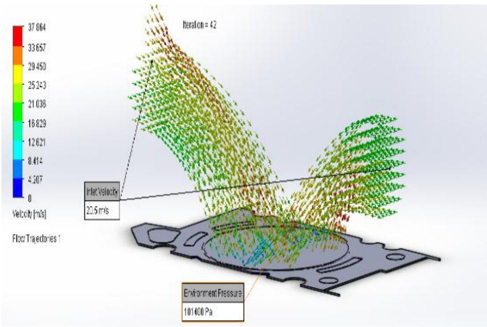


Fig. 16 Simulation of the air passage in the modified cylinder heads.

Fig. 17 Flow test of the modified cylinder head.

The tests of flow of the prepared head are realized in order to know the increase of percentage of flow that owns each conduit after being modified, besides maintaining a flow join in each cylinder, therefore the vehicle will have a power increase due To increase volumetric efficiency.

Power and torque curves of the prepared vehicle.

After tricking the cylinder head and subjecting the study vehicle to the same test on the automotive dynamometer, the following results are obtained: a power of 62.12 (HP) and a torque of 65.82 (ft-lb), its peak is reflected at 5000 RPM, in conclusion has a power increase of 4.45 (HP) and a torque increase of 5.85 (ft-lb), in addition the air-fuel mixture improves remarkably in comparison with the standard stock, and does not descend of the 10 kg Of admission of air, its mixture in high RPM rises until arriving to the 12.30 kg of air, approaching very little to the stoichiometric mixture.

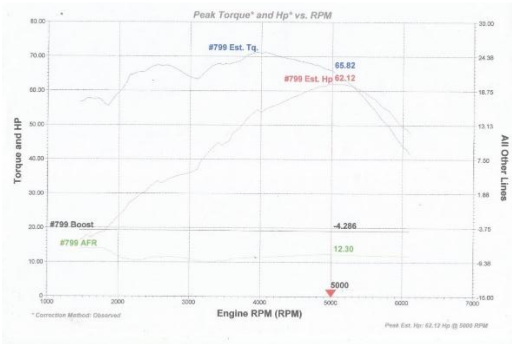
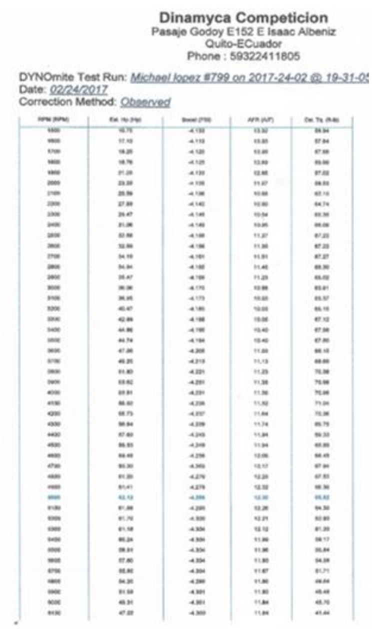


Fig. 18 Torque and power curves obtained on dynamometer with modified cylinder head.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Date: 02/24/2017
Correction Method: Observed

Fig. 19 Roller dynamometer results detailed report.

MATHEMATICS AND EQUATIONS

Single cylinder.

$$Cu = \frac{\pi \, .d^2}{4} . L \qquad (1)$$

Where,

Cu = Unitary cylinder capacity.

Π = 3.1416

D = Diameter of the cylinder expressed in cm.

L = Piston stroke (distance between PMS and PMI) expressed in cm.

Total Displacement.

$$Ct = \frac{\pi \, .d^2}{4} . L . n^{\circ} \qquad (2)$$

Where,

Cu = Unitary cylinder capacity.

Π = 3.1416

D = Diameter of the cylinder expressed in cm.

L = Piston stroke (distance between PMS and PMI) expressed in cm.

N ° = Number of cylinders.

Compression Ratio.

$$Rc = \frac{Vu+Vc}{Vc} \qquad (3)$$

Where,

Rc = Compression ratio (expressed as a number)

Vu = Unit volume. The volume of a single cylinder. To calculate it, simply cancel in the formula of the displacement.

Vc = Volume of the compression chamber.

CONCLUSIONS.

- By means of the flow check equipment for cylinder heads, an increase of 8% in air flow and a lower pressure of 0.8 in H2O was verified in the entire cylinder head that underwent oversizing, in addition it was evidenced that the percentage of air flow was Kept uniform in each of the cylinders.

- With the help of Solidworks software, a total volume increase of 3.64 cm3 was found in the inlet and exhaust ducts of the prepared cylinder head, which generated an increase of air flow velocity of 0.33 m / s in each cylinder, for Such a reason this cylinder head is more efficient compared to the standard cylinder head because of the greater amount of air entering the combustion chamber.

- By preparing the cylinder head, it was possible to increase the air intake diameter in the intake duct by 2 mm and in the exhaust duct by 1 mm which is reflected in the increase of nozzle volumes of 2.04 cm3 for intake And 1.6 cm3 for escape properly verified in the software and analytically.

- With the increase of total airflow of 8% that increased in the cylinder head; The test of the vehicle in the automotive dynamometer generated a power increase of 4.45 (HP) and a torque increase of 5.85 (ft-lb), in addition the air-fuel mixture improved notably up to 12.30 kg of air and 1kg of gasoline, Approaching very little to the stoichiometric mixture that must have a gasoline engine that is theoretically 14.7 kg of air and 1 kg of gasoline.

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