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THE POWER INCREASE AND MOTOR TORQUE OF GM 1.0 VHC WITH SUPERCHARGER (OVERFEEDING)

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Abstract. *Along the supercharger study, comes the search for improvements in power and torque at low engine revs VHC 1.0 - GM adapted for better performance in everyday or even sports, and cost analysis compared to values of vehicles that have the Same power from the factory. The power increase will come with the supercharger acquired from an EATON M24 supercharger with the necessary adaptations in the system, in addition to the necessary changes in the vehicle to withstand such modification. The main expected result of this change will be the approximately 60% to 80% increase in horsepower and torque in an engine that originally had 77cv and 9.5kgfm. It is expected that with supercharger adaptation it can cause great power and torque gains at initial engine speeds in GM engines, so those gains can benefit the owner, whatever the need.*

Keywords: *Power. Engine. Supercharger. Supercharging.*

1. INTRODUCTION

The automotive market is constantly evolving, cars with ever smaller engines, with more net power and higher torque at low revs. Examples range from the more affordable models, through luxury cars, to supercars, with turbocharged engines or adapted to a type of compressor motors.

To choose the compressor, you must take into account the engine displacement and the use of the car. The supercharger has the function of pushing more air into the cylinders. This type of compressor is widely used in the case of the Ford Fiesta, these models more compact and adapted for engines with injection, only push the air and not the fuel as in the older versions. The fuel will only be injected very close to the intake valves. Unlike the turbo that reuses exhaust gases, the compressor is connected directly to the engine, the crankshaft pulley, the valve control, or wherever the engine can rotate. With the actuation done in this way, the operation is instantaneous, practically on the first touch of the accelerator. This brings benefits by making a supercharged car run in a similar way to an aspirator, but with high efficiency and power.

A major reason for choosing the model is the thermal efficiency, the ability it has to compress the air without generating heat, because hot air is not recommended for the air / fuel mixture. The EATON M24 supercharger, because it is compact, there is not enough heating to hinder operation, so there is no need to install an intercooler.

2. METHODOLOGY

In addition to the EATON M24 supercharger, shown in Fig. 1, the VHC engine will receive extra parts to aid in the desired results. The modification will take place in stages, starting with a simple exchange of the initial, intermediate and final components of the engine. That is, by changing the sports air filter, the original spark plugs replaced to the Iridium (with the appropriate spark plugs cables) and the original exhaust manifold replaced for the 4x1 (sporty).



Figure 1. EATON M24

Then, the electronic programming of the engine will be analyzed, adjusting the new modifications, to start the second stage, where the EATON M24 will enter, with the appropriate belt and pulley according to the calculation of the ratio between the pulley of the crankshaft and of the supercharger shaft. It will accompany in this stage, the alteration of the nozzles, with the intention of maintaining the adequate air-fuel ratio.

Finalizing the project with the last step, replacing the original electronic injection of the vehicle to the sport where you can program appropriate maps of the use of the altered engine (you can create street map for daily life and map for competitions). And if necessary, change the fuel pump, either in programming it or even replacing it to a more suitable design requirement.

As for vehicle safety, an extra step will be added, in which it will have no relation to the engine, but to the structure of the vehicle. At this stage happen to replace the rear brake, the disc brake instead of the brake drum, and suspension that will make it lower will, which in addition to security, transmit power more complete wheels.

3. RESULTS AND DISCUSSION

For the calculation of the ratio between pulleys have been adopted as the safety margin maximum rotation:

$$\frac{16500 \text{ rpm (Compressor)}}{6000 \text{ rpm (Motor)}} = 2,75 \quad \text{Eq. (1)}$$

Table 1. Rotations of the EATON M24

Engine RPM	Compressor RPM
6000	16500
3000	8250
1500	4125

And as compression ratio, the use of absolute pressures:

$$\frac{P2}{P1} = \frac{177 \text{ kPa}}{109 \text{ kPa}} = 1,6 \quad \text{Eq. (2)}$$

Volumetric efficiency is the relationship between the volume of fuel-air mixture to each cylinder admits and nominal volumetric capacity of the cylinder and varies with the rotation.

Table 2. Results of corrected flow

Volumetric efficiency	Corrected flow (m ³ /h)
91%	333,33
84%	154,76
63%	57,78

With greater volumetric efficiency of compressor develops a greater flow.

In the map of polytropic efficiency, Fig. 2, you can get the value used to describe the efficiency of a compressor, and each island of efficiency has a certain percentage.

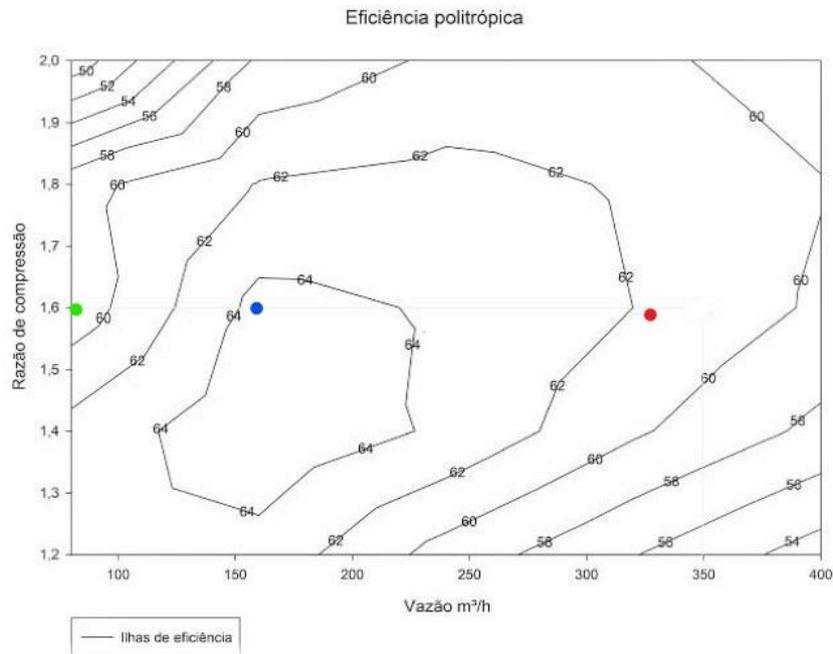


Figure 2. Map of polytropic efficiency

To calculate the isentropic efficiency, was used the following formula:

$$\frac{n-1}{n} = \frac{k-1/k}{\epsilon} = \frac{1,4-1/1,4}{\epsilon} \quad \text{Eq. (3)}$$

k – Ratio of specific heats (cp/cv);
 ϵ – Polytropic efficiency;

Table 3. Isentropic and polytropic efficiency

Compressor RPM	Polyt. Effic.	Isent. Effic.
16500	61% (red)	46%
8250	65% (blue)	44%
4125	59% (green)	48%

The intake temperature is equivalent to room temperature given by 29° C, this is, 302 K and the discharge temperature was calculated through the formula based on the first law of thermodynamics and the equation of amount of heat received by a body.

$$T2 = \frac{P2^{n-1/n}}{P1} \cdot T1 = \frac{177^{n-1/n}}{109} \cdot T1 \quad \text{Eq. (4)}$$

Table 4. Discharge Temperature

Discharge temperature(K)
376,37
371,30
379,19

According to Michael Moran, have the motor standard air cycle Otto, follow the following procedures:

Process 1-2: is isentropic compression of the air as the piston moves from bottom dead point to upper dead point.

Process 2-3: is a constant volume heat transfer into the air from an external source while the piston is at upper dead point. This process is intended to represent the ignition of the fuel-air mixture and the rapid burning.

Process 3-4: is isentropic expansion (power).

Process 4-1: complete the cycle through a constant volume process in which heat is rejected by air as the piston is at bottom dead point.

Having these processes governed by the equations:

$$v_{r2} = \frac{v_{r1}}{r} \quad P_e = P_s \cdot \frac{T_e}{T_s} \quad v_{r4} = v_{r3} \cdot r \quad \text{Eq. (5)}$$

$$\eta = 1 - \frac{u_4 - u_1}{u_3 - u_2} \quad \text{Eq. (6)}$$

v_r – Specific Volume

r – Compression ratio of the engine, 12,6:1

P – Pressure

T – Temperature

u – Internal energy per unit mass

η – Calorific Efficiency

s; e – Starting and Ending

Adopting the initial pressure and temperature values being the same from the compressor discharge situation, this is, $P_1 = 1,746\text{atm}$ e T_1 (K) in accordance with the rotation, and the maximum temperature reached by the motor, T_3 , 2250K. Thus creating the table 5.

Table 5. Calculation of calorific efficiency

Rotation		
6000 rpm	3000 rpm	1500 rpm
Situation 1		
$T_1 = 376,37\text{K}$	$T_1 = 371,3\text{K}$	$T_1 = 379,19\text{K}$
$P_1 = 1,746\text{atm}$	$P_1 = 1,746\text{atm}$	$P_1 = 1,746\text{atm}$
$u_1 = 269,06$	$u_1 = 265,4$	$u_1 = 271,1$
$v_{r1} = 352,04$	$v_{r1} = 364,11$	$v_{r1} = 345,33$
Situation 2		
$T_2 = 965,51\text{K}$	$T_2 = 954,5\text{K}$	$T_2 = 971,98\text{K}$
$P_2 = 56,43\text{atm}$	$P_2 = 56,55\text{atm}$	$P_2 = 56,39\text{atm}$
$u_2 = 749,25$	$u_2 = 720,37$	$u_2 = 746,01$
$v_{r2} = 27,94$	$v_{r2} = 28,9$	$v_{r2} = 27,4$
Situation 3		
$T_3 = 2250\text{K}$	$T_3 = 2250\text{K}$	$T_3 = 2250\text{K}$
$P_3 = 131,5\text{atm}$	$P_3 = 133,3\text{atm}$	$P_3 = 130,53\text{atm}$
$u_3 = 1921,3$	$u_3 = 1921,3$	$u_3 = 1921,3$
$v_{r3} = 1,864$	$v_{r3} = 1,864$	$v_{r3} = 1,864$
Situation 4		
$T_4 = 1023,61\text{K}$	$T_4 = 1023,61\text{K}$	$T_4 = 1023,61\text{K}$
$P_4 = 4,75\text{atm}$	$P_4 = 4,81\text{atm}$	$P_4 = 4,71\text{atm}$
$u_4 = 779,21$	$u_4 = 779,21$	$u_4 = 779,21$
$v_{r4} = 23,48$	$v_{r4} = 23,48$	$v_{r4} = 23,48$
Efficiency		
$\eta = 56,47\%$	$\eta = 57,21\%$	$\eta = 56,76\%$

The power, that is, the force from the burning, held on the piston causes the rotation of the shaft at any given moment, tells you how many horsepower the engine has, so being able to determine the increase generated by the Eaton M24 supercharger. However, the most effective way to determine the power is by means of dynamometer, due to this, the resulting value in this article will only be a theoretical value. Using the equation below to inferring the power.

$$Pot = \frac{P_c \cdot Q_c \cdot 4186}{\eta \cdot 3,6 \times 10^6 \cdot 0,73551} \quad \text{Eq. (7)}$$

Pot – Power (cv)

P_c – Calorific Power of the fuel (Gasoline = 11377 kCal/kg; Alcohol = 7099 kCal/kg)

Q_c – Fuel mass flow (kg/h)

η – Efficiency of the Rotations (6000rpm, 3000rpm e 1500rpm)

Extracting of Table 2, it is known that:

6000 rpm – 333,33 m³/h of air

3000 rpm – 154,76 m³/h of air

1500 rpm – 57,78 m³/h of air

Through the air fuel ratio (15,2:1 Gas; 9,03 Alcohol) obtained mass flow rate of each fuel. And so completing the values of the powers in the table 6 and Fig. 3.

Table 6. Resulting Powers

Rotation (rpm)	Gasoline (cv)	Alcohol (cv)
1500	47,54	49,93
3000	128,34	134,8
6000	272,85	286,58

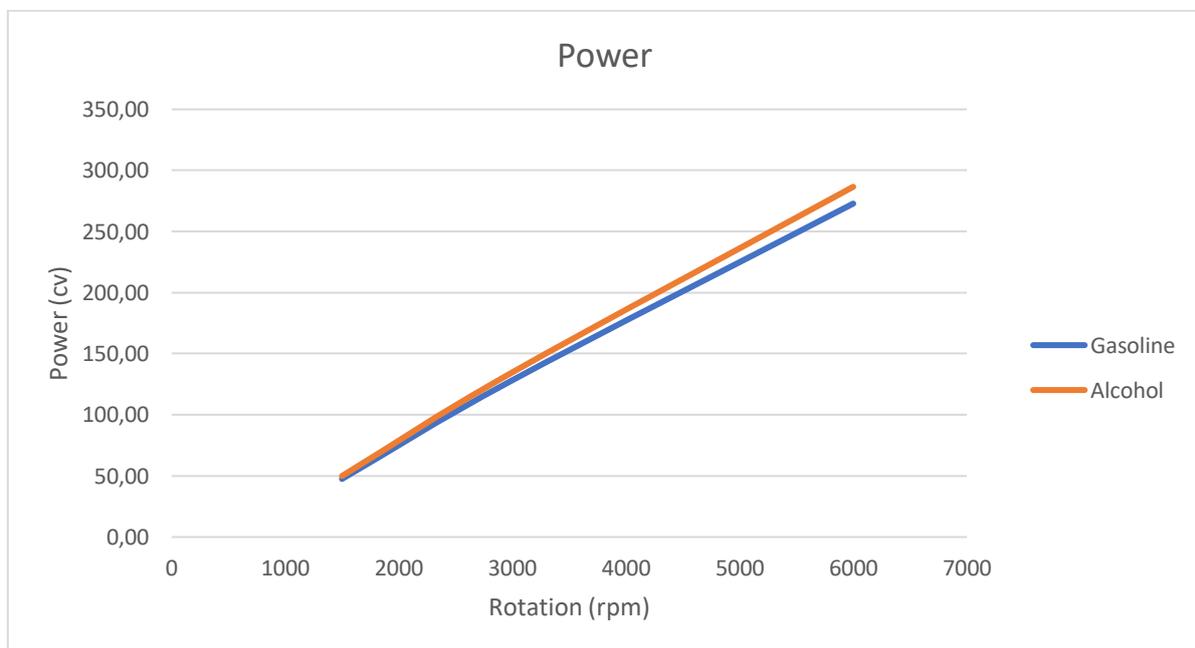


Figure 3. Power chart

From the relationship between rotation and power, you can discover the theoretical values of the engine torque, using the equation below.

$$T = \frac{Pot \cdot 716,2}{n} \quad \text{Eq. (8)}$$

Table 7. Resultings Torques

Rotation (rpm)	Gasoline (kgfm)	Alcohol (kgfm)
1500	22,70	23,84
3000	30,64	32,18
6000	32,57	34,21

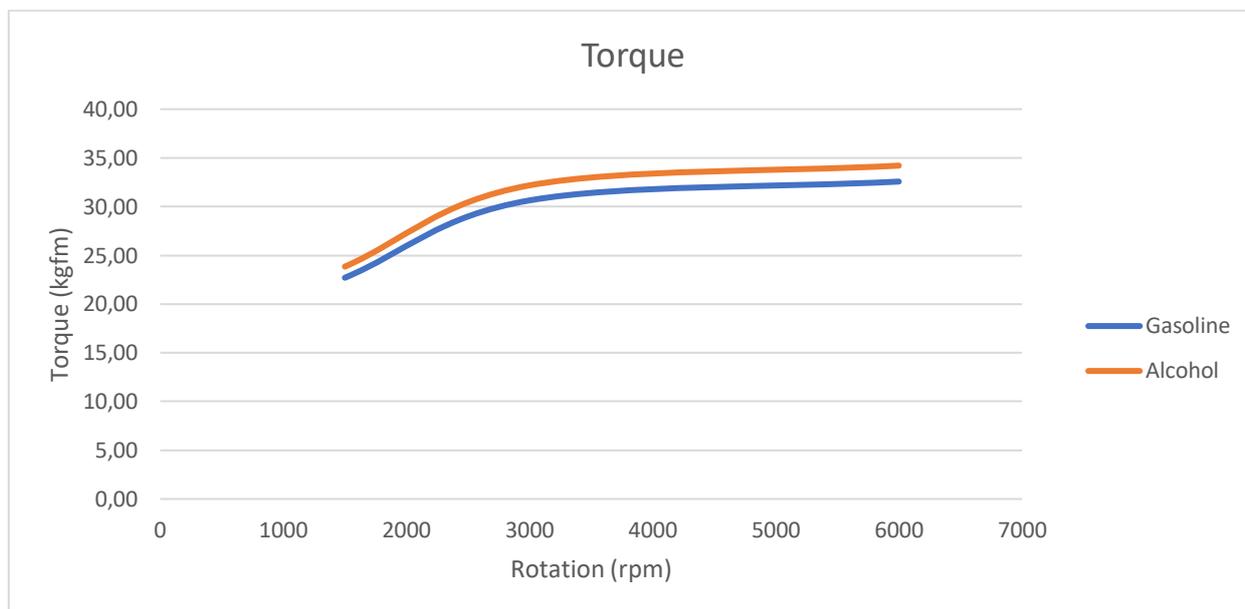


Figure 4. Torque chart

Recapping the values found are only theoretical, even demonstrated by increasing torque curve, which usually does not happen if the engine torque was estimated by means of dynamometer. But even in theoretical values is noted the growth of value in relation to the initial torque.

4. CONCLUSION

Comparing theoretical results with the initials is possible to affirm that the adaptation with supercharger can cause major power and torque gains in initial rotations in 1.0 GM engines. Thus, the gains help in everyday moments in town or on the road, as per example, uphill, initial acceleration, overtaking or competitions (such as drag racing) in which the owner of the vehicle may participate.

As mentioned earlier, the power is theoretical discovery, taking into account possible mechanical losses over the engine components, and adopting this loss as about 55% of the maximum power of the engine with EATON M24 Supercharger VHC can reach 150,06cv (Gas)/ 157,61cv (alcohol). This was the main result obtained in this work, the increased power and torque in a motor that had initially 77cv and 9,5kgfm, having as a consequence the engine will suffer more wear and will have an increase of fuel consumption for a supercharged.

The compressor shown more flexible by acting from the lowest engine revs and rising power as the engine rpm increases, providing with this also better driving the vehicle. Another advantage is your compressor durability because it uses special oil, and lubrication is independent of your engine. There is no contact between the rotors, so the compressor spins for a long time without need for rectify.

5. REFERENCES

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6. RESPONSIBILITY NOTICE

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