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Senior Design Project Report

Design of Turbocharge System for an Existing Gas Engine

In partial fulfillment of the requirements for the

Degree of Bachelor of Science in Mechanical Engineering

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Abstract

Turbocharger is a turbine driven air compressor and forced induction device powered by exhaust gases from the internal combustion engine. A turbocharger consists of two chambers connected by center housing. The two chambers contain a turbine wheel and a compressor wheel connected by a shaft which passes through the center housing. The response of the turbine to the engine exhaust, dictates the response of the compressor and thus the engine air inlet. Turbocharger response time (also known as turbo lag), is directly related to the size of the turbine and compressor wheels. Small wheels accelerate rapidly; large wheels accelerate slowly. While small wheels would seem to have an advantage over larger ones, they may not have enough airflow capacity for an engine. So, to minimize turbo lag, the intake and exhaust breathing capacities of an engine must be matched to the exhaust and intake airflow capabilities of the turbocharger.

For this project, a turbocharge system has to be designed and manufactured to fit an existing gasoline engine. Students must have taken the Internal Combustion Engine Course and have a strong background in thermodynamic & fluids. The students must show experimentally and numerically the advantages of using a small turbocharger in terms of the following: Turbochargers deliver more power output and a greater torque, which in turns improve their vehicle performance on the road. And main Components of Turbocharge design system is: Turbine, compressor and connecting shaft Optional requirements: Intercooling

Acknowledgements

The project advisor, Dr. Nader's sincere directives crowned these endeavors. It was incredible to get his professional direction that positively impacted work on a major deal. He is addressed as the most outstanding generous greetings for every one of his reviews, recommendations, and instructions.

Full gratitude reaches out to the PMU officials. They permitted us viably to make use of the university's facilities. They likewise permitted us to make use of the industrial facilities and library available. Their efforts are appreciated. Their part with the development of students is certainly life-changing.

Then again, the team members' effort was indisputable. The division of work among every team was beneficial and exceptional as well. Every team member has been helped to carry out their functions efficiently and effectively. The group leader addressed his strongest gratitude to individual members of the team, including Khaled Al-Hamimi, Nasser AlOtaibi, Mahmoud Shahin, Zeiad AlHamdan and Faisal AlAsmari.

Chapter 1

Chapter 1: Introduction

1.1 Project definition

How can turbocharge effect on the car engine? No one can deny that the turbocharge plays a big part in engines world. First of all, turbocharge is a turbine driven air compressor and forced induction device powered by exhaust gases from the internal combustion engine. As a matter of fact, we all known how the engines saving and providing a time for a humanity also, doing a thing that hard and exact for human to reach it for example, manufacturing, drilling, and production. However, one of the important engines in our life is car engine which, can divided into many types depends on the engine capacity known by (CC) they also give it another name defined by engine displacement. In addition, it depends on the number of cylinders, piston and a lot of parts that could show which one to choose between them. Moreover, the strength and type of these characteristics are also determined by their ability to modify and supply the addition of the turbocharger.

On the other hand, in our senior project we chose one of many types of engines, which is a V8 car engine. To demonstrate clearly, in this project we are going to add a turbo charge for the engine that we chose, to improve the performance of the engine and obtain a high efficiency.

1.2 Objectives

The main objectives that we are looking for in this project are to:

- Increase engine performance and efficiency by installing a turbocharger
- Improve combustion with increased air delivery to the engine by the turbocharger
- Change the exhaust system
- Design the turbocharge system: Turbine, compressor and connecting shaft
- Quantify engine performance before and after the turbocharger

1.3 Project specifications

When gas turbine is used to boost the pressure of air which is to be supplied to the engine, it is known as Turbocharger. Kinetic energy of exhaust gases from the engine empowers Turbochargers. In simple terminology, it can be termed as an air pump which is the form of the forced induction. It consists of a gas turbine which is coupled to a compressor. At same shaft both are keyed. Compressor operates according to the rotation of turbine. On gas turbine exhaust gases from the engine fall. Turbine rotates and initiates the compressor. Air is compressed in compressor to be fed in the engine. If it's petrol engine then it's air, else air-fuel as per diesel engine. Pressure of air or air-fuel mixture becomes higher than atmospheric pressure. Output power of the engine is associated with increase in pressure fuels. In adverse situations smooth operation of engine is smooth due to increase in pressure. Its working comprises of four steps i.e. Capture, Spin, Vent and Compress. It can be divided into following parts:

1) Turbine Discharge
2) Compressor Discharge
3) Charge Air Cooler
4) Intake Valve
5) Turbine Inlet
6) Compressor Inlet
7) Exhaust Valve

1.4 Applications

The demand of the project is the Turbocharger which can work in congruence with already existing gasoline engine. Usage of Turbocharger must be defended by students by high lightening its benefits such as:

- Volumetric Efficiency of engine can be increased by it.
- Produced Out power can be increased.
- It takes less input of fuel or air-fuel mixture.
- In various adverse situations, it allows the engine to work smoothly.

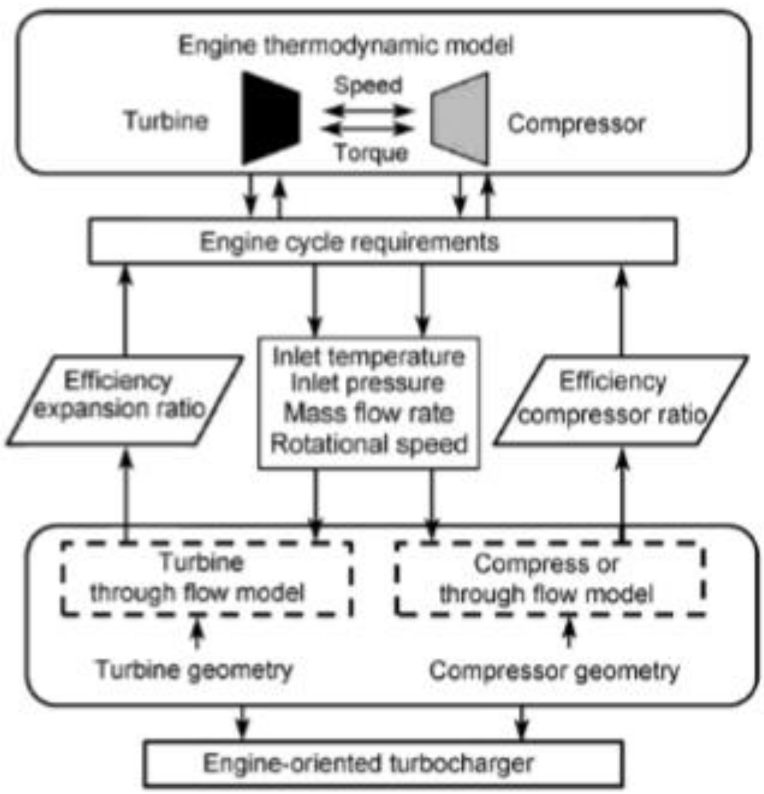
Chapter 2

2 Chapter 2: Literature Review

2.1 Project Background

Zhang says “Transportation framework speaks to 20% to 25% of the CO2 in the environment and this offer tends to increment. Enhancing the proficiency of vehicle inner burning motor power frameworks assumes a basic part in the usage of worldwide vitality preservation and condition security techniques. Turbocharging innovation is today considered as a promising route for motor vitality sparing and CO2 diminishment. Significantly more noteworthy accentuation of turbocharging innovation is being set on scaling down the motors to expanding efficiency and decreasing CO2 outflows. Progressed turbocharging innovation may decrease the motor dislodging volume while keeping a similar execution regarding torque and power contrasted with the underlying bigger motor, and at the same time guarantee a change in motor effectiveness. Amid the most recent couple of years, a few auto creators have introduced 1.8– 2.0 L turbocharged motors. The exhibitions of these turbocharged motors are commonly like those of normally suctioned motors with 2.5 L relocation. The lessening of fuel utilization is normally over 10%, with running conditions nearer to the best proficiency territory. The turbocharging for the scaled back motor could likewise reduce the grating misfortune. Motor turbocharging is the mix of an interior burning motor and a turbocharger. A turbocharger configuration is a noteworthy test for motor execution change. Amid the conventional motor advancement process, the turbocharger is chosen from accessible item records in light of the trademark maps. The picked turbocharger is one of the arrangement items by the part provider, which is outlined and created by the turbo-hardware specialists, and there is an absence of thought of motor task conditions, particularly at the off-plan conditions. Turbocharger configuration ought to be a coordinated method including changing the turbocharger qualities into determination of the motor execution to fulfill the motor task necessities. The task of a turbocharger is on a very basic level unique in relation to that of a responding motor, so a turbocharged motor has numerous unpredictable qualities. The turbocharged motor execution is resolved in substantial part by the procedures collaboration amid activity of the turbocharger and the motor, particularly at off-outline tasks. It might well be important to enhance the execution of the mix by turbocharger plan and motor cycle advancements in the meantime, to incorporate new contemplations, streamlining turbocharger outline and motor framework combination, with the thought of general task execution.

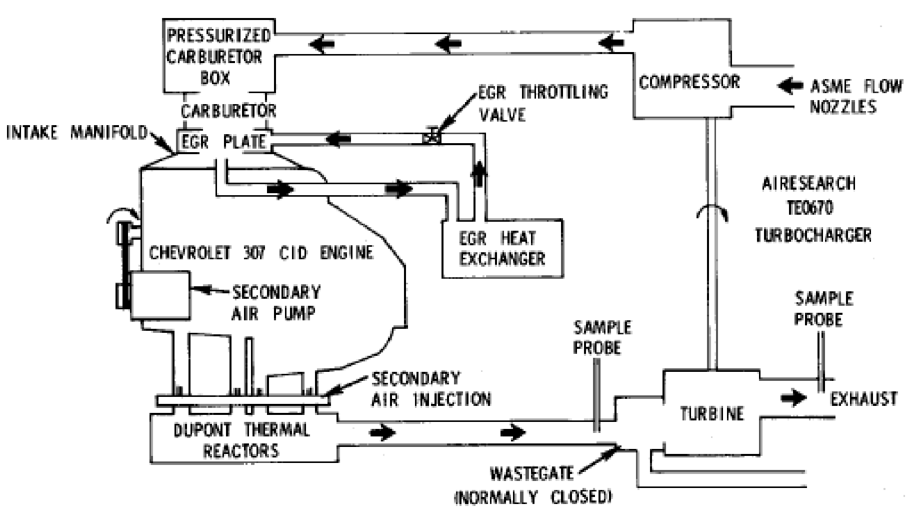
To encourage the turbocharger originator to proficiently produce the most appropriate outline, the reason for this exploration is to set up another incorporated plan technique taking into air conditioning include motor cycle necessities the turbocharger improvement process as quickly as time permits. The turbocharger is coordinately planned based on motor cycle advancement and this outline will enhance motor over execution. A 1.8 L fuel motor turbocharger was utilized as a case to represent the improvement of this approach turbocharger through stream display, the geometry and the execution information will be moved into the motor model for cycle execution reenactment. In light of a particular arrangement of motor necessities, the approach will recognize conceivable turbocharger configuration yield parameter esteems that can meet these prerequisites. An enhancing task methodology is then utilized to create plausible plan choices, and after that the focused-on motor arranged turbocharger will be acquired". [1]



1Figure 2.1 Turbocharge integrated approach

2.2 Previous Work and Comparative studies

John F. Schweikert and John H. Johnson says "Turbocharging, notwithstanding expanding a motor's energy yield, can be adequately used to keep up deplete discharge levels while enhancing efficiency. This paper displays the discharge and execution comes about acquired from a turbo charged multi cylinder start motor with warm reactors and fumes gas distribution (EGR) worked at consistent state, part load conditions for four motor rates. When contrasting a turbocharged motor with a bigger dis arrangement normally suctioned motor of equivalent power output, the outflows communicated in grams per mile were moderately unaltered both with and without EGR. Be that as it may, turbo charging gave a normal of 20% change in mileage both with and without EGR. When contrasting the turbocharged and non-turbocharged forms of a similar motor without EGR at a given load and speed, turbocharging expanded the hydrocarbon (HC) and carbon monoxide (CO) emanations and diminished oxides of nitrogen (NOx) emanations. With the expansion of EGR, turbocharging expanded every one of the three discharges. When looking at turbocharged and non-turbocharged motors of equivalent removal on the overwhelming obligation 133- -mmooddee dynamometer cycle, turbocharging decreased CO discharges also, expanded the HC and NOx discharges both with and without ERG great potential for decreasing discharges. Thomas (5) detailed on the discharge attributes of a Volkswagen retrofitted with a turbocharger unit. The turbocharger establishment appeared a slight decrease in discharges, in spite of the fact that whether this was expected to the turbocharger or a distinction in carburetor change is obscure. The adjustments in street execution contrasted with the stock vehicle were emotional. For instance, the turbocharger lessened the 50-80 mph hanging loose from 30 to 20 s, however mileage under street stack conditions remained un-changed. Turbocharging can likewise be utilized adequately to decrease vehicle fumes discharges from bigger traveler autos or trucks It would permit an extensive relocation normally suctioned SI motor (400-450 in3 to be supplanted by a little uprooting turbocharged SI motor (300 inpro3duci)ng approach most extreme control yield". [2]



2Figure 2.2 Turbocharged Engine Installation Schematic.

Also, Hiroyuki Sugihara, Yuzo Aoyagi, Shin Endo, Tetsuya Otani, and lsao Joko states that “The optimum air quantity for minimizing BSFC was studied experimentally on heavy duty diesel engine under the restrictive conditions of NOx emission, exhaust smoke and Pmax. Also, the performance characteristics of the waste gate control turbocharging, variable geomeuy turbocharging, sequential turbocharging and two-stage turbocharging were discussed.

The following conclusion have been obtained:

1) In the low engine speed range where the air quantity is insufficient, when the air quantity is increased, Pmax does not increase due to retardation of injection timing while the smoke concentration and BSFC can be reduced substantially. It is therefore advisable to maximize the air quantity as far as possible. The methods to increase the air quantity in the low engine speed will be the waste gate control turbocharging, the variable geometry turbocharging (VGT), the sequential turbocharging and the two-stage turbocharging. As practical methods, the waste gate turbocharging and VGT were compared with the conventional turbocharging. The waste gate control turbocharging and VGT increase the air quantity in the low engine speed over that of the conventional turbocharging. They are the effective methods for torque recovery in the low engine speed.

2) In the middle and high engine speed ranges, when the air quantity is increased, the smoke concentration and BSFC tend to decrease but its reduction effect is rather insignificant. Over the air excess ratio 2 in the high engine speed range where the air quantity is sufficient, the efficiencies of combustion and gas exchange work cannot be improved even if the air quantity is increased. Moreover, BSFC tends to be worsened by an increase in friction due to the increase of Pmax. Under the present technical limitations, the target value of air excess ratio is around 2. It is therefore important to optimize the air quantity while taking account of the smoke concentration, BSFC requirement and Pmax limit in the middle and high engine speed ranges”. [3]

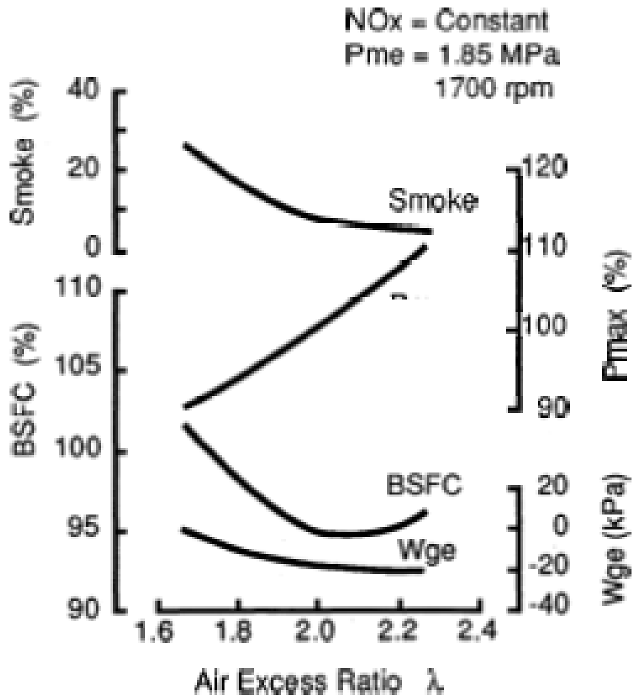


Figure: 3.3 Changes of Engine Characterizes versus Air Excess Ratio at low Engine Speed

Chapter 3

3 Chapter 3 system Design

3.1 Design Constraints

In Saudi Arabia students usually faced a problem which is the lack of parts in the available markets which is required in the projects. So, due to that, we could not be able to manufacture the turbocharger itself. Also, our point of view is to keep the body of the car original. So, we faced a problem with the location of turbocharger itself. It took from us some time trying to figure out the best location we can install the turbocharger so based on that we can manage our design. Moreover, the same thing repeated in the intercooler pipes as we want to do not cut and weld the chassis we found a solution to change the position of the inlet. In addition, the turbocharger we decided to purchase it rather than do the manufacturing in local markets. In fact, as you know if we try to manufacture it abroad it is going to be coastally so basically due to the time limitation we will not be able to submit the project before the deadline these are constraints we face it. In addition, turbocharger should be selected on how many hours power we want. Although, we should put on our consideration the throttle valve inlet and based on that we can select the turbo size and design the system itself. Our target is to increase the performance 100 horse power or more.

3.1.1 *Standards:*

Standards	Codes
J1349 Certified Power Engine Data for 5.7L V8 as used in 2016 MY Dodge Charger R/T AWT - Level 2	CPFC2_09MYCHATX
Internal combustion engines -- Determination and method for the measurement of engine power -- General requirements	ISO 15550:2016
Turbocharger Connections	J1135_197607
Coolant System Hoses	J20_201503
Turbocharger Gas Stand Test Code	J1826
AS6300 Valve Spring	AS6300-1
Flange - Two-Bolt Exhaust	AS222B
Automotive Pipe Fittings	J530_201803
Engine Charge Air Cooler (CAC) Nomenclature	J1148_200405
High Temperature Materials for Exhaust Manifolds	J2515_201712
Wrought aluminum and aluminum alloys -- Cold-drawn rods/bars, tubes and wires -- Part 5: Drawn square and hexagonal bars and wires -- Tolerances on form and dimensions	ISO 6363-5:2012

3.2 Design Methodology

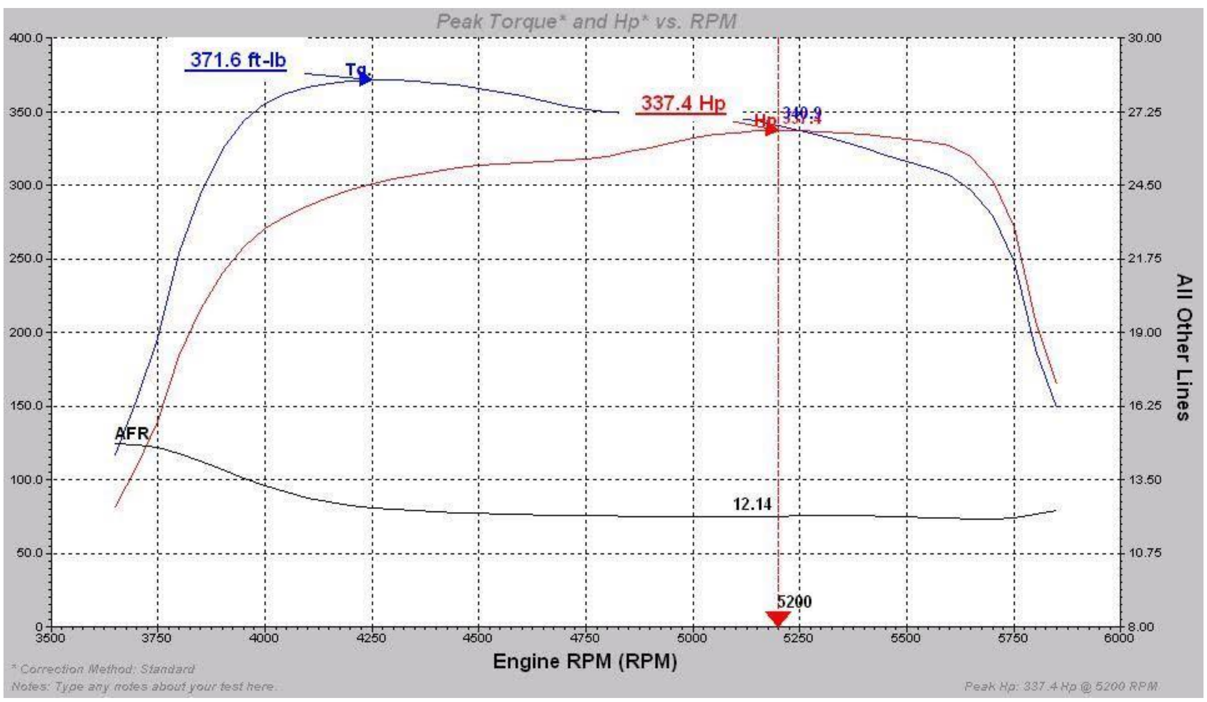
The design methodology for achieving the objectives of the project needs to experience a few critical stages. The result will be founded on what has been utilized effectively in the design system to get the final prototype of the project. To get the final prototype we need to take after the next stages:

1- Have a background on IC engines and a good relevant research to insure the first stage is completed.
2- Design the drafts drawings of the system through SOLIDWORKS.
3- Selecting a turbo that is applicable for the selected engine which is 5.7 Dodge Charger Hemi.
4- Select of appropriate an intercooler due to the heat generated from the exhaust.
5- Manufacture and assembly the system parts.
6- Testing before and after the turbocharger by dynamometer to show the difference on the performance and check if it is applicable.
7- Generate a future recommendation for turbocharge systems.

3.3 Theory and Theoretical Calculations:

In this project, there are seven main objectives that need to be calculated before starting to install the system of turbocharge. One of these things is the break power $\dot{W}b,$ is the power output of the engine, and measure by a dynamometer. Another thing is the Mach number that should be less than 1, because, when the Mach number equal 1 it will be choked flow. The mean piston speed is the average speed of the piston in a reciprocating engine. And also, will calculate the mass flow, the mass Airflow rate, the critical mass and The Brake Mean Effective Prussure

The below calculations are from dynamometer test before turbocharge based on the following figure.



4Figure: 3.1 Peak Torque and Horsepower Vs RPM.

1Table 3.1: data collection for the car from Excel data log

ENGINE RPM	Torque	Volumetric efficiency	Pressure inlet	Pressure ratio	Inlet temperature	Volume displacement	Strok	Valve diameter
RPM	***N.m***	***%***	***kpa***		***K***	***Letter***	***mm***	***mm***
4250	***503.8***	***101.100***	***101.3***	***0.982***	***301***	***5.7***	***90***	***50***

3.3.1 *The Brake Mean Effective Pressure bmep*

$$\text{bmep} = \frac{4\,\pi\,\tau}{\text{Vd}} \qquad \text{(Eq. 3.1)}$$

Where:

bmep: The Brake Mean Effective Prussure

τ: Torque

Vd: Volume Displacment.

When:

$\tau = 503.8\ \text{N.m}$

$\text{Vd} = 5.7\ \text{letters}$

$$\text{bmep} = \frac{4\,\pi\,(503.8)}{5.7/1000}$$

$\text{bmep} = \mathbf{1110.69\ KPa}$

3.3.2 *The Brake Power, $\dot{W}b$*

$$\dot{W}b = 2\pi\tau N \qquad \text{(Eq. 3.2)}$$

Where:

$\dot{W}b$: Brake Power

τ: Torque

N: Mean Speed(rpm)

When:

$\tau = 503.8$ N.m

$N = 4250$ rpm

$$\dot{W}b = 2\pi(503.8)\left(\frac{4250}{60}\right)$$

$\dot{W}b = \mathbf{224.220\ KW}$

$\dot{W}b$ = **300.7 hp**

3.3.3 *The Mean Piston Speed ($\bar{U}P$)*

$$\bar{U}P = 2NS \quad \text{(Eq. 3.3)}$$

Where:

$\bar{U}$P: Mean Piston Speed

N: Mean Speed (rpm)

S: Stroke (four Strok)

when:

N = 4250 rpm

S = 90.0 mm

$$\bar{U}P = 2\left(\frac{4250}{60}\right)\left(\frac{90.5}{1000}\right)$$

$$\bar{U}P = \mathbf{12.82 m/s}$$

3.3.4 *The mass Airflow rate ($\dot{m}_a$)*

$$\dot{m}_a = e_v \rho i \, Vd \left(\frac{N}{2}\right) \qquad \text{(Eq. 3.4)}$$

where:

$\dot{m}_a$: Air flow rate

e_v: Volumetric Efficiency

ρi: Density of the air

Vd: Volume Displacment

N: Mean Speed(rpm)

3.3.4.1 Density of the air

$$\rho i = \left(\frac{\rho_i}{R\ Ti}\right)$$

Where:

Pi: Density of the air

Pi: Pressure inlet

R: Gas constant

Ti: Inlet temperature

when:

$Pi = 101.3$ kpa

$R = 0.287$

$Ti = 28$ °C

$$\rho i = \left(\frac{101.3}{0.287 * (28 + 273)}\right)$$

$\rho i =$ **1.1726 kg/m³**

when:

$e_v = 100.1\%$

$\rho i = 1.1726$ kg/m³

$Vd = 5.7$ letters

$N = 4250$ rpm

$$\dot{m}_a = \frac{1}{2}(1.001)(1.1726)\left(\frac{5.7}{1000}\right)\left(\frac{4250}{60}\right)$$

$$\dot{m}_a = \mathbf{0.237}\ \left(\frac{\mathbf{Kg}}{\mathbf{s}}\right)$$

3.3.5 *Mass flow rate ($\dot{m}$)*

$$\dot{m} = \rho_i \ A_f \ c_o \left[\frac{2}{\gamma-1} \left(\ \left(\frac{P_2}{P_1} \right)^{\frac{2}{\gamma}} - \left(\frac{P_2}{P_1} \right)^{\frac{(\gamma+1)}{\gamma}} \right) \right]^{\frac{1}{2}} \quad \text{(Eq. 3.5)}$$

where:

$\frac{P_2}{P_1}$: pressure ratio

A_f : effective area

γ: 1.4

ρ_i :Density of the air.

c_o : sound speed

3.3.5.1 ***sound speed***

$$c_o = \sqrt{\gamma \, R \, T_i}$$

where:

γ: 1.4

T_i: Inlet temperture

R: Gas constant

when:

$\gamma = 1.4$

$T_i = 28\ °C$

$R = 0.287$

$$c_o = \sqrt{1.4\ (0.287)(28 + 273)}$$

$$c_o = \mathbf{10.997\ m/s}$$

3.3.5.2 *Effective area*

$$A_f = C_f A_V = C_f \frac{\pi}{4} d^2 \text{ (seat)}$$

Where:

C_f: flow coefficient

A_V: Valve area

d: Diameter

When:

C_f: 0.41

d: 52 mm

$$A_f = 0.41 \frac{\pi}{4} (0.052)^2$$

$$A_f = \mathbf{8.71 \times 10^{-4}\ m^2}$$

when:

$$\frac{P_2}{P_1} = 0.982$$

$$A_f = 8.71 \times 10^{-4}\ m^2$$

$$\gamma = 1.4$$

$$\rho_i = 1.1726\ kg/m^3$$

$$c_i = 10.997\ m/s$$

$T_i = 28\ °C$

$$\dot{m} = (1.1726)(8.71 \times 10^{-3}(10.997)\left[\frac{2}{1.4-1}\left((0.982)^{\frac{2}{1.4}} - (0.982)^{\frac{(1.4+1)}{1.4}}\right)\right]^{\frac{1}{2}}$$

$$\dot{m} = \mathbf{0.0178\ \frac{kg}{s}}$$

3.3.6 *The Mach number (M):*

$$\frac{P_1}{P_2} = \left[1 + \left(\frac{\gamma-1}{2}\right) M^2\right]^{\frac{\gamma}{\gamma-1}} \qquad \text{(Eq. 3.6)}$$

where:

$$\frac{P_1}{P_2} = \frac{P_{low}}{P_{high}}$$

when:

$$\frac{P_2}{P_1} = \frac{P_{high}}{P_{low}} = \text{pressure ratio} = 0{,}982$$

$$\frac{P_1}{P_2} = \frac{P_{low}}{P_{high}} = \frac{1}{0.982} = 1.0183$$

$$\frac{1}{0.982} = \left[1 + \left(\frac{1.4-1}{2}\right) M^2\right]^{\frac{1.4}{1.4-1}}$$

$$M = \mathbf{0.1611}$$

3.3.7 *The critical mass ($\dot{m}_{cr}$)*

$$\dot{m}_{cr} = \rho_I A_f c_o \left(\frac{2}{\gamma+1}\right)^{\frac{(\gamma+1)}{2(\gamma-1)}} \quad \text{(Eq. 3.7)}$$

where:

$\dot{m}_{cr}$: Mass critical

A_f: Effective area

ρ_I: Density of the air.

$\gamma = 1.4$

c_o: sound speed

when:

$A_f = 8.71 \times 10^{-4}\ m^2$

$\gamma = 1.4$

$\rho_i = 1.1726\ kg/m^3$

$c_o \coloneqq 10.997\ m/s$

$$\dot{m}_{cr} = 1.1726\,(8.71x\,10^{-4})\,(10.977)\left(\frac{2}{1.4+1}\right)^{\frac{(1.4+1)}{2(1.4-1)}}$$

$$\dot{m}_{cr} = \mathbf{0.07140\ kg/s}$$

3.4 Product Subsystems and selection of Components:

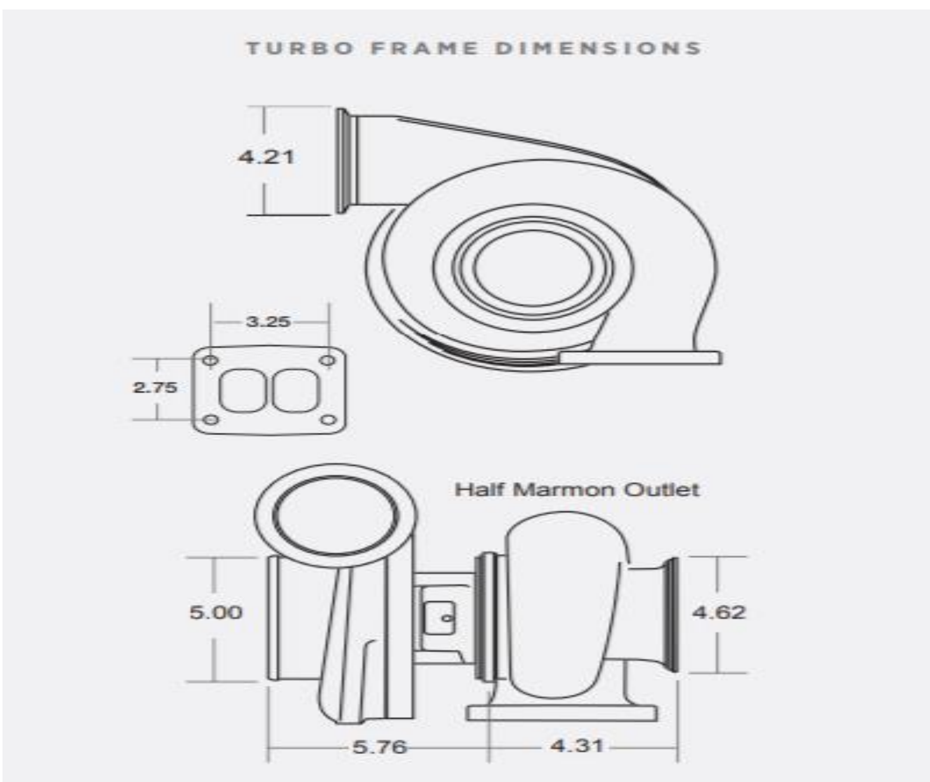
3.4.1 *Turbocharge Selection:*

The selection of the turbocharger for a system is possibly the most important decision that there in the entire process. A properly selected turbocharger with some nice features will wonderfully compliment the engine while simplifying the system design and plumbing. However, a poorly chosen turbocharger will do little to increase engine power while causing one headache after another over the system design and plumbing. A turbocharger is chosen primarily based on its size but there are several other desirable features to look for as well. The team went through a lengthy turbocharger selection process marked by repeated compromises leading to the final decision.

5Figure 3.2 Turbocharge.

3.4.2 *Turbocharge Sizing:*

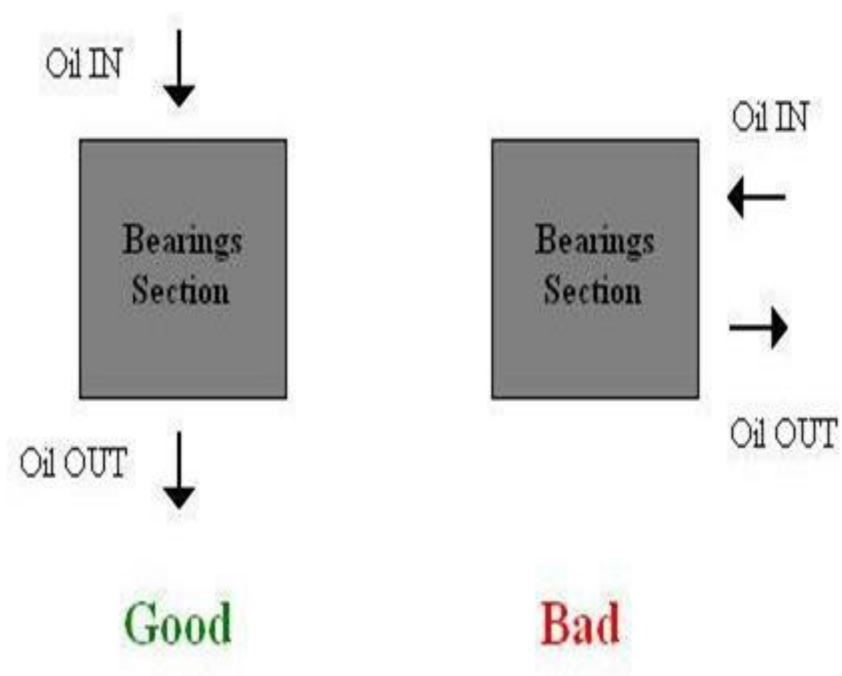
There are two separate parts of the turbocharger that need to be sized correctly, the compressor and the turbine. However, before either of these components can be sized, the objectives of the turbocharged system need to be determined. While engine displacement and peak horsepower are important pieces of information, a little planning needs to be added to this knowledge before proceeding with the selection of a turbocharger.



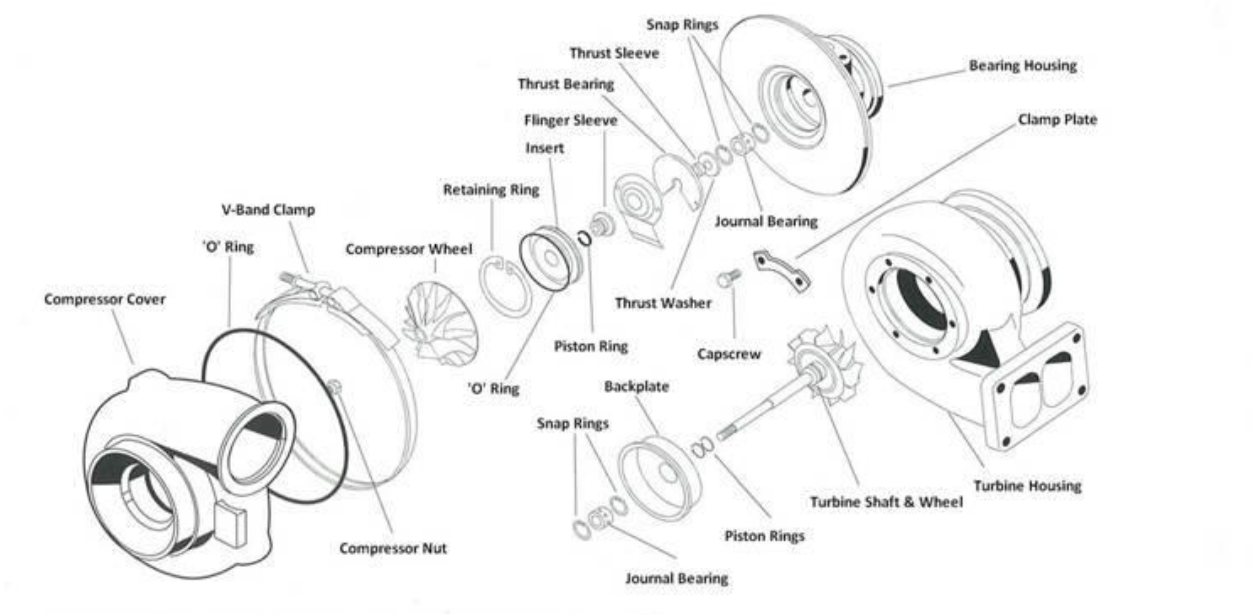
6**Figure 3.3: Sizing of Turbocharge.**

7Figure 3.4 Parts of Turbocharge.

Finally, the connections for all inlets and outlets should be looked at. The compressor inlet and outlet will both likely be designed for a hose to be clamped on to them. If this is the case, they should have a lip to assist in clamping. Their diameters should also be standardized so standard sized hose can be purchased. The bearings section will have an oil inlet and outlet for sure but may also have a oil inlet and outlet. These inlets and outlets should be examined to determine how easy it will be to acquire and connect the right hoses for the oil and, possibly, water. The oil inlet and outlet absolutely should not be on the same face. They should be on opposite faces. The same should be true for the water inlet and outlets. If the inlet and outlet are on the same face, the small size of the turbocharger can create major problems in fitting all the necessary connections into that small area. The turbine inlet and outlet will most likely be bolt on connections requiring flanges. Preferably the turbocharger manufacturing will produce gaskets and flanges for the turbine, which saves the trouble of having to design and machine custom ones. Thicker flanges and flange connections seal better and are less likely to fail under the stress they experience.



8Figure 3.5 Good and bad oil inlet and outlet orientations.



9**Figure 3.6 The internal parts of Turbocharger.**

3.4.3 *Finding the Right Turbocharge for the Project*

At the start of the project, the team was given an unused turbocharge. After reviewing the rationale for our selection in our report, the decision was made to start the turbocharge selection process from scratch. This decision was made after examining the airflow data that was used to map the compressor. The data seemed to contradict itself and its source was not cited, making it suspect. The plan for this year was to get the naturally aspirated engine running with a restricted intake, and to then use an airflow sensor to experimentally acquire airflow data necessary to properly map a compressor. An ideal compressor map was to then be constructed and used to locate the most compatible turbocharger. Since the engine never successfully ran and the data acquisition system was never completed, this experimental data was never obtained and an ideal compressor map was never made. The turbocharger selection process thus had to proceed without enough data to make a proper decision.

In addition to the lack of data problem, a lack of choices problem also existed. Further complicating things was the restrictor. The restrictor was going to cause the engine to consume less air and produce less power than a normal 600cc engine. This means that a turbocharger designed for a 600cc engine could end up being too large for this system. The team decided to try to find the smallest turbocharger it could to try to compensate for the intake restrictor. Since no empirical data could be gathered to properly size the turbochargers, this seemed like as good a plan as any.

The search for small turbochargers thus began. One requirement, however, was that any turbochargers that were found had to have a compressor map. Even though the system could not be properly plotted on the map, being able to compare the compressor maps of two turbochargers is enough to determine which is better suited for smaller airflow rates characteristic of smaller engines. The team spent an extensive amount of time trying to find alternative turbochargers. The internet was searched from auction websites to turbocharger manufacturer websites to forums. Junkyards and motorcycle shops were contacted. An old turbocharger found lying around the shop was even investigated until it was found to have severely damaged bearings. However, after all that, there were no viable alternatives. The closest thing to a feasible alternative was the IHI RHF3. The IHI website indicates that this turbocharger is well suited for engines as small as and handles airflows up to 222.5 CFM. A complete compressor map could not be found for the RHF3, but Fig. 4.8 shows a simplistic compressor map comparison between the RHF3 and other members of the IHI RH series.

3.5 Manufacturing and assembly (Implementation):

3.5.1 *Turbocharger*

The Turbocharger is used by connecting it to the throttle valve where it will then be closed using a flange. In addition, we tried our best to be accurate in the design and the dimensions to ensure the airflow which pressurized do not lose it or get leaked. Also, the oil Turbocharge will give a great output since and also the long-life term will be smooth of it because it will reduce the scratches and friction for the bearings.

10Figure 3.7 Turbocharger

3.5.2 *Wastegate*

The wastegate is a valve small in size, which is used to control the how much of boost the turbo makes. It opens once the airflow comes out of the manifold and once the boost reaches the level we need directly the rest of the air will be discharged by the wastegate. In addition, the goal is a daily usage of the car so the boost was 8 PSI. Also, in our project the Wastgate will be external.

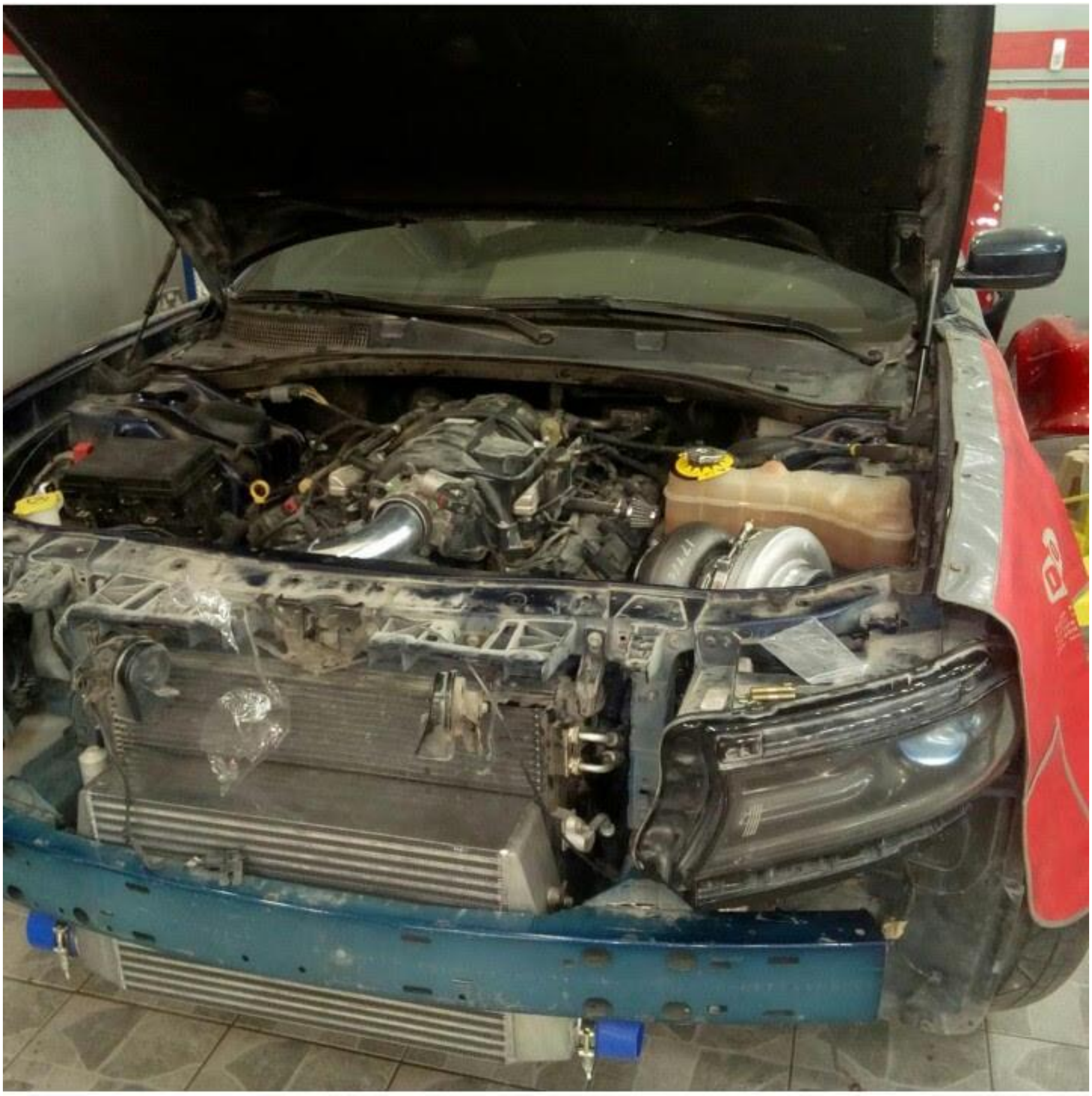
3.5.3 *Valve Spring*

Due to the huge pressure that will became from the turbocharger so the original valve lifter will be damaged. Furthermore, we had to change the valve spring and purchase a high stiffness spring. To ensure the head of the chamber keep run smoothly.

11Figure 3.8 Valve Spring

3.5.4 *Intercooler*

An intercooler, in general is a radiator designed to cool the hot "boosted" air coming out of the turbocharger. Because compressing air raises its temperature. Intercooling goes hand in hand with turbocharging always. We fabricate the inlet elbow to ensure and keep the car original rather than a fabrication into the body of the car or the chassis. Also, we used an aluminum to do the piping.



12Figure 3.9 Intercooler

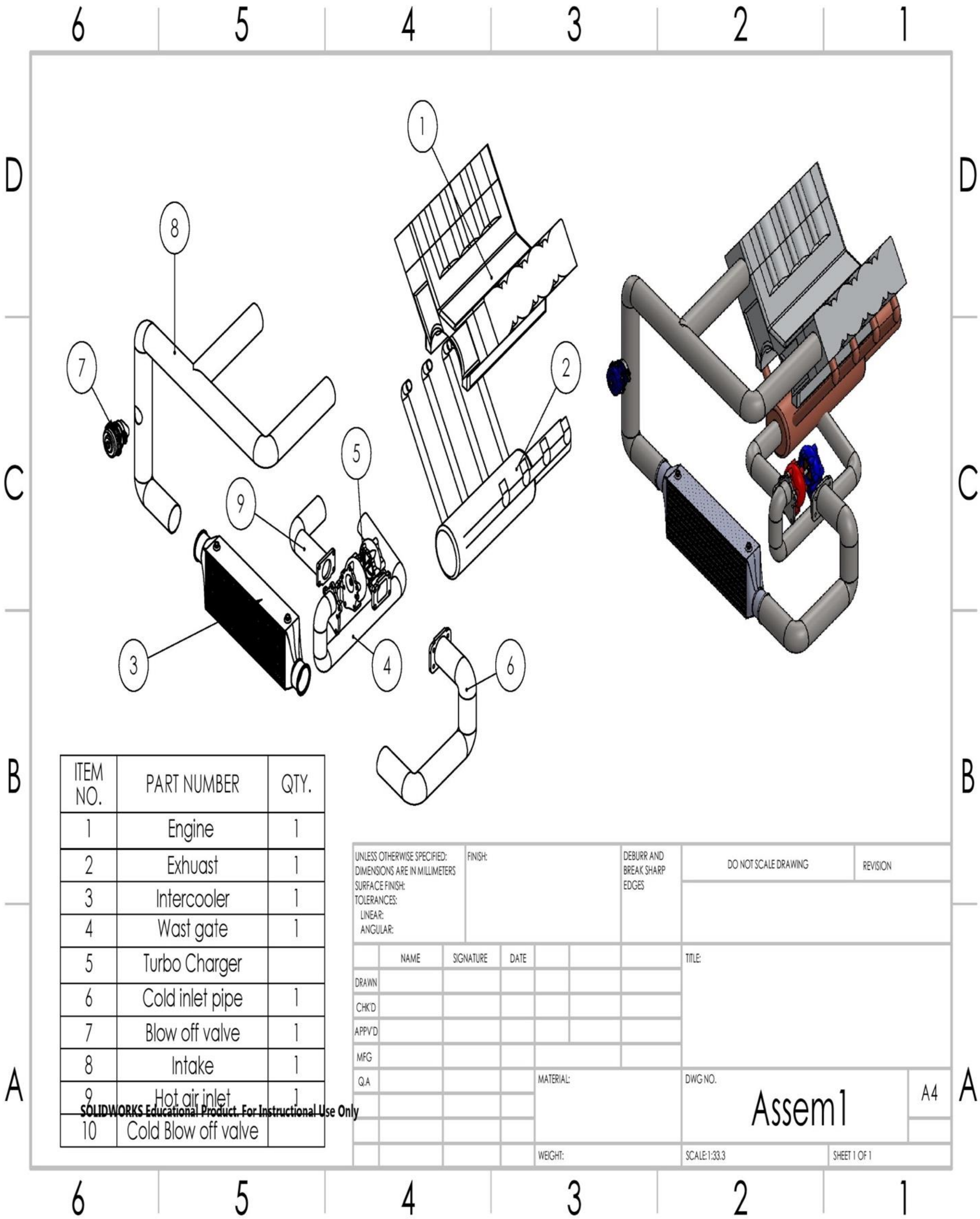
3.5.5 *Blow of Valve*

Blow of valve is small valve locate before the throttle valve to bypass the air once the throttle is closed. So, we put the blow of valve in our consideration and it will be connected by an aluminum pipe.

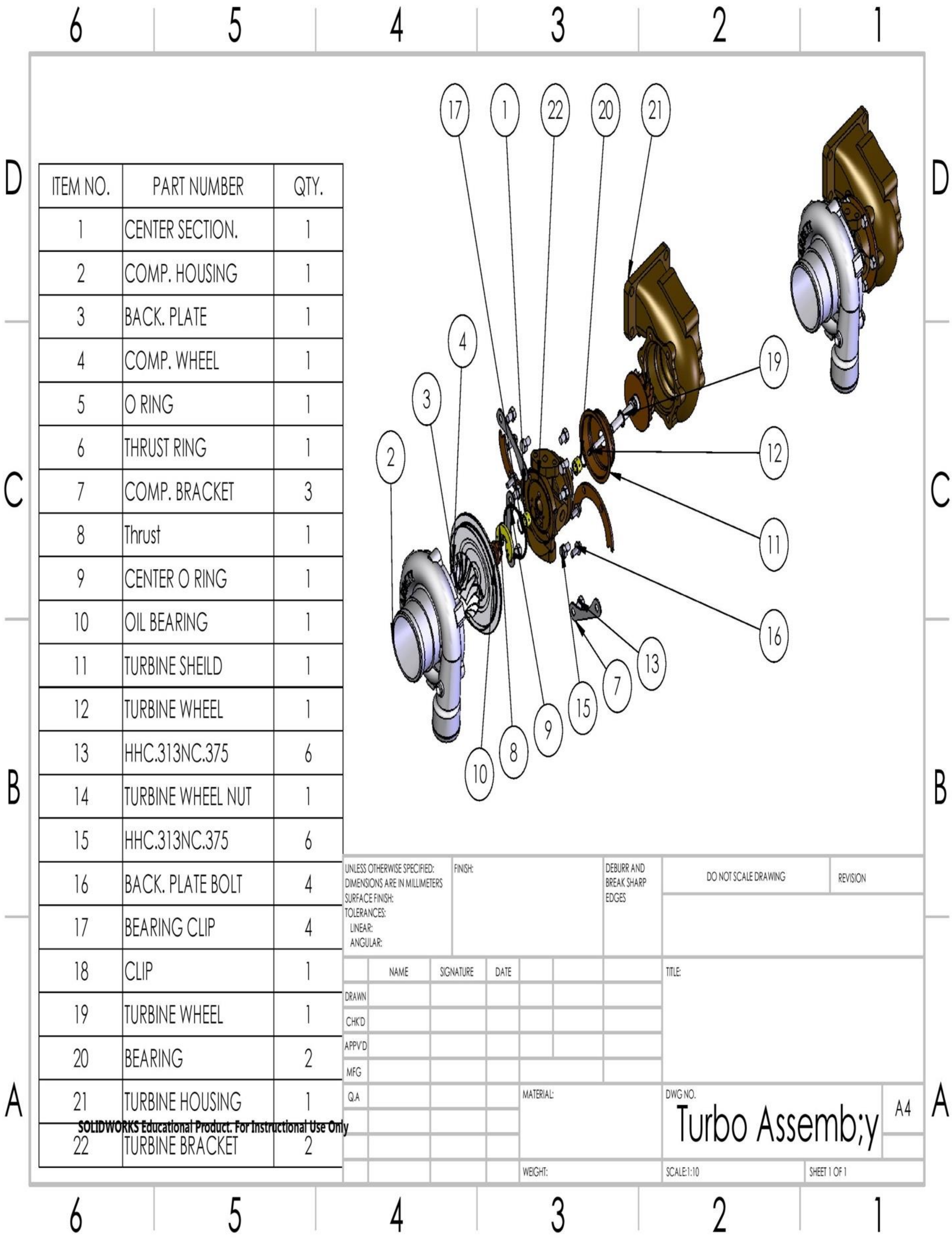
13Figure 3.10 Blow of valve

We designed our project system in Solidworks program. And in following pages the design assembly that the team members decide to did it like this, and here it is some 2d drawing already that shows in Fig (3.7) the block of engine, Exhaust, Intercooler, Wastegate, Turbocharger, Cold inlet pipe, blow off valve, Intake, Hot air inlet and cold blow off valve.

In Fig (3.8) shows the center section, comp. housing, back plate, comp wheel, O ring, thrust ring, comp bracket, Thrust, center O ring, Oil bearing, Turbine shield, turbine wheel, Turbine wheel nut, Back plate bolt, Bearing clip, Clip, Bearing, Turbine housing and Turbine bracket.



14Figure 3.7 Assembly of Engine (SOLIDWORKS).



ITEM NO.	PART NUMBER	QTY.
1	CENTER SECTION.	1
2	COMP. HOUSING	1
3	BACK. PLATE	1
4	COMP. WHEEL	1
5	O RING	1
6	THRUST RING	1
7	COMP. BRACKET	3
8	Thrust	1
9	CENTER O RING	1
10	OIL BEARING	1
11	TURBINE SHEILD	1
12	TURBINE WHEEL	1
13	HHC.313NC.375	6
14	TURBINE WHEEL NUT	1
15	HHC.313NC.375	6
16	BACK. PLATE BOLT	4
17	BEARING CLIP	4
18	CLIP	1
19	TURBINE WHEEL	1
20	BEARING	2
21	TURBINE HOUSING	1
22	TURBINE BRACKET	2

15Figure 3.8 Assembly of Parts (SOLIDWORKS)

Chapter 4

4 Chapter 4: System Testing and Analysis

4.1 Dynamometer

16Figure 4.1 Dynamometer

As shown in fig 4.1 the dynamometer, or "dyno", is a device for measuring force, moment of force (torque), or power before and after turbocharger. For example, the power produced by an engine, motor or other rotating prime mover can be calculated by simultaneously measuring torque and rotational speed (rpm). Also, the device will be used to calculate the volumetric efficiency, pressure ratio, intake air temperature and manifold absolute pressure. The specifications below will give a detailed about the dynamometer. [1]

Specifications:

- Maximum speed: 200 MPH / 322 KPH
- Maximum horsepower \ torque: 2000 HP / 2000 FT LBS
- Drums: 1
- Drum diameter: 24 IN / 61 CM
- Drum weight: 81 IN / 205 CM
- Maximum axial weight: 3000 LBS / 1361 KG per Axle
- Air requirement: 100 PSI
- Operating temperature range: 32 to 158 F / 0 to 70 C
- Timing accuracy: +/-1 Microsecond
- Drum speed accuracy: +/-1/100th MPH
- RPM accuracy: +/-1/10th RPM

Blow off valve:

17Figure 4.2 blow off valve

Here's how it works, a blow-off valve is connected to the intake tract. Inside the valve's main housing is a vacuum chamber with a spring, diaphragm and valve. The diaphragm reacts to pressure changes and at a predetermined vacuum it's pulled toward the vacuum source compressing the spring inside the housing. (4) The spring is connected to a valve that pulls away from its seat and releases the unwanted boost pressure. On some BOVs, an adjustment screw lets you control at what pressure in the intake system the valve is activated. It is also possible to swap the spring to change the activation point. The location of the blow off valve is after the throttle body fixed on the intake pipe. The specifications below will give a detailed about the blow off valve.

Specifications:

- A single Q BOV can support up to 1,800hp
- Use if vacuum at ideal is between: -14in/hg to -17in/hg
- spring pressure (PSI): -9.00
- Assembly Designation: BV 44MM
- -2psi spring for turbocharge applications
- The V-Band design aluminum mounting clamp gives a very clean and unique appearance. The clamp uses Stainless Steel hardware for a long lasting, corrosion-free appearance.
- The valve seal utilizes a Viton O-ring that is clamped in place to prevent the possibility of sticking to the seat and pulling out.
- The valve stem and guide are Teflon-lubricated, hard anodize-coated for wear resistance.

Waste gate:

18Figure 4.3 waste gate

A waste gate is a boost-controlling device that operates by limiting exhaust gases going through the turbocharger, controlling the maximum boost pressure produced by the turbocharger itself. A waste gate consists of an inlet and outlet port, a valve and a pressure actuator. A pressure actuator, controlled by boost pressure determines whether the waste gate is open or shut. In its resting position, a waste gate is shut, and as the boost pressure builds, force is applied to the actuator. When the boost pressure exceeds the spring value, the actuator will progressively open the waste gate, bypassing some of the exhaust gases therefore maintaining the boost pressure at the set level. To put it simply – a waste gate prevents the boost pressure from climbing indefinitely and consequently blowing the engine. The location of the waste gate under turbocharge fixed on exhaust pipe. The specifications below will give a detailed about the waste gate. [3]

Specifications:

• Size: 3" X 10" X 1.0"

• An internal Nickel Chromium Alloy valve

• Assembly Designation: 46mm

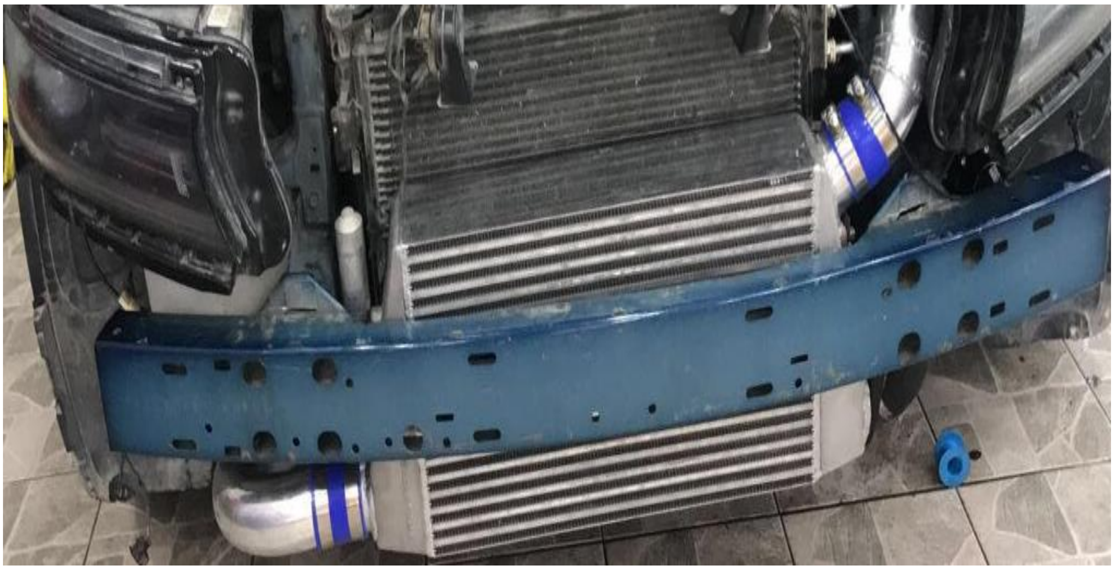
• 5 different 17-7 precipitation hardened springs for further adjustment of boost levels

• Standard clamp-style flange configuration for easy mounting

• A satin black anodized finish with 6061 aluminum billet cap

• All clamps necessary for installation

Inter cooler:



19Figure 4.4 inter cooler

The intercooler's job is to cool down the air after it has been compressed by turbocharge, but before it enters the engine. Turbochargers work by compressing air, increasing its density before it reaches the cylinders of the engine. By squeezing more air into each cylinder, the engine is able to burn proportionally more fuel, creating more power with each explosion (2). The intercooler works to counteract this process, cooling the compressed air to provide the engine with more oxygen, and improving the combustion in each cylinder. In addition, by regulating the temperature of the air, it also increases the reliability of the engine, by ensuring the air to fuel ratio in each cylinder is maintained at a safe level. The location of the inter cooler is in front center of the car as shown in the figure below.

Specifications:

Size: 10.5" X 22" X 4.5"

Overall length: 30"

Flow rate: 1300CFM

Efficient: 860 HP

Pressure drop: Less than 2 psi pressure drop, at max flow

Pressure checked: to 150ps

4.2 Results, Analysis and Discussion

4.2.1 *Goals:*

After this experiment, the main thing that need to be is to increase the power and torque of the engine by using turbocharge. Also, the second thing is to improving the combustion inside the engine to make it work smoothly and give more power and make the engine more efficient. So, the purpose of this experiment is to making the engine more powerful with turbocharge.

4.2.2 *Experimental methodology*

1- Measuring device: dynamometer is the main devise in this experiment which is by dynamometer measuring the horsepower and torque before and after turbocharge will be known.

2- Tuner: the main job of the tuner is to program the computer of the car to make the turbocharge work well and to avoid any mistake that will make damage on the system.

3- Blow off valve: it is work as a valve that release the pressure on the pipes. When the throttle body close there is high pressure inside pipes if it is closed the job of blow off valve here is to release this pressure.

4- Inter cooler: to cool the hot air that comes from exhaust, then the hot air enters to the cooler, then from the intercooler to the turbocharge.
5- Waste gate: the used of waste gate is to limiting exhaust gases going through the turbocharger, controlling the maximum boost pressure produced by the turbocharger itself.

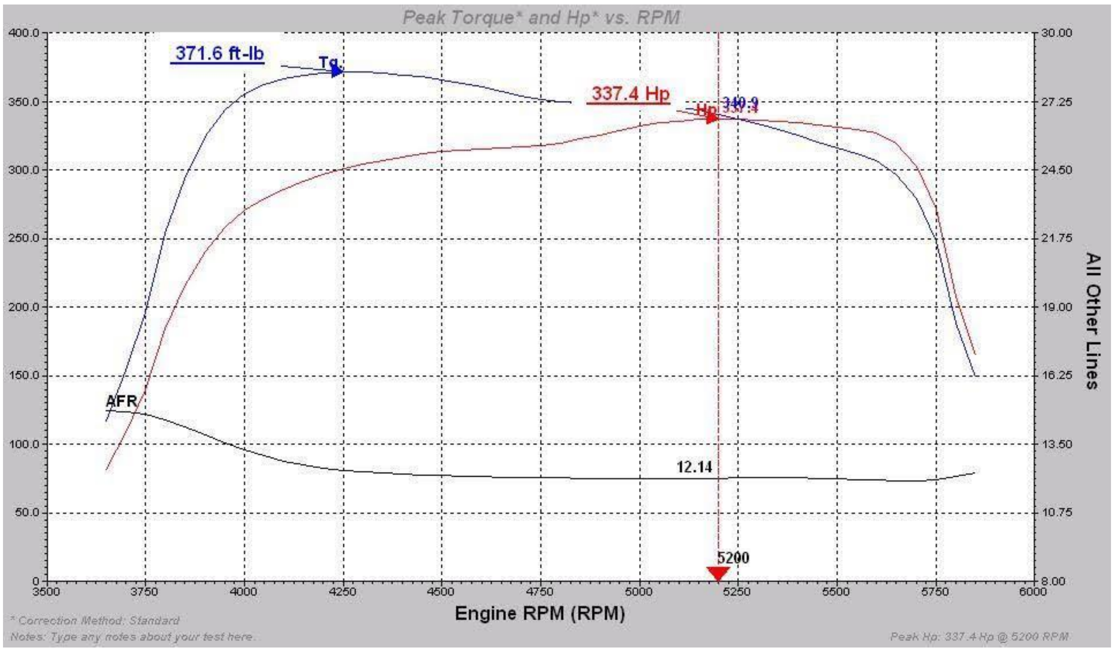
4.2.3 *System testing*

Procedure:

In the beginning, put the car on the dynamometer and fix it on the dynamometer by using ropes installed in the ground to prevent the car from sliding or deflecting from the dynamometer. After that, connect the computer of the car by the tuner computer to programme and put new set up for the car. Then, accelerate the car by passing the gear until the fourth gear, on the fourth gear the tuner presses the entire throttle until the car takes its maximum speed. Faunally, the maximum power and torque comes from the engine will show up as a diagram with horsepower and torque number on the computer like a figure 4.5.

Result before turbocharge:

After doing the dynamometer test, the results before insulting turbocharge on the car will show up clearly in figure bellow. Moreover, the results will show and explain very well in this section. Also, there are three graphs will show in this section which is the horsepower, torque, and horsepower with torque versus rpm.

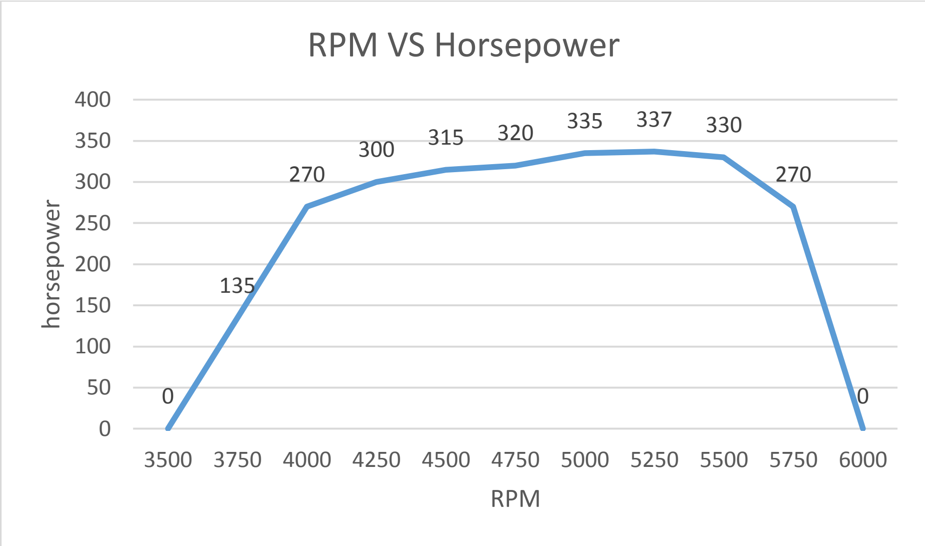


20 Figure 4.5 Dynamometer before Turbocharge.

After run the car on the dynamometer without turbocharge Fig (4.5), there is as shown in the figure that the two parameters which is the maximum horsepower and torque versus rpm. Before insulting turbocharge the maximum horsepower is 347 hp at 5200 rpm, and the maximum torque is 380 ft-lb at 4250 rpm. In addition, after installing turbocharge on the car there will be for sure big different in both horsepower and torque, and that will be clear if the car takes run test after turbocharge.

2Table 4.1 Data for RPM and HP.

RPM	3500	3750	4000	4250	4500	4750	5000	5250	5500	5750	6000
Horsepower	0	135	270	300	315	320	335	337	330	270	0

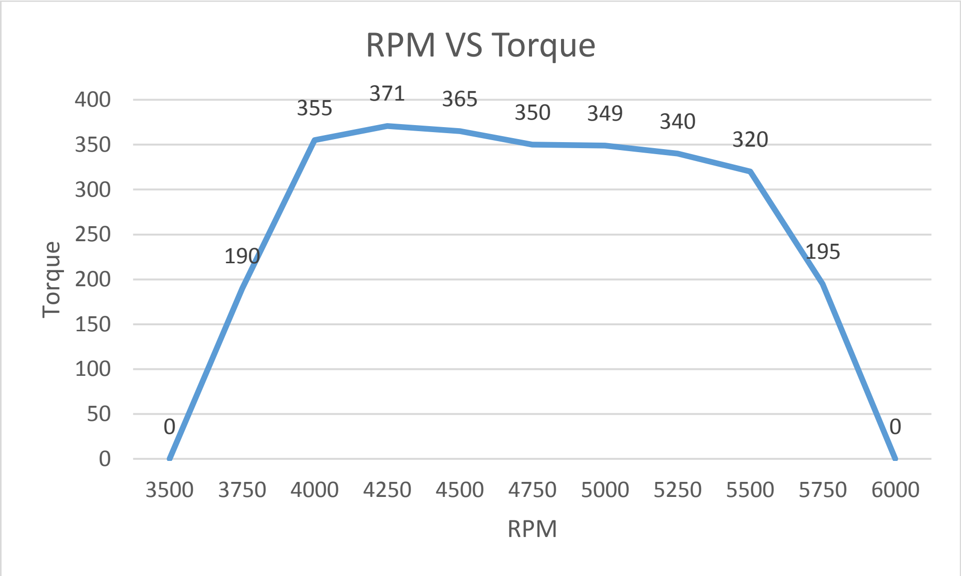


21Figure 4.6 RPM VS Horsepower before Turbocharge.

Here in Fig (4.6), shows the comparative between the rpm and horsepower. In Fig (4.5) the results were the maximum horsepower at what rpm and it was 347 hp at 5200 rpm, but here in Fig (4.6) the results are in each rpm what is the horsepower. So, as shown in this figure the horsepower is increasing and this is good.

3Table 4.2 Data for RPM and Torque.

RPM	3500	3750	4000	4250	4500	4750	5000	5250	5500	5750	6000
Torque	0	190	355	371	365	350	349	340	320	195	0

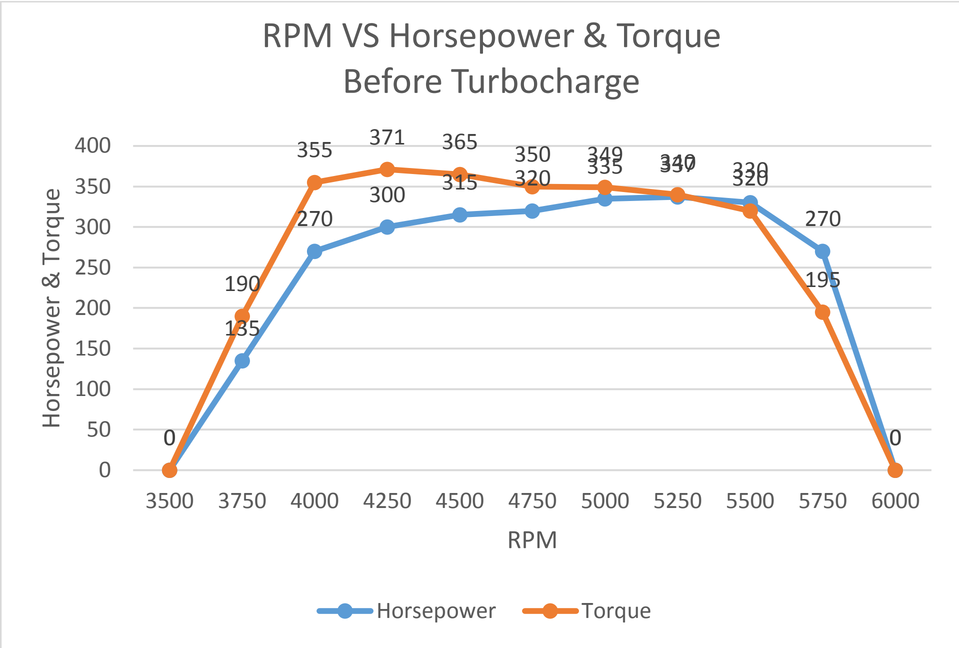


22Figure 4.7 RPM VS Torque before Turbocharge.

Here in Fig (4.7), show the comparative between the rpm and torque. In Fig (4.6) the results were the maximum torque at what rpm and it was 380 ft-lb at 4250 rpm, but here in this figure the results are in each rpm what is the torque. So, as shown the torque is increasing and this is good.

4Table 4.3 Data for RPM&HP and Torque.

RPM	3500	3750	4000	4250	4500	4750	5000	5250	5500	5750	6000
Horsepower	0	135	270	300	315	320	335	337	330	270	0
Torque	0	190	355	371	365	350	349	340	320	195	0



23Figure 4.8 RPM VS Horsepower& Torque before Turbocharge.

Here is in Fig (4.8) show the relation between horsepower and torque together versus rpm before turbocharge. Both horsepower and torque are increasing and that is good indicator to make sure that the dynamometer work well.

Result after turbocharge:

After doing the dynamometer test, the results were good after insulting turbocharge on the car. Results will show and explain very well in this section. Also, there are three graphs will show up in this section which are the horsepower, torque, horsepower and torque together and pressure ratio between break power after and before turbocharge versus rpm. Moreover, the break power after turbocharge have been change and here is below the break power after turbocharge.

- The break power for the car after turbocharges:

$\dot{W}b = 2\pi\tau N$

Where:

N: 4250 rpm

τ: 732 N.m

$\dot{W}b = 2\pi(732)\left(\frac{4250}{60}\right)$

$\dot{W}b = \mathbf{325.68\ KW}$

$\dot{W}b$ = ***436.7 hp***

And this is the ratio between the break power after turbocharge and the break power before turbocharge:

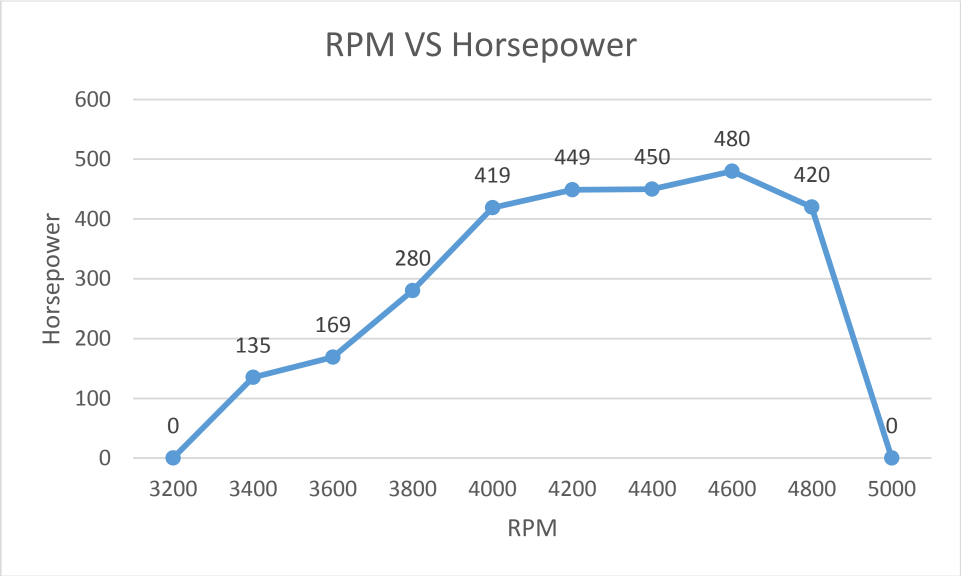
$$\frac{\dot{W}b_{TC}}{\dot{W}b_{NA}} = \frac{\mathbf{325.68\ KW}}{\mathbf{224.220\ KW}} = \mathbf{1.45}$$

24Figure 4.9 Dynamometer after Turbocharge.

After run the car on the dynamometer with turbocharge, there is as shown in the figure 4.9 that the two parameters which is horsepower and torque have increase comparative with old run before insulting turbocharge on the car. Before insulting turbocharge the maximum horsepower and torque was 347 hp, torque 380 ft-lb, but after insulting turbocharge the maximum horsepower and torque is 483.3 hp at 4680 rpm, torque 552 ft-lb at 4100 rpm.

5Table 4.4 Data for RPM and HP.

RPM	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000
Horsepower	0	135	169	280	419	449	450	480	420	0

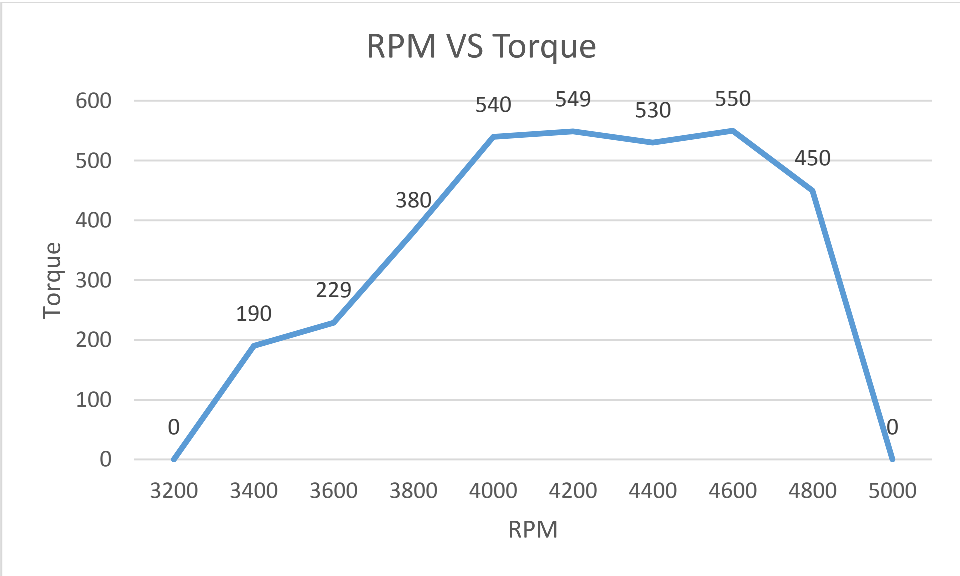


25Figure 4.10 RPM VS Horsepower after Turbocharge.

Here in Fig (4.10), show the comparative between the rpm and horsepower. In Fig (4.9) the results were the maximum horsepower at what rpm and it was 483.3 hp at 4680 rpm, but here in figure (4.10) the results are in each rpm what is the horsepower. So, as shown in figure the horsepower is increasing and this is good and because of turbocharge.

6Table 4.5 Data for RPM and Torque.

RPM	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000
Torque	0	190	229	380	540	549	530	550	450	0

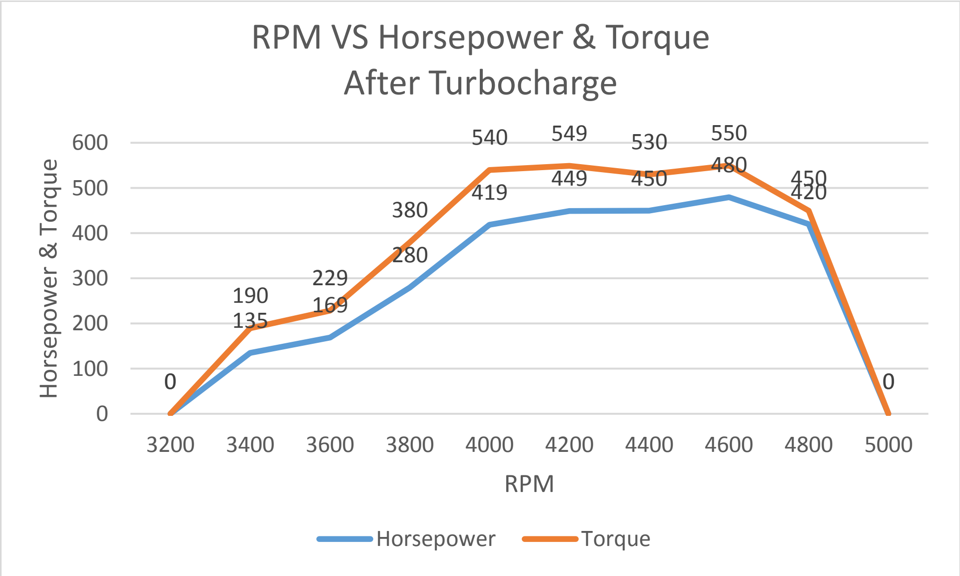


26Figure 4.11 RPM VS Torque after Turbocharge.

Here in Fig (4.11), show the comparative between the rpm and torque. In Fig (4.9) the results were the maximum torque at what rpm and it was 552 ft-lb at 4100 rpm, but here in figure the results are in each rpm what is the torque. So, as shown in this figure the torque is increasing and this is good and because of turbocharge.

7Table 4.6 Data for RPM & HP and Torque.

RPM	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000
Horsepower	0	135	169	280	419	449	450	480	420	0
Torque	0	190	229	380	540	549	530	550	450	0

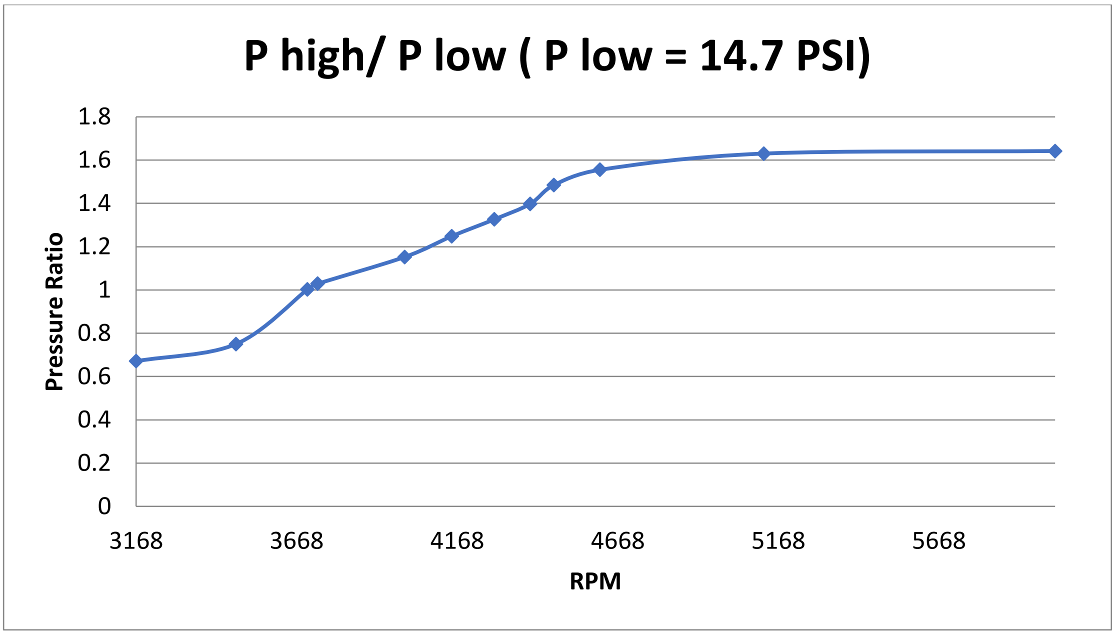


27Figure 4.12 RPM VS Horsepower& Torque after Turbocharge.

Here is in Fig (4.12), show the relation between horsepower and torque together versus rpm after turbocharge. Both horsepower and torque are increasing and that is good indicator to make sure that the dynamometer work well.

8Table 4.7 Data collection Dyno Sheet.

RPM	P high/ P low (P low = 14.7 PSI)
3168	0.670922925
3479	0.749855102
3702	1.002437415
3734	1.028571156
4005	1.152408844
4151	1.247916327
4284	1.326059184
4395	1.397097959
4469	1.48392381
4613	1.554962585
5123	1.629948299
6030	1.641787755



28Figure 4.13 Pressure Ratio Vs RPM.

Here in the Fig (4.13), explain the relation between the RPM and the pressure ratio of the compressor. When the pressure ratio more than 1 the turbo charge will start working. We choose Manifold Absolute Pressure because we do not have a sensor to measure the turbocharge pressure. In addition, we divide the Manifold Absolute Pressure by 14.7 PSI when it is the start point of the charging of the turbo.

4.2.4 Analysis:

After installing turbocharge on the car and after testing the system we observe good results which is the horsepower and torque as shown in the figure5, it was increasing. The results before turbocharge was horsepower 347 hp, torque 380 ft-lb, and we got after turbocharge horsepower 483.3 hp, torque 552 ft-lb. the results were very good because the different was more than what we expected.

Chapter 5

5 Chapter 5: Project Management

5.1 Project plane:

We have identified and drawn up the project plan so that we can accomplish our task to the fullest and that the completion of the project on time. It lies at the beginning from the bottom to the top, taking into account the presence of all members in meetings and work to get the best results and increase the times of delivery to reach the desired goal.

9Table 5.1 Dates, tasks, and description of all the tasks.

No	Task	Assigned to	Start Date	End Date	# Of Workdays	%Completed
1	Meeting with advisors	All members	20-Jan-18	25-Jan-18	5	100%
2	Meeting with All members (Brainstorming)	All members	26-Jan-18	28-Jan-18	2	100%
3	Assigning Tasks to team Members	All members	29-Jan-18	30-Feb-18	1	100%
4	Looking for car	All members	30-Jan-18	6-Feb-18	6	100%
5	Looking for workshops & shops to find the required	All members	10-Feb-18	15-Feb-18	5	100%

6	Second meeting with team members	All members	18-Feb-18	19-Feb-18	1	100%
7	Complete chapter 1 and 2	All members	21-Feb-18	24-Feb-18	3	100%
8	Workshop and Dynamometer test (Stock)	All members	28-Feb-18	2-Mar-18	2	100%
9	System Design and standards	All members	3-Mar-18	8-Mar-18	5	100%
10	Manufacturing process	All members	9 -Mar-18	12-Mar-18	3	100%
11	Installing the Turbocharge and the parts	All members	12-Mar-18	14-Mar-18	2	100%
12	Completing Chapter 3	All members	16-Mar-18	24-Mar-18	8	100%

13	Preparing for Midterm presentation	All members	26-Mar-18	1-April-18	5	100%
14	Record Midterm presentation	All members	2-Apr-18	4-Apr-18	2	100%
15	Dynamometer test (Modified)	All members	7-Apr-18	10-Apr-18	3	100%
16	Completing chapter 4	All members	11-Apr-18	15-Apr-18	3	100%
17	Completing chapter 5	All members	12-Apr-18	16-Apr-18	4	100%
18	Completing chapter 6	All members	14-Apr-18	16-Apr-18	2	100%

5.2 Contributions of team members

Table 5.2 shows the work and project aim, tasks and how the group members divided into two people to finish each chapter separately to achieve the desired and achieve the goal.

10Table 5.2 Contribution of team members.

Team Member	Contribution percentage
Faisal AlAsmari *	**20%**
Khaled AlHamimi	**20%**
Nasser AlOtaibi	**20%**
Mahmoud Shaheen	**20%**
Zeiad AlHamdan	**20%**

5.3 Project Execution Monitoring

5.3.1 Meetings with Advisors:

To have a good work, we arrange with our advisor and co-advisors to meet them once a week to solve the problems that we faced and be on the right side and avoid any mistakes could be happened in the project at all. Moreover, our advisor Dr. Nader Nader helps us a lot in the difficulties that we faced. In addition, sometimes we need also our co-advisors help us so, we arrange with them to have a time with them one time in two weeks. However, we have been chosen the right advisor and co-advisors for this project, because they help us a lot.

5.3.2 Team meetings:

As we mention in the Gantt chart, before we start working in the project we decide between each us to divide the work by having a new style of teamwork which is, each one of the group members take one chapter and chose one or more from the team members to be to become an assistant for him in the chapter. To more explanation, by using this style we are saving the time and arrange the work between us also, at the end of each week we arrange a meeting between all the group members to negotiate and discuss the work that is done.

5.3.3 Other activities:

Our project is containing three major important steps lies in the proper completion of the project. The first step, prepare for the project by reading every single small point about it and looking for the difficulties that might face us and find a solution for it. The second step, find the charts and information about the car before modified to be calculated in chapter three. The third step, test the car to make sure that the system works on the car successfully and collect the data that need to be taken from the car after modified (with turbocharge). We tried to work on all the steps carefully to accomplish the target.

5.4 Challenges and Decision Making

The most issue that we challenge us on it is the time conflict and how we can manage the time between us to have a meeting each weekend. However, between the members, there are no issues in attending all the meetings and do the work that required of him. In addition, the second issues some parts when we order it we have a problem to make it fit in the engine of the car that we chose so, we have to make a decision by modifying and fabricate some parts. The huge problem that we faced in the parts we solved by fabrication such as:

5.4.1 location of the turbocharger:

The major part of our senior project is turbocharged, which the entire project is about it. We faced an issue in the location of it how we can put it in a location inside the car with caution from places away from the air and inappropriate to approach the car to work in the right manner and the ideal way. Depends on that, we make our decision by finding the right place for the turbocharger.

5.4.2 piping of the intercooler:

This type of part is important in our project and plays an important part in our project after the turbocharge; we faced that when we order the intercooler the inlet and outlet holes of it were the same levels, which mean in the inlet is on the opposite side of the outlet. Regards to this, we have to make one of two choices, either cut the chasses or change the inlet position so, we make a decision by changing the inlet position.

5.4.3 car programming (tuning):

The issue here is the computer cannot read when the boost is high above 10Psi. According to that, we solve this issue by putting the boost controller on 8 to10 Psi. After that, the computer can read the amount of air that comes inside.

5.5 Bill of Materials

Table 5.3 shows the item, description, quantity and how much does cost us in the project in details.

11Table 5.3 Project bill of materials and budget.

#	Item	Description	Quantity	Price
1	Turbocharge	BrogWarner Company The part number# S375-177101 Size:76mm	1	4000SR
2	Intercooler	TRE Company Size: 4.5 inch Inlet and outlet: 3 inch	1	2300SR
3	Blow of valve	TAIL Company Size: 44 mm	1	520 SR
4	Westgate	Precession Company Size:46mm	1	500 SR
5	Manifold	Al-Otaibi Company Size: 2.5inch Steel	2	1500 SR
6	Down Pipe (for the turbocharge)	Al-Otaibi Company Size: 3-inch Steel	1	1200 SR
7	Exhaust	Al-Otaibi Company Size: 3 inch	1	2500 SR
8	Dynamometer test	PMD Garage	4	800 SR
9	Installing fee	Alziyani workshop	-	7000 SR
		TOTAL		**20,120 SR**

Chapter 6

6 Chapter 6: Project Analysis

6.1 Life-long Learning

There were many things that required us effort workmanship and patience to accomplish it in the desired manner while taking into account the maintenance of time and organization of work in the right manner. Based on this, the project requires some programs that explain and explain the idea required of the project to deliver them in the correct way to the listener and reader through some of the most important programs: Solid work, a program that demonstrates how to manufacture and work and some pieces and the project in full. And took from that program a lot of time to master some of the complex and difficult to clarify. Also, we had to finish some pieces of the project at a specific time, then the pieces must be assembled in full and presented in some way to clarify the full project work.

Contrary to this, in the project, there were many accurate calculations that need to be reviewed and re-reviewed to obtain the required numbers that prove the validity of the theory put forward from the beginning and is the basis of the project and the idea of the mother. In addition, each of the members of the group was required to check and verify the correctness of the matters mentioned in the main laws by going to the advisors and co-advisors.

6.2 Impact of Engineering Solutions

In an essential feeling of our work, the thought is productivity. That is our key, and that is what we have to accomplish. On the off chance that we can demonstrate that present gear could be arranged to do much more than planned that would spare a great deal of cash. The effect of the venture touches numerous parts of our lives from the power going to our homes to the water we drink even the modern machines used to transport all that we see. We need to expand the productivity of everything that warmth exchange assumes a part in, and we begin with radiators since it is what we could bear the cost of with the time we had. Warmth exchange assumes a part of the transportation, control age, and even water generation. Expanding the productivity of transport would diminish fuel utilization. On the off chance that the effectiveness of a ship that vehicles merchandise is expanded, that implies it requires less fuel to run, and that makes it less expensive, and that outcomes in more moderate products for all. In the event that we make the trucks that move metal from mines more productive that would mean they can work more and lower the cost of organizations making them ready to spend more on different things like expanding compensation. On the off chance that we make the autos we at present have run all the more effectively that implies we bring down the fuel utilization, and by that, we decrease the carbon impression on the planet. Expanding the effectiveness of energy creation would mean bringing down their effect on the condition. Most power plants depend on the warm exchange and utilize water to do that, which we have indicated is an exceptionally poor conductor of warmth. Suspending Nanoparticles in the water would as it required the acquaintance of ultrasound gadgets with suspending the particles and avert precipitation. That would enormously cut the cost of energy since they can give a similar sum less fuel, and by consuming less fuel we would lessen the carbon impression on the planet.

6.3 Contemporary Issues Addressed

Our reality doesn't have a limited measure of assets accordingly we have to do the most with the assets, we are coming up short on, and we additionally need to deal with the planet that we are gradually murdering. With little changes to even the current machines and framework we can accomplish this. With the rising fuel costs, we can have our autos devour less fuel by making them devour it all the more productively. We can likewise have control plants that are up and running get the most vitality out of the fuel they devour, which will spare Saudi a ton of barrels that could be sold on the open market. These have an exacerbated advantage in light of the fact that the spare the earth. Therefore, turbochargers manufacturing companies such as HKS, BorgWarner and ZAGE will benefit from using this project.

Chapter 7

7 Chapter 7: Conclusion and future recommendations

7.1 Conclusion

To conclude our work in some few words, our project is to design of turbocharge system for an existing gas engine. That was to make a system that can make the turbocharge work with engine by our chosen. However, this work was required from us to be submitted in four months also, we have make all the calculation that is required from us in details. To make it clear more, the work divided into two parts, one is along the workshops that contain what is efficiency of the car before and after and the other part depend on the calculation of the result that we have it from the workshops, that mean the two parts each one is depends on the other. Moreover, we have also the hidden parts which is, the reports work that each member of the group should done his job in the right way. Depends on the previous, that's way we have to work as team to finish all the work on a good way and have the professionally work done also, to accomplish this mission to the fullest.

7.2 Future recommendations

The project can be developed in a number of ways that can help to strengthen and improve project performance by adding another turbocharge which they call it (Twin-turbo) by addition of turbocharger will significantly improve performance but will increase the budget required to perform the project. On the other hand, most car companies add the turbocharging to most modern cars from 2016 to 2019 by adding it on a small engine to get high performance of the car while reducing the expenses also, turbocharge on the display will change many of the calculations and numbers used and will show the difference between the old and modern performance. In addition, the project can be developed so that the type of materials used in the aluminum system instead of the stainless steel is changed to maintain the heat and get the required performance. The optimum form of completion will in turn become more expensive but these additions ensure superior performance.

In the other hand, the size of the turbocharge and the engine plays as a the most important things to improve the performance in the project so, the turbo charge too much sizes each one depends on the engine that fit with to contain as much as possible of air. However, the size of the engine also, should fit the turbo that have been chosen to optimize the Format required.

Finally, I think the future of the machines in the development in terms of all the car companies to add the Turbocharge and Supercharge in most of its engine and this is something special where they developed the old idea is to do the enlargement of machines only with no consideration of other aspects that can improve performance and save money and reduce the weight of cars And it is the right way.

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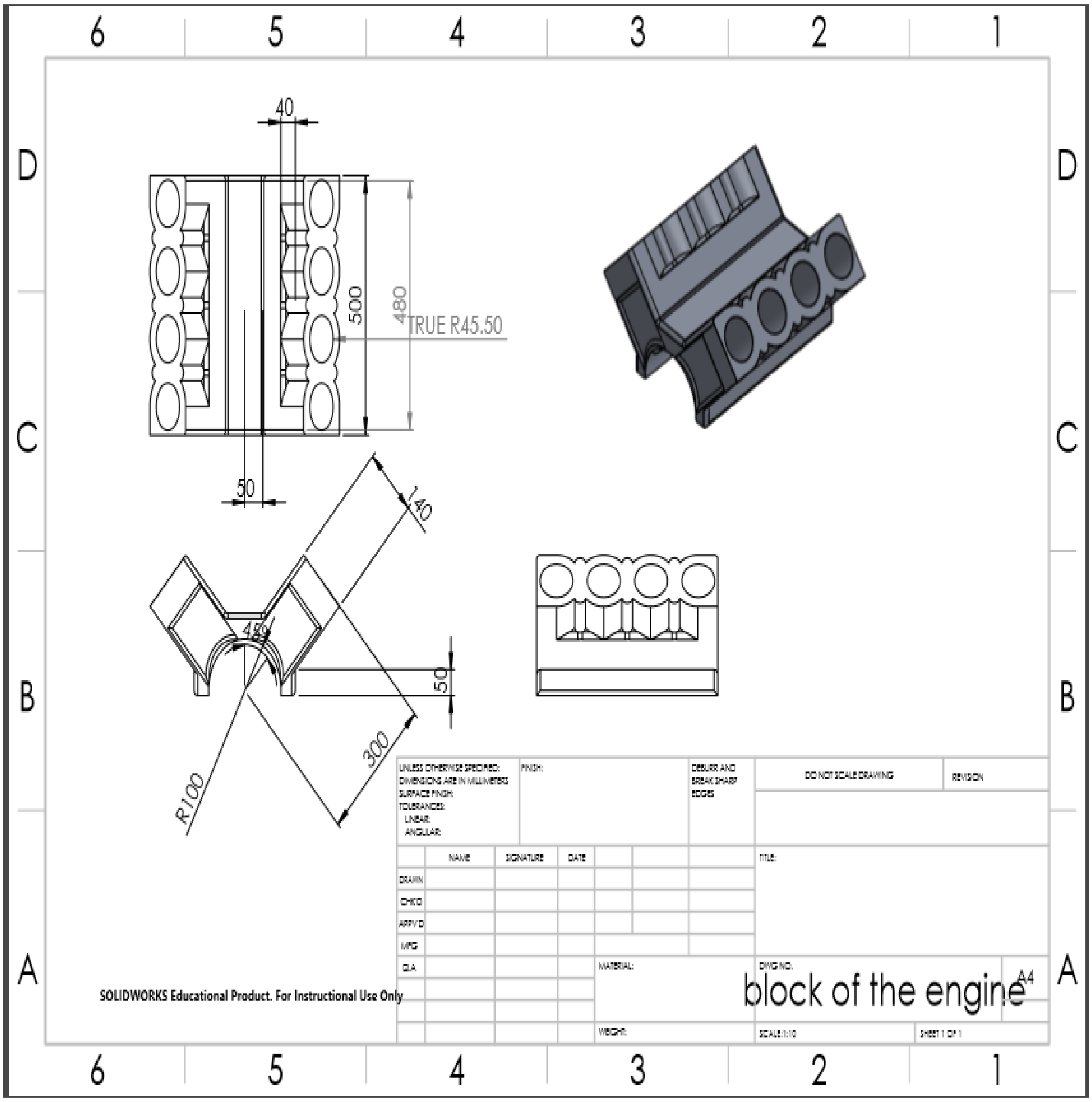
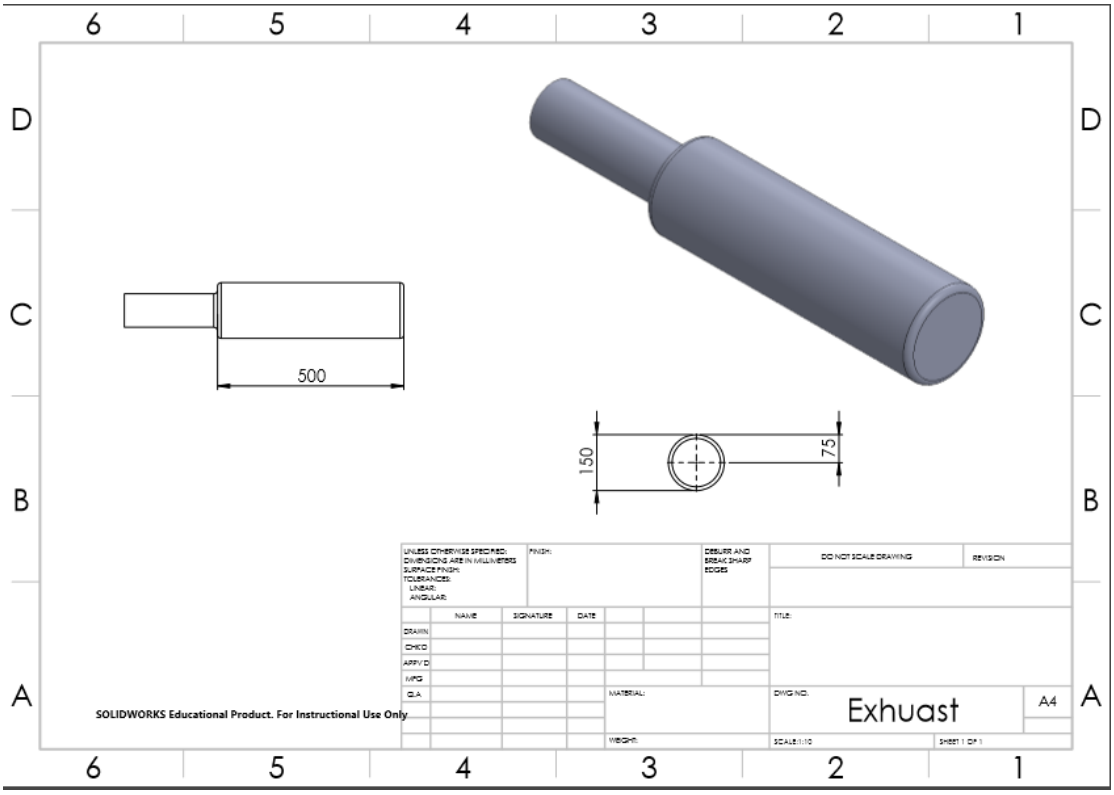
9 Appendix A: SolidWork (CAD)

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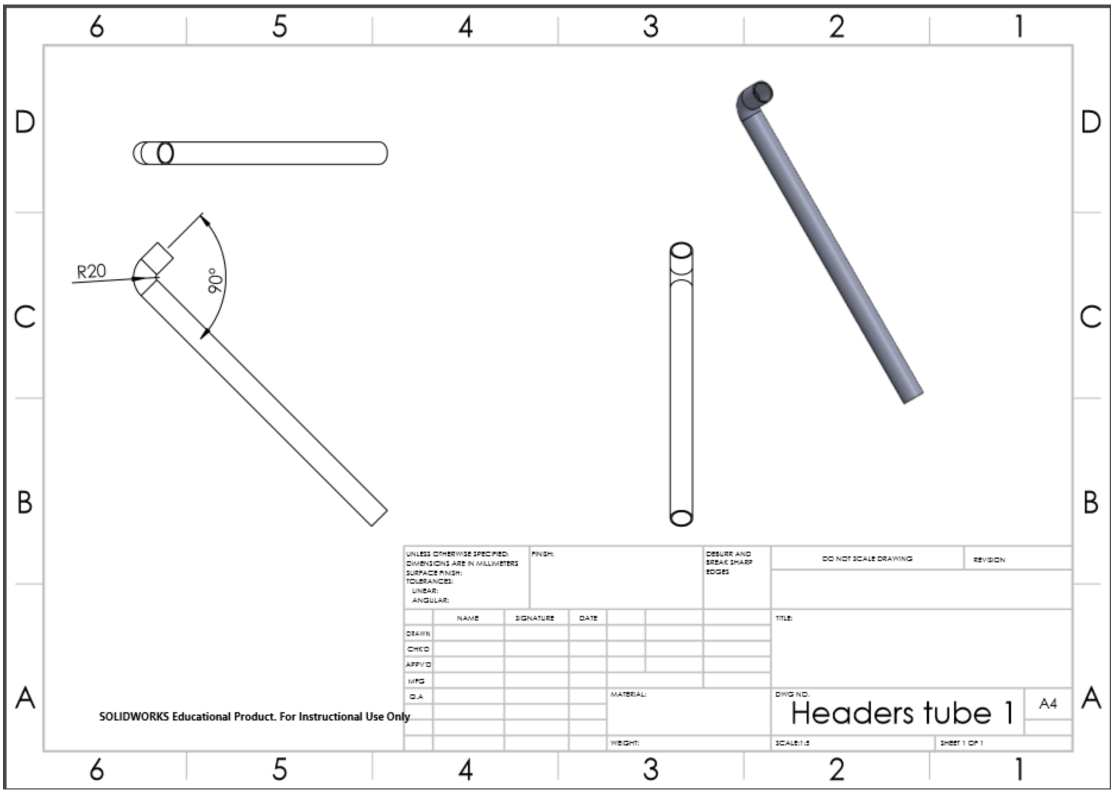
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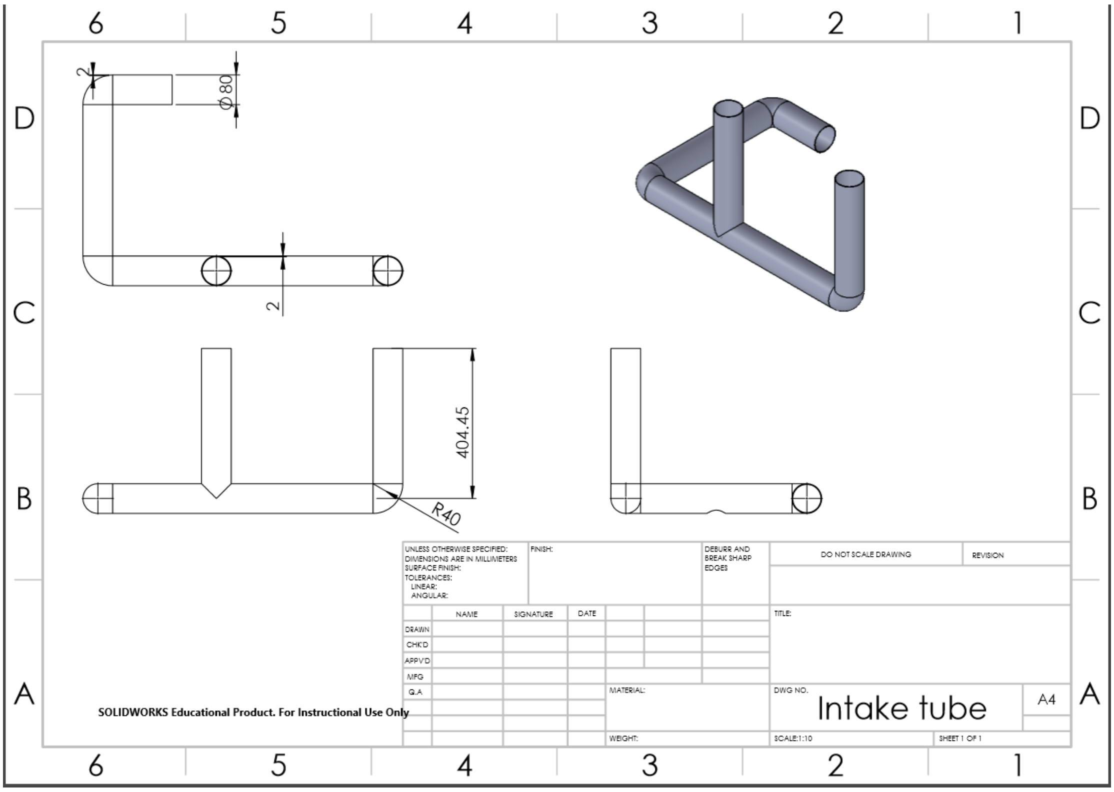

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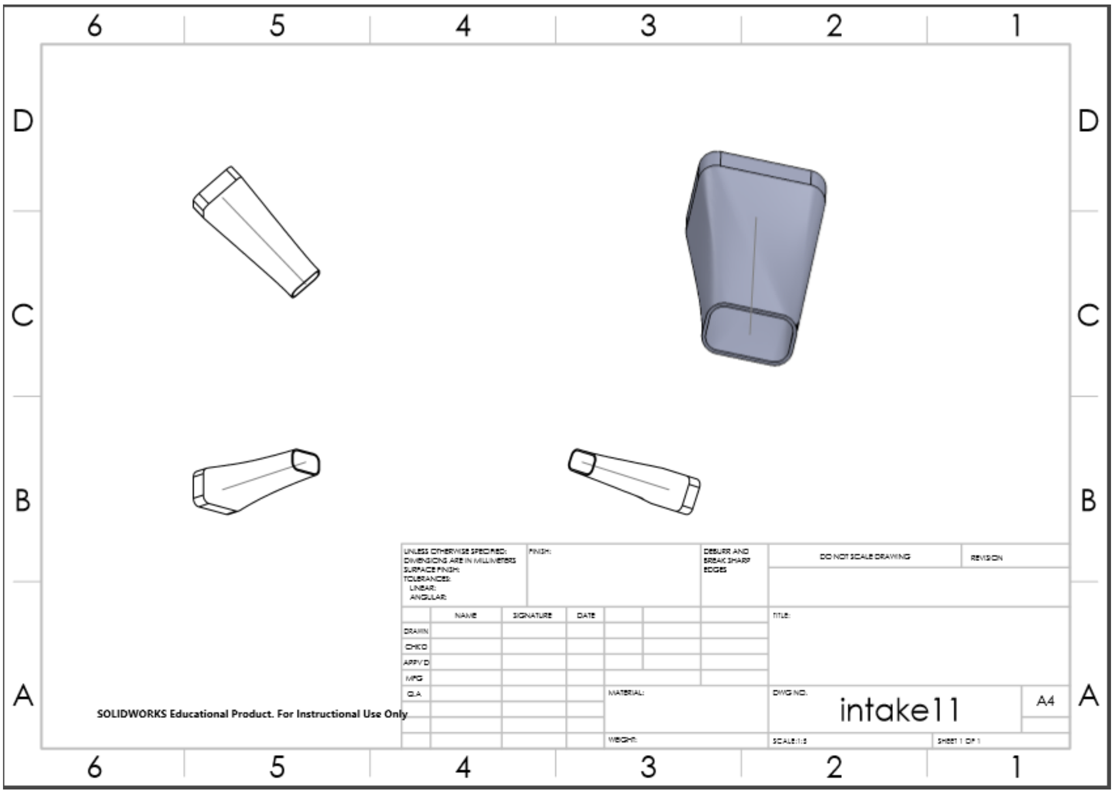

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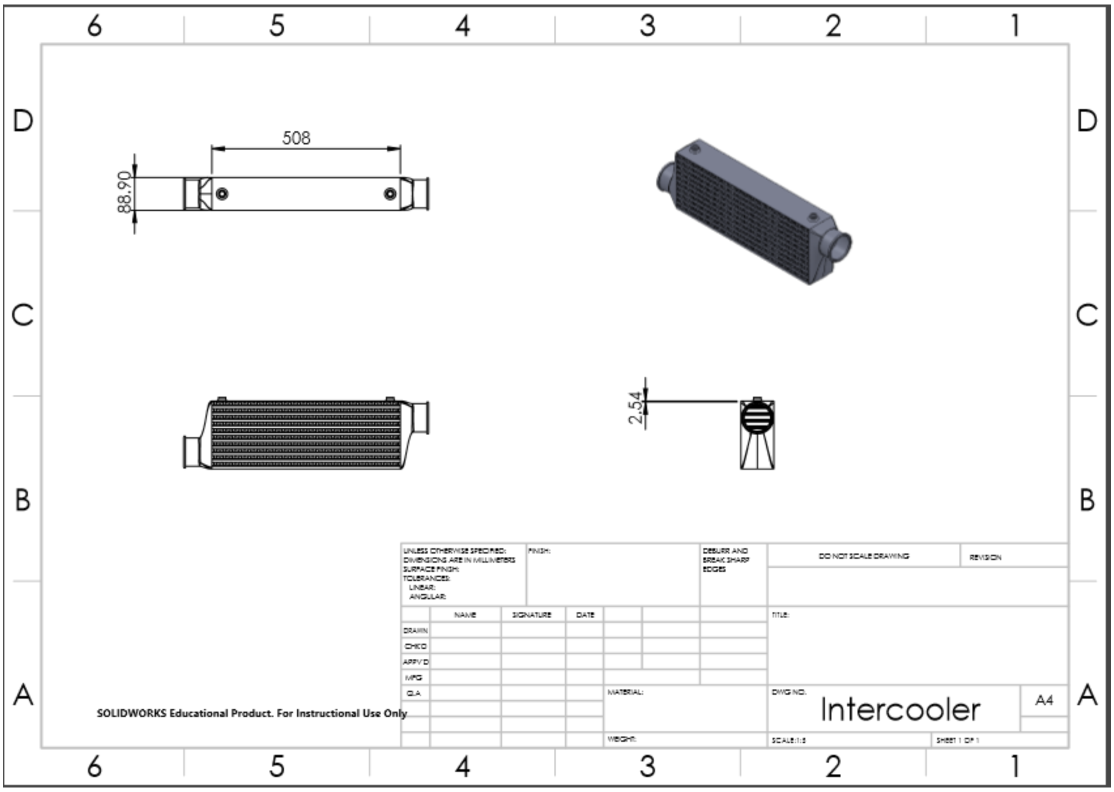
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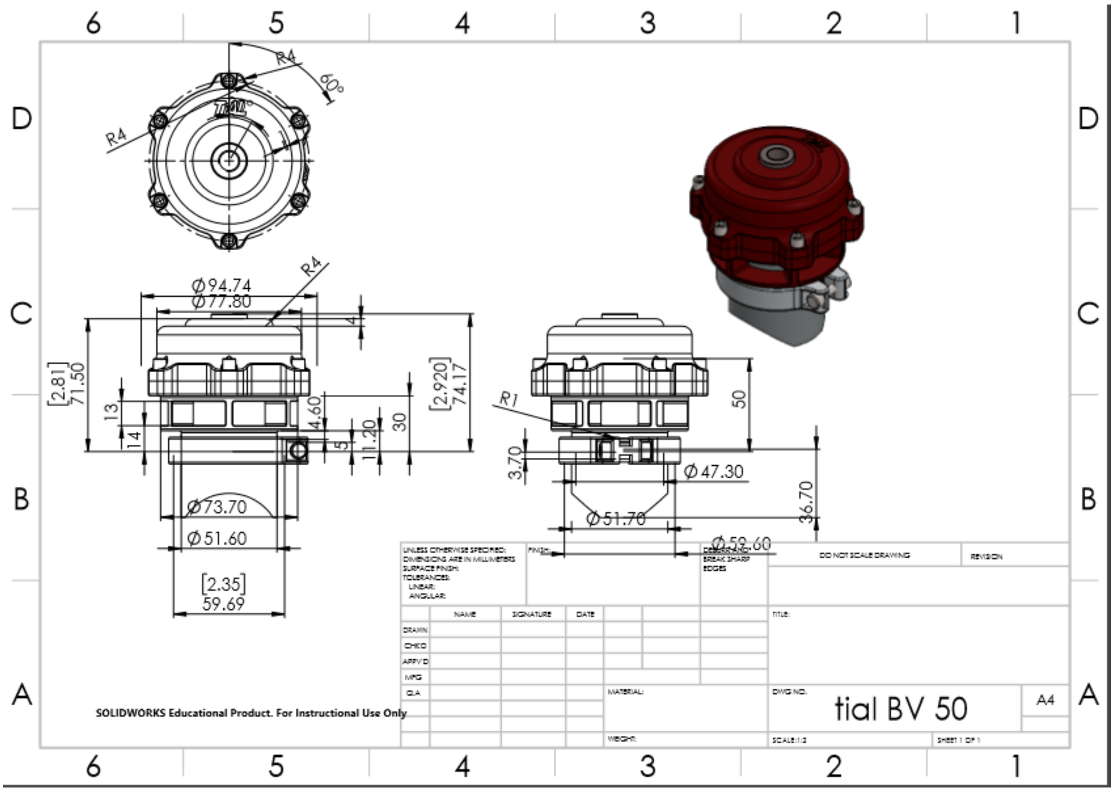
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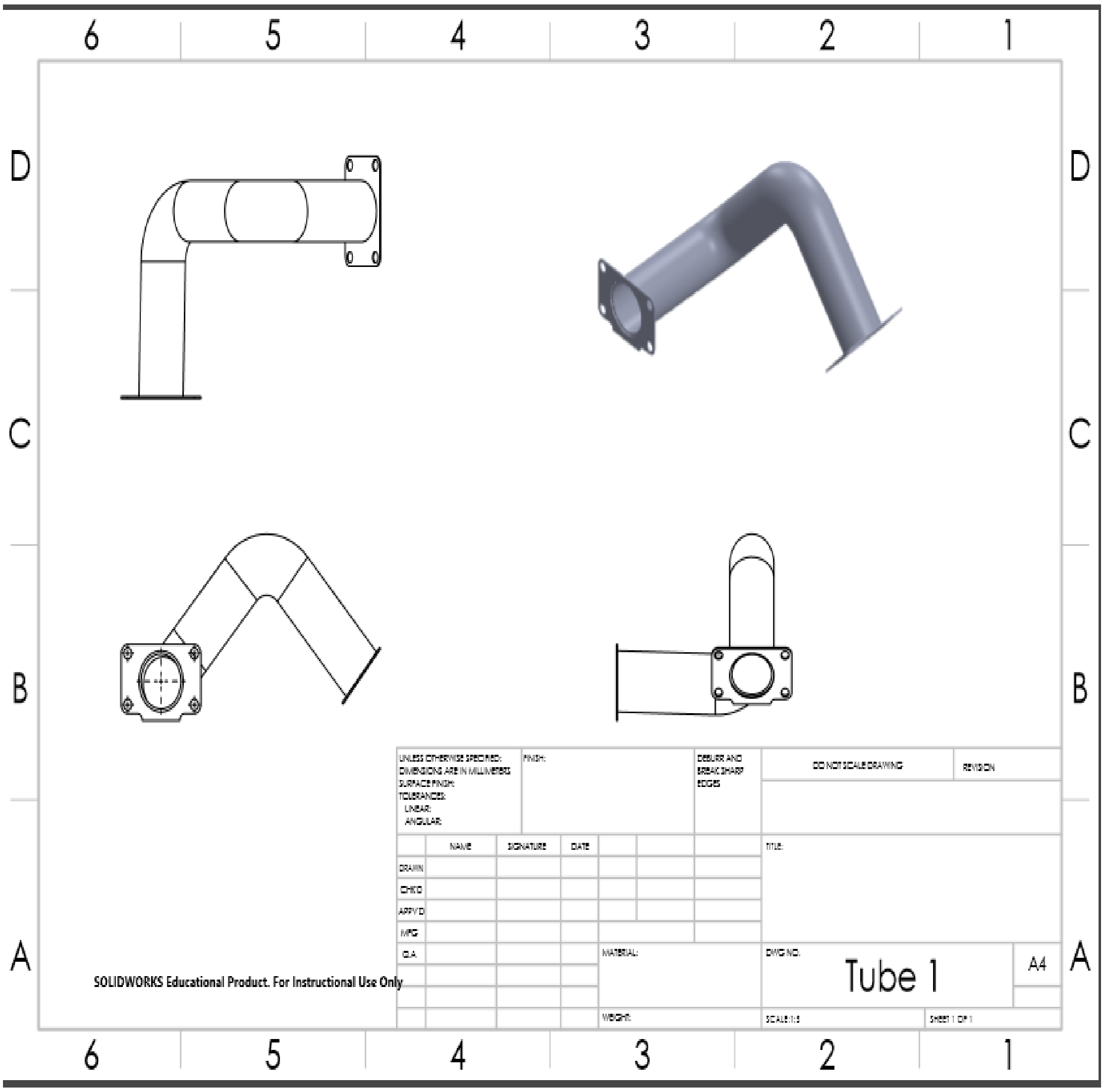
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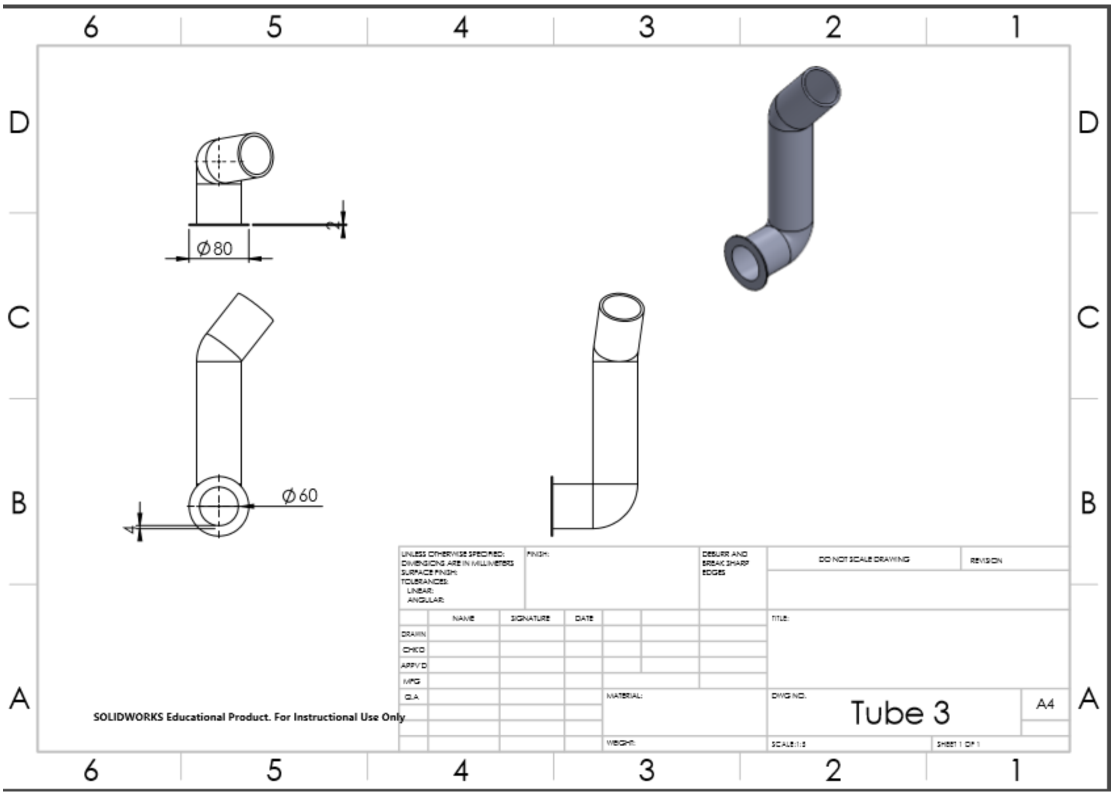
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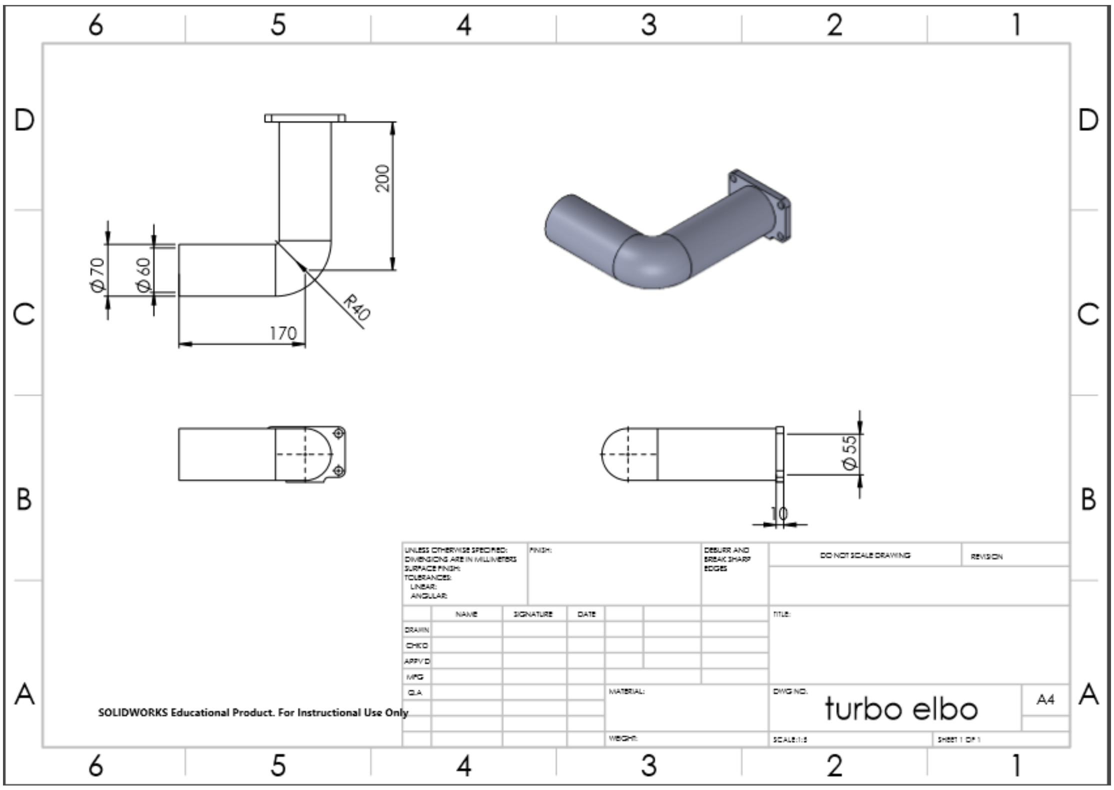
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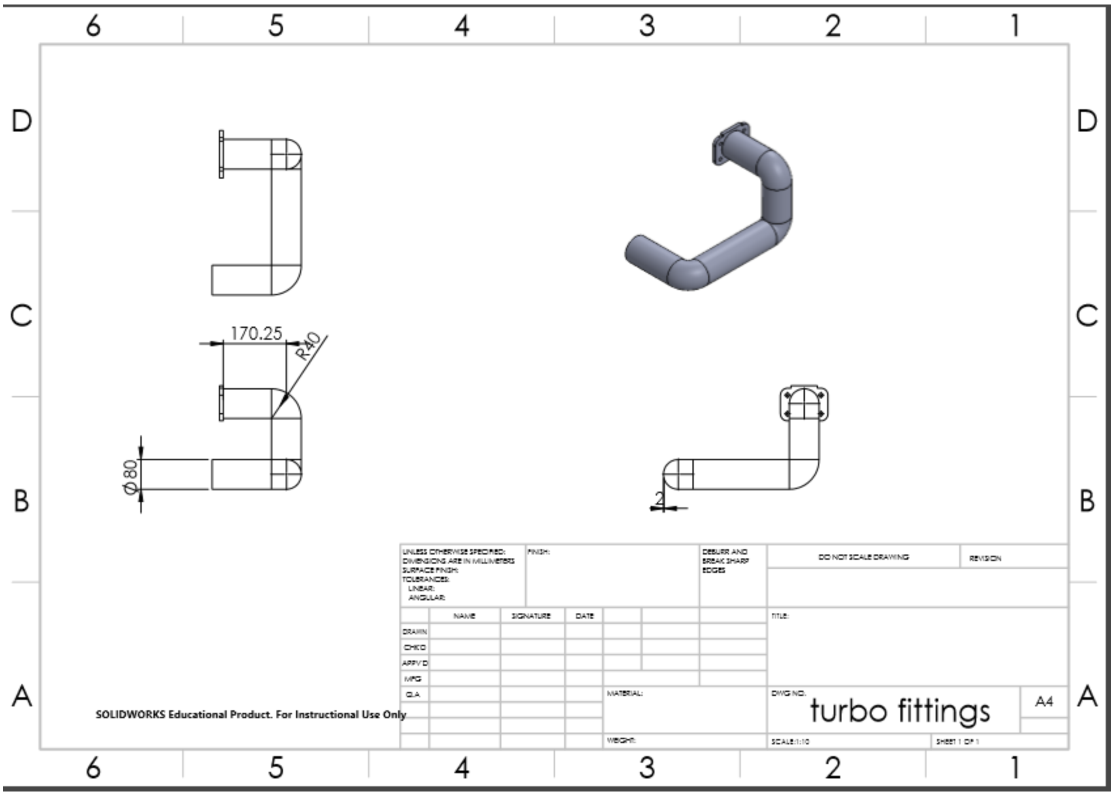
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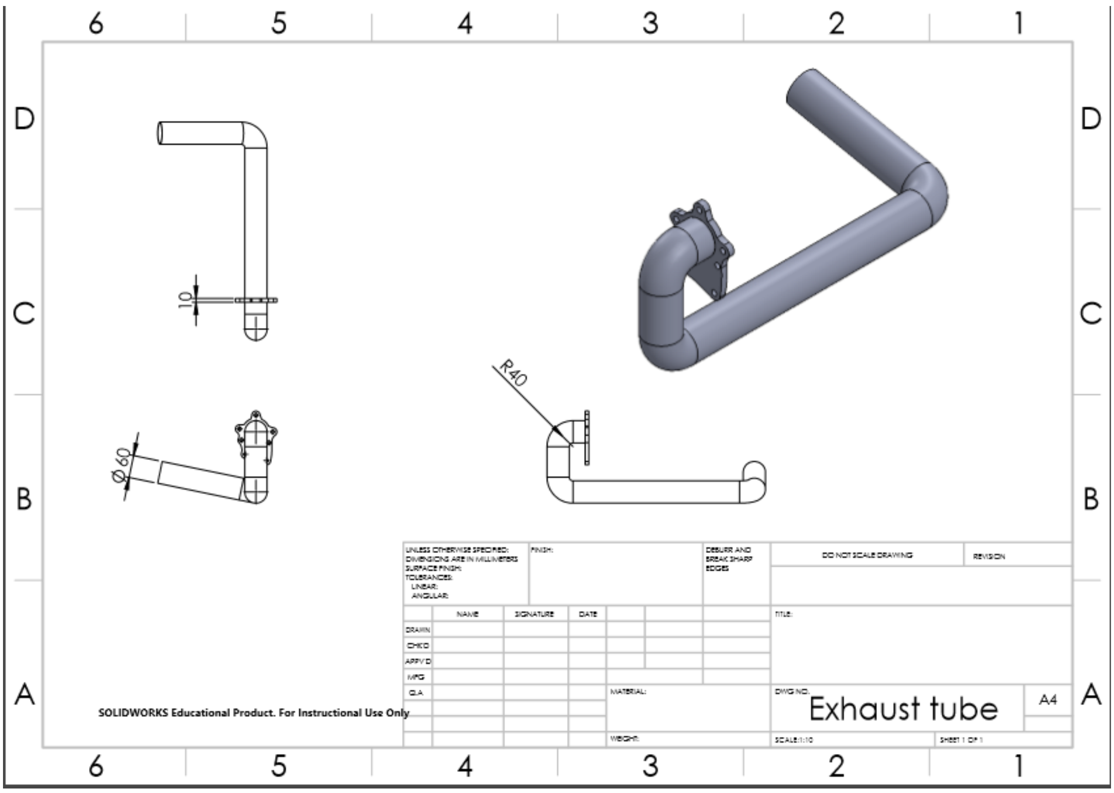
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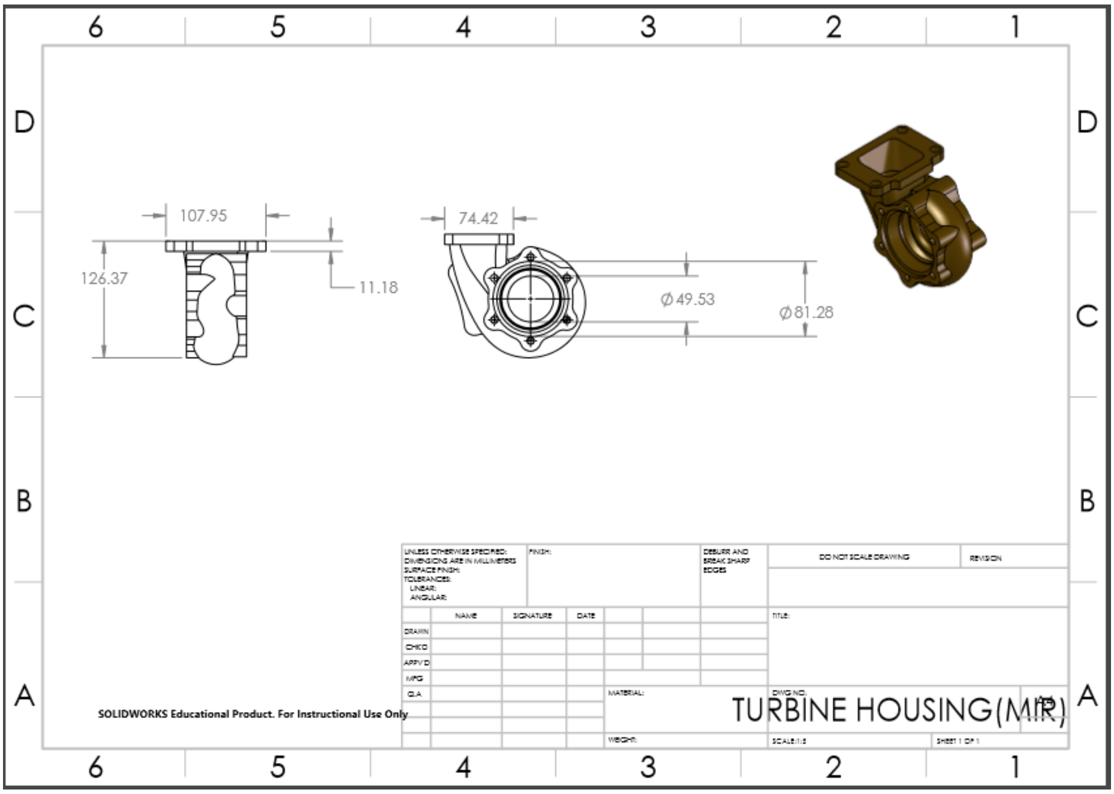
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9.1 Appendix B: Equations.

$$\text{bmep} = \frac{4\,\pi\,\tau}{\text{Vd}}$$

The Brake Power, $\dot{W}b$

$$\dot{W}b = 2\pi\tau N$$

The Mean Piston Speed ($\bar{U}P$)

$$\bar{U}P = 2NS$$

The mass Airflow rate ($\dot{m}a$)

$$\dot{m}_a = e_v \rho i\, Vd \left(\frac{N}{2}\right)$$

Density of the air

$$\boldsymbol{\rho i} = \left(\frac{\boldsymbol{Pi}}{\boldsymbol{R\,Ti}}\right)$$

Mass flow rate ($\dot{m}$)

$$\dot{m} = \rho_i\ \ A_f\ \ c_o \left[\frac{2}{\gamma - 1}\left(\ \left(\frac{P_2}{P_1}\right)^{\frac{2}{\gamma}} - \left(\frac{P_2}{P_1}\right)^{\frac{(\gamma+1)}{\gamma}}\right)\right]^{\frac{1}{2}}$$

$\boldsymbol{Effective\ area}$

$$\boldsymbol{A_f = C_f\,A_V = C_f\,\frac{\pi}{4}\,d^2\,(seat)}$$

The Mach number (M):

$$\frac{P_1}{P_2} = \left[1 + \left(\frac{\gamma - 1}{2}\right) M^2\right]^{\frac{\gamma}{\gamma - 1}}$$

The critical mass ($\dot{m}_{cr}$)

$$\dot{m}_{cr} = \rho_I \, A_f \, c_o \quad \left(\frac{2}{\gamma + 1}\right)^{\frac{(\gamma+1)}{2(\gamma-1)}}$$

Appendix C – Pictures of Turbo Engine