Turbocharger

&

Supercharger

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The main reason for thinking abuot
Invention of the turbocharger is that
The higher the plan rises above the sea
Surface (fig ١،٢) the less oxygen will
Be . This is that we need in the combustion
Process , so there must be a solution until
The turbocharger was invented , and after
Turbo used in aircraft also used with the
Car to increase the power of engine and
Become small engine with high power to
Decrease the volume of engine in a car
To be lightly and fast .

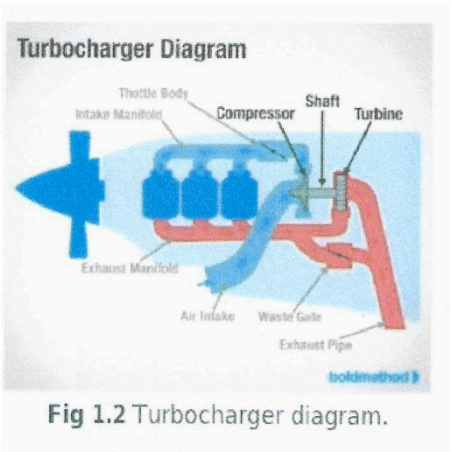

Fig ١،٢ turbocharger diagram

١. Component of turbocharger :

Turbocharger contains from major three items as shown fig ١،٣ let us to Look how these component work before we move to different types of Turbocharger .

١. Turbine
٢. Shaft
٣. Compressor
٤. Center housing
٥. Intercooler
٦. Waste gate
٧. Blow - off valve

١. Turbine

The engine produces exhaust gases at high
Temperature under pressure then passes
Through the turbine of the turbocharger and
Push the turbine wheel that rotated the shaft
Between the turbine and compressor that
Convert heat and pressure to usable kinetic
Energy . we should choose the wheel of
turbine carefully to maximizing the capabilities
of turbocharger , that small size cause extra back pressure and chock the engine and the big size can cause lag and make the aim from

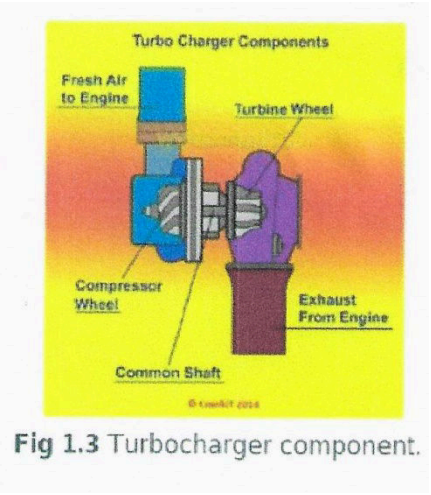

Fig ١،٣ Turbocharger component

turbocharger difficult to achieve it .

٢. Shaft

Shaft transmits the rotation from the turbine to the compressor .

٣. Compressor

Compressor makes pressure different the air sucked into throttle body . Intake manifold and to the combustion chamber to increase the density Od air , power , and complete combustion . The boost is the primary Reason why turbocharger function as an add-on to natural – aspired Engines .

٤. Center housing

It made from material that can with stand the pressure and heat , it Lubricates and support the bearing of the turbocharger .

٥. Intercooler

As more pressure accumulates inside the turbocharger system heat Is produced . The intercooler solves this issue by refrigerating the air Going through the device before reaching the intake manifold as Shown (Fig ١,٤) .

٦. Waste gate

It is regulating the movement of the exhaust gas inside the turbocharger System , in state have not regulator that can create an extra amount of Boost and damage the component of engine .

٧. Blow – off valve (BOV)

The Blow – off valve (Fig ١,٤) eases the extra pressure mechanism that Accumulates during operation of the engine . The trapped compressed air Only fly back to the compressor wheel when the throttle is discharged . If that happens , a compressor surge can occur , causing unnecessary load Damage to the system . The blast valve operates in the same way as the

Waste gate to handle this situation .

How turbocharger work .

After explaining the different component of turbocharger m we go to Show how turbocharger work (Fig ١,٤) .

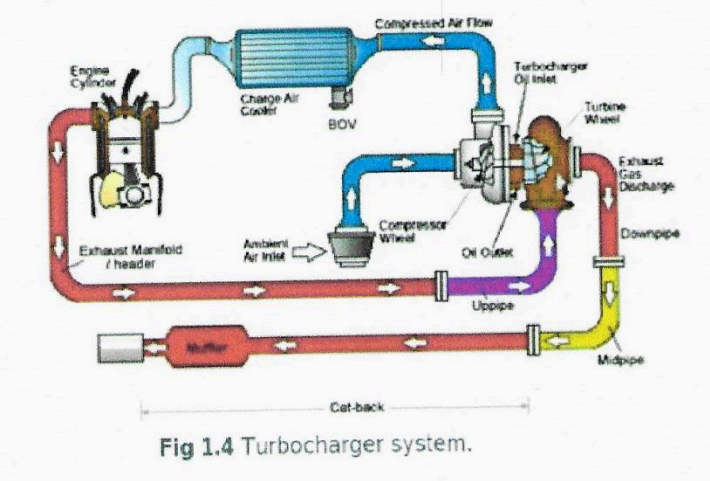

Fig 1.4 Turbocharger system.

Fig ١,٤ turbocharger system

١. The exhaust gas exit from the engine and go through the pipe to the Turbine wheel .

٢. The exhaust pushes the turbine wheel and exiting from turbine .

٣. The turbine wheel makes compressor wheel at the same speed of it , Then compressor suck the ambient air to the system .

٤. The compressed air goes to intercooler if it present , then to the block Engine by manifold .

Types of turbocharger :

After talking about the component turbocharger and how it works , new It is the role of the types of turbocharger .

١. Single - Turbo .
٢. Twin – Turbo .
٣. Twin – Scroll Turbo .
٤. Variable Geometry Turbo .
٥. Variable Twin Scroll Turbo .
٦. Election Turbo .

١. Single Turbo

Single turbocharger (Fig ١،٥) have unlimited variability . Differing the Size of the compressor wheel and the turbine will result in totally Different torque properties . Large turbos will deliver high top – end Capacity , but smaller turbos will deliver better low – end grunt as they Spool more rapidly . Single turbos also feature ball bearing and journal Bearing . Ball bearing give the compressor and turbine less friction to Spin on , so they are faster to spool (while adding cost) .

Advantages

* Cost efficient way to increase the power and Efficiency of the engine
* Generally , its simple .
* Allows for using smaller engine to get power as Larger engine but without the weight of larger

Fig 1.5 Single turbo.

Fig ١،٥ Single turbo

Disadvantages

٢. Twin-Turbo

Just like Single turbocharger when you use two turbochargers There are pienty of options (Fig ١,٦) . Each cylinder bank could Have a single turbocharger (V٦ , V٨ , etc) . Alternatively , one single Turbocharger could be used for low RPM and bypass to a larger high RPM turbocharger (١٤ , ١٦ etc) . you could even have two turbos of Similar size where one is used at low RPM and the two are used at Higher RPM . Twin – scroll turbos are used on the BMW X٥ M and X٦ M , one at either side of the V٨ .

Advantages

* For parallel twin turbos on 'V' shaped engines are very similar to Single turbos setups in advantages and disadvantages .
* It always for a much broader , flatter torque curve for sequential Turbos or using one turbo at law RPM , and both at high RPM . Great low – end torque but to high RPM the power does not Taper like a small single turbo .

Disadvantages

* Cost and complexity since you have Almost double the turbo components .
* There is another way that achieve similar Result as we will show below .

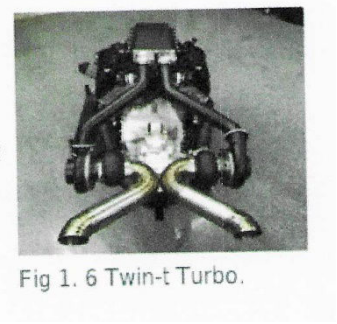
Fig 1. 6 Twin-t Turbo.

Fig ١,٦ Twin – t Turbo

٣- Twin – Scroll Turbo

Twin – scroll turbocharger (Fig ١,٧) are stronger than single – Scroll turbos in almost every way . The exhaust pulses are broken Down by using two scroll . for instance , on four – cylinder engines (firing order ١-٣-٤-٢) , cylinder ١ and ٤ could feed into one turbo

Scroll, while cylinder ٢ and ٣ feed into a seqarate scroll. Why Would that be beneficial ? Let us say cylinder ١ ends its power Stroke as the piston reaches the dead center of the rim , and the Exhaust stroke , closes the exhaust valve , begins to open . As this Occurring cylinder ٢ ends the exhaust stroke , closes the exhaust Valve , and opens the intake valve , although some overlap occurs . The exhaust pressure from cylinder ١ will interfere with cylinder ٢ pulling in fresh air in a typical single - scroll turbo manifold , as both exhaust valves are temporarily open , minimizing how Much pressure the turbo hits and interfering with how much Air cylinder ٢ pulls in . That problem is eliminated by dividing The scroll .

Advantages

* The energy that drive to turbine is more That makes more power will produced .
* A wider ranger of efficient boosting RPM Is possible based on the various scroll Design
* Without hampering exhaust scavenging , More valve overlap is possible , implying More versatility in tuning .


Fig 1. 7 Twin-scroll turbochargers.

Fig ١،٧ Twin-scroll turbocharger

Disadvantages

* Cost .
* Requires an engine configuration and exhaust design such As ١٤ and V٨ where ٢ cylinders can be supplied at even Intervals to each turbo scroll .

٤. Variable Geometry Turbocharger (VGT)

Perhaps one of the most outstanding forms of turbocharger , due Exotic material requirements , VGTs (fig ١،٨) are limited in production (though common in diesel engines). Inside the turbocharger , internal Vanes alter the area – to – radius Radio (A l R) to much the RPM. A low A l R radio is used at low RPM to increase exhaust gas velocity And to spool the turbocharger up Quickly. The A l R radio increases as The revs rise , allowing for improved . Airflow . The effect is a low turbo lag , A low boost threshold and a fast , big Torque band .

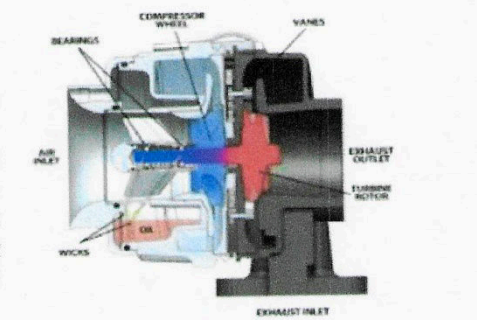

Fig 1.8 Variable Geometry Turbocharger.

Fig ١،٨ Variable Geometry turbocharger

Advantages

* Flat and wide torque curve .
* Effective wide PRM range .
* Needs only one turbo , which simplifies a sequential turbo Setup into something more compact .

Disadvantages

* Typically used only in diesel applications where exhaust gases Are lower so that no heat damage is caused to the vanes .
* Cost usually holds them our for gasoline applications as Expensive metals must be used to ensure reliability , but Very few VGT gasoline engines are available because of the Associated costs .

٥- Variable Twin – Scroll Turbocharger

As shown Fig ١,٩

Advantages

* Significantly cheaper (in theory) than VGTs , making gasoline Turbocharging an acceptable case .
* Enables a wide and flat torque curve .
* Depending on the option of content , more durable in Construction versus a VGT .

Disadvantages

* Cost and complexity comprising using A single turbo or traditional twin- scroll.
* The technology gas been used before (e.g . quick spool valve) but in the Production world it does not seem to Catch on . The technology poses Additional challenges .

Fig 1.9 Variable Twin-Scroll Turbocharger.

Fig ١,٩ Variable Twin- Scroll Turbocharger

٦. Electric Turbochargers

Aeristech's proprietary full Electric Turbocharger Technology (Fig ١,١٠) is a revolutionary enabling technology that will help Vehicle manufacturers meet strict future emissions regulations While providing excellent response across the entire engine Operation range , including at low engine rpm and vehicle speed . Feet is the ideal solution for extreme engine downsizing and Increased engine performance using a single – stage turbine . Dropping a powerful electric motor in mix removes almost all of A turbocharger's disadvantages . Lag Turbo? Farewell . Not ample Exhaust gases ? No trouble . Can't Turbo produce produce at low Ends ? Now it does ! But there are also certainly drawbacks of the

Electric route in the next step of modern turbocharging .

Advantages

* By attaching an electric motor directly to the compressor Shaft , turbo – lag and inadequate exhaust gasses can be Practically eliminated by spinning the compressor with Electrical power when necessary .
* The waste energy can be extracted by linking an electric Motor to the exhaust turbine (as a done in formula ١) .
* Has very wide effective PRM range and even torque Throughout .

Disadvantager

* Cost and difficulty , as you now must Consider the electric motor , added Controls , and make sure it stays Cool To avoid reliability problems .
* packaging and weight become a Problem with the addition of a battery On board , which will be necessary to Supply sufficient power to the turbo When needed .
* With lower cost we can use VGTs or Twin- scroll with similar benefits .

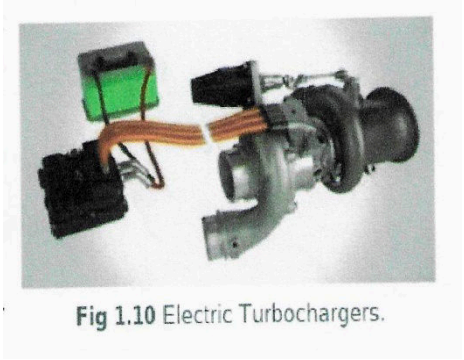

Fig 1.10 Electric Turbochargers.

Fig ١،١٠ Electric Turbocharger

Turbocharger and diesel engine

Turbodiesel refers to any Diesel engine equipped with a turbocharger . As Per other engine types , turbocharging a diesel can greatly increase its power Output . Turbocharging of diesel engines began in the ١٩٢٠s with large , Marine and stationary engines . it mostly used in diesel engine to increase the Volumetric efficiency of a combustion chamber . Because diesel engine is a Self-ignition engine So , turbocharger increase the air pressure with the Help of exhaust air from the engine . pressurized air occupies more

Volume in the combustion chamber .

By the late ١٩٢٠s , many manufacturers , such as Sulzer Bros , Guy , Daimler – Benz , and paxman , had manufactured large turbodiesels For marine and stationary use . Subse`uent technical advances ,made It possible to use turbochargers on smaller engines operating at higher Engine speeds (RPM), and turbodiesel locomotive engines began to Appear in the late ١٩٤٠s . in the early ١٩٥٠s trucks started using Turbo- diesel .

Turbocharger in petrol engine

The diesel engine with turbocharger spread but the petrol engine is are Due to many reasons te**oc**chnical and economical . The reasons return to Different between the petrol system and diesel system . The petrol System used the carburetor to mix the fuel and air or fuel injection System until the mixture enter to manifold then to the cylinder . the Spark is started to burn the compressed mixture . the temperature of Combustion must below down the temperature of self – ignition to Prevent the knock occuration . once the combustion started the flam Front takes time to burn the fuel through the combustion chamber . the Compression ratio of the engine must be enough low to prevent knock Phenomena .

Knock occurs if the temperature of mixture reaches to self – ignition Temperature and burnt before reach the front flam to it . knock produce Strong pressure wave in combustion chamber that make damage in Cylinder head and piston . Unlike a diesel engine it needs knock and need Enough high compression ratio that its self – ignition .

Performance of turbharger

In the early ١٩٦٠s ,. Buick (Fig ١,١٨) and Olds mobile fabricated a limited Number of turbocharged passenger cars in the United States . More Recently Turbocharged vehicles have been sold To the public by Audi, BMW , Porsche , Saab , Gm , and ford . The Audi , BMW, Porsche And Saab are high - performance models of Cars that are usually manufactured as naturally Aspirated . They were equipped with fuel injection and Similar equipment in the Expensive and performance cars and they Manufactured few numbers Of cars and sold it at a huge price . The GM Buick , on the other hand , Is not intended as a high – performance vehicle to combine fair performance With good fuel economy .

After using engine smaller than normal of this car with turbocharger to Keep the performance as the big engine of it . the turbocharger ٣,٨ litre V٦ Buick engine is the same in acceleration as ٥,٧ Litre V٨ engine at the Same car (fig ١,١٩) , reduction in weight from ٤٠ kg to ٥٠ kg , ٥ percent Saving in fuel consumption and and with a maximum compressor pressure Ratio ١,٦:١ and the torque increases by ٥٩ and ٤٣ percent .

Advantages and disadvantages of turbocharger

Mainly the advantaged and dis advantaged of turbocharger as following :

* Advantages

In addition to the additional power added by the turbocharger , it also does Not consume energy from the primary energy of the engine as supercharger, It saves energy and takes advantages of the wasted energy inherent in the Exhaust gases and makes it a reason to increase the power of the engine by Bushing air . the engine with the turbocharger is also characterized by its Highter power than naturally aspirated engine , especially in high places Where there is no high air level .

Turbocharger improve fuel efficiency . Taking a naturally aspirated engine And slapping a turbocharger will not improve fuel efficiency. The best way Is to reduce the engine size and add turbocharger to engine , and this is what Manufacturers do . for example, If we have a ٢,٥ L inline ٤ cylinder naturally Aspirated engine and decease it to ١,٤ L with a turbocharger that gives the Same result or better and due to small size it consume small amount of fuel Comparing with another with another engine give the same power without Turbocharger .

* **Disadvantages**

The turbocharger has two main disadvantage comparing with naturally Aspirated or supercharger. First one the head due to powered from the Exhaust gas that make it very hot , sometimes the turbo glowing to red At a certain condition if the engine works in its limits condition of it for Continuous time , for that we see vents in the hood or down the side in A turbocharger sports cat to try move the air through the engine and keep Cool . Second one the turbo lag that mean the lag in the time of the Response of turbocharger after you put your foot on the throttle . in low Speed the exhaust gas become low for that the turbocharger take sometime To give us the required response until reach to optimal state to distinguish The effect .

Turbo in future

Turbochargers have undergone a major transition over the last ٥٥ years. Today turbochargers are almost as complex technically as the engine to Which they are fitted . Twin – scroll turbos , variable geometry turbos And even belt – assisted twin .

Superchargers and Turbocharger :

A superchargers is an air compressor that increase the pressure or density Of air supplied to an internal combustion engine . This gives each intake Cycle of the engine more Oxygen. Letting it burn more fuel and do more Work , Thus increasing power . power for the supercharger can be provided Mechanically by means of a belt , gear , shaft , or chain connected to the

engine's crankshaft .

when power is provided by a turbine powered by exhaust gas, supercharger is known as a turbo supercharger – typically referred to simply as a turbocharger or just turbo . Common usage restricts the term supercharger to mechanically driven units .

General Overview of Superchargers :

Superchargers are an external mechanism driven off the engine's Auxiliary drive belt . The mechanism can work in many fashions , But all have the same basic effect : to increase the force on the Incoming air to the engine . Since superchargers are belt – driven , they Do create small amounts of parasitic drag on the engine , however the Effects of the supercharger greatly out weigh the drag .

Generally , superchargers work with gear ratio to created the desired Speed of the impeller (or other air – moving mechanism) . If fewer Boosts is desired , a larger drive – pulley can be interchanged onto the Supercharger . If greater boost is desired , a smaller pulley is used . However , boost level can be controlled in other ways too . A waste or Blow – off – valve can be used in conjunction with a correctly sized pulley To have great control over boost levels .

The points to be noted during supercharging are :

١. It increases power output of the engine .
٢. Super charging results in higher forces . The engine should be Designed to with stand these higher forces .
٣. The power required for air compression has to be taken from Engine it self . but net power output will be more than power Output without super charging for the same capacity .
٤. The higher pressure and temperature may lead to detonation . Therefore fuel with better antiknock characteristics is required .

٣,٣ Forced induction :

Forced induction is the process of delivering compressed air to the Intake of an internal combustion engine . A forced induction engine Uses a gas compressor to increase pressure , temperature and density Of the air . An engine without forced induction is considered a Naturally aspirated engine . forced induction is used in the automotive And aviation induction to increase engine power and efficiency . A Forces induction engine is essentially two compressors in series . The Compression stroke of the engine is the main compression that every Engine has an additional compressor feeding into the intake of the Engine makes it a forced induction .

A compressor feeding pressure into another greatly increases the total Compression ratio of the entire system . This intake pressure is called Boost . This particularly helps aviation engines , as they need to operate At high altitude .

Higher compression engines have the benefit of maximizing the amount Of useful energy extracted per unit of fuel . Therefore , the thermal Efficiency of the engine is increased in accordance with the vapor Power cycle analysis of the second law of thermodynamics . The Reason all engines are not higher compression is because for any Given octane , the fuel will prematurely detonate with a higher than Normal compression ratio .

This is called pre – ignition , detonation or knocks and can cause severe Engine damage . high compression on a naturally aspirated engine can Reach the detonation threshold fairly easily . However , a forced Induction engine can have a higher total compression without detonation Because the air charge can be cooled after the first stage of Compression , using an intercooler .

One of the primary concerns in internal combustion emission is a Factor called the NOx fraction , on the amount of nitrogen | Oxygen

Compounds the engine produces , This level is government regulated For emission as commonly seen at inspection stations . High Compression cause high combustion temperatures . High combustion Temperature lead to higher NOx emission , thus forced induction can Give higher NOx fraction .

٣,٤ Superchargers :

A supercharger is an air compressor that increases the pressure or Density of air supplied an internal combustion engine . This gives Each intake cycle of the engine more oxygen , letting it burn more fuel And do more work , thus increasing power . power for the supercharger Can be provided mechanically by means of a belt , gear , or chain Connected to the engine's crankshaft .

When power is provided by a turbine powered by exhaust gas , a Supercharger is known as a turbo supercharger - typically referred To simply as a turbocharger or just turbo . Common usage restricts The term supercharger to mechanically driven units .

٣,٤,١ Objectives of Super Charging

Mainly super charging is done to induct more amount of air into Cylinder per unit time and hence to burn more amount of fuel to Increase power out put .

Following are be Objectives of Supercharging

١. To obtain better performance from the existing engine .
٢. To compensate for loss of power due to high altitudes for Air craft engines .
٣. for a given weight and bulk of the engine , super – charging Increases power out put .
٤. This is important in air craft , marine and automotive engine Where weight and space are considered .

٣,٤,٢ Advantages and Disadvantages of Super Charging Advantages :

١. power output of the engine can be increased .

٢. More quantity of charge can be inducted in to engine cylinder .

٣. Better atomization of fuel is possible .

٤. Better mixing of air and fuel can be obtained .

٥. Better scavenging of exhaust gases is possible .

٦. Torque is improved for whole speed range and better torque at Low speeds .

٧. Faster acceleration of the engine is possible .

٨. The specific fuel consumption is lowered slightly .

٩. A better mechanical efficiency and sufficient combustion is Possible .

١٠. In CI engines , exhaust smoke is reduced .

Disadvantages

١. Detonation tendency increases in SI engines .

٢. Heat losses due to turbulence and thermal stresses are more .

٣. The valve overlap period increases up to ٦٠^{o} of crank angle .

٤. Better lubrication is required .

٥. Better cooling of piston and valve is required .

٦. It increases cost of the engine .

How to maintain Superchargers

* Air is constantly being into the engine making it prone to Overheatig so be sure to check your coolant and ensure System is function .
* Since Superchargers eat up gas , be sure to check fuel levels .
* A supercharger belt has a life expectancy of ٨٠،٠٠٠- ١١٠،٠٠٠ km And should be replaced before reaching this point .
* Oil should be changed after every ١٦٠،٠٠٠ km (a harder Working engine requires more protection) .

* Check your supercharger air filter for clogging .