

Turbocharger technology vs crdi in diesel engine engineering essay



**ASSIGN
BUSTER**

A turbocharger is a gas compressor that is used for forced-induction of an internal combustion engine. A form of supercharger, the turbocharger increases the density of air entering the engine to create more power. A turbocharger has the compressor powered by a turbine, driven by the engine's own exhaust gases, rather than direct mechanical drive as with many other superchargers.

OPERATING PRINCIPLE

A turbocharger is a small radial fan pump driven by the energy of the exhaust gases of an engine. A turbocharger consists of a turbine and a compressor on a shared shaft. The turbine converts exhaust heat and pressure to rotational force, which is in turn used to drive the compressor. The compressor draws in ambient air and pumps it in to the intake manifold at increased pressure, resulting in a greater mass of air entering the cylinders on each intake stroke.

The objective of a turbocharger is the same as a supercharger; to improve the engine's volumetric efficiency by solving one of its cardinal limitations. A naturally aspirated automobile engine uses only the downward stroke of a piston to create an area of low pressure in order to draw air into the cylinder through the intake valves. Because the pressure in the atmosphere is no more than 1 atm (approximately 14.7 psi), there ultimately will be a limit to the pressure difference across the intake valves and thus the amount of airflow entering the combustion chamber. Because the turbocharger increases the pressure at the point where air is entering the cylinder, a greater mass of air (oxygen) will be forced in as the inlet manifold pressure increases. The additional air flow makes it possible to maintain the

<https://assignbuster.com/turbocharger-technology-vs-cr-di-in-diesel-engine-engineering-essay/>

combustion chamber pressure and fuel/air load even at high engine revolution speeds, increasing the power and torque output of the engine.

Because the pressure in the cylinder must not go too high to avoid detonation and physical damage, the intake pressure must be controlled by venting excess gas. The control function is performed by a wastegate, which routes some of the exhaust flow away from the turbine. This regulates air pressure in the intake manifold.

COMPONENTS

The turbocharger has four main components. The turbine (almost always a radial turbine) and impeller/compressor wheels are each contained within their own folded conical housing on opposite sides of the third component, the centre housing/hub rotating assembly (CHRA).

The housings fitted around the compressor impeller and turbine collect and direct the gas flow through the wheels as they spin. The size and shape can dictate some performance characteristics of the overall turbocharger. Often the same basic turbocharger assembly will be available from the manufacturer with multiple housing choices for the turbine and sometimes the compressor cover as well. This allows the designer of the engine system to tailor the compromises between performance, response, and efficiency to application or preference. Twin-scroll designs have two valve-operated exhaust gas inlets, a smaller sharper angled one for quick response and a larger less angled one for peak performance.

The turbine and impeller wheel sizes also dictate the amount of air or

exhaust that can be flowed through the system, and the relative efficiency at <https://assignbuster.com/turbocharger-technology-vs-crدي-in-diesel-engine-engineering-essay/>

which they operate. Generally, the larger the turbine wheel and compressor wheel, the larger the flow capacity. Measurements and shapes can vary, as well as curvature and number of blades on the wheels. Variable geometry turbochargers are further developments of these ideas.

The centre hub rotating assembly (CHRA) houses the shaft which connects the compressor impeller and turbine. It also must contain a bearing system to suspend the shaft, allowing it to rotate at very high speed with minimal friction. For instance, in automotive applications the CHRA typically uses a thrust bearing or ball bearing lubricated by a constant supply of pressurized engine oil. The CHRA may also be considered “water cooled” by having an entry and exit point for engine coolant to be cycled. Water cooled models allow engine coolant to be used to keep the lubricating oil cooler, avoiding possible oil coking from the extreme heat found in the turbine. The development of air-foil bearings has removed this risk.

PRESSURE INCREASE

In the automotive world, boost refers to the increase in pressure that is generated by the turbocharger in the intake manifold that exceeds normal atmospheric pressure. Atmospheric pressure is approximately 14.7 psi or 1.01 bar, and anything above this level is considered to be boost. The level of boost may be shown on a pressure gauge, usually in bar, psi or possibly kPa. This is representative of the extra air pressure that is achieved over what would be achieved without the forced induction. Manifold pressure should not be confused with the volume of air that a turbo can flow.

In contrast, the instruments on aircraft engines measure absolute pressure in millimetres or inches of mercury. Absolute pressure is the amount of pressure above a total vacuum. The ICAO standard atmospheric pressure is 29.92 in of mercury (101.325 kPa) at sea level. Most modern aviation turbochargers are not designed to increase manifold pressures above this level, as aircraft engines are commonly air-cooled and excessive pressures increase the risk of overheating, pre-ignition, and detonation. Instead, the turbo is only designed to hold a pressure in the intake manifold equal to sea-level pressure as the altitude increases and air pressure drops. This is called turbo-normalizing.

Boost pressure is limited to keep the entire engine system, including the turbo, inside its thermal and mechanical design operating range. The speed and thus the output pressure of the turbo is controlled by the wastegate, a bypass which shunts the gases from the cylinders around the turbine directly to the exhaust pipe. The maximum possible boost depends on the fuel's octane rating and the inherent tendency of any particular engine towards detonation. Premium gasoline or racing gasoline can be used to prevent detonation within reasonable limits. Ethanol, methanol, liquefied petroleum gas (LPG), compressed natural gas (CNG) and diesel fuels allow higher boost than gasoline, because of these fuels' combustion characteristics. To obtain more power from higher boost levels and maintain reliability, many engine components have to be replaced or upgraded such as the fuel pump, fuel injectors, pistons, valves, head-gasket, and head bolts.

CHARGE COOLING

Compressing air in the turbocharger increases its temperature, which can cause a number of problems. Excessive charge air temperature can lead to detonation, which is extremely destructive to engines. When a turbocharger is installed on an engine, it is common practice to fit the engine with an intercooler, a type of heat exchanger which gives up heat energy in the charge to the ambient air. In cases where an intercooler is not a desirable solution, it is common practice to introduce extra fuel into the charge for the sole purpose of cooling. The extra fuel is not burned. Instead, it absorbs and carries away heat when it changes phase from liquid to vapor. The evaporated fuel holds this heat until it is released in the exhaust stream. This thermodynamic property allows manufacturers to achieve good power output by using extra fuel at the expense of economy and emissions. Over time a Charge Air Cooler (CAC) can leak losing boost pressure, and reducing fuel economy. It is common practice to test a CAC during routine service, particularly in trucking where a leaking CAC can result in a 20% reduction in fuel economy.

CRDi

CRDi stands for Common Rail Direct Injection meaning, direct injection of the fuel into the cylinders of a diesel engine via a single, common line, called the common rail which is connected to all the fuel injectors.

Whereas ordinary diesel direct fuel-injection systems have to build up pressures a new for each and every injection cycle, the new common rail (line) engines maintain constant pressure regardless of the injection

sequence. This pressure then remains permanently available throughout the
<https://assignbuster.com/turbocharger-technology-vs-cr-di-in-diesel-engine-engineering-essay/>

fuel line. The engine's electronic timing regulates injection pressure according to engine speed and load. The electronic control unit (ECU) modifies injection pressure precisely and as needed, based on data obtained from sensors on the cam and crankshafts. In other words, compression and injection occur independently of each other. This technique allows fuel to be injected as needed, saving fuel and lowering emissions.

Common rail direct fuel injection is a modern variant of direct fuel injection system for petrol and diesel engines.

On diesel engines, it features a high-pressure (over 1, 000 bar/15, 000 psi) fuel rail feeding individual solenoid valves, as opposed to low-pressure fuel pump feeding unit injectors (Pumpe Düse or pump nozzles). Third-generation common rail diesels now feature piezoelectric injectors for increased precision, with fuel pressures up to 1, 800 bar/26, 000 psi.

In gasoline engines, it is utilised in gasoline direct injection engine technology.

PRINCIPLES

Solenoid or piezoelectric valves make possible fine electronic control over the fuel injection time and quantity, and the higher pressure that the common rail technology makes available provides better fuel atomisation. In order to lower engine noise the engine's electronic control unit can inject a small amount of diesel just before the main injection event (" pilot" injection), thus reducing its explosiveness and vibration, as well as optimising injection timing and quantity for variations in fuel quality, cold

starting, and so on. Some advanced common rail fuel systems perform as many as five injections per stroke.

Common rail engines require no heating up time and produce lower engine noise and emissions than older systems.

Diesel engines have historically used various forms of fuel injection. Two common types include the unit injection system and the distributor/inline pump systems. While these older systems provided accurate fuel quantity and injection timing control they were limited by several factors:

They were cam driven and injection pressure was proportional to engine speed. This typically meant that the highest injection pressure could only be achieved at the highest engine speed and the maximum achievable injection pressure decreased as engine speed decreased. This relationship is true with all pumps, even those used on common rail systems; with the unit or distributor systems, however, the injection pressure is tied to the instantaneous pressure of a single pumping event with no accumulator and thus the relationship is more prominent and troublesome.

They were limited on the number of and timing of injection events that could be commanded during a single combustion event. While multiple injection events are possible with these older systems, it is much more difficult and costly to achieve.

For the typical distributor/inline system the start of injection occurred at a pre-determined pressure (often referred to as: pop pressure) and ended at a pre-determined pressure. This characteristic results from “ dummy” injectors

in the cylinder head which opened and closed at pressures determined by the spring preload applied to the plunger in the injector. Once the pressure in the injector reached a pre-determined level, the plunger would lift and injection would start.

In common rail systems a high pressure pump stores a reservoir of fuel at high pressure – up to and above 2, 000 bars (29, 000 psi). The term “common rail” refers to the fact that all of the fuel injectors are supplied by a common fuel rail which is nothing more than a pressure accumulator where the fuel is stored at high pressure. This accumulator supplies multiple fuel injectors with high pressure fuel. This simplifies the purpose of the high pressure pump in that it only has to maintain a commanded pressure at a target (either mechanically or electronically controlled). The fuel injectors are typically ECU-controlled. When the fuel injectors are electrically activated a hydraulic valve (consisting of a nozzle and plunger) is mechanically or hydraulically opened and fuel is sprayed into the cylinders at the desired pressure. Since the fuel pressure energy is stored remotely and the injectors are electrically actuated the injection pressure at the start and end of injection is very near the pressure in the accumulator (rail), thus producing a square injection rate. If the accumulator, pump, and plumbing are sized properly, the injection pressure and rate will be the same for each of the multiple injection events.

Most of the people who used to be called “gearheads” will at least be familiar with the term CRDI and how it applies to engines for cars and trucks.

The letters stand for common rail direct injection, which is a fairly recent

design for diesel engines that may also be suitable for passenger

<https://assignbuster.com/turbocharger-technology-vs-cr-di-in-diesel-engine-engineering-essay/>

automobiles. Though originally intended for commercial use, this design is now in wide use around the globe.

The method is chosen by more and more manufacturers and by individual users because it is fuel efficient as other diesel technologies were. However, CRDI has also provided a tremendous boost in diesel-engine performance. The improvement is mainly due to the common-rail design, which has tubes that connect all the injectors. These injectors are based on the direct-injection concept, as was the case in the past. But the common-rail design was quite a step forward.

Fuel in the common tube or “ rail” is under a set amount of pressure which causes the fuel to be “ atomized” or broken down to its smallest particles. This allows the fuel to combine with the air much more efficiently. With proper direct injection, fuel use is highly efficient, with much less waste fuel escaping the system unused.

The newest electronic technology has also allowed CRDi engines to better control the amount of fuel used, the pressure within the system and the timing of both the injection of fuel and the electronic charge applied to make the fuel burn. Injectors in the common rail direct injection engine have controls on the injector heads that allow slight variances in the amount of fuel put into the cylinders.

As is the case with almost all automobiles, trucks and motorized equipment today, a “ computer” or electronic “ brain” controls the various factors, including amount of fuel, timing of injection, timing of the charge and the pressure within the tubes or common rails. According to those who have <https://assignbuster.com/turbocharger-technology-vs-crdi-in-diesel-engine-engineering-essay/>

used this technology in both test and commercial applications, the CRDI method greatly reduces engine and vehicle vibration, allows the engine and vehicle to run more quietly and reduces the cost of operation significantly.

For the most part, traditional, classic carburetion engines have been replaced by such methods as MPFI or multi-point fuel injection designs for gasoline engines and CRDI or common rail direct injection for diesel engines. MPFI was first developed some years ago in response to the call for more fuel-efficient engines. The need for better emission standards made MPFI popular, since it allowed for better gas mileage in automobiles.

CRDI for diesel vehicles has improved performance by as much as 25 percent, according to some studies. This gives the vehicle more power and makes the technology more attractive for passenger vehicles. These engines run much more smoothly, with efficiency greatly enhanced by higher pressure possible in the common-rail or tube design. While the CRDI engine is a little more expensive than previous technologies, the savings in fuel cost can help recoup the initial expensive over time.

HOW THE CRDi ENGINE WORKS

DISADVANTAGES

In cold weather, high speed diesel engines that are pre-chambered can be difficult to start because the mass of the cylinder block and cylinder head absorb the heat of compression, preventing ignition due to the higher surface-to-volume ratio. Pre-chambered engines therefore make use of small electric heaters inside the pre-chambers called glowplugs. These engines also generally have a higher compression ratio of 19: 1 to 21: 1. Low speed

and compressed air started larger and intermediate speed diesels do not have glowplugs and compression ratios are around 16: 1. Some engines use resistive grid heaters in the intake manifold to warm the inlet air until the engine reaches operating temperature. Engine block heaters (electric resistive heaters in the engine block) connected to the utility grid are often used when an engine is turned off for extended periods (more than an hour) in cold weather to reduce start-up time and engine wear. In the past, a wider variety of cold-start methods were used. Some engines, such as Detroit Diesel engines and Lister-Petter engines, used a system to introduce small amounts of ether into the inlet manifold to start combustion. Saab-Scania marine engines, Field Marshall tractors (among others) used slow-burning solid-fuel 'cigarettes' which were fitted into the cylinder head as a primitive glow plug. Lucas developed the Thermostart, where an electrical heating element was combined with a small fuel valve in the inlet manifold. Diesel fuel slowly dripped from the valve onto the hot element and ignited. The flame heated the inlet manifold and when the engine was cranked, the flame was drawn into the cylinders to start combustion. International Harvester developed a tractor in the 1930s that had a 7-litre 4-cylinder engine which started as a gasoline engine then ran on diesel after warming up. The cylinder head had valves which opened for a portion of the compression stroke to reduce the effective compression ratio, and a magneto produced the spark. An automatic ratchet system automatically disengaged the ignition system and closed the valves once the engine had run for 30 seconds. The operator then switched off the petrol fuel system and opened the throttle on the diesel injection system. Recent direct-injection systems

are advanced to the extent that pre-chambers systems are not needed by using a common rail fuel system with electronic fuel injection.