

Global Growth of Diesel Engines and PM Usage

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ABSTRACT

Diesel engines are trying to make inroads in North America and growing at a steady pace globally. This article describes briefly the diesel engine and their components. Market growth is identified and a number of parts that are suitable for powder metal is indicated.

INTRODUCTION

Green revolution is changing the automobile architecture. Government mandates on emissions and miles per gallon forced automobile manufacturers to rethink and employ newer or once abandoned (due to cost) technologies. Diesel engines are popular in Europe and Asia and are less popular in North America. This is because of earlier versions of diesel were noisy and required a wait period for ignition to initiate. Relative cost of diesel to gasoline also is not attractive. This article describes the status of diesel engines globally and powder metal opportunities in diesel engines.

DIESEL ENGINES

Diesel engines operate differently from gasoline-powered engines. In the case of gasoline engines a fuel mixture is introduced in to engine cylinder and ignited with a spark. In the case of diesel engines air is compressed in the cylinder increasing the temperature of air due to molecular friction and diesel fuel is sprayed into the chamber-causing ignition. There are two types of diesel engines, 2-strokes and 4-strokes. Two-stroke engines are popular in lawn and garden, outboard motors, power supplies etc. Four-stroke engines are preferred in the automobile application. In a two-stroke engine during the piston position at the bottom dead center compressed air is blown in through the walls of the cylinder which scavenges combustion gases from previous stroke and on the upward stroke when the piston passes through the dead center valves are closed and the air is compressed and at the top dead center diesel fuel is injected and combustion begins forcing the downward motion of the cylinder and at the same time exhaust gases are expelled. In the case of two-stroke engine the

power is generated every stroke compared to four-stroke diesel where power generation is every other revolution. In a four-stroke engine the cycle begins with intake stroke wherein air is sucked in or by turbochargers forced in at high pressure and the valves close. Compression begins until the piston moves to top dead center and fuel is injected creating power stroke. The exhaust stroke begins following ignition with the piston approaching the bottom dead center and moves upward to begin the next cycle. This is similar to four-stroke gasoline engine. In the intake stroke air is aspirated in the older versions however recently turbo charging is used to increase the density of air in the cylinder.

In the following discussion components of diesel engines (Figure 1) are described and powder metal opportunities are highlighted.

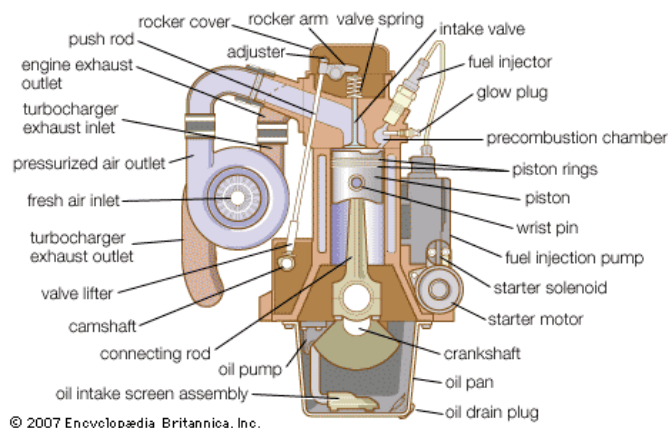


Figure 1. Diesel engine. Brief description (Source: Encyclopedia Britannica)

Cylinder block is made from sand castings of gray or alloyed cast iron. The main components of cylinder are piston pin, piston pin bearing, **connecting rod**, **connecting rod bearing** and **cylinder liner**. Pistons are made out of cast iron. Piston rings assist in sealing the cylinder with combustion gases and heat transfer from the piston to cylinder walls. The piston ring face is a bearing surface, high temperature; scuffing wear has to

be considered in choosing a material. Coatings and surface treatments are often applied.

Connecting rod translates linear motion to rotational motion of the crankshaft. Rod is connected to piston pin. The connecting rod carry very high tensile and compressive stresses and bending loads. Fatigue strength is major factor in designs. A number of different designs has been adapted to overcome some of these high stress requirements.

Cylinder liners are of wet and dry type based on how the heat transfer takes place. Aluminum liners hard faced or steel liners are popular.

Fuel delivery to the combustion chamber and delivery is controlled by overhead camshaft. There are single overhead camshaft (SOHC) or dual overhead camshaft (DOHC) configurations. Block mounted camshaft is generally used in heavy-duty diesel engines and is of limited use in high-pressure fuel injection systems. The cam operation is by one of four means: direct acting, end pivot rocker, center pivot rocker and center pivot rocker with lifter, push rod type. The direct acting cam and center pivot rocker are preferred. However, direct acting cam increases the height of inline engine. Overhead cam components are: camshaft, valve, rocker, rocker cover, **fuel injector** and engine retarder. Camshaft assembly includes: bearings, **bearing caps**, and **drive gear**. The valve assembly includes: **valve guide**, **valve seat**, and valve rotator spring cap, valve locks.

Crankshaft pulleys transmit power to cooling fans, **alternators**, **water pumps**, and **hydraulic pumps**. **Pulleys** are manufactured using cast iron or steel. Main crankshaft bearings are made using steel with a thin layer of bearing material. **Bearing materials** are made of Cu-Sn. Gear train is a link from crankshaft to camshaft and provides power to camshaft and other components. Gear train consists of **crank gear**, **oil pump drive gear**, a **bull gear**, an adjustable idler gear, and a **camshaft drive gear**. Gear train also drives fuel pump, accessory drive for alternators and air compressor.

Most gears are spur gear, however helical and herringbone gear is also used. Most gear materials are case hardened 4140 grades. Flywheels transfers power interface with engine and transmission.

Important aspect of diesel engine is the fuel injector. Earlier models use mechanical injection system. Fuel injector is a self-contained with injection pump, high-pressure passages, metering devices, injection nozzle. Electronic version can precisely control the fuel metering at various engine speeds and loads. This allows fuel economy optimization. Fuel injection in electronic injector is controlled by a **magnetic solenoid**. Each fuel injector is located next to the each cylinder head supplies fuel at high pressure. In common rail systems (Figure 2),

Common Rail tube branches to a number of injector valves. High-pressure pump supplies fuels at 200MPa. Common rail engines are given different names by different automakers. CDI (Daimler Chrysler) TDCi (PSA), dCi Renault) CDTi (Fiat, Isuzu) CRDi (Hyundai) DI-D (Mitsubishi), Hdi (Ford), D-4D (Toyota) DiCOR (Tata Motors), CRDe (Mahindra Motors) etc.

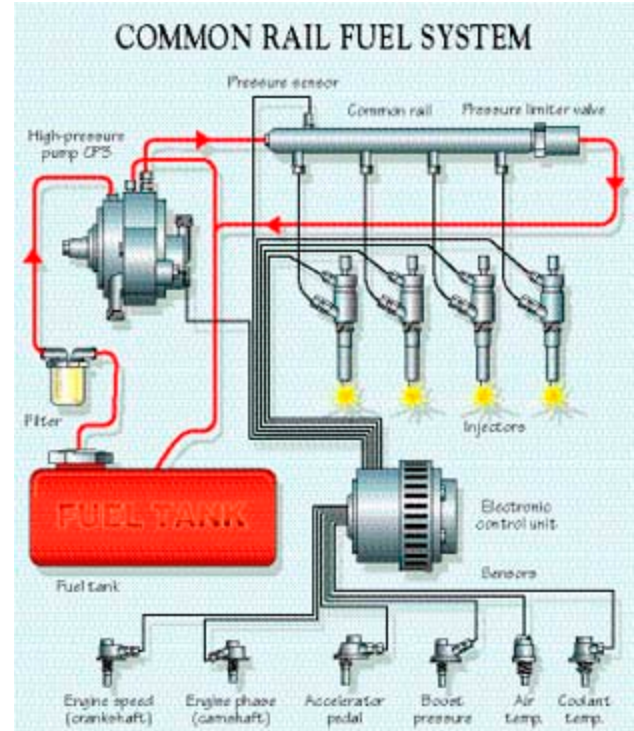


Figure 2. Typical Common Rail system

Sensors are used extensively to maintain optimum performance of engines. Crank position sensor is used for fuel injection. Throttle position sensor, pressure sensors for turbo boost, temperature sensors, fluid level sensors, vehicle speed sensor are a few of the examples.

A discussion on **turbochargers** is appropriate as it provides good opportunity for powder metal growth. Naturally aspirated engines power output is limited by the quantity of air available. Turbo chargers provide the solution. There are two types of pressure boosters; mechanically driven superchargers, exhaust energy driven turbochargers. Superchargers use piston and screw **compressors** and are gear driven and consume energy from the engine. The exhaust gases drive turbochargers. The turbine wheel extracts energy from the exhaust gases and drives the compressor. Turbochargers compressor ratio increases as the ambient pressure decreases like in higher altitudes and function at all altitudes.