CHAPTER 1

INTRODUCTION

1.1 MODERN FUEL INJECTION SYSTEM FOR CI ENGINES

A common rail direct injection engine (CRDI) engine is one, where fuel is injected directly into cylinders of CI engine through a common pipe which is connected to all fuel injectors. In the normal direct injection CI engines the systems have to necessary pressure for every cycle. The new system (CRDI) maintains same pressure in all sequence of fuel injection, there for the pressure in the fuel line is constant. The load and speed of the engine controlled by engine control unit based on the readings received from the sensors fitted on crank shaft and cam, the engine management system controls pressures of injection very precisely according to the need. In fact compression and fuel supply occurs independently. This technique make it possible to control the fuel injection as per requirement and causes lower SFC and emissions the timely supply which is also accurately controlled quantity wise reduces unburned fuel.
1.1.1 Historical development

The CRDI prototype was first developed by Mr Robert Huber in the country of Switzerland. The technology was further modified by Dr Marco Ganser at the research station in the Federal institute of Technology –Zurich, Switzerland. The commercial production of the vehicle where started in Japan during 1990 s. In the present day CRDI engines, the technology remains same. The opening of the injector is done electronically and is governed by an engine management system which is named as ECU. During 1990 a lot of development in this field taken place due to collaborative research between Elasis, Fiat and Magneti Marelli the first using CRDI system was brought out in the year 1997 (model Alfa Romeo 156 2.4 JTD, and later on that same year Mercedes-Benz C 220 CDI). During the same time CRDI systems were introduced in rail and marine applications. CRDI system based on hydraulic system (Circa 1942) were introduced which is also named as a modified common rail the engines were having the cams necessary for various purposes.

During this time engines developed were having two injectors for every cylinder some engines with turbo chargers was having four injectors for every cylinder. These systems used diesel oil and low grade fuel oil (with viscosity 600 cSt) this were heated to high temperatures of 130 °C in order to reduce the viscosity. Today the CRDI engines penetrated considerably in the passenger car market. Various manufacturers Honda Fiat and Audi use this technology.

1.1.2. Principle of operation

Today’s fuel injection technology based on the solenoid valves which ensure fine control of fuel injection period and fuel metering. The high
pressure used in technology ensures finer fuel dispersion to control the engines vibrations and noise the engine ECU first inject small quantity of diesel called pilot injection followed by main injection. This considerably reduces the explosiveness and noise as well as optimizing the timing of injection and controlling the fuel quality. The cold starting features were improved. Today’s modern CRDI systems ensures even fine injection per stroke CRDI systems requires very short heating time of the order of less than 10 s, which also depends on the ambient conditions. Historically diesel systems used various types of fuel injection. The general types were a distributed system and unit injections system. The old systems were able to measure the fuel accurately and were able to adjust the injection time precisely there were several limiting factors as they were driven by cams the pressure of fuel injection varied according to the speed of the engine. Thus the maximum pressures of injection corresponds to maximum speed of the engine and the highest injection pressure decrease with engine speed this trend is same for all pumps including the one CRDI system, the unit or distributor system.

The accumulator system is not present and pressures of injection depend upon the instantaneous pressure developed. Due to complex design and cost the multiple injection type were not favoured in all system. Typically in distributor systems a pre-determined value of pressure is set for start and end of injection. The injectors in cylinder head were opened and closed at the set pressures which are applied by a spring pre load on a plunger. Once the pressure reached the set level the plungers will lifted and injection occurs.

In CRDI systems there exist a reservoir for storing fuel at high pressure of the order of 2000 bars. Common rail means that the fuel injectors were supplied from a common reservoir which is an accumulator for storing fuel at high pressure the injectors were fed from this accumulator. Fuel injectors were
controlled by ECUs. The injectors were actuated by a hydraulic valve which were opened and cause fuel injection at desired pressure. The injection pressure depends only on accumulator pressure. There for injection pressure at the start and end of injection remains same which also ensures a constant injection rate. The sizes of the pump, the accumulator and pipes were adjusted such that the injection pressure and rate of injection will be the same for all the events during multiple injections.

1.2 FEATURES

1.2.1 Merits

The following are the advantages CRDI engines. Passenger cars fitted with this engines have 25% more power and torque than normal CI engines the rate of acceleration is superior and level of vibration and noise is lower other features are increased mileage lower pollution, minimum specific fuel consumption and higher performance. In the Indian market diesel prices are considerably lower than that of petrol and thus increases viability of use CRDI systems.

1.2.2 Demerits

Apart from the positive features the systems have few demerits cost of CRDI engine is higher than ordinary engine more over the maintenance cost and cost of spare parts are higher further it is not possible to alter ordinary machines to CRDI engines.
1.3 APPLICATIONS

The important uses of CRDI engines are in the marine and locomotive utilities further, most car manufacturers ranging from normal to executive cars shifted to this technology. Many of the Indian car manufacturers Maruthi, Hundai motors, Honda, General Motors, and Fiat have shifted to this technology. Luxury manufacturers like Mercedes and BMW have also adopted this technology. Car manufacturers have adopted their own names for their CRDI engines. Irrespective of the minor disadvantages the stake holders appreciate the benefits of the system.

This technology is now dominating across the developed countries. A revolutionary has taken place in the CI and SI engine (with use of GDI Technology). Some of the merits other than discussed previously are reduced amount of particulates in the exhaust. The controlled injection timing and enhanced recirculation of exhaust gas. Injections spread over two steps increases quality of combustion. Higher atomisation of the fuel corresponding to higher injection pressures is achieved. The computer controlled systems make the entire system smaller and increases the torque even at lower engine rpm all this modification leads to increased cost of engine. Normal engines cannot be converted into this technology. With introduction of CRDI technology the CI engine run like petrol engines the chief reason for the popularity of CRDI systems is the superior performance and increased fuel economy. The engine control module (ECU) (Figure 1.1) is also called as power train control module (PCM) is unit which are connected to a series of actuators on the compression ignition engine for getting an optimal performance.
Based on certain key parameters, The ECU determines the necessary quantity of the fuel to be supplied to the cylinder. The position of the throttle sensor shows the position of throttle pedal further lowering of the pedal causes increased intake of the air into the engine and ECU ensures injection of corresponding quantity of the fuel (in most engine intake fuel quantity is fixed) due to various reasons the engine has not warmed up, fuel injection will increased which causes the engine operate slightly rich until warming up the system. Today’s injection system uses stacked piezoelectric wafers with solenoids giving an atomised mixture during injection. Another resend feature is the introduction of variable geometry turbo chargers with flexible vanes. This turbo chargers allow the control of incoming air quantity according to the
load. The technology offers lower SFC and increased operating features. There is increased boost lag due to reduction in the inertia of turbo impeller.

A pilot accelerometer control (PAC) uses a system to measure engine noise and vibration which is used as a feedback signal to give instruction to the ECU so as to inject the optimum quantity of fuel which will provide smooth combustion and meet required demand of power. The current research in the CRDI engine is concentrated on the variable geometry injection, by which the fuel injection quantity can be changed over a broad range and variable valve timing (Mitsubishi 4 N 13 engine). This technique is already well developed for petrol engines. Today’s major challenge to the diesel engine researchers is the tougher regulations on pollution. The following are certain key research projects in the CI engine. The Hy-Trans projects developed by m/s Ford allows ignition to start in 400 ms which saves considerable amount of fuels in city roads and few other methods to increase the combustion efficiency.

These methods include HCCI technology which is being studied by diesel engine manufacturers in Japan and Sweden. Research and developments is in progress that uses di methane ether DME) as the fuel. A new diesel engine that uses a heat exchanger by a copper alloy (Cupro Braze) which is superior in terms of performance and operating life. The key features are increased strength resistance to corrosion and lower pollutants formation. In this technology the components of the systems are intelligent and they are electronically controlled. The conventional injectors are replaced by electrically controlled solenoid injectors. Injectors are opened by signals from ECU depending upon parameters like speed of the engine load on the system and temperature of the engine.
In the CRDI systems the major space where the combustion takes place is located at the top of the piston. Supply pressure for the injectors is maintained constant an injector based on the solenoid valve receives fuel from the constant pressure storage tank. In direct injection engine fuel injection pump supply diesel through separate fuel lines to the injector. The pump generates the high pressure required. The fuel is compressed to 1000 bar using the fuel pump. The fuel then flows to rail through a high pressure pipe from here fuel is distributed to the injectors which then admitted to the main cylinder the common rail system usually operated along with a turbo charger to produce more output and meet required norms of pollution. These systems in general increase the engine power, response of the throttle, fuel efficiency, and pollution control.

1.4 BIO DIESEL

Bio diesel is new generation liquid fuel generated from vegetable or animal fats and is good substitute to diesel. It can be mixed with diesel in any proportion and characteristics are very similar to diesel. The exhaust emissions are lower. The fossil sources like coal petroleum and natural gas constitutes major part of the energy consumption. These limited souses are expected to exhaust in the coming future. Thus renewable sources like bio mass hydro wind solar hydrogen and nuclear gaining importance. These new fuels have a potential to solve many current social and economic problems like air pollution, global warming. The various environmental concerns and sustainability issues are addressed. Bio diesel based on vegetable oil has a potential to act as a green source of energy with a calorific value closed that of diesel. The vegetable based oil was not accepted as a fuel source due to the high charges involved than petroleum products. But the issues like increase of petroleum price and political uncertainties related to their availability renewed
interest in the vegetable oil based biodiesel. Bio diesel started competing with petroleum products during 1980s.

The economics of bio diesel depends up on the base stoke, geographic area variable crop production in different seasons, the price of crude oil and other factors. Price of biodiesel was double than that of petro diesel. The major reason for high price is attributed to the high price of the feed stoke it is also possible to use feed stokes like yellow grease pork lard and beef tallow. Methyl esters also can be produced from the byproduct (tall oil) of paper manufacturing. Tall oil consists of fatty acids, traces of unsaponifiables and resin acids. The acid fraction of the tall oil consists of oleic acid linoleic acid and the isomers. The fatty acids of tall oil can easily convert to their esters with reaction by methanol. The resin acids are esterified with hindered effect. One of the major reasons for the recent attraction of biodiesel because positive impact on environment.

The major hindrance for the popularization of the biodiesel is the cost involved. The commercialization of the byproducts may also be included in scope of biodiesel production so as to lower the cost of biodiesel. For example bio diesel can be produced from waste cooking oil, and there is scope of producing glycerin as a byproduct. The calorific value of vegetable oil close to that of diesel so far vegetable oils not favorite due to their high expense than petroleum fuels. However there is increase in the petroleum price and issues in the availability makes vegetable oil as an attractive alternative. The major sources of vegetable oils for conversion to biodiesel are soybean oil, Jatropha oil, rubber seed oil etc. some of these is used as food product makes biodiesel production more challenging. However there are some low cost sources like waste cooking oil and animal fat which have a scope to convert as biodiesel.
The large amount of free fatty acid (FFA) presents in this oil cause certain problem in convention.

Extraction of bio diesel is economically feasible if it is produced from non-edible oil sources. Jatropha curcas has a non-edible oil source and the tree is capable of growing draught environment. This is one of the cost effective source of biodiesel. The extracted oil has high viscosity causing the direct use of this difficult to the engine. The high viscosity causes problems in fuel atomization and fuel penetration. This also causes high engine deposits and thickening of lubricating oil.

The chemically altered vegetable oil named as biodiesel can be directly used in any diesel engine without major alteration of the engine. Bio diesel is generally used in low concentration as blend with diesel. Very few studies are available about the impact of bio diesel in un modified engine and day to day use in the vehicles. The plant is generally cultivated in dry lands. The seeds are collected and oil is extracted. Following is chemical composition of Jatropha oil Moisture 6.20%, Protein 18.00%, Fat 38.00%, Carbohydrates 17.00%, Fiber 15.50%, Ash 5.30%. The seed contains 25 to 30 % oil. The oil contains 21% saturated fatty acids 79 % unsaturated fatty acids. Some chemicals in the seed is poisonous making Jatropha oil unfit as a cooking oil for human need.

The oil is also used for producing soaps, as a illuminant in lamps it has a capability to burn without producing smoke. It is an alternative to kerosene in the stove. The oil is rich in nitrogen, potassium and phosphorus. And can also be used as a organic manure. The process of pyrolysis can be used for producing products from Jatropha oil cake. The products can be classifies into solid liquid and gaseous products. Liquid is used as fuels in the furnace.
The liquid can be converting to high grade fuel by Transesterification process. Thus Jatropha oil is promising, commercially viable fuel in the diesel engines. Its chemical, physical and performance characteristics are similar to that of diesel’ this fuel can be used in cars without much change in design. The fuel can be used for lighting and cooking. It can be used in diesel engines for generators, pumps, farm machines. Jatropha oil is used for manufacture of candles soaps and in cosmetic industry. Thus this fuels a practical alternative for diesel engines. To counter accumulate on of greenhouse gases across the atmosphere