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Retrofication of Mechanical Speed Governor with Electronic Speed Governor for Heavy Duty Diesel Engines

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Abstract: **The engine speed controller used in heavy duty/off road conventional diesel engine by the adaption of mechanical/electronic governor. In order to control engine speed, the governor controls the amount of fuel using fuel rack. In mechanical type the flyweights present in centrifugal governor are used to control the fuel rack which in turn controls the plunger present in fuel injection pump to control the fuel input to the engine according to the speed of the engine or as per the engine demand. In electronic governor the fuel rack is connected to throttle actuator lever and driven from ECU in electronic governor. We have retrofit mechanical governor to electronic governor to obtain smoother and better performance of engine.**

I. INTRODUCTION

Worldwide electronic explosion is so that even for a small purpose we are addicted to use electronic instruments, equipment's or devices. Present day electronics has grown so much that it's overtaking all the conventional methods and is setting up its own platform. By retrofitting old device to electronically control devices. These things are happing due to its reliability, flexibility and capability of digital electronics.

This electronic explosion has also acquired in automotive market due to its precise amount of output and it has also solved unsolvable problems by conventional methods. The content and complexity of electronics for circuit design, processing, power control sensing, signal conditioning and transient suppression are destined to increase even more in future vehicles.

There many categories of electronic systems used as automotive parts. Each of these systems requires an electronic control unit (ECU). In this project retrofitted a Mechanical system with an Electronic system for the purpose of governing the fuel injection pump. 'Electronic Engine Management' is the art of electronically controlling , calibrating, and equipping an engine to maintain its best performance, fuel economy and continuously diagnosing system faults.

After obtaining and comparing the results of both mechanical governed engine and electronically governed engine satisfactory results were obtained and in future this engine will be retrofitted or equipped with an electronic governor. The report submitted below explains us the importance of the electronic system advantages and disadvantages of electronic governor and the methods what all we have undergone for the replacement of mechanical to electronic governed engine.

A. Engine Used

The engine used for performance study is made up of 4 cylinders, turbocharged, direct injection, and water cooled engine. This engine is used in applications of heavy duty or off road vehicles. Engine delivers power output 72kW and 375 Nm torque. This engine configured with Electronic Governor, inline high pressure fuel injection system, Waste Gate turbocharger, Re-entrant piston, Exhaust Gas Recirculation, Charge Air cooler and Diesel Oxidation catalyst.

B. Governor

The basic function of governor is to limit the no load speed. It must ensure that the speed of the engine does not exceed the maximum speed specified by the manufacturer. Depending on the type of governor the additional function of the governor can be to maintain the desired speed viz idling speed or speeds within the range between idling and maximum speed. Further in this report we have discussed about the functions of governor, type of governors and we have made an engine studies on both type mechanical and

electronic governors. The results of both engine studies have been compared with each other and have been discussed about their advantages and disadvantages below in this report.

II. OBJECTIVES

The main objectives of this work are:

A. Retrofication of mechanical to electronic governor.
B. Achieving better performance by usage of electronic governor.
C. To control rack position of the governor very precisely based on the demand of engine by usage of electronic governor.
D. To run the engine using electronic governed system, to obtain the engine performance test results and emission results as per the company specifications.
E. To avoid shut down problems in a long run process.

III. MATERIAL AND METHODS

A. Technical Specifications of engine

Configuration	Inline, 4 Cylinder, Turbocharged
Displacement	4.33 liters
Bore / Stroke	105 mm / 125 mm
Power	72 kW @ 2200 rpm
Torque	375 Nm @1300 rpm

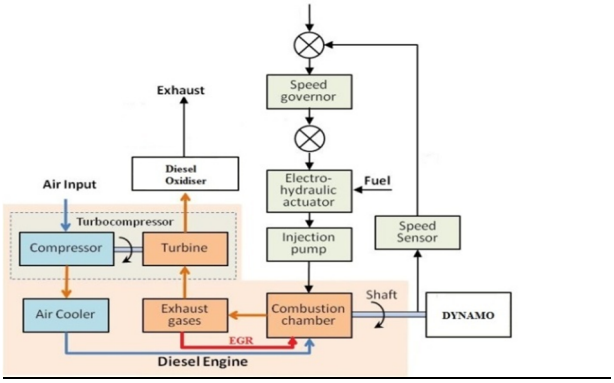

Fig.3.1 Schematic Layout of the engine

B. Functions of governors

The basic function of governor is to limit the no load speed. It must ensure that the speed of the engine does not exceed the maximum speed specified by the manufacturer. Depending on the type of governor the additional function of the governor can be to maintain, the desired speed viz idling speed or speeds within the range between idling and maximum speed.

C. Mechanical Governors

Governors employing the principle of centrifugal force are called mechanical governors. These are most widely used on diesel engines. The mechanical governor is mounted on the fuel injection pump. The control rack of fuel injection pump is connected to

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the governor through a flexible joint and the governor control lever is connected to accelerator pedal.

D. Electronic Governor System

Electronic governor senses this engine speed and converts into e electrical pulses or frequency and sends it to electronic control unit. Electronic control unit senses these pulses or frequencies and controls the actuator which in turn controls the fuel injecting pump. Thus at various loads or speeds the electronic governor works efficiently.

These governors typically are retrofitted to applications that now require a governor. They pick up the engine speed from the flywheel ring gear's teeth and control it electronically.

If the engine is running at some intermediate speed between idling and maximum, but at less than full load, any change in load will cause a speed change. Electronic governor senses this engine speed and converts into e electrical pulses or frequency and sends it to electronic control unit. Electronic control unit senses these pulses or frequencies and controls the actuator which in turn controls the fuel injecting pump. Thus at various loads or speeds the electronic governor works efficiently.

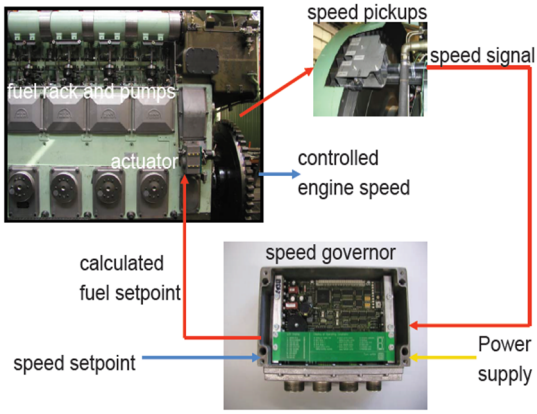

Fig.3.2 Layout of Electronic Governor Working System

E. Functions of Engine Testing

1) To carry out testing of products as per the Specification and Process sheet.

2) To carry out "Performance trials and approval, Fast Cycle / Endurance Test", as per the guideline of Design and Development Department.

3) To carry out the final assembly, primer and finish painting of tested products as per the process qualifying parameters and procedures drawn.

IV. RESULTS AND DISCUSSIONS

A. Torque for Variable Speed

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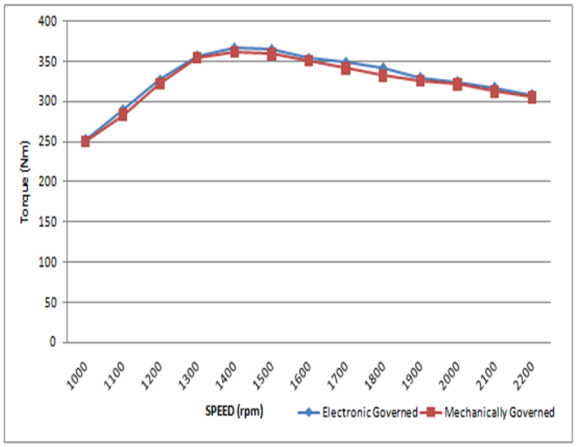

Fig.4.1: Variation of Torque (Nm) for Variable Speed (rpm)

The difference between mechanical and electronic governed interims of the torque versus speed is as shown in above graph and there is no much difference between each other's values and by seeing the values we can conclude that there is an difference about less than 1% between each other and electronically governed engine will slightly dominate then the mechanical governed engine interims of torque value.

B. Power for Variable Speed

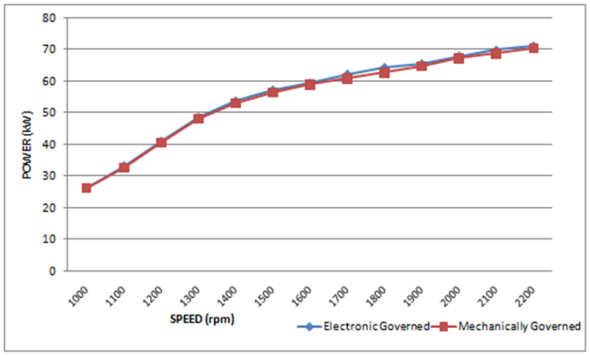

Fig.4.2: Variation of Power (kW) for Variable Speed (rpm)

The difference between mechanical and electronic governed interims of the Power versus Speed is as shown in above figure and there is no much difference between each other's values and by seeing the values we can conclude that there is a difference about less than 1% and electronically governed engine will have almost the same values as compared to the mechanically governed engines. There is slight increment in the value of power at speeds between 1600 to 1800 rpm in electronic governed engine when compared with mechanically governed engine and it is about nearly to 2% and electronically governed engine dominates in this matter also due to its precise time of injection.

C. Brake Thermal Efficiency for Variable Speed

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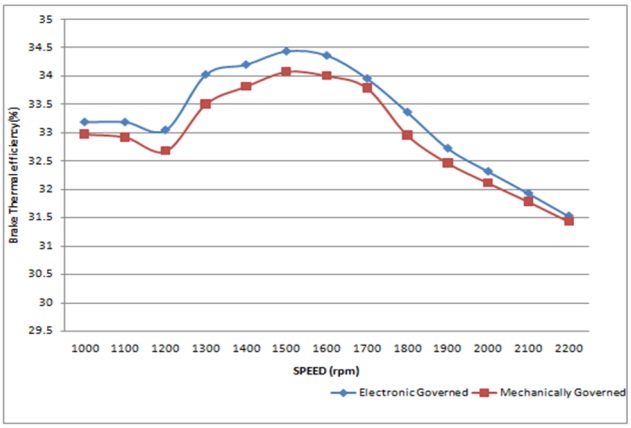

Fig.4.3: Variation of Brake thermal efficiency (%) for Variable Speed (rpm)

Figure we can conclude that there is slight difference in electronic governed engine and mechanical governed engine. Thus we can say electronic governed engine has greater brake thermal efficiency when compared with mechanically governed engine. The difference between each other values is about 0.5% to 1% at the start from 1000 to 1300 rpm, at speeds above 1300 to 1600 there is much difference compared to previous and is about more than 1% and the difference in both the values becomes closer, the difference will be about less than 1% above speed 1600 rpm until the maximum speed about 2200 rpm speed is reached. In every case electronic governed engine will dominate because of its greater values obtained in power and thermal efficiency is directly proportional to power

D. Specific Fuel Consumption for Variable Speed

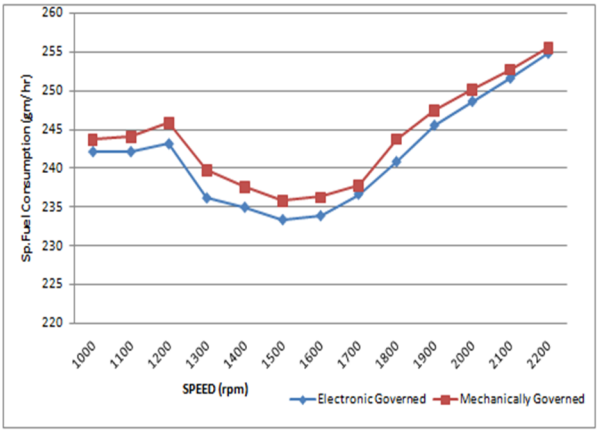

Fig.4.4: Variation of Sp. Fuel Consumption (gm/hr) for Variable Speed (rpm)

The difference between the electronic governed and mechanical governed engine is that electronic governed engine has lower specific fuel consumption compared to mechanical governed engine due to its precise time of fuel injection. There is not such a large difference between the mechanical governed and electronic governed engine. The difference is about 1% to 2% from the start at 1000 rpm till end up to 2200rpm.

E. Exhaust Gas Back Pressure for Variable Speed

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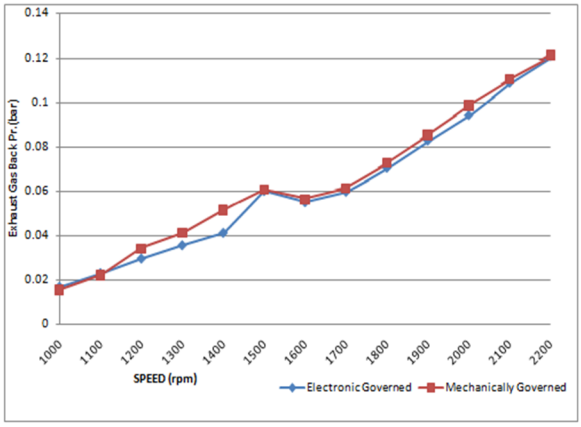

Fig.4.5: Variation of Exhaust Gas Back Pressure for Variable Speeds (bar) v/s Speed (rpm)

Electronic and mechanical governed engine has no greater difference between each other's values at the start is less than 1% and the difference again increases between the values 1300 to 1500rpm and is about 2 to 3% and mechanically governed engine dominates and at the end above 1400 rpm the difference becomes much lesser and is about less than 1% till 2200rpm is reached. Mechanically governed engine or electronically governed engine does not affect much on the exhaust gas back pressure much.

V. CONCLUSION

By introduction of the Electronic governing system the advantages observed are as follows:

A. Rack position of the governor was controlled very precisely based on the demand of engine.
B. All the engine parameters were monitored continuously.
C. ECU is interfaced to an external output or monitors all engine parameters.
D. ECU will send alarms, warnings for the engine abnormalities hence protects the engine for rough running.
E. Engine diagnostics and operating variables such as amount of fuel to be sent to the cylinder was varied according speed variations.
F. Engine problems through the display unit easily detected and can be solved.
G. As observed by the test results that there is the some decrement in fuel consumption in electronic governed engine due to its precise time of rack controlling and fuel injection then that of mechanical governor. Further precise metering of fuel as per the variable operating conditions electronic governor is necessary.

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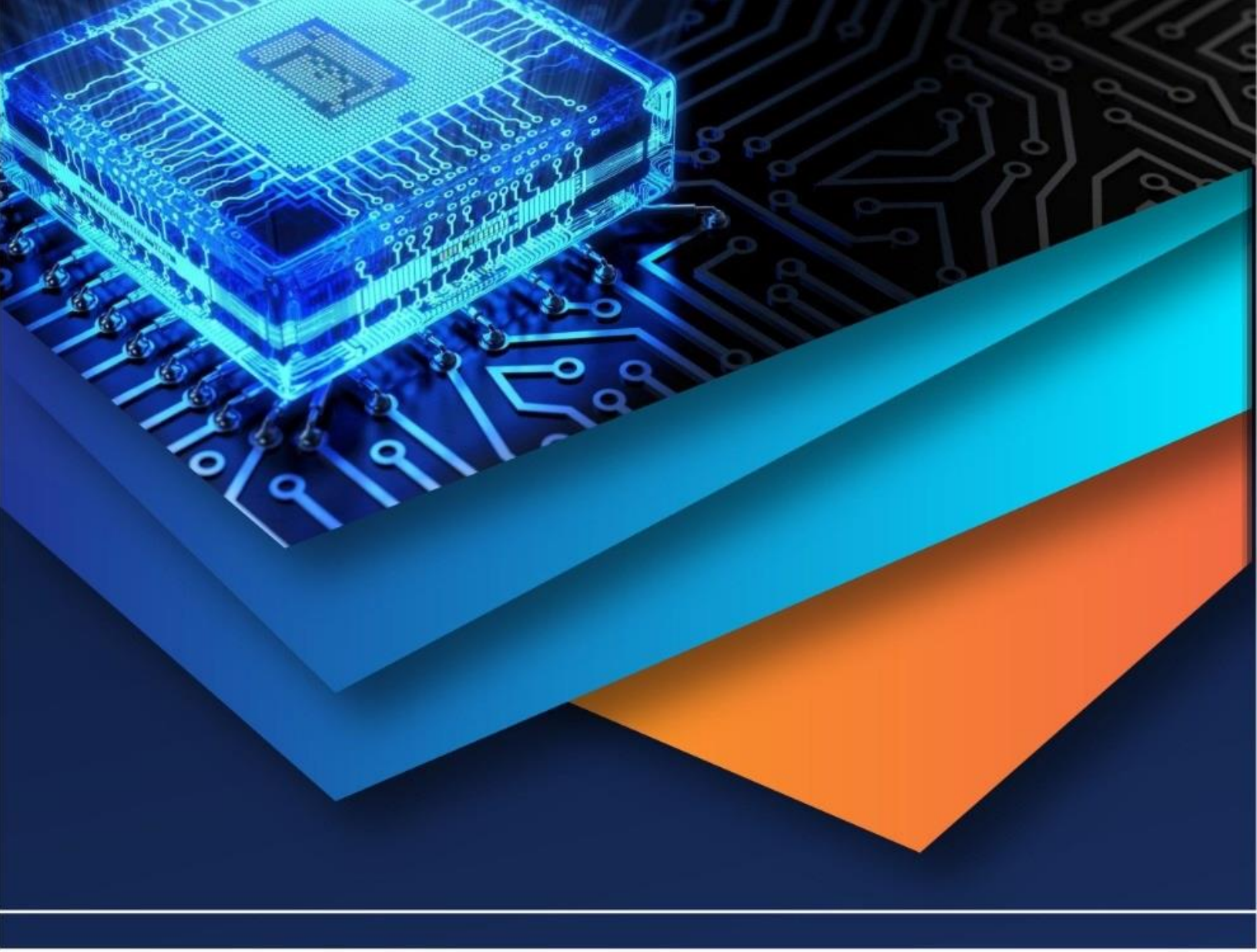

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