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A STUDY ON THE MODELING OF INLET VALVES OF GDI ENGINE

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ABSTRACT
All across the world, Gasoline Direct Injection (GDI) engines are commonly employed in passenger cars. Such engine technology is in higher demand as a means of lowering fuel consumption and emissions. GDI engines have a higher efficiency and emit fewer pollutants. In a GDI engine, fuel and air are combined inside the combustion chamber. The mixing of fuel and air inside the combustion chamber is aided by the inlet valve. To improve the performance of GDI engines, we included two modifications to the inlet valve: valve masking and valve shrouding. CFD tools were used to create the model.

Keywords: GDI engine, Inlet Valve, Valve Masking, Valve Shrouding, CFD tools

1. INTRODUCTION
The gasoline direct injection engine (GDI), sometimes known as the petrol direct injection engine (PDI), is a type of engine that is widely utilised in automobiles around the world. In 1925, the first GDI engine was developed for a low-compression truck engine. However, in recent years, the car industry has boosted its use of GDI. Lower fuel consumption and more output results in improved volumetric efficiency, very efficient intake and relatively high compression ratio deliver high performance and response, lower octane requirement and more precise air-fuel ratio control, faster starting reduces CO2 emissions, and improved transient response are some of the main advantages of GDI engines.

A gasoline direct injection (GDI) engine is one that runs on gasoline that is injected directly into the combustion chamber. The design is designed to control emissions and reduce fuel consumption. This model was created with the use of a CFD tool; more compression occurs inside the combustion chamber as a result of this design, resulting in enhanced efficiency, torque and dynamic driving characteristics, as well as lower pollution levels. Valve shrouding and valve masking are two design alterations to the typical valve design that are employed inside the valve. The air-fuel mixture is delivered directly into the combustion chamber and swirled by the shroud wall. The combustion efficiency and engine performance are improved by swirling the air-fuel mixture within the combustion chamber.

2. LITERATURE REVIEW
Nowadays, internal combustion engines are one the reason behind global warming. The use of internal combustion engines increased a lot during these days as the number of automobiles is increasing rapidly. Because gasoline or diesel combustion is very cost effective, to improve the efficiency, performance etc. new design aspect is developed.

Mirko Baratta and his team presented a paper on "Combustion chamber design for a high-performance natural gas engine: CFD modeling and experimental investigation" (Baratta et al. 2019). In this journal, they have introduced valve masking in combustion chamber. The paper was mainly based on high performance, monofuel, spark ignition engine running on natural gas. In this paper, they have added a masking in the inlet manifold. By providing masking, a small portion of manifold is covered. Normally masking is done by extending the valve seat of the inlet. So, the air fuel mixture coming through the inlet comes into the combustion chamber through the unmasked region. The air hit on the walls of masked region and mixes morewith the injected fuel inside the combustion chamber which gives efficient mixing of air and fuel.

M Manikandan proposed a paper on “CFD analysis of fluid flow inside a pentroof combustion chamber with different piston shapes” (Manikandan et al. 2017). The Performance of an internal combustion engine depends upon the motion of gas inside the combustion chamber. During intake and compression process, it is found that flow on combustion chamber is influenced by the design of combustion chamber and piston shape. A good design of combustion chamber would increase efficiency.

In the past, many researchers (Achuth and Mehta in 2001, Chang-sik et al. In 2001; Huang et al. In 2008; Kurniawan et al. In 2007; Murali and Mallikarjuna in 2010; Trigui et al. in1999) studied in fluid flow inside a combustion chamber (Achuth and Mehta, 2001). A study (Achuth and Mehta in 2001) found that changing intakevalve lift and pentroof angle of combustion chamber head will increase efficiency and motion. The larger

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the pentroof angle more the vortex structure near the compression at top dead center (TDC).So the design of pentroofgeometry increases motion inside the chamber as well as efficiency.

From the literature review, it seems that lot of studies have done in valve masking and pentroof geometry design. However, very less research has done on GDI Engines considering valve masking and pentroof geometry design. Modifications to the inlet valves of the GDI engine is a possible means for improving the efficiency of the engine. Therefore, this study is conducted to design the masking of inlet valve of a GDI Engine and also designing a pentroof geometry for combustion chamber which will increase fluid flow inside the chamber.

3. GDI ENGINE

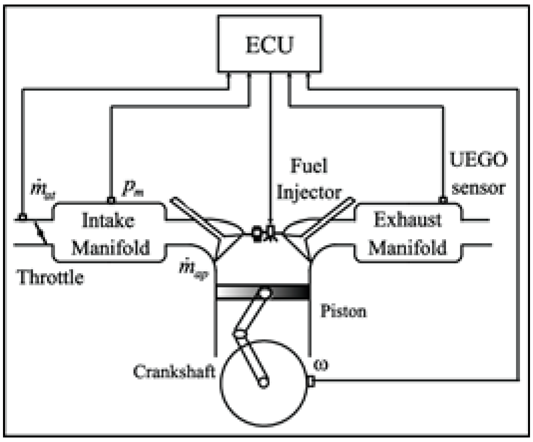

Fig. 1. GDI Engine

GDI or Gasoline direct injection is a type of fuel injection used by many modern vehicles. GDI engine works in such a way that, a common fuel line injects gasoline at higher pressure directly into the combustion chamber of each cylinder. This result in precise control of injection timing and the amount of fuel delivered. It has many benefits than conventional fuel injection. With GDI technology, it can draw more power from smaller engine and result in improved fuel efficiency and reduced emissions.

The main components of GDI engine are fuel tank, electric fuel pump, fuel filter, high pressure pump, rail, pressure regulator, fuel-pressure sensor, high-pressure injectors, piston, crankshaft, intake manifold, exhaust manifold. The GDI engine operates into two modes,

i) Stratified mode during low load and low speed operation.

ii) Homogeneous stoichiometric mode at higher loads and at all loads and higher speed.

4. MODELING OF INLET VALVES

All internal combustion engines use valves for fuel intake and exhaust gases emission outside the combustion chamber. GDI engines also use this type of valves for air intake and exhaust gas emission. The valve designs in this project are created with the help of CATIA V5 &Ansys software. The two designs are valve mask and shroud.

CATIA V5 is a computer aided design software used to design various products we see in our daily life. It is used in multiple stages of product development from concept to manufacturing of the product. Ansys Design Modeler provides unique modeling functions for simulation that include parametric geometry creation, concept model creation, CAD geometry modification, automated cleanup and repair, and several custom tools designed for fluid flow, structural and other types of analyses.

Initially, normal engine inlet valve was designed. There are three main parts: cylinder, inlet manifold and inlet valve. The required cylinder dimensions are provided in Table I below (Feng et al. 2016)

TABLE – I: DESIGN PARAMETERS

Sl No.	Part	Dimension
1	Bore	82.5mm
2	Stroke	8.2mm

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3	Clearance	6.0142mm
4	Pentroof angle	40 degrees

The modeling process is done on CATIA V5 software. A base circle with diameter 82.5mm is drawn. The circle is then extended with the sum length of stroke and clearance lengths. A triangle with 40 degrees inclination is created using line tool. The inlet manifold design is produced then. The plane on pentroof geometry is selected to draw inlet valve and manifold.

The inlet manifold fates are created using the spline and rib definition tool. Inlet manifold with required dimensions are drawn on the surface. Two manifold faces are required from each circle on the plane. For that by using mirror tool the manifold is made. An axis for the manifold is drawn and each faces and axis are joined using spline definition tool. The valve seat is made with the help of shaft definition tool. Then the inlet valve is made by using the transaction definition tool. The shape of the inlet valve is recreated from valve seat. The half of inlet valve geometry is made. Using shaft definition tool the inlet valves made.

The inlet valve of normal engine is modified by incorporating two inlet valve designs.

(i) Valve shrouding

(ii) Valve masking

Valve shrouding (Fig 2) is the process of adding material to the inlet valve. Only 45 degree of the total valve opening is used for valve shrouding. Valve shrouding partially restricts the flow air into the cylinder.

Valve masking (Fig 3) is the process of extruding the valve seat downwards.The valve seat is extruded 8mm downwards to achieve masking. Only 45 degree of the valve seat is used for valve masking. It also partially restricts the flow of air into the cylinder.

The flow of air will be through the unmasked or unshrouded areas. So the flow after these designs will be more turbulence it increases the mixing rate of air and fuel. It improves the output characteristics.

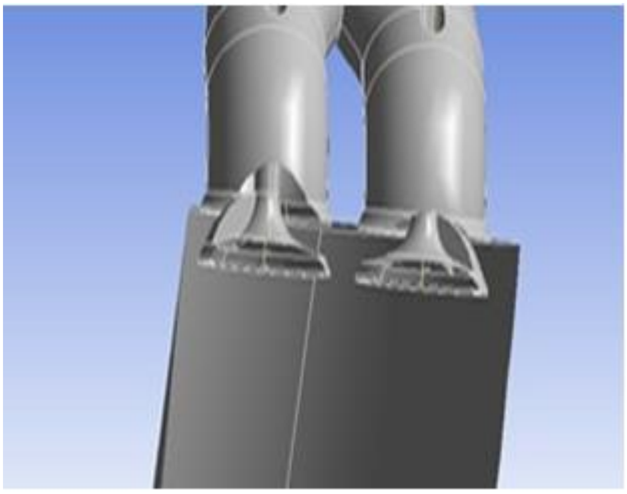

Fig. 2. Valve Shrouding

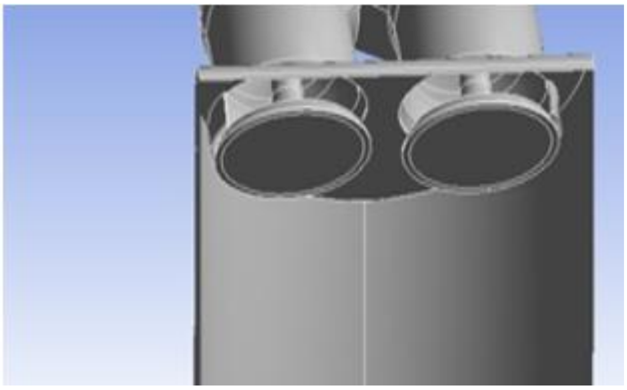

Fig. 3. Valve Masking

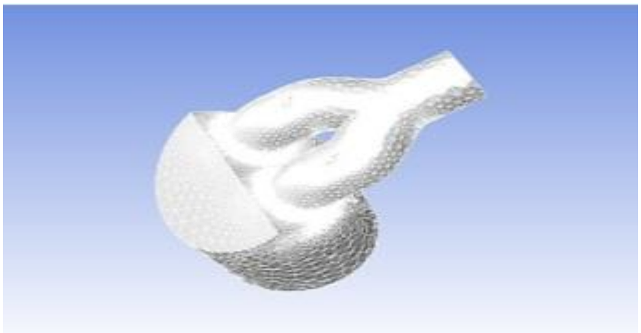

Fig. 4. Engine Cylinder and Inlet Manifold

5. RESULT& DISCUSSIONS

Valve mask and valve shroud redirects the incoming air from the turbocharger and it increases the turbulence. This increased turbulence helps in faster mixing of air and fuel. It thereby reduces combustion time and henceprovide faster combustion than a normal GDI engine.

6. CONCLUSIONS

The valve designs for GDI engine are created using CATIA V5 software. The proposed design is supposed to restrict the air flow through the perimeter of inlet valve and redirect its flow stream. Thereby it increases the rate of air fuel mixing by increasing swirl flow inside the combustion chamber. It then provides increased efficiency of the engine with increased power output. Further analysis of the model has to be done.

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