Components of a petrol engine engineering essay

Introduction:

Petrol Engine was developed by the German engineers Karl Benz and Gottlieb Daimler in 1885. This invention was considered to be one of the greatest achievements in the automotive industry.

A petrol engine uses petrol typically known as gasoline in the United States, as a fuel. Inside the engine, the burning of fuel coupled with air forces the hot gases to expand against various parts of the engine and cause them to move. Hence, petrol engines are termed as internal-combustion engines. Additionally, petrol engines are highly compact and lightweight for the power produced by them. The rate at which it generates work is typically computed in horse power or watts[1].

In essence, a petrol engine is seen as a composite piece of machinery that comprises of as much as 150 moving parts. Moreover, it is a reciprocating piston engine, wherein a multiple pistons are seen moving up and down within cylinders. For the working of the petrol engine, a mixture of air and petrol is introduced into space surrounding the piston and is then ignited. Then, the gases produced push the pistons down, thereby producing power. This engine-operating cycle repeats itself after every four strokes, either downward or upward movement of the piston, and this is termed as the four-stroke cycle. Further, the movement of the pistons causes the crankshaft to rotate, which has a heavy flywheel attached at its terminal. From the flywheel the power is transmitted to the car’s driving through the transmission of clutch, gear system, and final drive[2].

The primary purpose of this report is to provide a profound knowledge about lightweight petrol engines. The study outlines the use of various components used for the manufacturing and the production of lightweight petrol engines. It discusses the properties that make these materials most appropriate for constructing lightweight engines.

The following section focuses on the primary components of the lightweight petrol engine

Parts of a Petrol Engine:

The major components of the petrol engine can be categorized into a number of systems:

The Fuel System: The fuel system is responsible for pumping fuel from the petrol tank into the carburettor, where it mixes with air and gets sucked into the engine cylinders. Further, with the help of electronic fuel injection, it traverses directly into the cylinders from the tank through an electronic monitor.

The ignition system: This system supplies the sparks in order to ignite the fuel mixture within the cylinders. It boosts the 12-volt battery voltage by means of an ignition coil and contact breaker, up to the rates of 18, 000 volts or greater. Through a distributor, these pulses then travel to the spark plugs inside the cylinders, where they can produce the sparks. Due to the ignition of the fuel inside the cylinders, temperatures of approximately 700 or more are produced, when the engine must be cooled to avoid overheating[3].

Water-cooling system: Almost all engines nowadays have a water-cooling system, which allows circulation of water through channels within the cylinder block, thereby extracting the heat. The water flows through pipes within a radiator, which is cooled by fan-blown air. Most motorcycles and cars are air-cooled, where the cylinders are surrounding by several fins to offer a large surface area for the air.

The Lubrication system: This system also reduces some amount of heat; however, it main job is keeping the moving parts of the engine coated with adequate oil, which is continuously pumped under pressure to the crankshaft, valve-operating gear as well as the camshaft[4].

The underlying principle behind the working of any reciprocating internal combustion engine is that if a small amount of high-energy fuel such as gasoline is placed in a small, enclosed space and ignited, it produces an incredible amount of energy in the form of expanding gas. This released energy can be used to propel a potato 500 feet. For such cases, the energy is converted into potato motion. This energy can also be used for more productive purposes, such as if one creates a cycle which allows explosions to set off like hundreds of times per minute, and if that energy is harnessed is a profitable way, then you have the core of the car engine[5].

Figure 1: Parts of a Petrol Engine

Most cars today use what is commonly known as a four-stroke combustion engine, as aforementioned, in order to translate gasoline into motion. Further, the four-stroke approach is also called as Otto cycle, as invented by Nikolaus Otto in 1867[6].

The four basic strokes for working of a petrol engine are:

The intake stroke

The compression stroke

The combustion stroke, and

The exhaust stroke

As shown in the figure below, a device known as piston replaces the potato of the potato cannon. As depicted, the piston is attached to a crankshaft by means of a connecting rod. Every time the crankshaft revolves, it has the impact of “ resetting the cannon”[7].

When the piston starts at the top, it opens the intake valve and pushes the piston down to let the engine fill in air and gasoline, thereby making the intake stroke. Just the smallest drop of gasoline is mixed into the air for the intake stroke to take place. Next, the piston rotates back up in order to compress this fuel and air mixture. This compression stroke tends to make the explosion more powerful. When the piston reaches the peak of its stroke, a spark is produced by the spark plug for igniting the gasoline[8]. Then, the gasoline charge within the cylinder explodes, forcing the piston to move down. As soon as the piston reaches the bottom of its stroke, the exhaust valve is forced open and the exhaust eventually leaves the cylinder to exit from the tail pipe[9].

The engine is now ready to start the next cycle, hence it intakes yet another charge of gas and air. It can be noted that the movement coming out of an internal combustion engine is rotational, whereas the movement generated by a potato cannon is linear. This linear motion in an engine is translated into rotational motion by the crankshaft. Further, the rotational motion is appropriate since a car driver plans to turn or rotate the wheels of the car with it anyway. The force exerted from the expansion stroke travels through the axis of the rotor; it would not cause the rotor to rotate. But, it also passes via the centre of the eccentric portion of the main shaft and the resultant moment leads to the rotation of the shaft and as the rotor locks with the fixed pinion, it should also turn. The role of the shaft hence matches with that of the crankshaft within a reciprocating piston engine[10].

Perhaps, the design of the engine becomes complex that the aforesaid simplified description. Furthermore, efficient sealing arrangements taking place between the rotor and its housing are highly indispensible, with respect to the differential thermal expansion of the rotor and its housing. In addition, the construction of appropriate sealing systems was in use since the beginning period of petrol engines. These sealing systems or grids comprise of apex seals in order to keep the leakage of gas from one chamber to the other past the apices of the rotor, preferably attached to side seals in order to prevent any leaks from the side faces of the rotor and its end covers. However, experiences have indicated that apex seal lubrication is a complete loss system[11]. Earlier oil was added into the fuel but nowadays, it is more common to meter oil into the induction pipe with a separate pipe. Additionally, lubrication of the bearings, gears, and so on, of engine parts that have oil cooled rotors, is done using the oil circulating through the rotor. Engines that have charge cooled rotors contain the oil mist carried by the charge lubricate these parts[12].

Cylinder lies at the core of the engine, where the piston moves upwards and downwards in it. A four-stroke internal combustion engine consists of just one cylinder, which is typically used by most lawn mowers, but almost every car has more than one cylinder, commonly four, six and eight in number. An engine having multiple cylinders has its cylinders arranged in any of the three ways, namely inline, V or flat, as depicted in the diagram below.

In an inline engine, the cylinders are arranged in a line in a single bank.

Figure 2: Inline cylinders, where cylinders are arranged horizontally in a single line within a single bank

In a V engine, cylinders are arranged in two banks set at an angle to one another.

Figure 3: V shaped, where cylinder are placed in two banks set at a certain angle to each other

In a flat engine, the cylinders are arranged in two banks on opposite sides of the engine.

Figure 4: Flat shaped, where cylinders are placed within two banks set on opposite sides of the engine

Different configurations are associated with different benefits and limitations in terms of manufacturing costs, smoothness, and shape features. Such advantages and disadvantages decide the appropriateness of the engine for specific vehicles.

Internal combustion engines are comprised of a variety of parts, and every part holds its own location and function which may stimulate the functionality of other parts. The following section discusses the engine parts in detail:[13]

Cylinder Block

The Cylinder block is the bore of the cylinder where the fresh charge of air/fuel mixture is ignited, compressed by the piston and finally expanded to give the desired power to the piston.

Cylinder Head

Here, the inlet and the exhaust valve are carried. It admits the fresh charge of mixture through inlet valve and exhausts the burnet gas from the exhaust valve. A spark plug, in case of petrol engine and an injector for a diesel engine is mounted on cylinder head

Spark plug

The spark plug is responsible for supplying the spark for igniting the air-fuel mixture to enable the combustion to take place. The spark must occur at just the right instant of time for things to work accurately.

Valves

The intake and exhaust valves are opened at the perfect moment to let in air as well as fuel and to let out exhaust. It can be noted that both these valves are shut throughout compression and combustion so as to seal the combustion chamber[14].

Piston

As aforesaid, the piston is a cylindrical metallic piece which moves up and down within the cylinder

Piston Rings

Piston rings offer a sliding closure between the external edge of piston and the internal edge of the cylinder. The piston rings have the following functions:

The avoid leakage of the fuel-air mixture and the exhaust of the cylinder chamber, into the sump on compression and combustion processes

Secondly, they also prevent the oil in the sump to leak out into the combustion area, in which it is burnt and lost[15].

Almost every car that “ burns oil” and must need a quart added every 1, 000 miles burn it since the engine is old enough and the rings do not seal anything properly[16]

Connecting Rod

The connecting rod acts as a connection between the piston and the crankshaft. Additionally, the rod can rotate at both ends so as to enable flexibility when its angle changes with the movement of the pistons and as the crankshaft rotates.

Crankshaft

The crankshaft converts the up and down motion of the piston into uniform circular motion similar to a crank in a jack-in-the-box does.

Sump

The sump is placed around the crankshaft and contains come quantity of oil that collects at the base of the sump.

Carburettor

The carburettor does the job of converting petrol in fine spray and mixing with air in proper ratio as demanded by the engine

Fuel Injector

The fuel injector is used only in diesel engines and gives out fuel in fine spray under pressure[17].

Manufacturing Processes:

The aggregation of the design and manufacturing process is driven by implementations. These processes vary in detail in every manufacturing company. From the perspective of te turnkey industry, the following is the representation of that process:

Conceptual Design: also termed as “ functional design” or “ preliminary design”, this process focuses not only on the aesthetic matters such as styling, but also on practical matters like simulation and industrial design to enable the overall manufacturing process. This stage involves an extensive use of paper and pencil, oils and brush, and sculptor’s clay as the primary tools of the conceptual designer in the automotive industry. Nowadays, modernized CAD/CAM systems offer the designer more and more powerful and robust tools which release him of the need to construct physical models and demonstrations. Companies such as Aries, Cognition, etc. have witnessed an opportunity to offer design engineers totally new and modern, computerized ways to look at the design engineering process, thereby providing methods and schemes which are way ahead of the conventional techniques and enable engineers to use much greater freedom of exercising their creativity[18].

In essence, photorealistic delivery output is gaining increasing popularity and is becoming a significant capability for conceptual design. In addition to allowing management to see the design as it would look after being manufactured, it also allows designers to try out different versions of the design without the need to have additional investments in effort and cost which conventional prototyping methods traditionally demand.

Analysis and Refinement:

A variety of high-level capabilities fall under this category. This technique is loosely termed as CAE, or just “ engineering,”. Furthermore, processes like Finite Element Modelling and Analysis is effectively carried out as part of this engineering procedure. This stage of the refinement process that is purported to discuss a fundamental design to real-world limitations as well as to iterate on a given design until its behaviour is acceptable. Even in the constricted discipline of FEM and FEA, there exist several specialized disciplines. And these specialized can be fatigue analysis, and thermal, vibration and magnetic analysis. However, plastics, iso-plastics, as well as composites tend to make the analysis more complex. Indeed, the practice of finite-element analysis and modelling can be considered as one of the more practical " applications" upon which an existing design can be subjected; however there are a large number of others as well[19].

Additionally techniques or other disciplines of analysis such as interference analysis, mass properties, complying with safety and/or corporate regulations and standards, structure design and enforcement of local codes are all considered to be the requirements for a design to be satisfying, and typically, that design should successfully pass these analyses prior to being considered for construction or manufacturing.

During the designing phase of an automobile, for instance, a primary issue which could hinder between the processes is the stress analysis, which is only related to major parts of the engine or body. More time-consuming and less cost-effective is the bio-technical design of windshields, panels of equipments and instrument, seats, and so on. A modern engine for water pump should not only be effective and generate a defined volume of water per minute; however, it must also be capable of fitting comfortably inside the various other components which constitute the engine.

Design for Manufacture:

This stage can also be termed as " design modeling," and it another step in " reality design." Usually, an alleged " finished" design is considered impractical to manufacture. Further, factors such as setup costs, coherency with current manufacturing techniques or excessive complexity can rule out the consideration of an otherwise good design, thereby causing that design to undergo significant modification.

Essentially, a large number of applications are there which clearly satisfy this prerequisite. For instance, the lifetime of a stamping tool may tend to have a significant impact on the longer-term productivity of a segment that manufactures press parts; this prerequisite alone can have a great influence on its design. Furthermore, for the plastic injection process, a number of designs are immediately made infeasible because of their inability to be used for the realistic flow properties of the liquid plastic which is being injected within them at greater temperatures and pressures. Even a small difference of 5% in the injection process and cooling time for a complex mould is likely to a drastic difference among profitability and loss to an organization that functions with very little room to spare[20].

For any given practical availability of real machine equipments, pedestrian considerations including the planning and design of clamps for holding parts when they are being machined as well as machine-to-fit tolerances are accounted for make-or-break decisions for any manager or executive to make. And in addition to this area are component design, assembly verification, and mechanical and electronic design.

Drafting and Documentation:

In this world of AutoCAD, any efficient engine manufacturing process requires state-of-the-art documentation and drafting; however, this area depicts a relatively smaller portion of a mid-scale manufacturer’s CAD/CAM universe. Further, in-depth drafting is not a requirement more than one-third of the requirement. For this stage, technical demonstrations, schematics and diagrams, and layout are equally essential. Even before the days when geometrical models did not exist, in-depth drafting was used for representing the “ meat” of any practical design. Because of the substantial limitations of existing design systems, most of the detail drafting might not appear across a geometric model. Consider the example of fillets and chamfers which can appear only as “ characteristics” of models and can never be depicted as actual geometric models. If taken as a practical issue, it is relatively simpler to represent a fillet with the help of a symbol on a drawing, and then to removing a cut out by means of a single path from a ball-end mill, next is to go through the complex mathematics needed for representing it geometrically. And this is something known to and used by practical designers[21].

Several other aspects of the detail drafting process in engine manufacture is closely related to what we consider as “ drawing creation,” and which has a primary purpose of aiding the final downstream machining process. Even though factors such as surface finish features, tolerance constraints, detail magnification, as well as other similar factors of detail drafting are not taken to be part of the geometrical model, yet they tend to become part of the entire depiction of the design by virtue of the accessibility offered to draftsmen, to the original model and the ability to work directly on a local presentation of it, although they are restricted to modify it. Therefore, draftsmen can be experts in drafting and drawing creation, without the need of being expert designers.

Toolpath Creation & Machining:

This stage is also termed as “ manufacturing engineering,” and it is one of the most complex and demanding processes. Framed equally with “ manufacturing preparation” together with “ manufacturing simulation,” most of the companies spend heavy budgetary amounts of their CAD/CAM budget. Further, manufacturing preparation involves design of tool, pattern nesting, designing of fixture, development of sheet metal, quality control analysis, as well as the actual NC programming itself[22].

Moreover, manufacturing simulation involves coordination of measuring machines, NC flame cutting, NC tube welding and bending, wire EDM, milling and drilling, off-line robotics, turning, and the most crucial portion of NC toolpath verification process. Although machining is essentially done directly off the model geometry, yet it cannot be considered as “ automatic” by any means as per the demonstrations of it imply[23].

By most designers and industry experts, N/C is seen more of an art from rather than science; even old-fashioned schemes of creating machined parts have not been ignored.

Construction of geometry is typically the simplest face of the N/C process. Because of the shortcoming witnessed in the algorithms provided by most vendors, “ work-arounds” always have to be introduced, such as the power of the user to straight away edit the tool path that is being created. The main intention of Toolpath simulation is to let the user to have a look at the form of the completed portion which will emerge out of the machining process, and to directly correct any problems which are detected. Furthermore, the development and maintenance of postprocessors that convert geometric toolpath demonstrations into a language that can be understood by each machine tool, is an industry in itself.

Installing the Rest of the Parts

The various parts of engine are installed in the following way:

Engines are made and installed at the manufacturer's Engine shop. Castings of engine blocks, crankshafts as well as heads are obtained from suppliers and are machined into the vehicle with its exact specifications. More than 150 computer-controlled machines conduct precision cuts to such engine parts. In addition, a highly sophisticated test lab performs precision computer computations in order to ensure the machining procedure cuts and drills the metallic pieces to desired approximations. Once the machining and the precision measurement testing are done, the engine parts are placed across a conveyor system onto engine assembly at which team members go about detailing the procedure in order to assemble the pieces of the engine together[24]. In essence, all engines are initially cold-tested for determining any leaks, then, hot-tested by igniting the engine to make sure it adheres to the manufacturing specifications. The vehicle transmission is then married to the newly assembled engine for completing the assembly process. Followed by final quality check, the engine is sent across on a trestle towards the chassis section where it is accompanied with the drive train and the remaining vehicle[25].

Firstly, the camshaft is installed followed by the accurate lining up of the timing marks. Then, the camshaft is forced up against the valves in order to force them open. Next, the rocker rods/arms and pushrods are installed.

These pushrods and rocker arms will present the amount of torque specifications over the rocker arms, depending on the kind of engine. Further, the intake multiplier makes use of RTV across their gaskets in order to hold them firmly at their places. Lastly, the valve covers are laid across and the engine is placed within given the vehicle by means of bolts for protecting it into the engine compartment. Followed by this step, the remaining accessories are gradually installed, including the fuel injector, carburettor and the fuel pump[26].