Introduction of piston and exhaust valve engineering essay

Engineering

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INTRODUCTION OF PISTON AND EXHAUST VALVE

In most of the IC engine piston and exhaust valve plays a vital role in bringing a complete process of engine mechanism. The piston are made out of casting process with metals like aluminium, steel, cast iron. Whereas exhaust valve is made out of steel in normal cars but in very high performance engine they generally use titanium as a material for exhaust valve. Nowadays Austenitic steel are also used for racing cars. The exhaust valve is used let out the burnt air fuel mixture before the piston moves towards bottom dead centre since lot of heat generated during exhaust of the burnt fuel air mixture the exhaust valve should have high heat resistant property in order to withstand thermal effect. This primary report therefore focuses on the following such as functions of each component, loading

modes, material selection using CES and the surface consideration of the material to be used.

FUNCTIONS OF PISTON WITH OTHER COMPONENTS

The basic function of piston is to convert thermal energy to mechanical energy by the combustion of air fuel mixture inside the cylinder using necessary spark plug or carburettor for the ignition of the mixture. To enable the piston movement the driving thrust on the piston converts linear piston motion to rotary crankshaft movement (Heisler, 1999) The movement of piston from TDC to BDC the inlet valve is opened for suction and compression of air fuel mixture and exhaust valve remains closed and at the end of compression stroke the exhaust valve slightly opens for release of the burnt air fuel mixture with the crankshaft angle of 180̊ and the piston will once again move from BDC to TDC for the exhaust stroke. During the piston movement the air fuel mixture is compressed with very high pressure therefore the temperature of the air fuel mixture raises and causes the fuel to burn inside the cylinder or the fuel can be ignited by inducing spark with the help of the spark plug during combustion (Heisler, 1999). Major function of the piston is to force the burnt gas out the combustion chamber and induce the fresh air fuel mixture for the continuous linear movement of the piston and this continuous movement of the piston repeats until the cycle completes.

PISTON LOADING MODES AND IN SERVICE CONDITION

Pistons are induced to high mechanical and thermal loads during their operation. The result of mechanical loads can be of following reasonsPeak

pressure which may reach up to 200 bar in combustion chamber (MAHLE, 1995)High acceleration which can cause faster movement of the piston which results high inertial force . The result of thermal loads can be of following reasonThermal stresses are due to high temperature gradient during heavier loads of the piston which generates lot of heat to piston headHigh power to be delivered by the engine may also cause increase in the thermal stress (MAHLE, 1995)Hence piston in the engine is exposed varying load conditions which may result in some problems like: piston crown scuffing, wear, fracture, cracked rings, oil leakage, engine seizure due unburnt hydrocarbons. Considering material for piston pure aluminium cannot be used as material for piston because it has low tensile strength therefore normally aluminium alloys, cast iron, medium carbon steel is used as a material for piston but when considering Y- alloy which is more strength compared to other aluminium alloys which is mixture of 4% copper, 2. 5% nickel, 12% silicon alloy and has tensile strength upto 300 N/mm2 and linear coefficient of expansion 0. 00245/˚C (Heisler, 1999).

FUNCTION OF EXHAUST VALVE WITH OTHER COMPONENTS

Exhaust valve functions as release of burnt gas during exhaust stroke and the exhaust valve is generally situated in cylinder head of an IC engine. In particular type of IC engine exhaust valve is bigger than intake valve it is due to the fact that releasing of exhaust gas from the cylinder is sometimes critical than introduction of air fuel mixture to the combustion chamber (Anon., n. d.). Exhaust valve opening and closing times should be optimal since it plays a major role in building up high power and mileage of the

engine. By opening the poppet valve at the critical time the piston is therefore able to push out and clear spent gasses out the combustion chamber without sacrificing intake charge flow into the cylinder (Anon., n. d.)Exhaust valve opens before BDC and expels out the burnt gas into the exhaust manifold and in order to make efficient function of engine, exhaust valve can be opened early thus by permitting the remaining kinetic energy of combustion to blow out the cylinders and to make the piston rely on its exhaust stroke to expel out the spent gasses (Heisler, 1999). Closing of exhaust valve after TDC is because the momentum of outgoing exhaust gas column leaves vacuum (Heisler, 1999). Sometimes during the operation there can be a valve overlap, where the inlet and exhaust valve opens at the same time of interval which could cause to sacrifice engine performance (Heisler, 1999).

EXHAUST VALVE LOADING MODES AND IN SERVICE CONDITION

The exhaust valve is subjected to thermal stress due to high temperature of the spent gasses and also it is comprised of compression ratio, ignition pressure and various other forces during its course of action (BASSHUYSEN, 2004). The major loading modes to be considered for exhaust valves areMechanical loading in valve seat areaLow cycle fatigueValve closing forceSpring preloadThermal stressHigh temperature corrosionLow temperature corrosionDynamic loading on the seat by valve deflection, which occurs due to combustion pressure impinged on valve head (BASSHUYSEN, 2004). Deformation due to tensile stressHence the materials like 21-4N austenitic steel, TI-834 titanium, super alloy can be used Since the

exhaust valve is exposed to high temperature at 700̊ C (WARD, n. d.). Even the materials selected needed to have high dimensional accuracy and high temperature resistant in order to have proper sealing of combustion chamber (AHMAD, n. d.). Criteria for selecting the proper material should have following factorsHigh temperature corrosionHot hardnessHot strengthResistance to oxidationResistance to seizing and galling (AHMAD, n. d.)

MATERIAL SELECTION USING CES FOR PISTON

In fig1 the graph shows the material indices for tensile strength/density in " X" and thermal conductivity/ thermal expansion coefficient. Fracture toughness: 30mpaFatigue strength: 120mpaMaximum service temperature: 250̊ Caadithya 1. jpgFigureIn fig 2 the graph shows material indices between Maximum service temperature in " Y" axis thermal conductivity in " X" axisaadithya 4. jpgFigureIn fig 3 the graph shows about the price of the material that is sorted out. aadithya 3. jpgFigure price graph for pistonOn considering all the loading modes, operating condition and surface factors, cost, the better material that can be selected for piston is medium carbon steel.

MATERIAL SELECTION USING CES FOR EXHAUST VALVE

In Fig 4 the graph shows material indices between yield strength/density in " Y" axis and fracture toughness/density in " X" axis. Fracture toughness: 20mpaFatigue strength: 150mpaMaximum service temperature: 625̊ Caadithya ev1. jpgFigure 4In fig 5 the graph shows material indices between thermal conductivity in " Y" axis and thermal coefficient of expansion in " X"

axis. aadithya ev4. jpgFigure 5In fig 6 the graph shows price of the material indices selected. aadithya ev2. jpgFigure 6On considering various operating condition and loading modes, cost, stainless steel can be selected as material for the exhaust valve

CONSIDERATION OF SURFACE FOR PISTON

Heat conduction consideration: Material is considered to be medium carbon steel it can be austenitised at 850-900̊C and after slow cooling it becomes like ferrite pearlite microstructure which results in excellent strength and toughness and for improving further more the steel can be quenched and reheated to a temperature of 500-600̊C and this will trap carbon in supersaturated solution and later it forms into iron carbide this stage is called tempering (MICHAEL ASHBY, 2007)Crack resistance: The major critical problems are thermally induced cracking on the piston head and scuffing on the cylinder bore (SUZUKI, 1990). The piston head should be treated with anodising process, which is currently the most effective countermeasure against heat cracking, corrosion and wear of material surface and chemicals used for this process are potassium hydroxide (KOH), or sodium hydroxide (NaOH) (Anon., n. d.).

CONSIDERATION OF SURFACE FOR EXHAUST VALVE

Corrosion resistance: Material is considered to be stainless steel for substantial amount of chromium can be added to it so that it can form a protecting layer against rust and even nickel can also be used for material toughness at low cryogenic temperature for stainless steel pressure vessels to store liquefied gases and sometimes both chromium nickel can also be

used for strengthening steel (MICHAEL ASHBY, 2007). Thermal resistance: when considering stainless steel, austenitic stainless steel provides good strength and high heat resistant property. To improves wear, welding of hardened wafer tip with the tip of the valve stem and in some cases the austenitic steel can be welded with martensitic steel and form a two piece valve which increase wearing of the stem and heat resistant head and the junction which forms a barrier which reduces heat transfer to the stem (CARLEY, 2005).