MODELLING AND FABRICATION OF CYLINDER HEAD FOR SINGLE CYLINDER TWO STROKE ENGINE

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ABSTRACT

Automotive technology is very important to people nowadays. To help them to move someplace to other place in short time. Automotive technology is very fast growing because of their needed in human life. The two stroke engine is reciprocating engine in which the piston takes over any valve functions in order to obtain power stroke each revolution of the crankshaft. This involves the use of ports in the cylinder walls which are covered and uncovered by movements of piston. Two stroke engines are used for motorcycles, lawn mowers, chain saw and marine engine. Cylinder Head is one of the important parts in engine part. The purpose of The Cylinder Head to cover the movement of piston from Bottom Dead Centre to Top Dead Centre and also combustion chamber in The Cylinder Head is very important in combustion process.

ABSTRAK

Teknologi Automotif begitu penting dalam kehidupan seharian kita. Ia menolong manusia bergerak dari satu tempat ke satu tempat yang lain dalam masa yang singkat. Teknologi Automotif mudah berkembang kerana kepentingannya dalam kehidupan manusia. Enjin dua lejang adalah engine perulangan dimana omboh mengambil alih fungsi injap dimana untuk mengekalkan lejang kuasa pada setiap pusingan *crankshaft*. Ini melibatkan kegunaan ruang dalam silinder dimana ditutup dan tidak dilindungi oleh pergerakan omboh. Enjin dua lejang digunakan untuk motosikal, gergaji rantai dan juga enjin kapal. *Cylinder Head* adalah salah satu bahagian yang penting dalam bahagian engine. Kegunaan *Cylinder Head* adalah melindungi pergerakan omboh dari puncak tertinggi (TDC) kepada puncak bawah (BDC) dan juga ruang pembakaran dalam *cylinder head* untuk proses pembakaran

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This project title is modelling and fabrication of cylinder head for single cylinder two stroke engines. First of all, two stroke engine is a simple and light engine that piston takes over valve function in operating cycle. It is used for lightweight power units which can be employed in various attitudes as handheld power tools [5].It is different from four strokes that had valves to control air flow in operating cycle. Two-stroke engine was develop since 1876, in 1900 there were engineers develop this engine with special emphasis on the various solution proposed for improving gas exchange process [1]. The first two stroke engine for marine was use in 1905, this engine employed uniflow scavenging with scavenge air valves in cylinder head and exhaust ports in the lower part of the liner [1]. The characteristic of two-stroke cycle engine are one power stroke per revolution, scavenging with fresh charge, direct fuel injection, emissions and addition lubricating. Two-stroke cycle can be used with both spark-ignition and compression-ignition. Common applications are where weight low, small bulk, simple construction and high power output are the prime consideration [1]. For the information, the largest and the smallest internal combustion engines today are two-stroke cycle engine. There are some example of special applications, free-piston compressor engines, gas producers and pulse-jet engine [1]. The cylinder head is made of cast iron or aluminium and it is strong to distribute the gas forces acting on the head as uniformly as possible through the engine block [2]. It is also contains spark plug for SI engine or fuel injector for CI engine.

1.2 Problem Statement

Mostly the cylinder head was made by casting process. This project is to produce the cylinder head by using Rapid Prototyping

1.3 Objective of Project

The main objective of this project is to fabricate a cylinder head for single cylinder 30.5 cc two stroke spark-ignition (SI) engines.

1.4 Scope of Project

There are four scopes in this project:

i) Reverse engineering.

ii) Three dimension Computer Aided Design (CAD) modelling of original production cylinder head which is design the original cylinder head using CAD method that is Solid Work Software.

iii) Simplify the design by just maintaining the key dimension such as clearance volume, port dimension, and spark plug location in accordance of machining capabilities.

iv) Fabricating the simplified model cylinder head using Rapid Prototyping

1.4 Project Organization

Chapter 2: Find literature about the basic component of two stroke engines, operating cycle of two stroke engine and advantage and problem of two stroke engines. This chapter is about the theory of two stroke engine.

Chapter 3: First work in this chapter is drawing the original cylinder head and then simplifies complex geometry of cylinder head. Then simulate the drawing using Cosmos Flow Software. After transfer drawing to G-code using Master Cam Software then machining process is begin. CNC Milling Machine is used for this process, machine simulator calculate machining time and machine running till cylinder head is produce.

Chapter 4: The results provide detailed information on results and discussion on this project which are the prediction of internal flow. Result also from machining process or rapid prototyping

Chapter 5: Summaries the result and provides conclusions of the present work. Recommendations for further works are also presented in this chapter.

1.5 Author's Contribution

Three dimensional modelling was developed using Computer Aided Design (CAD) Software. Introduce the step of in-cylinder flow analysis was predicted by Cosmos Flow Software. Machining process for cylinder head is using Computer Numerical Control (CNC) Milling or Rapid Prototyping.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter concludes about general internal combustion engine, two-stroke engine characteristic and application then about machining process and also problem of scavenging.

2.2 Internal Combustion Engine

The purpose of internal combustion engines production of mechanical power from the chemical energy contained in the fuel. In internal combustion engines, as distinct from external combustion engines, this energy is released by burning or oxidizing the fuel inside the engine [2]. The work transfers which provide desire power output occur directly between fuel air mixture and component of engine. The internal combustion engines are spark-ignition (SI) and compression-ratio or diesel engine. Beau de Rochas outlined the conditions under which maximum efficiency in an internal combustion engine could be achieved, there were the largest possible cylinder volume with the minimum boundary surface, the greatest possible working speed, the greatest possible expansion ratio and the greatest possible pressure at the beginning of expansion [3].

2.2.1 Classification of Internal Combustion Engines

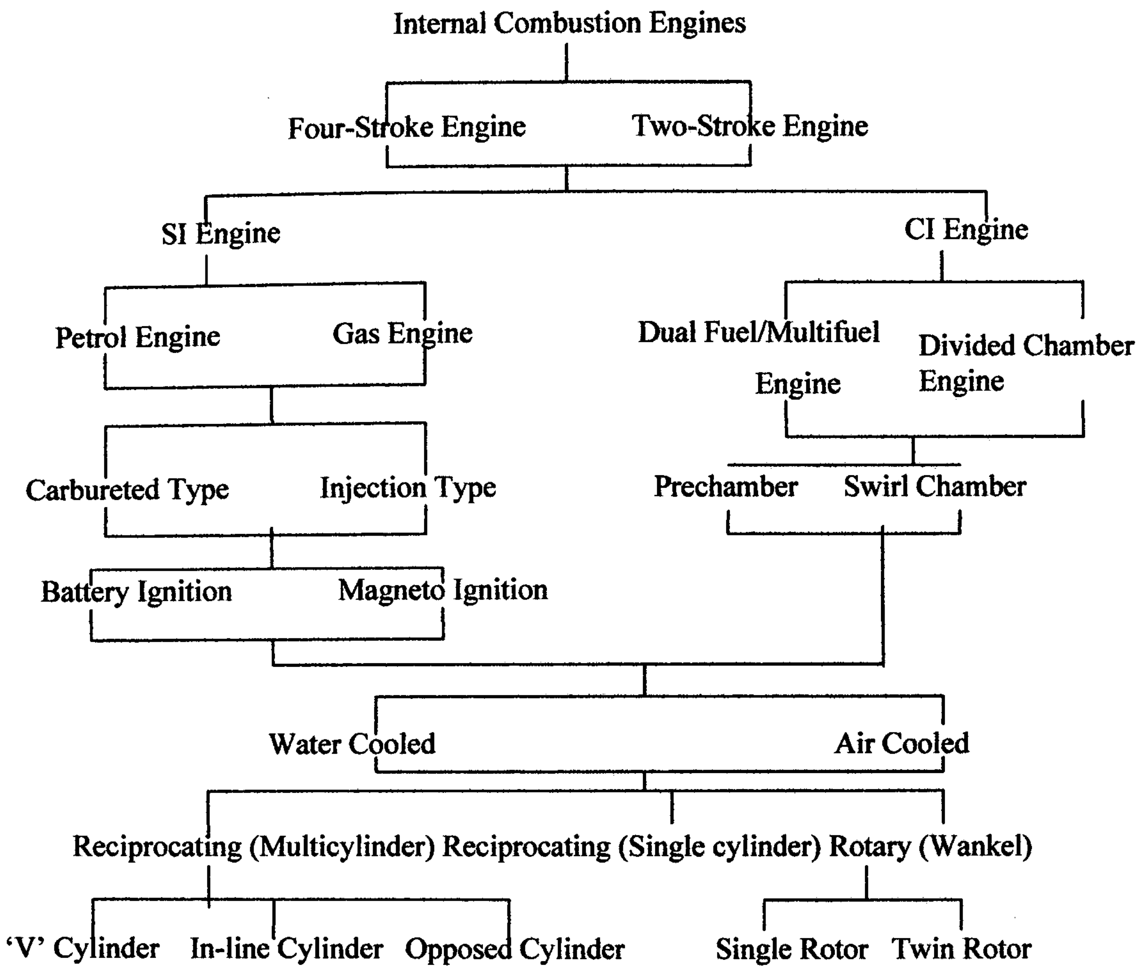


Figure 2.1 : The classification of internal combustion engines [4]

2.3 Two-Stroke Engine

Two-stroke cycle lacks separate intake and exhaust strokes, a scavenging pump is required to drive the fresh charge into cylinder. In one of the simplest and most frequently used types of two-stroke engine design, the bottom surface of the piston in conjunction with that portion of crankcase beneath each cylinder is used as the scavenging pump [1].

2.3.1 Characteristics of The Two-Stroke Cycle Engine

i) *One power stroke per revolution.* Doubling the number per unit time relative to the four-stroke cycle increase power output per unit displacement volume. The output of two-stroke engines range from 20% to 60% above those of equivalent size four-stroke unit. Doubling the number of power strokes per unit time also halves the intervals between combustion-generated pressure impulses.

ii) *Scavenging with fresh charge.* Inherent in the two-stroke cycle is the process of scavenging the burned gases from the engine cylinder with fresh charge [1]. Under normal condition, about 20% of fresh charge that enters the cylinder is lost due to short circuiting to the exhaust. In carburetted spark ignition engines, the result in very high hydrocarbon emissions and poor fuel economy compared with four-stroke engine.

iii) *Emissions.* The emissions characteristics of two-stroke cycle engines are obviously important and different from four-stroke engine. It is requirements that must be met depend on the application and are especially strict in transportation arena. Conventional two-stroke spark ignition engines with carburettor which are scavenged with a premixed fuel air mixture have extremely high unburned hydrocarbon emissions due to the significant amount of short circuiting fresh charge [1].

iv) *Lubrication.* Crankcase scavenged two-stroke engine cannot use conventional four-stroke wet sump lubrication systems because large quantities of oil would be drawn into combustion chamber.

2.3.2 The Cylinder Head

The two-stroke cylinder head either air or water cooled, certainly doesn't look very exiting but its design has a large bearing on how well engine will run. Manufactures use various external shapes and cooling fin patterns but the main requirement is the cooling area is large enough to adequately cool the engine [3]. What are more important are the shape of the combustion chamber and the location of spark plug location. Over the years, combustion chambers were design but only a couple are conducive to a reliable, high horse power engine. Researchers have found that the gases at the very outer limits of the combustion chamber called 'end gases' that self-ignite to cause detonation. Detonation occurs when a portion of the fuel air mixture begins to burn spontaneously after normal ignition takes place. End gases are heated by surrounding metal of the piston crown and combustion chamber and also by the heat radiating from advancing spark-ignited flame. If the spark flame reaches the outer edges of the combustion chamber quickly enough, these end gases will not have time to heat up sufficiently to self-ignited and precipitate detonation. Herein lies the key to prevent detonation-keep the end gases cool and reduce the time required for the combustion flame to reach the end gases [3]. The most obvious step that would satisfy the second requirement is to make the combustion chamber as small as possible and then place the spark plug in the centre of the chamber. Naturally combustion flame will reach the end gases in a small combustion space more quickly than if chamber were twice as wide. Additionally, a central plug reduces flame travel to minimum [3].

2.4 Fabrication Process Theory

2.4.1 CNC Machining

Computer Numerical Control (CNC) Machine required G-code or M-code to operating, please refer to appendix to see the list of codes.

2.4.2 Rapid Prototyping

Rapid prototyping mostly used in the development stage of new product. It is a technology which considerably speeds the iterative product development process.

Advantages of Rapid Prototyping:

i) Reduce product development time and cost
ii) Get product to market fast
iii) Enhance communication between marketing, engineering, manufacturing and purchasing
iv) Present physical model at critical design reviews
v) Perform functional prototype testing before committing to tooling
vi) Generate precise production tooling

Disadvantage of Rapid prototyping:

i) Investment cost very high
ii) Maintenance cost too high
iii) Limitation on materials available

Application of Rapid Prototyping

i) Visualization
ii) Product verification (it is test for functionality)
iii) Iterative product development
iv) Optimization
v) Fabrication or manufacture
vi) Medical and bioengineering

Table 2.1 : The characteristic of rapid prototyping technologies

Supply phase	**Process**	**Layer creation technique**	**Phase change type**	**Materials**
Liquid	Stereolitography	Liquid layer curing	Photopolymerization	Photopolymers (acrylates, epoxies, colorable resins, filled resins)
	Solid-based curing	Liquid layer curing & milling	Photopolymerization	Photopolymers
	Fused-deposition modeling	Extrusion of melted polymer	Solidification by cooling	Polymers (ABS, polyacrylate, etc), wax, metals & ceramics with binder
	Ballistic-particle manufacturing	Droplet deposition	Solidification by cooling	Polymers, wax

Powder	Three-dimensional printing	Layer of powder & binder droplet deposition	No phase change	Ceramic, polymer & metal powders with binder
	Selective laser sintering	Layer of powder	Laser driven sintering melting and solidification	Polymers, metals powders with binder, metals, ceramics & sand with binder
Solid	Laminated-object manufacturing	Deposition of sheet material	No phase change	Paper, polymers

Classifications of Rapid Prototyping are:

i) Subtractive (Removal of material)
ii) Additive (Adding of material)
iii) Virtual (Advanced computer base visualization)

Subtractive process

Subtractive process use a computer based prototype technology to speed the process. If it is for shape verification, a polymer or wax is used but for actual application, a machining process still required. Essential technologies for subtractive prototyping are computer, interpretation software, manufacturing software or CNC machinery [4].

Additive process

This process built workpiece or parts in layer by layer which is slice by slice and require elaborate software. The steps for this process are:

i) Gain drawing file in CAD file
ii) Computer then constructs slice of a three dimensional parts
iii) Slice analyzed and compiled to provide the rapid prototyping machine
iv) Setup the proper unattended and provide rough part after a few hours
v) Finishing operation sanding and painting

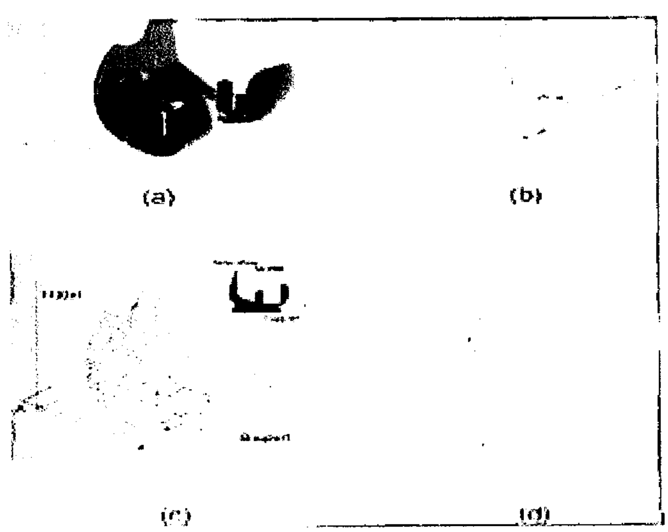


Figure 2.2: Additive process

Virtual process

Modelling and simulation of all aspects of prototype by a realistic visualization. All aspects of design process such as mechanical design, kinematics, dynamics and controls but complicated versions use virtual-reality headgear and gloves with appropriate sensors. Advantage of this process are instant rendering of parts where the best design in shortest lead time of complex product and process and allows the exotic, unconventional design be prototyped, rapidly and cost-effectively.

Applications of Rapid Prototyping

i) *Production of individual part.* Rapid Prototyping can be used to manufacture marketable products directly especially involve the polymer parts. Pattern used in investment casting also produced with Rapid Prototyping technique shown in figure

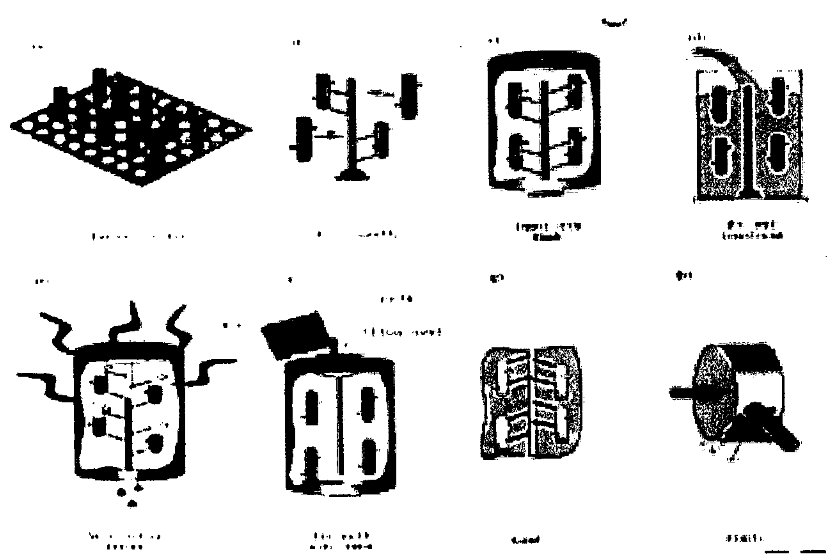


Figure 2.3: The steps for investment casting that used rapid prototyping wax

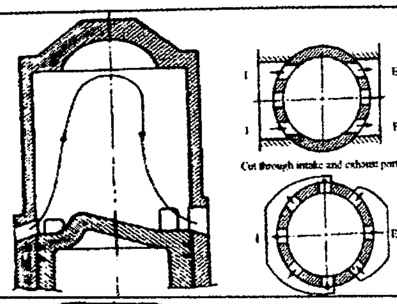
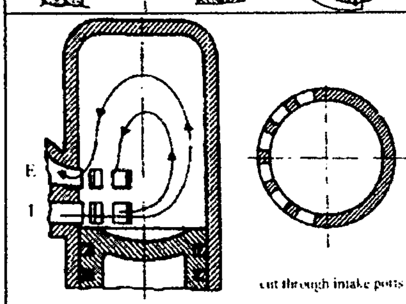
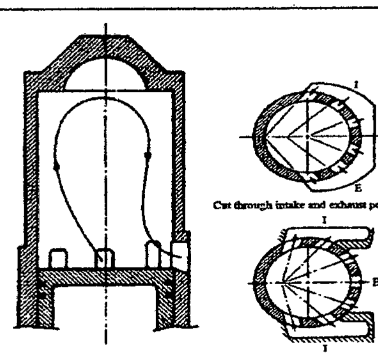
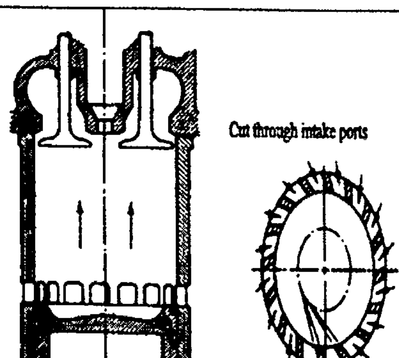
ii) *Rapid tooling.* Typically used to describe a process which either uses as Rapid Prototyping model as a pattern to create a mold quickly or uses the Rapid Prototyping process directly to fabricate a tool for a limited volume of prototypes.

2.5 Problems of Scavenging

2.5.1 Type of Scavenging

Scavenging is the operation of clearing the cylinder of burned gases and filling it with fresh mixture-the combined intake and exhaust process. There are three classification of scavenging (cross scavenged, loop scavenged, uniflow scavenged). The problem of scavenging is at there is a short circuiting directly between scavenge ports and exhaust ports in loop scavenged at 24 crank angles. Uniflow scavenged is perfect scavenging.

Table 2.2: Types of scavenging

	Cross Scavenging
 MAN-Loop Scavenging	 SCHLURNE-Loop scavenging
	Uniflow Scavenging

2.5.2 Scavenging Efficiency

The purity of charge can be measure from the success of scavenging in the cylinder from combustion of preceding cycle. It is controlled by shape of combustion chamber and scavenging arrangement. Experiment to determine the purity is relatively simple, consisting only of analysis of gas sample taken during compression stroke.

In German technical literature the term scavenging efficiency has been widely used. It define as

$$\eta sc = \frac{Vret}{Vch} = \frac{Vret}{Vret+Vres} \qquad (2.1)$$

It can be shown that the delivery ratio, scavenging and trapping efficiency are related by the following equation

$$Rdel = \frac{Crel\ \eta sc}{\eta trap} \qquad (2.2)$$

Scavenging efficiency is a term somewhat similar to purity and expresses the measure of the success in clearing the cylinder of residual gases from the preceding cycle. Scavenging efficiency indicates to what extent the residual gases means that all the gases existing in the cylinder at the beginning of scavenging have swept out.

2.5.3 Perfect Scavenging

The fuel air mixture should remain separate from the residual products of combustion with respect to both mass and heat transfer during scavenging process [4]. Fresh charges are pumped into the cylinder by the blower through inlet port then push the products of combustion in cylinder out through exhaust port. However when sufficient fresh air has entered to fill the entire cylinder volume the flow abruptly changes from one of products to one of air [4]. This ideal process will represent perfect scavenging without any short circuiting loss.