"I declare that I have read this thesis and in my opinion, it is satisfactory in term of scope and quality for the award of the Degree of Mechanical Engineering (Design and Innovation)"

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Date : 7 MEI 2007

RESEARCH AND ANALYSIS OF THE TWO-STROKE SWIVEL MOTION ENGINE

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This thesis is submitted to Faculty of Mechanical Engineering as a requirement to get award of Degree of Mechanical Engineering (Design and Innovation)

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Mei 2007

"I declare that whole of this report is the result of my own work except as any area that told in the references".

Signature : ……………………………………………..

Name : ZAMRI ANUAR BIN ZAINOL ABIDIN

Date : 7 MEI 2007

To my beloved mum, Noraini and dad, Zainol Abidin.

To my grateful supervisor, Mr Shamsul Anuar b. Shamsudin.

To all my sibling and my friend.

You all made everything priceless.

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ABSTRACT

In the research about the two stroke engine with swivel motion, a performance analysis of the two stroke engine with swivel motion had been implemented. This analysis is to compare the performance of the swivel motion engine against normal motion engine. The analysis had been done using COSMOS Works and COSMOS Motion software. The analysis are for measure the performance and the material selection of the two stroke with swivel motion engine. The result show that the two stroke engine with swivel motion will produce 14.59 kW power at 7000 rpm and maximum 20.36 N-m of torque at 6500 rpm. From mechanical analysis, the suitable materials for some parts of the engine are Gray Cast Iron, Aluminum Alloy, Alloy Steel and Ductile Iron.

ABSTRAK

Dalam menjalankan kajian keatas enjin 2 lejang jenis gerakan sendeng, satu analisis mengenai prestasi enjin telah dijalankan. Analisis yang telah dijalankan ini adalah bertujuan untuk membanding prestasi enjin 2 lejang jenis gerakan sendeng dan enjin 2 lejang yang biasa. Analisis ini juga bertujuan untuk mengukur prestasi enjin 2 lejang jenis gerakan sendeng dan pemilihan bahan yang sesuai untuk elemen enjin tersebut. Analisis yang dijalankan menggunakan perisian *COSMOS Works* dan *COSMOS Motion*. Analisis-analisis ini dapat mengukur prestasi dan ketahanan bahan yang akan dipilih untuk elemen-elemen enjin. Keputusan analisis menunjukkan bahawa enjin 2 lejang jenis gerakan sendeng akan memberikan kuasa sebanyak 14.59 kW pada 7000 rpm dan maksimum tork ialah 20.36 N-m pada 6500 rpm. Manakala keputusan daripada analisis bahan pula mendapati bahan-bahan yang boleh digunakan ialah besi mulur, *aluminium alloy*, *alloy steel* dan *ductile iron*.

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LIST OF SYMBOLS

SYMBOL	DEFINITION
B	- Piston bore
S	- Piston stroke
R	- Ratio of two con rod length to stroke
TDC	- Top Dead Center
BDC	- Bottom Dead Center
EPO	- Exhaust Port Opens
EPC	- Exhaust Port Closes
IPO	- Inlet Port Opens
IPC	- Inlet Port Closes
OSA	- One Step Ahead prediction
CA	- Crank Angle
RPM	- revolution per minute
CAE	- Computer Aided Engineering
PSM	- Projek Sarjana Muda
FEM	- Finite Element Methods
PDS	- Product design specification

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CHAPTER 1

INTRODUCTION

1.1 Generally In Two-Stroke Engine

The two-stroke engine is widely used at the small-size and very large size ends of the engine market. In its small-size spark-ignition engine forms, the two-stroke cycle engine is relatively cheap, compact and light, simple and robust. This is the basis of its market appeal in mopeds, scooters, motorcycles and snowmobile, in portable devices such as chain-saws and bush cutters, in agricultural and construction devices such as lawn mowers, disc saws, and snow blowers, in the outboard marine engine arena, and in light and in remotely piloted aircraft. The very large diesel engines used in marine and power-generation applications are also two-stroke cycle engines. These large internal combustion engines are the most efficient and most effective prime movers currently available, and can achieve energy conversion efficiencies (useful work output relative to fuel energy input) of up to 55%. The two-stroke diesel has also been used in the locomotive and in parts of the truck market.

1.2 Objective of Project

There are 3 main objectives of this project that have been set as a project goal in order to accomplice this thesis and they are:

- To understand the type of swivel motion engine
- To suggest a design of swivel two-stroke engine for using in certain applications and to fulfill current standardization.
- To make an analysis using COSMOS Application.
- To make optimization to achieve charge flow and smooth product combustion.

1.3 Scope of Project

In order to complete this project in the particularly time, it demand a lot of time consumer and resources from every types of medium such as internet, journals, text book, and other references that related to crashworthiness study field. In generally, the scope of study that consisted in this thesis accomplishment is:

1. To implementing a literature review and research about two-stroke engine and the engine optimization.
2. To select a type of an analysis that consist fluid dynamic analysis.
3. Do a research of a current two-stroke cycle engine and make a validation of the current engine.
4. To produce an optimization procedure with current engineering applications.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Two-Stroke Engine

Internal combustion engines are used to produce mechanical power from the chemical energy contained in hydrocarbon fuels. The power-producing part of the engine's operating cycle starts inside the engine cylinders with a compression process. Following this compression, the burning of the fuel-air mixture the releases the fuel's chemical energy and produces high-temperature, high-pressure-combustion products. These gases then expand within each cylinder and transfer work to piston. Thus, as the engine is operated continuously, mechanical power is produced.

Almost all internal combustion engines utilize the reciprocating piston-in-cylinder geometry shown in Figure 2.1. The oscillating motion of the piston is converted to the rotary motion needed to transmit mechanical power through the connecting rod and crankshaft arrangement shown. Each upward and downward movement of the piston is called a stroke.

There are two basics types of internal combustion engine: the spark-ignition engine (sometimes called the Otto-cycle engine), and the compression-ignition engine, which is often call the diesel. In the spark-ignition engine, the fuel-air mixture is essentially premixed prior to combustion which is initiated with a spark discharge. In the diesel, air alone is inducted and compressed: fuel is injected into the cylinder just before combustion commences. The injected fuel vaporizes and mixes rapidly with the high-temperature compressed air and spontaneously ignites, burning as it mixes. The two-stroke cycle is used in both spark-ignition and diesel engines.

The two-stroke were developing twice as much power as four-stroke of the same size because the number of cycles per unit time would be twice as large. However, because in the two-stroke cycle engine the burned gases are pushed out from the cylinder by the entering fresh charge, loses due to mixing of fresh charge and burned gases are unavoidable, and the theoretical power advantage of the two-stroke engine over its four-stroke counterpart cannot be fully realized.

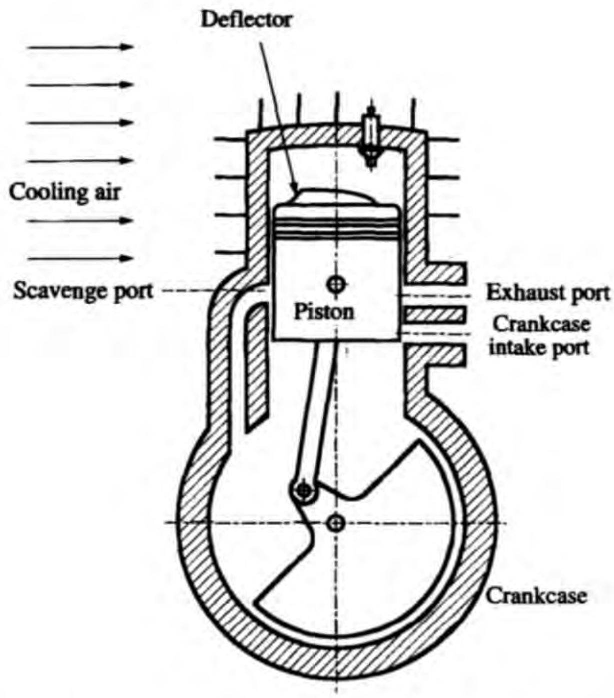

Figure 2.1 A crankcase-scavenged two-stroke cycle engine

2.2 Principles of Two-Stroke Cycle Engine

As the two stroke cycle lacks separate intake and exhaust strokes, a scavenging pump is required to drive the fresh charge into the cylinder. In one of the simplest and most frequently used types of two-stroke engine designs, the bottom surface of the piston in conjunction with that portion of the crankcase beneath each cylinder is used as the scavenging pump. Figure 2.2 shows the typical sequence of cycle events in this type of engine. The cycle begins while the piston traveling upward toward the top center (TC) crank position and the crankcase intake port is uncovered by the piston. Fresh air (either air or fuel-air mixture) enters into the crankcase through the intake manifold while the charge within the cylinder continues to be compressed by the upper part of the piston. The charge is then ignited (either by an electrical discharge in a spark-ignition engine or by a spontaneous ignition process in a diesel), combustion occurs and the burned gases in the cylinder expand as the piston travel toward bottom center (BC). At the same time, as the crankcase volume decreases and the intake port is still open, some of the fresh charge may escape to the atmosphere through the intake manifold in a reverse flow. Approximately 60^0 after TC, the inlet port closes (IC), and the fresh mixture in the crankcase is then compressed. The in-cylinder gas exchange process begins as the exhaust port is opened (EO). As the piston continues its downward travel, it then open the scavenge or transfer ports. When both the scavenge and exhaust port are open, the cylinder is subjected to a pressure gradient that simultaneously governs the inflow and outflow streams through the open ports.

During this period-the scavenging period-the compressed fresh charge in the crankcase flows through the transfer ducts into the cylinder and scavenges are burned combustion products out of the cylinder through the exhaust port. The port and the projection on the piston (the deflector) are shaped so that most of the fresh air charge will sweep up to the top of the cylinder before flowing to the exhaust port. This is done to scavenge the combustion products more completely from the upper part of the cylinder and prevent significant amount of the fresh charge from flowing directly to the exhaust port, a process call short-circuiting. In the second half of the period, the piston travels upward, the crankcase volume increases, and the reverse flow from the cylinder to the crankcase through the scavenge ports may occur depending on the charging pressure and engine speed. The gas exchange process is completes when the piston covers up and closes the port (EC).

An alternative to using the crankcase to compress the fresh charge prior to scavenging is to employ an external pump. A positive displacement Roots blower can be used or centrifugal compressor, driven from the crankshaft. In larger two-stroke cycle engines a blower and a turbocharger can be combine together. The crankshaft-driven blower provides compression for starting, and at the lower speed; at higher speeds, the turbocharger provides higher air flow rates, and hence higher power for a given size engine.

The most efficient gas exchange process will completely replace the products of combustion by fresh charge, at charge pressure and temperature, without wasting any fresh charge through exhaust. In practice, the gas exchange process is far from this perfect displacement process; although part of the fresh charge does displace combustion products without mixing or loss, another part mixes with the combustion products, and other portions short-circuit directly to the exhaust port. The success of the scavenging process is a function not only of the geometry of the cylinder and port assembly, but also of factors such as how the fresh charge is introduced into the cylinder (external blower, crankcase and surge tank), engine speed, engine load, and atmospheric conditions.

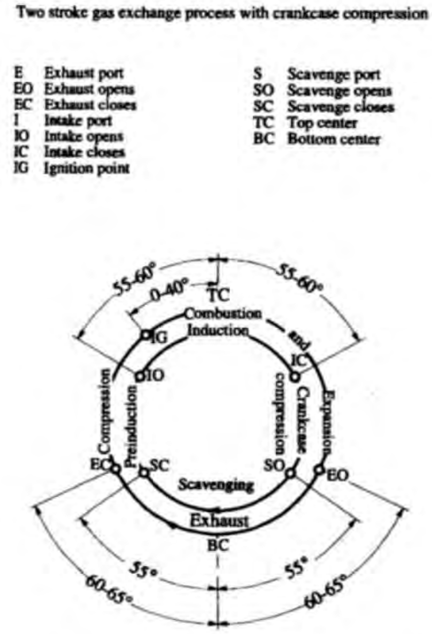

Figure 2.2 Typical sequence of two-stroke cycle event

2.3 Characteristics of Two-Stroke Cycle Engine

2.3.1 One power stroke per revolution

Doubling the number of power stroke per unit time relative to the four-stroke cycle increases the power output per unit displaced volume. It does not, however, increase by a factor of 2. The outputs of two-stroke engines range from only 20% to 60% above those of equivalent-size four-stroke units. The lower increase in practice is a result of the poorer than ideal charging efficiency: that is, incomplete filling of the cylinder volume with fresh air. Doubling the number of power strokes per unit time also halves the intervals between combustion-generated pressure impulses. There is, however, a major disadvantage: the higher frequency of combustion events in the two-stroke cycle engine results in higher average heat-transfer rates from the hot burned gases to the engine's combustion chambers walls. Higher temperature and higher thermal stresses in the cylinder head, and especially the piston crown.

2.3.2 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. This gas exchange process has several consequences. First, charging losses are predictable. Under normal operating conditions in a typical two-stroke engine, about 20% of the fresh charge that enters the cylinder is lost due to short-circuiting to the exhaust. In carbureted spark-ignition engines, this process results in very high hydrocarbon emissions and poor fuel economy compared with the four-stroke cycle engine. However, as both exhaust and intake ports can be situated near the bottom end of the cylinder and can be covered and uncovered by a long-skirt piston (Figure 2.1). This simplest geometric two-stroke cycle configuration obviates the need for valves and their actuating gear. This substantially simplifies the engine structure and the production process, and significantly reduces engine cost. However, because the opening and closing of the ports are symmetrical around BC, the intake closes before the exhaust and a simple supercharging process is therefore not possible. For this and other reasons, externally blown two-stroke scavenging systems are also in common use that, because they normally use valves to control the exhaust (and sometimes inlet) flows, lose the simplicity of the crankcase-scavenged design.

The importance and complexity of the gas exchange process in two-stroke engines should already be apparent. There is the obvious complexity of the in-cylinder flow as the fresh charge displaces and also mixes with the burned gases, and partially short-circuits the cylinder by flowing directly into the exhaust. In addition, a reverse flow of fresh charge through the intake manifold occurs at low engine speeds, and a reverse flow of cylinder charge through the scavenge duct occurs at high engine speeds. These flows re partly responsible the deterioration of the cylinder charging process at off-design speeds, which, in turn, results in a falloff in torque. Furthermore, the effectiveness of the scavenging process is sensitive to the exhaust manifold pressure, which makes it difficult to employ a turbo charging system, a catalytic converter, noise-reduction devices, and an engine brake system. Throttling the intake of the two-stroke cycle engine to reduce airflow at part load, as is done in four-stroke spark-ignition engines, further complicates the scavenging process. Throttling of the exhaust flow is also sometimes used to control the scavenging process.

2.3.3 Direct fuel injection

Because there is a substantial (of order 20%) loss of fresh air during the scavenging process due to short-circuiting and mixing with exhausting burned gases, direct injection of fuel into the cylinder is especially attractive with the two-stroke cycle. In this case, the gas exchange process is performed with fresh air alone, and the required amount of fuel injected into the cylinder after the exhaust ports and valves are closed. Thus no fuel is lost with the exhaust air and the severe fuel consumption and hydrocarbon emission penalties of premixed-charge two-stroke engine are avoided. The two-stroke diesel always operated with direct fuel injection and has been competitive with four-stroke cycle diesels in large sizes in marine applications. Direct-injection two-stroke spark-ignition engines also show promise of competing with conventional port-fuel-injected spark-ignition engines in several applications. They obviously avoid the fuel short-circuiting of conventional premixed two-stroke cycle engines. Because the injected fuel spray at light and intermediate load only partially mixes with the air in the cylinder, these engines operate in stratified-charge modes which provide satisfactory combustion when operating with substantial excess air: that is, well lean of the stoichiometric or chemically correct fuel-air mixture composition.

2.3.4 Emissions

The emissions characteristics of two-stroke cycle engines are obviously important and are different from those of four-stroke engine. The emissions