# MODELLING AND FABRICATION OF CRANKCASE FOR SINGLE CYLINDER 2-STROKE ENGINE

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## ABSTRACT

A crankcase is the lower part of engine which in single cylinder two-stroke engine the main function is to hold the crankshaft in parallel position and work as a vacuum medium to suck the combustion material. Mostly the crankcase is made from assembly two parts that is left side and right side

Mostly, many product of crankcase are manufactured using casting process, but in this final year project, the process in fabricate the crankcase is machining process.

Here, for the final year project, the title is modeling and fabricate of crankcase for single-cylinder two-stroke engine. The process is started from designing of the crankcase by using Solid Work program. The next stage is CFD modeling and simulation by using CAM method. After that the Solid Work format is converted to Master Cam format. Here, the simulation was running before transfer to CNC milling format.

## ABSTRAK


Kotak engkol adalah bahagian yang paling bawah di dalam enjin satu silinder dua lejang, fungsi utamanya ialah memegang batang engkol di dalam keadaan mendatar dan berfungsi sebagai ruang vakum untuk menyedut bahan pembakaran. Kebanyakan kotak engkol dibuat dengan menyambung dua bahagian iaitu bahagian kiri dan kanan.

Kebanyakan kotak engkol diperbuat daripada proses tiangan pasir, tetapi dalam projek akhir tahun ini, kaedah pembuatan yang digunakan untuk membuat kotak engkol ialah dengan menggunakan mesin.

Di sini, untuk projek tahun akhir, tajuknya ialah membuat model dan menghasilkan produk kotak engkol untuk enjin satu silinder dua lejang. Proses ini bermula dengan mereka bentuk kotak engkol dengan menggunakan perisian kerja pepejal, langkah seterusnya ialah menjalankan simulasi perhitungan gaya cecair dengan menggunakan perisian komputer penambahan pembuatan .setelah itu format untuk perisian kerja pepejal dtukar kepada format perisian untuk mengeluarkan arahan komputer. Disini, sumulasi dijalankan sebelum ditukar kepada format mesin arahan berkomputer.

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## LIST OF ABBREVIATIONS

$CR_{cc}$ Crankcase Compression

$V_{CC}$ Crankcase Volume at TDC

$V_{SV}$ Displacement Volume (volume displaced by the piston from TDC to BDC)

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# CHAPTER 1

# INTRODUCTION

## 1.1 Project Synopsis

Final year project is one of the subjects for this semester. In this subject, a project needs to do to fulfill the subject requirement. This project is dividing on two main phase that is modeling and fabrication. This project is to know how to modeling part and fabricate it. This project need a skill in using the software and analyzes the data from the simulation, also the skill to handle the heavy machine such as CNC machine.
This project is more on hands on,

## 1.2 Problem Statement

Mostly the cylinder head was made by casting process, but in this project the CNC machine is used to fabrication process. The design of the crankcase is must accordance to the machining capability because there are certain area in the design is cannot be produce by using machining process. This project also involves an analysis and simulation by using Cosmos Flow and Master Cam program on the design before the fabrication process.

## 1.3 Project Objectives

The main objective of this project is to modeling and fabricates a crankcase for single 30.5cc 2-stroke spark ignition engine.

## 1.4 Project Scopes of Work

1.4.1 Reverse engineering,

1.4.2 3D CAD modeling of original production crankcase, and

1.4.3 Simplify the design by just maintaining the key dimension such as cylinder bore in accordance of machining capabilities,

1.4.4 Fabricate the simplified-model crankcase using CAM method.

## 1.5 General Objective

Diploma final year project objective is to train the student to practice the knowledge and skill that have been gathered before in solving problem using academic research, to born an engineer that have enough knowledge and skill.

This project also important to train and increase the student capability to get know, research, data gathering, analysis making and then solve a problem by research or scientific research.

The project also will educate the student in communication like in a presentation and educate them to defend their research in the presentation.

The project also will generate students that have capability to make a good research report in thesis form or technical writing.

This project also can produce and train student to capable of doing work with minimal supervisory and more independent in searching, detailing and expanding the knowledge and experiences.

## 1.6 Specific Project Objective

Basically this project is base on this objective:

i. Study about the crankcase, what the function, and the method of making the same accordance to reverse engineering
ii. Apply the study, research, and fabricated.
iii. Work in time giving.
iv. Support the team in project management and problem solving.

## 1.7 Project Planning

This project is begun with made a research and literature review via internet, books, supervisor, and others relevant academic material that related to the title, this literature review takes about a week. The reviews not stop there. It continues along the way of this project because knowledge is so many to learn. The progress report must be submitted to supervisor by every week.

At the same week, doing the schedule management for this project, that is included schedule management. This is done using Microsoft Office Project using Gantt chart system. This also takes a week to accomplish.

The overhaul process is started by the next weeks, the process takes several days, this process are followed by measuring process. The measuring process inside the crankcase is more important in this project.

After measuring process is complete, the next process is redesign process by drawing the 3D drawing using Solid Works software, this process takes 2 weeks to accomplish. The drawing must be detail and accurate in measurement especially for the inner geometry of the crankcase.

The next stage in designing process is Computational Fluid Dynamics (CFD) modeling and simulation, this process need the instruction from many resource especially the supervisor to make sure the process can be done and successful. This process also takes 2 weeks to be done.

The next task is preparation of progress presentation, these tasks takes one more week to be done. On this particular week, I have to prepare the speech for the presentation

Before machining process, there is machining simulation by using Master Cam software, this process is preparation before machining process using CNC machine is done. This process is scheduled to be done in within two weeks.

Next task is the final report writing and final presentation preparation. This take about two week to accomplished. The report is guided by KUKTEM Thesis writing guided and also the guidance from supervisor. All the task is scheduled to take about fourteen weeks overall.

## 1.8 Project Organization

Chapter 2: literature review. This chapter is more on study about the crankcase.

Chapter 3: methodology. First work in this chapter is drawing the original crankcase and then simplifies complex geometry of the crankcase. Then simulate the drawing using Cosmos Flow software. For the next step is extract the G-Code by using Master Cam software and then transfer the G-Code into the CNC machine for the machining process.

Chapter 4: result. The result is getting from the final drawing and CFD simulation like graph velocity versus curve length also the machining simulation from Master Cam software.

Chapter 5: conclusion and recommendation. The conclusion is made base on the result and the recommendation is made from the problem due to process.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introductions

The purpose of this chapter is to provide a review of past research effort relate to modeling and fabricate of crankcase for single-cylinder two-stroke spark ignition engine.

The crankcase structure is subjected to miniaturize an engine, to concentrate heavy masses and to reduce friction loss of a balancer, the vacuum in the crankcase is needed to be maintained depend on engine operation. The crankcase vacuum greatly reduces oil migration around the piston rings in order to reduce oil consumption, decrease contamination of the combustion chamber from oil leakage, and reduce detonation tendency [1]. The crankcase vacuum also allows a reduction in oil ring tension which in turn reduces engine friction, resulting in high power output and cooler running engine during operation thereof. The crankcase design is need to support the crankshaft; the rotary mechanism of crankshaft must be independent from other force to reduce the mechanical loss. The transfer port is include in crankcase structure with function transferring the fuel/fresh air/lubricate mixture from the crankcase into the cylinder and this part is difficult to design [2].

## 2.2 Two-Stroke Engine

The two stroke engine employs the crankcase as well as the cylinder to achieve all the elements of the Otto cycle in only two strokes of the piston.

In a conventional two-stroke internal combustion engine, the vacuum caused by a piston moving away from the crankcase draws a mixture of fuel, air, and oil into the crankcase through a one-way valve or timed induction mechanism such as a piston port or rotary valve. Increased pressure produced by the piston moving toward the crankcase forces the mixture of fuel, air, and oil into the piston cylinder on the side of the piston away from the crankcase and, therefore, into the combustion chamber, which is at the portion of the piston cylinder that is the most distant from the crankcase, because such carbureted fuel cannot escape through the one-way valve or a now closed induction mechanism [3].

In the single-cylinder two-stroke spark ignition engine, there are two main of movement of piston that differentiates from other engine, that is compression stroke and power stoke. For the intake process, the fuel/air mixture is first drawn into the crankcase by the vacuum created during the upward stroke of the piston. The illustrated engine features a poppet intake valve, however many engines use a rotary value incorporated into the crankshaft [4].

During the downward stroke, the poppet valve is forced closed by the increased crankcase pressure. The fuel mixture is then compressed in the crankcase during the remainder of the stroke [4].

Toward the end of the stroke, the piston exposes the intake port, allowing the compressed fuel/air mixture in the crankcase to escape around the piston into the main cylinder. This expels the exhaust gasses out the exhaust port, usually located on the opposite side of the cylinder [4].

The piston then rises, driven by flywheel momentum, and compresses the fuel mixture. (At the same time, another intake stroke is happening beneath the piston).
At the top of the stroke, the spark plug ignites the fuel mixture. The burning fuel expands, driving the piston downward, to complete the cycle [4].

Since the two-stroke engine fires on every revolution of the crankshaft, a two-stroke engine is usually more powerful than a four-stroke engine of equivalent size [4].

## 2.3 Crankcase

As a compressor, this requires the crankcase to have relatively close tolerances between the crank and the crankcase, itself. It is also required that the crankcase be sealed. These factors isolate the crankcase from any lubrication that may be in other parts of the engine. Therefore, a secondary lubrication system is necessary. However, any oil in the crankcase would readily be pushed into the combustion chamber. Therefore, to minimize the oil that is pushed into the combustion chamber, oil is continuously added to the crankcase, but only in small quantities. In conventional two-stroke engines this is accomplished either by oil injection or by utilizing fuel which has been pre-mixed with a suitable quantity of oil. However, no matter how the lubrication is achieved, oil will be introduced into the combustion chamber and combusted. In addition, during the combustion process, such oil creates considerable smoke and other pollution [3].

Type of exposure of the crankcase

The crankcase is exposing to the vibration while engine is running. There are four main causes vibration in an engine, that is:

*i.* *Rotating part* – centrifugal force acts on all parts that rotate. Part such as the crankshaft, flywheel and clutch must be balance.

*ii.* *Power impulse* – the pistons deliver power to the crankshaft as impulses and this causes a type of rotary vibration in the crankshaft.

iii. *Reciprocating part* – the piston, in particular, produce an inertia force at the top and bottom of their strokes. This causes up-and-down vibrations in the engine.

iv. *Resonance* – vibrations can be transmitted between parts and amplified, even though the parts may not be directly connected.

*Crankcase pressure* – every time combustion occurs, a certain amount of blow-by (from combustion) escape past the piston ring. This blow-by produces a small crankcase pressure. The gases from blow-by are very acidic. If they are allowed to stay in crankcase area, the acids attack the oil and metal within the engine [2].

In average racing engine the induction cycle will take place during around 190° of crankshaft rotation. The exhaust cycle will occur over a period of 200 °. The transfer phase, however, has to be complete through 130 ° of crankshaft movement. Not only do the transfers have extremely short time in which to recharge the cylinder with fuel/fresh air/lubricant mixture, they must also control the flow pattern of the charge to prevent mixture loss out of the exhaust, and drive exhaust gases from the rear of the cylinder towards the exhaust port. Some engine had massive spaces in the crankcase and tuners reasoned, rightly enough, that filling the crankcase with a variety of *stuffers* would reduce crankcase volume and hence increase crankcase compression when the piston descended to BDC. Increasing crankcase compression naturally enough result in higher crankcase pressure which, all else being equal, raises transfer flow and improves maximum hp output. Tuner cited the reason for this as being due to the transfer stream erupting under considerable pressure into the cylinder. Because of this fuel/fresh air/lubricate mixture charge tended to behave like a wedge on entering the cylinder. It didn't break up and mingle with the exhaust gases, but pushed them out of the cylinder with the considerable force. So effective was this method of cylinder scavenging that the fuel/fresh air 'wedge' was actually being partly lost out of the exhaust before the port closed. Two-stroke tuners overcome this problem by opening the transfer port later and closing them earlier, reducing traditional transfer duration from 130 ° down to120 °. Because of more fuel charge being contained within the cylinder, power increased.

To ensure efficient pumping of the fuel/ fresh air mixture from the crankcase into the cylinder, one of the ways is by increasing crankcase compression [2].

All compression ratio value is the ratio of the maximum volume in any chamber of an engine to the minimum volume in that chamber. In the crankcase that ratio is known as the *crankcase compression ratio* $CR_{CC}$ and it's defined by;

$$CR_{CC} = \frac{V_{CC} + V_{SV}}{V_{CC}}$$

Where $V_{CC}$ is the crankcase volume at TDC. While it is true that the highest this value becomes the stronger is the crankcase pumping action, the actual numerical value is greatly fixed by the engine geometry of bore, stroke, con rod length, and the interconnected value of fly wheel diameter [2].

## 2.4 Machining Process

### 2.4.1 CNC Machine and G-Code

The modern CNC system used an internal micro processor (computer). This computer contains memory register storing a variety of routine that are capable of manipulating logical functions. That's means the part programmer or the machine operator can change the program on the control itself, with instantaneous results. This flexibility is the greatest advantage of the CNC system and probably the key element that contributed to such wide use of the technology in modern manufacturing. The CNC programs and the logical functions are stored on special computer chips, as *software instructions*, rather than used by the hardware connections, such as wires, that control the logical functions.

The program address G identifies a *preparatory command*, often called the G code. This address has one and only objective – that is to preset or to prepare the control system to a certain desired condition, or to a certain mode or a state of operation. For example, the address G61 is for exact stop mode. The term preparatory command indicates its meaning-a G code will prepare the control to accept the programming instructions following the G code in a specific way.

In the G-code system, there are four basic terms used. That is character, word, block, and program.

The character is the smallest unit in CNC program; it can have one of three forms:

i. digit
ii. letter
iii. symbol

Characters are combined into meaningful words. This combination of digit, letters and symbol is called the *alpha-numerical* program input. A program word is a combination of *alpha-numerical* characters, creating a single instruction to the system. Normally, each word begins with a capital letter that is followed by a number representing a program code or the actual value. Typical words indicate the axes position, federate, speed, preparatory commands, miscellaneous function and much other definition.

The block is used as a multiple instruction. A program entered into the control system consists of individual lines of instructions, sequenced in a logical order. Each line – called a sequence block or simply a block – is composed of one or several words and each word is composed of two or more characters. In the control system, each block must be separated from all other. To separate blocks in the MDI (manual data input) mode at the control, each block has to end with a special *End-Of-Block* code (symbol). This code is marked as EOB on the control panel. When preparing the program on a computer, the *enter* key on the keyboard will terminate the block with the same result (similar to the old *Carriage Return* on typewriters).when writing a program on paper first, each program block should occupy only a single line on the paper. Each program block contains a series of single instructions that are executed together.

### 2.4.2 Rapid Prototyping

Rapid prototyping (RP) process can be classified into three major groups:

i. Subtractive
ii. Addictive
iii. Virtual

As the name imply, subtractive process involve material removal from a workpiece that is larger than the final part. Additive processes build up a part by adding material incrementally to produce the part. Virtual processes use advanced computer-based visualization technologies. Almost all materials can be used through one or more RP operations. However, because their properties are more suitable for these operations, polymers are the workpiece material most commonly used today, followed by ceramics and metals. However, new processes are being introduced continually, and, thus, existing processes and material improved [5].

#### 2.4.2.1 Subtractive Processes

Making a prototype traditionally has involved a series of processes using a variety of tooling and machines, and it usually takes anywhere from weeks to months, depending on part complexity and size. This approach requires operators using material removal by machining and finishing operations – one-by-one – until the prototype is complete. To speed this process, subtractive processes increasingly use computer-based technologies, such as:

i. Computer-based drafting packages, which can produce three-dimensional representation of parts.
ii. Interpretation software, which can translate the CAD file into a format usable by manufacturing software.
iii. Manufacturing software, which is capable of planning the operations required to produce the desired shape.
iv. Computer-numerical-control machinery with the capabilities necessary to produce the parts [5].

When a prototype is required only for the purpose of shape verification, a soft material (usually a polymer or a wax) is used as the workpiece in order to reduce or avoid any machining difficulties. The material intended for use in the actual application also can be machined, but this operation may be more time consuming, depending on the machinability of the material. Depending on part complexity and machining capabilities, prototypes can be produced in a matter of from a few days to a few weeks. Subtractive systems can take many forms; they are similar in approach to the manufacturing cells Operators may or may not be involved, although the handling of parts is usually a human risk [5].

2.4.2.2 Addictive Processes

Additive rapid-prototyping operations all build parts in layers; they consist of *stereolithography, fused-deposition modeling, ballistic-particle manufacturing, three-dimensional printing, selective laser sintering and laminated-object manufacturing.* In order to visualize the methodology used, it is beneficial to think of constructing a loaf of bread by stacking and bonding individual slices on top of each other. The main difference between the various additive processes lies in the method of producing the individual slices, which are typically 0.1 to 0.5 mm thick and can be thicker for some systems [5].All additive operations required operations require elaborate software. The first step is to obtain a CAD file description of the part. The computer then constructs slices of the three-dimensional part. Each slice is analyzed separately, and a set of instructions is compiled in order to provide the rapid-prototyping machine with detailed