MODELLING AND FABRICATION OF CRANKCASE FOR SINGLE CYLINDER 100cc FOUR-STROKE ENGINE

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ABSTRACT

In manufacturing industry, sand casting is the suitable process to used for fabricate the crankcase four-stroke engine. The main objective of this project is to modeling and fabricates the crankcase for four-stroke engine using CNC milling machine at Faculty of Mechanical Engineering. The first step to fabricate the crankcase using CNC milling machine is create modeling of crankcase part in 2D and 3D drawing using Solidwork software. After finish create this drawing, it will transfer into Master CAM software to get the G-code and M-code of crankcase that CNC milling machine required for fabricate the crankcase. To get the actual G-code and M-code of crankcase, ability using Master CAM is very important. Although the methods that used to fabricate the crankcase using CNC milling machine is actual but it not means this project will be done with success. This is because the crankcase design has a complex shape to fabricate using CNC milling machine and confirmed capability diploma student is not able to make it because them are at beginner stage in Master CAM software which is very important in all kind of CNC machine. Other alternative that used to succeed this project is using the Rapid prototyping machine or 3D printing which it is varies easy to conduct for fabricate the model. Although the process fabricate a crankcase is failed because of wanting the raw material that 3D printing required but this project is assume done with success because 3D printing machine is able to fabricate whatever model that have a complex shape such as cylinder head for two-stroke engine.

ABSTRAK

Dalam industri pembuatan, tuangan pasir adalah proses yang sesuai digunakan untuk membuat kotak engkol bagi enjin empat lejang. Tujuan utama projek ini ialah membentuk dan membuat kotak engkol enjin empat lejang dengan mengunakan mesin kisar CNC yang terdapat di Makmal Fakulti Kejuruteraan Mekanikal. Langkah pertama untuk menbuat kotak engkol dengan menggunakan mesin kisar CNC ini ialah membentuk kotak engkol di dalam lukisan dua demensi dan tiga demensi dengan mengunakan perisian Solidwork. Setelah selesai proses membentuk, lukisan ini akan di dipindahkan kedalam perisian Master CAM untuk memdapatkan G-code dan M-code yang diperlukan oleh mesin kisar CNC untuk membuat crankcase. Untuk mendapatkan G-code dan M-cod yang tepat bagi kotak engkol ini, kemahiran mengunakan perisian Master CAM adalah amat penting. Walaupun kaedah-kaedah yang digunakan untuk membuat kotak engkol dengan mengunakan masin kisar CNC ini betul namun tidak bermakna projek ini berjalan dengan lancar. Hal ini kerana kotak engkol menpunyai bentuk yang complex untuk dibuat dengan mengunakan mesin kisar CNC dan terbukti tidak mampu dikendalikan oleh pelajar diploma yang masih diperingkat permulaan mempelajari perisian Master CAM yang amat berguna dalam semua jenis mesin CNC. Altenatif lain yang di cuba untuk menjayakan projek ini ialah menggunakan mesin pencetak 3D yang sangat mudah digunakan dalam proses pembentukan. Walaupun kotak engkol ini tidak dapat di buat kerana kekurangan bahan mentah yang diperlukan mesin pencetak 3D namun projek ini di anggap berjaya kerana mesin pencetak 3D ini berkemampuan menghasilkan pelbagai model yang mempunyai bentuk yang complex seperti kepala silinder enjin dua lejang.

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CHAPTER 1

INTRODUCTION

1.1 Project Synopsis

Final year project is one of the subjects for diploma last year student. In this subject, a project needs to do to fulfils the subject requirement. My project title is modeling and fabrication of crankcase for single block cylinder 100 cc four-stroke engine. The project involves the designing and fabricating. Firstly redesign the 2D and 3D drawing of crankcase using Solidwork software. Then get the G-code of crankcase using Master CAM software and transfer to CNC milling machine for fabricate the crankcase. Overall, this project will involve the development of skills in design, simulation and fabrication.

1.2 Problem Statement

Crankcases have a complex shape to design in 2D and 3D drawing. Because of that the previous researchers did not clearly how to get the real dimensions of crankcase and develop the three-dimensional modeling using Solidwork. Them is also not clear how to use Master CAM method for come out the G-code of crankcase part and transfer into CNC milling machine for fabrication process. The last is deliberate about machining problem and find the suitable method to solve.

1.3 Objective of Project

The main objective of this project is to modeling and fabrication of crankcase for single cylinder 100cc four stroke spark ignition (SI) engine.

1.4 Scopes of Project

Scope for this project is:

i. Reverse engineering.
ii. 3D CAD modeling of original crankcase.
iii. Simplify the design maintaining the key dimensions such as a cylinder bore in accordance of machining capabilities.
iv. Fabricate the simplified model cylinder block using CAM method.

1.5 Project Organization

Chapter 2: literature review. This chapter generally is about function of the crankcase. The function of crankcase is to protect the component in crankcase's area. For the mass production, crankcase is manufacture by casting process.

Chapter 3: Methodology. First work in this chapter is overhaul and measures the crankcase part. Secondly is drawing the original crankcase and then simplifies complex geometry of crankcase. For the machining process, firstly from the 3D drawing Solidwork software is transfer into Master CAM software to run the simulation of crankcase and get the G-code command. The G-code is use to run the CNC machine to fabricate and produce the crankcase part.

Chapter 4: Result and discussion. The G-code result come from Master CAM simulation is use for machining process. The original drawing is also the important result. The entire problem for machining process will be discus and analyzes.

Chapter 5: Conclusion. The aim of this project was to study about crankcase design. It will give more information about how to design and modeling crankcase using Solidwork and Master CAM, and then fabrication of crankcase for single block 4-stroke engine. Simplify the design maintaining the key dimensions in accordance of machine capabilities using the Solidworks and transfer to Master CAM to get the G-code for machining progress.

1.6 Author's Contribution

Solve the problem to design the crankcase using Solidworks and come out the 3D, 2D design and their dimensions. The suitable methods are used to get the real dimensions of crankcase part. To get the G-code and M-code of crankcase using Master CAM software and transfer to CNC milling for machining progress.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to provide a review of related the history about four-stroke cycle, the meaning of crankcase and their function. A review of other relevant research studies is also provided such as introduction the Computer Numerical Control (CNC) code or G-code. The purpose of the review about introduction the CNC code because it will use CNC machine to fabricate the crankcase justly follow the scope direction.

2.2 Introduction of Four Stroke Engine

Internal combustion engines using four-stroke cycle with spark ignition and compression ignition, use poppet valves to allow air to flow through the cylinder head cylinder and exhaust gases out. Very early engines used alternative valve types such as D slide valves that proved to be unsatisfactory, especially at higher speeds. The actuation of these valves is the subject at hand (Heywood, 1988). The four stroke engine was first demonstrated by Nikolaus Otto in 1876; hence it is also known as the Otto cycle. The technically correct term is actually four stroke cycles the four strokes of the cycle are intake, compression, power, and exhaust. (Kawamato *et al*, 1998).

2.2.1 Four Stroke Cycle

The figure 2.1 until 2.4 showed the operation system of four-stoke cycle with spark ignition and compression ignition:

Intake. Figure 2.1 show the piston moves downward, drawing a fresh charge of vaporized fuel/air mixture. The illustrated engine features a 'poppet' intake valve which is drawn open by the vacuum produced by the intake stroke. Some early engines worked this way, however most modern engines incorporate an extra cam/lifter arrangement as seen on the exhaust valve. (Hardenberg *et al*, 1999)

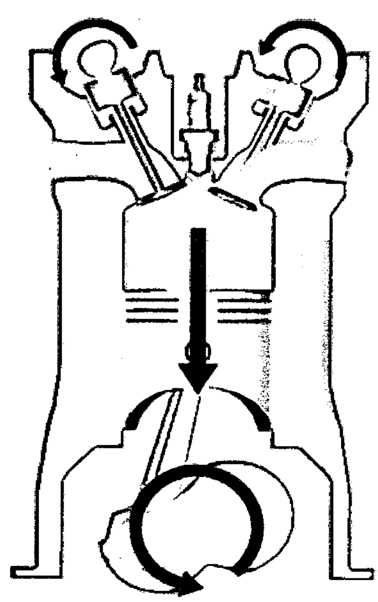

Figure 2.1: Intake phase (Keveney, 2000)

Compression. Figure 2.2 shows the piston rises the poppet valve is forced shut by the increased cylinder pressure. Flywheel momentum drives the piston upward, compressing the fuel/air mixture. (Hardenberg *et al*, 1999)

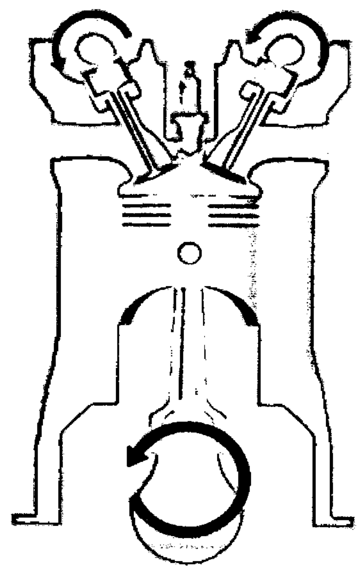

Figure 2.2: Compression phase (Keveney, 2000)

Power. Figure 2.3 show at the top of the compression stroke the spark plug fires, igniting the compressed fuel. As the fuel burns it expands, driving the piston downward. (Hardenberg *et al*, 1999)

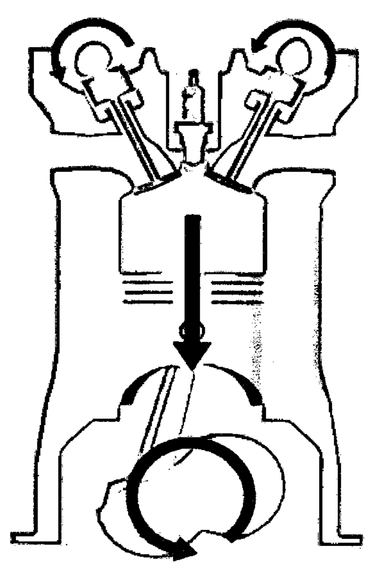

Figure 2.3: Power phase (Keveney, 2000)

Exhaust. Figure 2.4 show at the bottom of the power stroke, the exhaust valve is opened by the cam/lifter mechanism. The upward stroke of the piston drives the exhausted fuel out of the cylinder.(Hardenberg *et al*,1999)

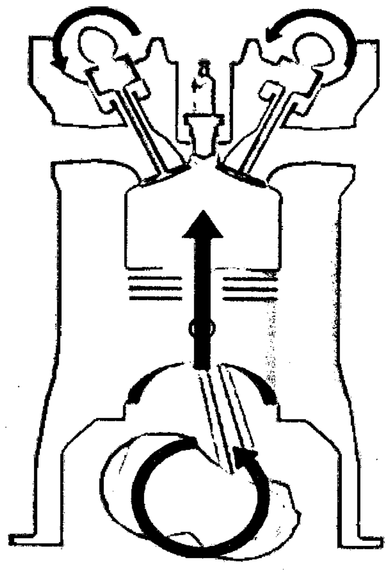

Figure 2.4: Exhaust phase (Keveney, 2000)

2.3 Crankcase

In a piston engine, the crankcase is the housing for the crankshaft. The enclosure forms the largest cavity in the engine, separated from the cylinders by the reciprocating pistons. Besides protecting the crankshaft and connecting rods from foreign objects, the crankcase serves other functions, depending on engine type. In a four-stroke engine, the crankcase is filled mainly with air and oil, and is largely sealed off from the fuel/air mixture by the pistons.(Harord Litz *et al*, 1974)

The engine crankcase is also the area below the crankshaft where the pan oil is, must be vented to prevent excess pressure from developing within it. As the combustion events occur some leakage of pressurized combustion gases part the ring, or blow-by (the unburned fuel and combustion by products that leak past the piston ring and enter the crankcase) is inevitable. If this pressure were not relieved the oil and gases in the crankcase could be blown out of the seals and back up past the rings into the combustion chamber (Takahashi et al, 2000). This would cause oil leakage and oil consumption (oil use through burning oil in the combustion chamber; this causes blue smoke out of the tailpipe)

2.4 Introduction of Master CAM

CAD/CAM is an acronym for Computer Aided Design / Computer Aided Manufacturing. In essence CAD is simply a drafting board in a computer and facilitates engineering and design with a monitor and a keyboard instead of a paper and pencil. The drawing is saved in an electronic data file for editing.

CAM is what can be done with the electronic data to help manufacture the engineered part represented in the electronic file. Although there can be hundreds of different manufacturing processes (stamping, forging, molding, etc) "CAM" when teamed with "CAD" as in "CAD/CAM" has come to refer almost exclusively as the process of machining the CAD geometry on CNC machinery. Of course the computer file alone cannot machine a part nor can the computer. But with a CAD/CAM system the electronic CAD file can be used to create another file of tool paths that can be fed into the controls of the CNC machinery.

A direct link between product design and manufacturing can be established using CAD/CAM software. Product engineers use a CAD system to establish the part geometry, dimensions, and tolerances. This design data can be transferred to the CAM system where the part programmers develop the CNC program to machine the part.

A CAD/CAM system can consist of separate or integrated CAD and CAM software. For a system using separate CAD and CAM packages, transfer of drawing geometry using either direct or indirect translation is required. In this case, part geometry is first created on the CAD system and then transferred to the corresponding CAM system. After the geometry has been recreated in the CAM system, the programmer specifies the tools that will be used. Detail information for each tool, such as material, diameter, number of flutes, and length, will be specified (above right)). Next the order of the machining process will be established (right). And finally a tool path with proper feed rate information is provided (below right)

An integrated CAD/CAM system is a dedicated system that will allow the user to create product geometry and generate CNC programs all in one package. Data transfer from CAD to CAM is not required, and there is no data compatibility problem. This feature is important since it ensures the accuracy and reliability of the data.(Micheal Sava and Joseph Pusztai)

2.4.1 Introduction of G-Code

G-code is a common name for the programming language that controls NC and CNC machine tools. Developed by the Electronic Industries Alliance in the early 1960s, a final revision was approved in February 1980 as RS274D. G-code is also the name of any word in a CNC program that begins with the letter *G*, and generally is a code telling the machine tool what type of action to perform. G-code files may be generated by CAM software. Those applications typically use translators called post-processors to output code optimized for a particular machine type or family. Post-processors are often user-editable to enable further customization, if necessary. Such software must be customized for each type of machine tool that it will be used to program. Some g-code is written by hand for volume production jobs. In this environment, the inherent inefficiency of CAM-generated g-code is unacceptable.(Warren S. Seames)

Table 2.1: Example of common Fanuc G-Codes

Code	Descriptions
G00	Rapid positioning
G01	Linear interpolation
G02	CW circular interpolation
G03	CCW circular interpolation
G17	X-Y plane selection
G18	X-Z plane selection
G19	Y-Z plane selection
G20	Programming in inches
G21	Programming in mm
G28	Return to home position
G33	Constant pitch threading
G34	Variable pitch threading
G40	Tool radius compensation off
G41	Tool radius compensation left
G42	Tool radius compensation right
G43	Tool offset compensation positive
G44	Tool offset compensation negative
G45	Axis offset single increase
G46	Axis offset single decrease
G47	Axis offset double increase
G48	Axis offset double decrease
G49	Tool offset compensation cancel
G53	Machine co-ordinate system
G54 to G59	Work co-ordinate systems
G73	High speed drilling canned cycle
G74	Left hand tapping canned cycle
G76	Fine boring canned cycle
G80	Cancel canned cycle
G81	Simple drilling cycle
G82	Drilling cycle with dwell
G83	Peck drilling cycle

Code	Descriptions
G84	Tapping cycle
G90	Absolute programming (type B and C systems)
G91	Incremental programming (type B and C systems)
G96/G97	Constant cutting speed (Constant surface speed)/Constant rotation speed (constant RPM)

2.5 CNC Milling Machine

Computer Numerical Control (CNC) Milling is the most common form of CNC. CNC mills can perform the functions of drilling and often turning. CNC Mills are classified according to the number of axes that they possess. Axes are labeled as x and y for horizontal movement, and z for vertical movement, as shown in this view of a manual mill table. A standard manual light-duty mill (such as a Bridgeport) is typically assumed to have four axes:

i. Table x
ii. Table y
iii. Table z
iv. Milling Head z

The number of axes of a milling machine is a common subject of casual "shop talk" and is often interpreted in varying ways. We present here what we have seen typically presented by manufacturers. A five-axis CNC milling machine has an extra axis in the form of a horizontal pivot for the milling head, as shown below. This allows extra flexibility for machining with the end mill at an angle with respect to the table. A six-axis CNC milling machine would have another horizontal pivot for the milling head, this time perpendicular to the fifth axis .CNC milling machines are traditionally programmed using a set of commands known as G-codes. G-codes represent specific CNC functions in alphanumeric format.(Richard *et al*)

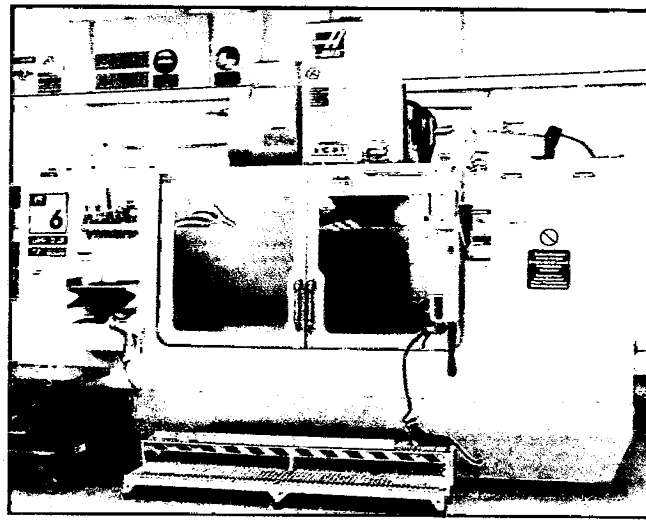

Figure 2.5: CNC milling machine (HAAS)

Figure 2.6: CNC milling machine (FANUC)

2.6 Software

The procedure for generating toolpaths and machining a model uses two software programs, Master CAM and Techno, corresponding to the two steps in the machining process. Master CAM is a full modeling software package as well as a machining software package and can be used for producing a 3D or 2D model, though is easiest to use a separate program such as form-Z or Alias. Modeling will be discussed later in this document. The Master CAM program has several methods for generating toolpaths from 2D data, 3D data and full 3D computer models. The second program, Techno, is proprietary software supplied by the producers of our milling machine. This program is for directly interfacing with the machining hardware. It can interpret toolpaths into a series of stepped movements in the X, Y and Z directions; it can also be used to manually position the machine head before machining. (Richard *et al*)

2.7 Modeling

If we are familiar with modeling software other than Master CAM it is often easiest to model in a separate modeling program. However - for the most consistently correct results it is best to model in Master CAM. For any 2D toolpaths it is highly recommended that you use Master CAM for you modeling. Its drafting program is similar to AutoCAD and it is a very powerful 3D modeler although its interface is rather burdensome and slow to use. Modeling with Master CAM will not be discussed here but the manuals offered extensive information on the Modeling/Design.module.of.the.software.(Richard.*et.al*)