STRESS ANALYSIS ON ENGINE BLOCK CONSIDERING THERMAL EFFECT

MUHAMMAD RAZIQ BIN ABU SAMAH

A report submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering (with Honours)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

DECLARATION

I declare that this project report entitled “Stress Analysis On Engine Block Considering Thermal Effect” is the result of my own work except as cited in the references.

Signature : .....

Name : MUHAMMAD RAZIQ BIN ABU SAMAH

Date : 28 JUNE 2019

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Honours.

Signature :. .....

Name of Supervisor : .....

Date : .....

DEDICATION

This project and research work is dedicated to my beloved parents for their enthusiastic caring throughout my life, my loving siblings, my supervisor and also all of my fellow friends for their encouragement and love.

ABSTRACT

A very complex demand from customer, laws and business requirements will have to be met by future design of internal combustion engines for light duty applications. Customers expect further improvements in durability, reliability, driving performance, fuel economy and ownership costs. Laws requirements focus on substantial reductions in emissions and fuel consumption. In order to maintain or having a better grow business in competitive environment, additional cost reductions in manufacturing will be essential. The focus for future development of gasoline engines will be on improvements in fuel economy combustion systems and reduction losses in part load operation. A combined experimental and analytical approach was followed in this study of stress and temperature on cylinder block under steady-state operation. First, experimental studies were performed to measure temperatures and stresses under stable conditions of operation. In addition, the value of stress at the point can be obtained by placing high temperature strain gauges on the engine block. Subsequently, the detailed stress distributions on the engine block were predicted by a finite element analysis. A comparison of the predicted stress on the analysis of finite elements were being compared with the experiment's stress value.

ABSTRAK

Keperluan pelanggan, perundangan dan perniagaan yang sangat kompleks perlu dipenuhi oleh enjin pembakaran dalaman masa hadapan untuk aplikasi tugas ringan. Pelanggan mengharapkan penambahbaikan selanjutnya dalam ketahanan, kebolehpercayaan, prestasi memandu, ekonomi bahan api dan kos pemilikan. Keperluan undang-undang memberi tumpuan kepada pengurangan besar dalam pengeluaran dan penggunaan bahan bakar. Untuk mengekalkan atau mengembangkan perniagaan dengan persekitaran yang sangat kompetitif, pengurangan kos tambahan dalam pembuatan akan menjadi penting. Tumpuan untuk pembangunan masa depan enjin petrol akan meningkatkan ekonomi bahan api melalui sistem pembakaran yang lebih baik dan mengurangkan kerugian dalam operasi beban bahagian. Pendekatan percubaan dan analitik gabungan diikuti dalam kerja ini untuk mengkaji tekanan dan suhu pada blok silinder di bawah operasi keadaan mantap. Pertama, kajian eksperimen dilakukan untuk mengukur suhu dan tekanan di bawah keadaan operasi yang stabil. Di samping itu, nilai tegasan pada titik boleh diperolehi dengan meletakkan tegangan suhu tinggi pada blok enjin. Selanjutnya, pengedaran tegasan terperinci pada blok enjin diprediksi oleh analisis unsur terhingga. Perbandingan tekanan yang diramalkan mengenai analisis unsur terhingga berbanding dengan nilai tekanan eksperimen.

ACKNOWLEDGEMENT

It is such a great pleasure and gratitude to acknowledge people whose guidance and encouragement contribute hugely towards the completion of my final year project.

First and foremost, I am grateful to the God as He gave me the opportunities to complete this thesis. Next, a huge thanks to my supervisor, Ir. Dr. Mohd Shukri Bin Yob, for being supportive in coaching and sharing knowledge with me, guiding me throughout two semester. In preparing this thesis, there were many people that give a hand towards my understanding and perspective which were the lecturers, seniors and my friends. Particularly, I want to convey my appreciation to all of them for all the guidance and advices.

Thank you very much to all my family who were never stop to support and motivated me. Finally, I wish to thank all of the people who have contributed directly or indirectly in helping me to complete this thesis.

TABLE OF CONTENT

PAGE

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATION

ICE	-	Internal Combustion Engine
EXE	-	External Combustion Engine
TDC	-	Top Dead Center
BDC	-	Bottom Dead Center
RPM	-	Revolution per Minute
CATIA	-	Computer Aided Three-dimensional Interactive Application
ANSYS	-	Analysis System
FEA	-	Finite Element Analysis
IGES	-	Initial Graphics Exchange Specification
STP	-	Standard Exchange Product

CHAPTER 1

INTRODUCTION

1.1 Background

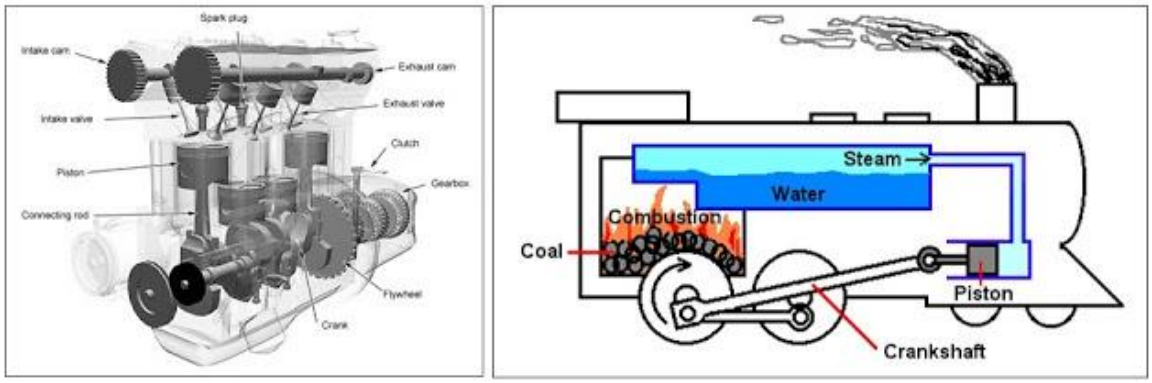
A motorcycle often called a bike, motorbike or cycle is a two, three-wheel motor vehicle. Nowadays, there have a four-wheeled motor vehicle according to the needs and modern invention. The design of the motorcycle depends on the needs such as travel, commuting, cruising, sport and off-road riding. In the other word, there are three type of motorcycle which is street, off-road and dual purpose. Each type of purpose provides either specialized advantages and each design creates a different position of riding.

The transmission is a mechanical component designed to transmit power from the engine to the drive axle which make the wheels drive the vehicle. There are three parts in the transmission which are gear, clutch and drive system. By carrying the gear ratio, the transmission can control the levels of power and speed of the wheels. For example, the transmission provides more power and less speed in a short range but it provides less power and high speed in a long range. Indirectly, it reduces the load on the engine and fuel economy while increasing the speed of the vehicle. There are two type of transmission which are automatic transmission and manual transmission.

In term of motorcycle, there must be have an engine. The engine is the heart of the motorcycle. There are two type that are mostly used around the world which is four strokes and two strokes internal combustion engine (ICE). A four strokes engine required the piston complete four separate stroke while turning the crankshaft. The four separate strokes are intake, compression, ignition and exhaust. Different with two strokes engine, the power

cycle completes with up and down movement of the piston during the only one crankshaft revolution. The end of the combustion stroke and the beginning of the compression stroke happen at the same time with the intake and exhaust function occurring simultaneously. Two strokes engine have a greatly reduced number of moving parts, so it can be more compact compared to four strokes engine. But, four strokes engine is more fuel economy due to more complete combustion of intake charge in four strokes engine.

The most vital components for the engine are engine block and cylinder head where the combustion process occur inside the components. There are two type of engine which are external combustion engine and internal combustion engine (Pankaj Mishra, 2016). Basically, the ICE is an engine in which a fuel (usually fossil fuel) is combusted in a combustion chamber with an oxidizer (usually air). The expansion of the high-temperature and pressure gasses produced by combustion in an ICE applies direct force to some engine components such as pistons, turbine blades or a nozzle (Mahesh Kumar, 2016). The ICE is quite different from external combustion engine (ECE), such as Sterling engine or steam, where the energy is delivered to a non-combustion product working fluid. Air, hot water, pressurized water or even liquid sodium, heat and some kind of boiler can be working fluids. Figure 1.1 below shows the example of ICE and ECE.



Internal Combustion Engine External Combustion Engine

Figure 1.1: The two type of engine (Pankaj Mishra, 2016)

The cylinder block is the basic framework of a engine. Piston ring, pistons and connecting rod was supported and holds by the cylinder block. The cylinder is a large hole inside the block of the cylinder, surrounded by the wall of the cylinder. Under combustion pressure, the piston travels quickly back and forth in the cylinder. The wall of the cylinder guides the moving piston, receives the pressure of combustion and transmit heat of combustion outside the engine. During operation, the cylinder wall must maintain a precise roundness and straightness of μm order(Hiroshi Yamagata, 2005). Typically, the cylinder bore wall experiences local wear at the top dead center (TDC) point where the oil film most likely fails and scratches along the piston's travel direction. Figure 1.2 shows the vertical scratches due to scuffing. The scratching grooves increase the oil consumption and blow-by (Jeff Smith, 2019).

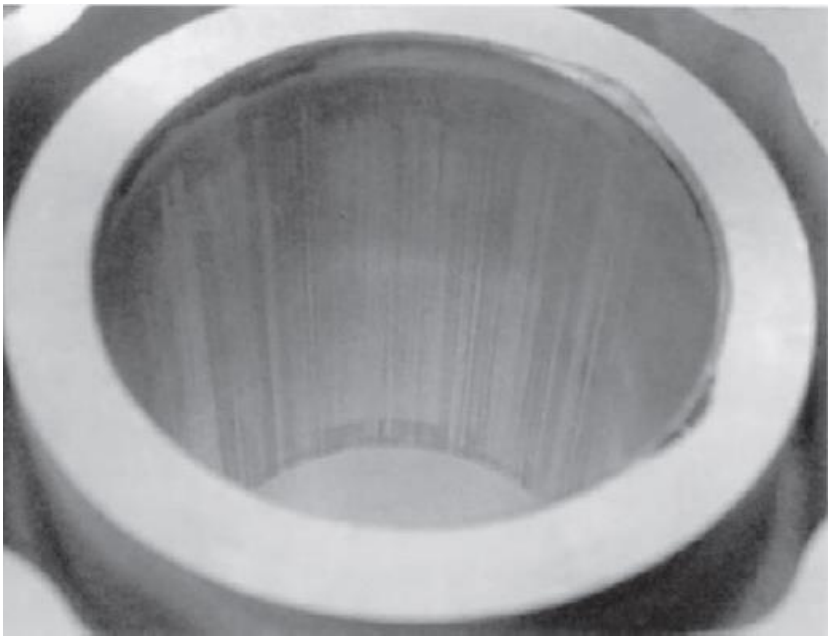


Figure 1.2: Vertical scratches due to scuffing inside the engine block (Hiroshi Yamagata, 2005)

A separate cast piece known as the cylinder head is covering the top of the cylinder. The cylinder head is bound to the top of the engine block by using bolt. In addition, the cylinder head is fitted some parts which is spark plug on the top, combustion chamber or known as a cylinder block and also fitted with valve for some engine. The main pupose of the cylinder head is to seal the cylinder's working ends and not to allow the gasses to enter and exit overhead valve engines (Vishal Sapkal, 2018). Heat generated during combustion is converted into mechanical power on the crankshaft and part of it loss through exhaust gasses and heat transfer to the environment. The cylinder head must withstand enermous pressures and very high temperature while retaining its shape and forming through the head gasket to seal the cylinder block. Figure 1.3 shows the example of the cylinder head.

Figure 1.3: The example of the cylinder head (David Fuller, 2015)

1.2 Problem Statement

Engine block will expose to high temperature during its operation. From this situation, the temperature will effect the strength of engine block and cylinder head. Usually, the effect of temperature will lower the yield stress of material of engine.

Besides, finite element model is widely used to predict stress of engine block. However, this finite element model fail to predict the stress of engine accurately. The best way by run the experiment to predict stress value on the engine block but it is costly and time consuming.

Furthermore, after the new engine was design, there is a constraint which is the engine is heavy and the geometry is quite large. Hence, the heat transfer from the surface to the surrounding is slow.

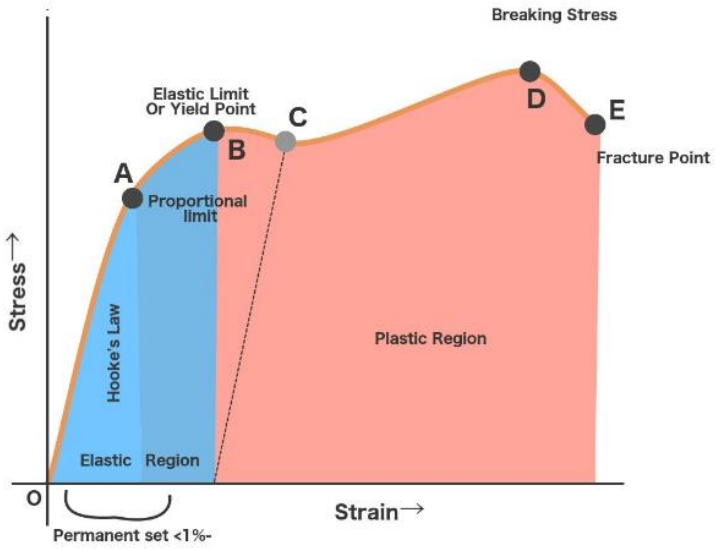


Figure 1.4: The general stress-strain graph for yield strength (Akash Peshin, 2016)

1.3 Objectives

The objectives of this project are as follows:

1. To determine stress of engine block for 2-stroke engine.

2. To compare the experiment and simulation result of the engine block.

1.4 Scope of Project

This study is to evaluate the stress of the two strokes engine. The experiment is use a pocket bike engine by changing the original engine block with the gray cast iron material of the engine block and cylinder head. The study also deals with analysis of product consists of two components, engine block and cylinder head. The CATIA software is used for design and ANSYS software is to make a simulation. Lastly, the material used for the engine block and cylinder head is gray cast iron while for the fin is used aluminium.

CHAPTER 2

LITERATURE REVIEW

2.1 Internal Combustion Engine

The fundamental chemical process of releasing energy from a fuel and air mixture is combustion, also known as burning. The ignition and the combustion of the fuel and air mixture happen in the engine by itself. The energy that created by the combustion will be converted to work. The combustion cause the piston move upward and downward which drive the crankshaft to rotate. Eventually, the system of powertrain drives the vehicle's wheel.

Nowadays, there are two types of internal combustion engine that has been used world widely which are the spark ignition gasoline engine also known as petrol engine and the compression ignition diesel engine. The basic cycle processes of the engine is intake, compression, ignition and exhaust (Jia *et al.*, 2016). There are some differences between the spark ignition gasoline engine and the compression ignition diesel engine on how they supply and burn the fuel.

For the spark ignition gasoline engine, there are two types of system to inject the fuel into the cylinder which are by using carburetor and fuel injected. During the process in carburetor, the fuel and air mixed before inducted to the cylinder but different with fuel injected where the fuel and air mixed in a cylinder. However, the concepts of these two types of mechanism still same because the ignition needs a fuel mixed with air during intake process to start the combustion during the piston compresses the fuel-air mixture.

For the diesel engine, there are two types of fuel system which are direct injection and indirect injection. In direct injection, the fuel was sprayed directly on top of the piston. The characteristic of this system is high fuel efficiency, noisy and easy cold starting ability. For indirect injection, the fuel was sprayed to a pre-chamber. The characteristic of this system is less fuel efficiency, less noise and need a pre-heating before starting. The concepts of these two system is the air fuel mixture ignites at high pressures and temperatures. The top dead center (TDC) is called when the piston reach at the highest point and the bottom dead center (BDC) is called when the piston reach at the lowest point in the cylinder. The ratio of the fuel to air is not the same throughout the cylinder for both diesel and spark ignition. In term of fuel consumption, about 27% efficiency of the engine, 30% is lost to the jacket cooling and 30% is exhausted to the environment (Humphrey, 1989). The ratio of the fuel to air is not the same throughout the cylinder for both diesel and spark ignition engine.

In any internal combustion engine, a cooling system is required. The function is to remove the excess heat from the engine and to make sure the engine operates at the most ideal temperature (Baba, 2007). Approximately, one-third of the fuel energy is converted into power. The exhaust pipe is another third unused and the other third becomes heat energy. Liquid cooling and air cooling are the types of cooling system. Basically, air cooling system is more often used in aircraft, motorcycles and lawnmowers and liquid cooling system is used in auto engine (University, 2018). The heat transferred from the combustion chamber to the cylinder head and dissipated into the air must be recovered (Baba, 2007).

A huge number of dissimilar design of internal combustion engine has been developed and formed for a different type of purpose and have their own strength and weakness. Since the internal combustion engine lead as a power supply for cars, boats and aircraft, it shows that the real strength of internal combustion engine is in vehicle application.

2.2 Type of Engine Cycle

There are many engine cycle types but usually two stroke and four stroke has been used. Every type of engine cycle has their own process, characteristic, advantages and disadvantages.

2.2.1 Four stroke

A four stroke cycle engine is an ICE that uses for different piston stroke (intake, compression, ignition and exhaust) to complete a single operating cycle. During the operating cycle, the crankshaft will rotate for two revolutions (720 degree). The most common type of small engine using the four stroke cycle engine.

The four stroke cycle engine comprises on oil tank, a crankshaft chamber and a lubrication system. Furthermore, the four stroke engine consists of a cam and a transmission mechanism connected between the cam and the chamber of the crankshaft in a matching manner (Bortolin and Hollis, 2017). In the first stroke, the piston travels downward while the intake valve open consists of fuel-air mixture being sucked because of the pressure difference. For the second stroke, the piston moving upward compressing the fuel-air mixture while the intake and exhaust valve were closed. When the piston reaches the TDC, the spark plug fires and burn the fuel-air mixture thus sending the piston to BDC. This process is called combustion stroke, also known as ignition. The last stroke is the exhaust stroke. As the piston moving upward, the exhaust valve is open to release the burnt fuel-air mixture to the exhaust pipe. When the piston at the TDC, the intake valve is open and the cycle begin all over again.

Due to high emission, high oil consumption and high noise, two stroke engine cannot meet increasingly stringent standards, as environmental protection and energy saving requirement are becoming increasingly strict at home and abroad (Daobing Huang, 2016)

while in general, four stroke engine produce more torque, fuel efficiency, durability and less pollution. At low revolution per minute (RPM), four stroke cycle engine always make additional torque than two stroke engine and is very suitable for heavyweight vehicle such as car and lorry. Besides, the four stroke cycle engine have a higher fuel efficiency than two stroke engines because once every four strokes fuel is consumed. Since the power is generated once every four stroke and no oil or lubricant is added to the fuel, the four stroke cycle engine causes less pollution. However, the engine is expensive and more complex compare to two stroke engine.

2.2.2 Two stroke

The two stroke engine is the simplest engine because it requires two stroke to complete one revolution for the engine process. A two stroke ICE with a compressed air inlet port and an exhaust port that controls the flow through appropriate valve (Coney et al., 2005).

As the two stroke's piston rises on compression, the negative pressure is created in the crankshaft. This negative pressure causes the fuel-air mixture to be inserted into the crankcase (Uenoyama et al., 2001). Some of type of intake port such as cylinder wall port, reed valve or rotary disk valve is open, it is allowing fuel-air mixture to flow through a carburettor into the crankshaft. When the piston reaches the TDC, at high pressure, a spark fires the compressed mixture. In the other word, the fresh intake charge is drawn into the combustion chamber and the previously burned charge is exhausted at the same time (Tomio Iwai, 1989).

However, there is a risk that the chamber will not be completely cleaned from the past combustion product due to the incoming fresh fuel-air mixture that will pass through the exhaust port and will be lost without being burnt. The advantages of two stroke engine

is lighter, simpler, less expansive to manufacture. Compared to four stroke engine, the combination of light weight and double the power gives two stroke engine a great power-to-weight ratio.

2.3 Working Principal of Two Stroke Engine

As the one cycle is fully completed in one crank revolution, the operation sequence of the parts can be represented in a circle (360 degree). The timing diagram and P-V diagram appears in Figure 2.1 and Figure 2.2.

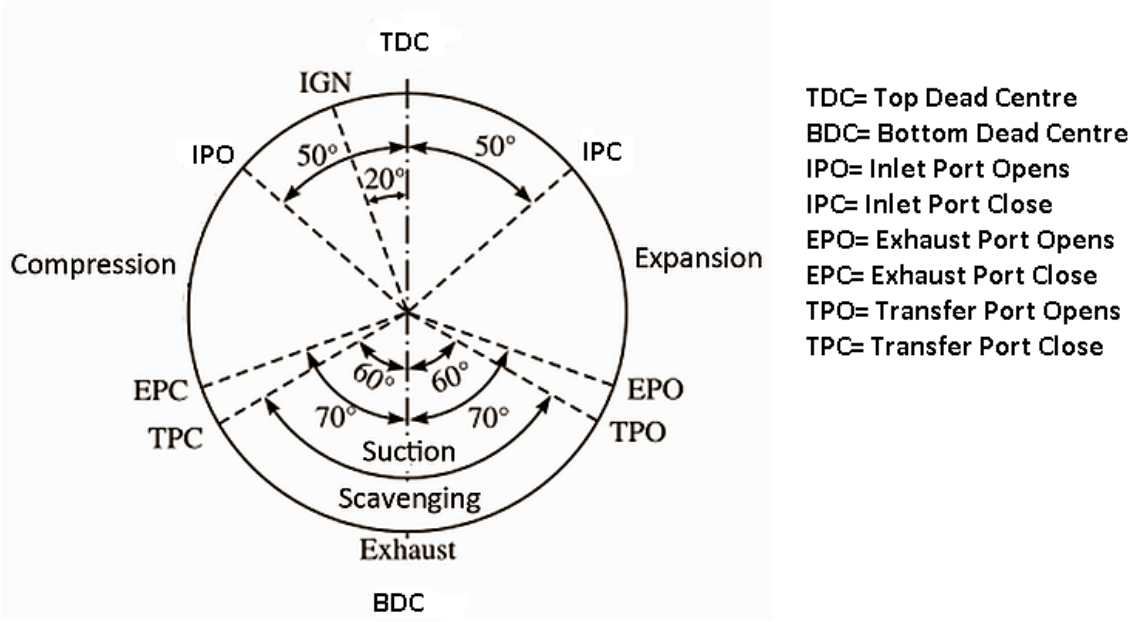


Figure 2.1: Timing diagram of two stroke Otto cycle (Saifadmin, 2018)