EXPERIMENT AND ANALYSIS OF INTAKE PIPE FOR SINGLE CYLINDER ENGINE

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ABSTRACT

Enjin pembakaran dalaman adalah salah satu daripada pengetahuan kejuruteraan yang indah. Pembakaran dalaman terdiri daripada dua kategori salah satunya adalah"Spark Ignition" (SI) dan "Compression Ignition" (CI). Banyak penyelidikan yang boleh dilakukan untuk meningkatkan prestasi enjin, penggunaan bahan api dan pelepasan bahan pembakaran. Salah satu daripada kajian tersebut ialah Eksperimen dan Analisis untuk rekabentuk ekzos motosikal. Objektif utama projrk ini ialah untuk mengkaji panjang ekzos yang pelbagai untuk meningkatkan prestasi enjin. Yang kedua adalah untuk mendapatkan kuasa dan tork yang tinggi pada kelajuan enjin (rpm) yang rendah berdasarkan perubahan ekzos parameter. Eksperimen ini menggunakan mesin Dynamometer 15kW. Terdapat dua jenis panjang ekzos yang akan di kaji iaitu 570mm dan 1140mm. Panjang ini diukur dari manifold sehingga sebelum penyerap bunyi. Sebelum menjalani eksperimen, tapak enjin untuk di ujikaji perlu dibina kerana enjin yang digunakan adalah perbezaan dari eksperimen sebelumnya. Untuk pembinaan tapak enjin, empat elemen terlibatkan secara langsung ialah lakaran, reka bentuk, analisis, dan fabrikasi. Daripada eksperimen yang dibuat terdapat tiga graf yang berbeza mengikut jenis-jenis ekzos pertama ialah graf asas, kedua ialah graf utk panjang ekzos 570mm dan panjang ekzos 1140mm. Graf ini ialah untuk graf kuasa dan graf tork berdasaekan kelajuan enjin. Jika terdapat perubahan panjang ekzos,graf tork akan berubah mengikut panjang perbezaan. Ekzos yang pendek akan menghasil bacaan graf tork dan graf kuasa lebih baik jika dibandingkan dengan yang asal. Tetapi ada had untuk memastikan panjang paip ekzos tidak memberi kesan buruk kepada enjin Secara konklusi nya, ekzos yang terbaik bagi meningkatkan prestasi enjin GT128 ialah ekzos 570mm dan keputusan ini boleh digunakan untuk perlumbaan formula pelajar.

ABSTRACT

Internal combustion engine is one of beautiful engineering knowledge in engineering scope. Internal combustion consists of two type categories which are Spark Ignition (SI) and Compression Ignition (CI). Based on internal combustion engine, a lot of research can be done to improve the performance of engine, fuel consumption, and emission. One of the researches is Experiment and Analysis of Intake Design for Single Cylinder Engine. The main objective is to study the variable design length to increase the performance of the engine. The second is to obtain high power and torque at low speed of engine (rpm) based on the change of intake parameter. The experiment is handle by utilize the Eddy Current Dynamometer 15kW. There are two difference length of intake pipeline which is 52mm and 73mm. the length that change are from 90 degree angle until joining of intake pipe. Before undergo the experiment, test rig of the engine need to fabricate because the engine that use is difference from previous experiment of dynamometer. To fabricate the test rig, four elements involve which are sketching, designing, analysis, and fabrication. These experiments consist of three different result which is baseline graph, length of intake 52mm and length of intake 73mm. The graphs are plot for power and torque graph versus speed of engine. When there are changes of the length of the intake pipe, the torque graph will be change according to the difference length. The increasing of the length, the result of torque and power graph will be more improve. But there are limit to make sure the intake pipe length not give bad impact to the engine. The result concluded that, the better length of intake pipe is the longer one which is 73mm and this result can be applied to student formula race.

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L	Pipe length , inch
Cs	Speed of sound in pipe, ft/sec
N	Engine speed at tune, RPM
ρ	Density of air (kg/m^3)
Vavg	Velocity of air in pipe (m/s)
D	Diameter of pipe (m)
μ	Dynamic viscosity (kg/m.s)

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Motorcycle is the most common vehicles used by Malaysians nowadays. Recent statistics shows that the total cumulative units of motorcycles owned by Malaysians till the end of 2010 is 9,441,907 units which stands as the highest number compare to the other types of vehicles. Other than that, compare to the year 2009, the total cumulative units for motorcycle is 8, 940, 230, which indicates that there is an increment in the units owned of about 501, 677 units. This shows that more Malaysians prefer to use
motorcycles rather than the others.

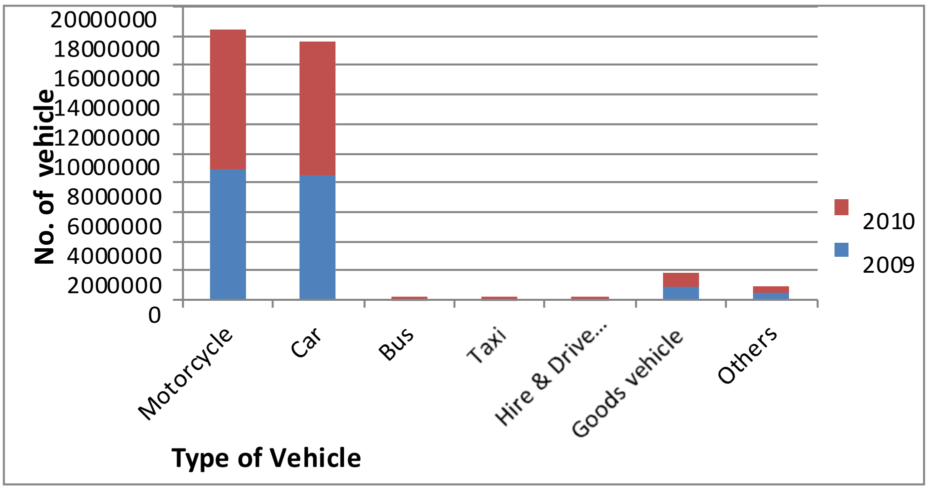

Figure 1.1: Population of vehicle in Malaysia

Source: Ministry Of Transportation(2011)

Besides, statistics by the Malaysia Road Transport Department shows that the number of new registered vehicles in Malaysia for the year 2010 for motorcycle is 498, 041 which is the second highest type registered after motorcars. As known, motorcycles is the highest types that involved in accidents every day, but not to deny, motorcycles is still considered as the most popular types being used due to their reasonable price and the performance aspects.

1.2 PROBLEM STATEMENT.

Performance of an engine based on the engine parameter. Investigation of the engine performance characteristics, especially for power and torque the important parameter that must consider is diameter and the pipe length for intake and exhaust. Different between performance and standard engine can be obtained from the power and torque graph. Standard engine have achieve maximum torque and power in high speed (RPM).

1.3 OBJECTIVE OF STUDY

a. To observe the performance graph of torque and power versus speed.

b. To develop Modenas GT 128 to achieve maximum torque and power in low RPM of engine refer to the intake pipe length.

1.4 SCOPE OF PROJECT

In this research, the experimental must be developed and the result of the experiment analyzed. Below are the scopes for this project:

i. Standard parameter of Modenas GT128 cylinder head

ii. Standard parameter of Modenas GT128 bore and stroke iii. Engine Dynamometer(Eddy Current 15KW)

iv. Length of the intake pipe

CHAPTER 2

LITERATURE REVIEW

2.1 INTERNAL COMBUSTION ENGINE

The internal combustion engine (ICE) is a heat engine that converts chemical energy in a fuel in to mechanical energy, usually made available on a rotating output shaft. Chemical energy of the fuel is the first converted to thermal energy by means of combustion or oxidation with air inside the engine. This thermal energy raises the temperature and pressure of the gases within the engine and the high-pressure gas then expends against the mechanical mechanisms of the engine. This expansion converted by the mechanical linkage of the engine to a rotating crankshaft, which is output of the engine. The crankshaft, in turn, is connected to a transmission or power train to transmit the propulsion of a vehicle.

In cars with internal combustion engine, a series of small explosions in the combustion chambers is what makes movements are possible. Those explosions are usually due to the presence of gasoline, but it would be impossible without the presence of oxygen, which helps a lot for the combustion to take place.

There are so many different engine manufacturers, past, present and future, that produces and have produced engine which differ in size, geometry, style and operating characteristics, that no absolute limit can be stated for any range of engine characteristics such as size, number of cylinders and stroke in a cycle.

Internal combustion engine, the type of ignition can be classified into two types and they are:

a. Spark Ignition (SI)

An SI engine starts the combustion process in each cycle by use a spark plug. The spark plug functions to give a high-voltage electrical discharge between two electrodes which ignites the air-fuel mixture in the combustion chamber.

b. Compression Ignition (CI)

The combustion process in a CI engine starts when air-fuel mixture self-ignition due to high temperature in the combustion chamber caused by high compression. For the ignition engine, they have two type of engine cycle and they are four-stroke cycle and two-stroke cycle. These basic cycles are fairly standard for all engines, with only slight variations found in individual designs.

2.2 INTAKE PIPE

Intake pipe is also known as intake manifold. Here, a manifold consist of a pipe that has a few numbers of outlets to or from the pipes, which are used to carry fuel to each cylinder in an internal combustion engine. It is usually made up of aluminums or cast iron due to the resistance of those materials towards high heat. Recently, in the industries, most of the manufacturers prefer to use composite materials in producing intake manifolds.

Intake manifold function is to take the air as it enters the engine through intake ports which is located in cylinder head. Air entering the cylinder is mixed with fuel and power produced from the combustion process. Intake manifolds do provides the correct fuel or air mixture to the cylinders, which helps to improve the engine efficiency and even comes with more power. This is due to the vacuum created by the intake manifolds. What happened is the air pressure inside the manifold is much lower than the external atmosphere (S.,A Sulaiman, 2010).

During the first stroke in an internal combustion engines, air from intake manifold is sucked into each cylinder through valves. These intake valves are then closed to enable the other three strokes which is compression, combustion and exhaust and then re-open when the cycles starts again. The intake manifolds are the one responsible to make sure enough air is available when the valve open for each intake stroke and to enable each cylinder receive the same amount of air as others.

The main problem associated with intake manifold is leakage. It can throw-off the ratio of air and fuel and will negatively impact the performance of the car. A leaking intake manifold will be resulting in a loss of power output, as the ratio of the mixture is imbalance. This causes the car to have trouble in accelerating or maintaining speeds due to the imbalance of mixture. If the leak is toward the bottom of the system, air will not be the only thing leak out. Due to less air, the amount of gasoline or fuel being sprayed into the manifold will be more than the air can handle. Thus, some of the gasoline or fuel will settle at the bottom of the pipes and leak out (Garrett, W., Balich,2000).

Intake manifolds have a major effect on an engine performance and emission of noise. Differences in engine outputs require different design of intake manifolds in order to achieve the best volumetric efficiency and thus, the best engine performance. During sprinting, the engine is ramped quickly at various speeds due to the twisty course tracks. It is very seldom that an engine could go at high speed for a long time. The race car constantly needs to apply brakes and re-accelerate when taking corners. It is important that the engine can deliver a high torque at even low speeds. This can be achieved with modification of the air intake manifold. (Chien, – Jong., Shih, 2012).

In a single cylinder engine, the maximum output performance achievable is related to the amount of air that is trapped in the combustion chamber. This is defined by the volumetric efficiency, which is the ratio of the mass of air trapped in the cylinder to that contained in the swept volume of the cylinder at inlet manifold density. If the volumetric efficiency could be increased significantly even at low speeds, the engine output would be expected to be higher.(Chien, – Jong., Shih,2012)

2.3 VOLUMETRIC EFFICIENCY

Volumetric efficiency is used only with a four-stroke cycle engine which is with the induction process. It can be defined as the volume flow rate of air into the intake system divided by the rate at which piston is displaced by the piston. (John, B., Heywood,2000)

In the model the wave propagation velocity is used to calculate the mass entered through the valve. The theoretical mass of air that will enter the engine is also calculated using the swept volume and atmospheric conditions. The volume efficiency can also be calculated in the model by comparing the ratio of the mass flow to theoretical flow (Gordon, P.,Blair,1999).

Those days before, old cars used only a single pipe to supply more than a cylinder with air, but now the engineers developed manifolds with a common plenum and equal pipe lengths to utilize pulsating flow in order to improve volumetric efficiency. Variable intake manifolds were developed to improve engine efficiency over a wider rpm range. This can be done altering the length of the pipe via a butterfly in the manifold. Speeds of the air had to travel through an elongated pipe to improve the low end torque at a low engine. On the other hand, at a higher engine, the speeds of the butterfly in the manifold opened to shorten the intake paths which then increase the volumetric efficiency. (R.,H, Boden, and Harry Schecter,1944).

The volumetric efficiency model is to describe the effectiveness of the air induction process. This is important as not all of the air flow into the intake is inducted to the engine, which can be described by the volumetric efficiency parameter. The manifold dynamic equation combines model of the flow restriction and the volume efficiency model into an overall intake manifold model which helps in identify the changes in manifold air pressure. There are certain factors that can affect the volume efficiency such as the fuel type, fuel or air ratio, fraction of fuel vaporized in the intake system, mixture of temperature uninfluenced by the heat transfer, ratio of exhaust to inlet manifold pressure, engine speed, and the intake and exhaust manifold port design as well as the intake and exhaust valve geometry size, lift and timings.(Ryan, V., Everett,2010)

2.4 EFFECT OF PIPE LENGTH.

Based on such modern concept, the performance and functionality in the small engine of motorcycle requires the maximum power at lower range speed and the flat torque curve over a wide speed range. The combustion is critical to the engine performance, the mechanical design of pipeline of air inlet system has been recognized as very important to engine performance (Chien, – Jong., Shih,2012). Below, the graph have shown the engine performance using different intake pipe length.

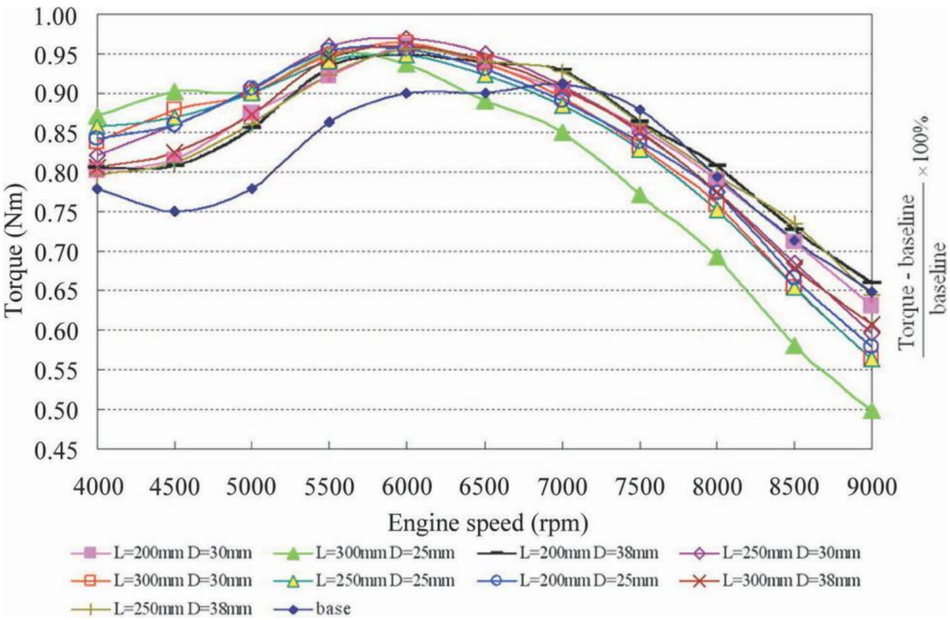

Figure 2.1.: Torque peak different according to the different intake pipe length, L.

Source: Chi-Nan Yeh (2012)

Varying the length of the inlet pipe at constant speed results in over of indicated mean effective pressure against pipe length. If the air flow in the intake pipe, it have a frequency ratio on it. Frequency ratio is define as the ratio of inlet pipe frequency to valve frequency. This frequency ratio is inversely proportional to the product of intake pipe length and engine speed (R.,H, Boden, and Harry, Schecter,1944). But, it have inversely with multi cylinder engine.

While the volumetric efficiency at low speed maybe improved by the use a long pipe. The improvement is expense of volumetric efficiency at high speed. Volumetric efficiency at high speed was not improve by additional inlet pipe length. Experimentally, it has been found that a significant gain in volumetric efficiency is attained when the reflected compression wave returns when the piston is at cranks at angle of 90 degree. At this point, the piston velocity is maximum. Matching the time it takes for the wave to return with the characteristic piston time, the required length of the pipe can be found.(R.,H, Boden, and Harry, Schecter,1944)

2.5 INTAKE BENDING ANGLE

Every type of intake manifold, have different angle. But, different bending angle have consume to the torque and power for an engine. If the angle pipe increased, the torque of an engine has increase in low RPM. (Osama, H.,Ghazal,2012).

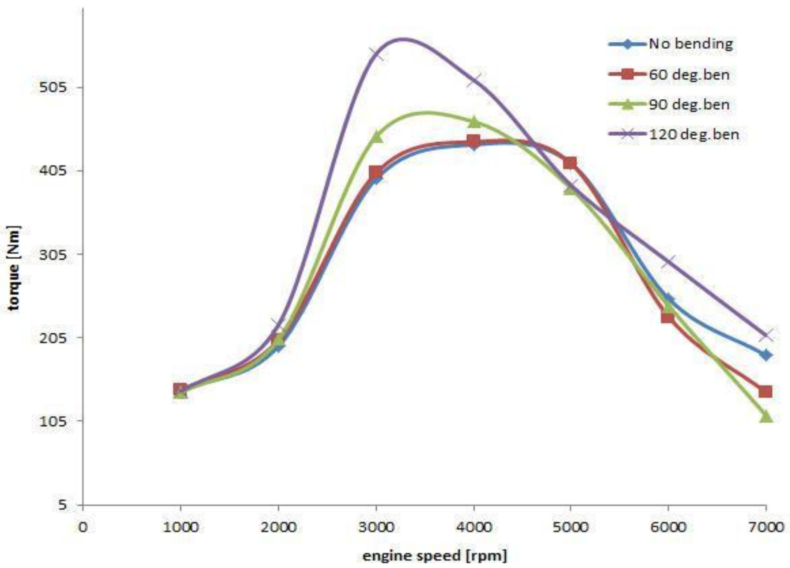

Figure 2.2: Torque against engine speed graph according to the different pipe bending

Source: Osama H. Ghazal(2012).

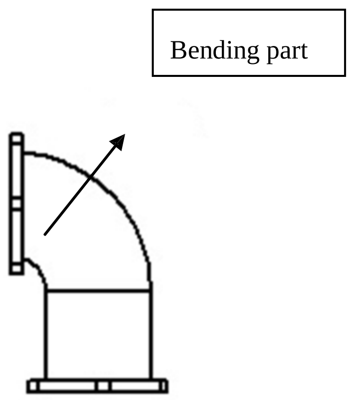

Figure 2.3: Intake pipe bending

2.6 INTERNAL FLOW IN INTAKE PIPE

In internal flow in intake pipe, Reynolds numbers have consuming the high percentage to the engine performance. The Reynolds numbers influence the performance because, from Reynolds numbers, the flow profile can be determined. Reynolds number can be effect by the diameter of the pipe and the pipe length. Flow profile is divided by 3 classes:

Reynolds numbers ≤ 2300 (laminar flow)

2300 ≤ Reynolds numbers ≤ 4000 (transitional flow)

Reynolds numbers ≥ 4000 (turbulent flow)

The transition from laminar to turbulent flow is relating with geometry, surface roughness, flow velocity, and type of fluid. The equation related to determine the Reynolds numbers is:

$$Reynolds\ numbers = \frac{Inertial\ forces}{Viscous\ forces}$$

$$Reynolds\ numbers = \frac{\rho Vavg\ D}{\mu}$$

ρ = density of air (kg/m^3)

Vavg = velocity of air in pipe (m/s) D = diameter of pipe (m)

μ = dynamic viscosity (kg/m.s)

Yunus A. Cengel and John M. Cimbala (2010).

Turbulent flow is selected to increase the performance of an engine in intake manifold category. It is needed because of the flow of mixture between carburation system and cylinder have advantages in increasing the velocity of mixture in intake pipe manifold. (Hee hak Ahn, Sunghyuk Lee, and Sehyun Shin ,1997).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this chapter describe the step of experiment from beginning of the project until the experiment and data analyses have done. Method are used in experiment to achieve the objectives within discuss the project scope. It is composed by four elements to completed the project which is sketching, design, fabrication, testing and experiment. Every element has flow and procedure to achieve the objective of this project.

The project has start with the design of the new test rig that suitable with new engine model which is Modenas GT128. Then project continued with fabrications of new test rig and assemble test rig with base of the dynamometer. After all the beginning step are success, hence proceed to another step which is fabrication of intake pipe design with different in length. Next proceed to experiment utilizing dynamometer using difference length of intake pipe and recorded the data. The overall methodology is as summarized in flow chart in Figurre 3.1.

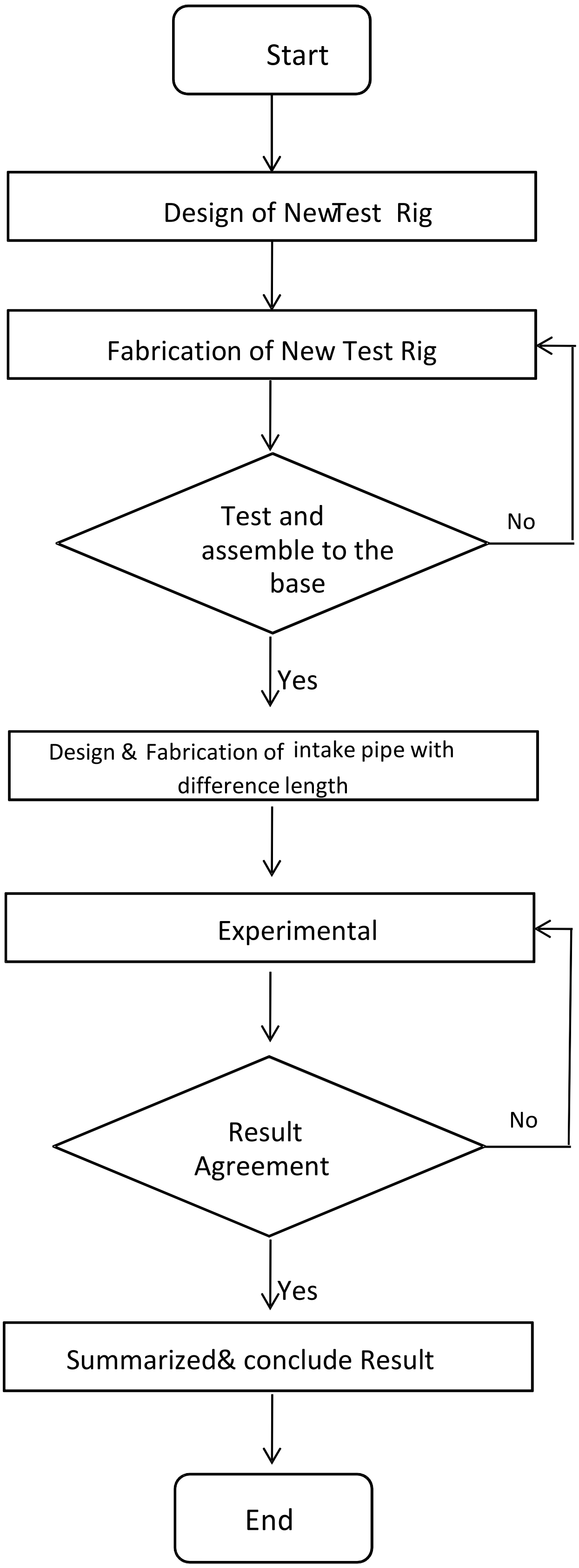

Figure 3.1: Methodology flow chart

3.2 DESIGNING THE TEST RIG FOR FOUR STROKE ENGINE

Engine test rig is the stand that holds the engine for going through the experiment by using engine dynamometer. The dimensions for new test rig actually follow the previous dimension. All the dimensions are same except the material that use for the test rig and the design. Previous test rig are only specific for FZ150i, hence it cannot be use for this experimental because it is use engine from GT128. First thing first before make a possible sketching for new design of the test rig is takes the dimension of the previous test rig including the height, width and length. Everything needs to be specified because it will connect to the dynamometer shaft to undergo the experiment. If the dimension is not correct the output shaft from engine that need to assemble with the input shaft of dynamometer are cannot mesh or connected. Figure 5 show the test rig of FZ150 that already connected to the input shaft of dynamometer.

Figure 3.2: Previous test Rig for FZ150i

Source: Dynamometer Lab FKM

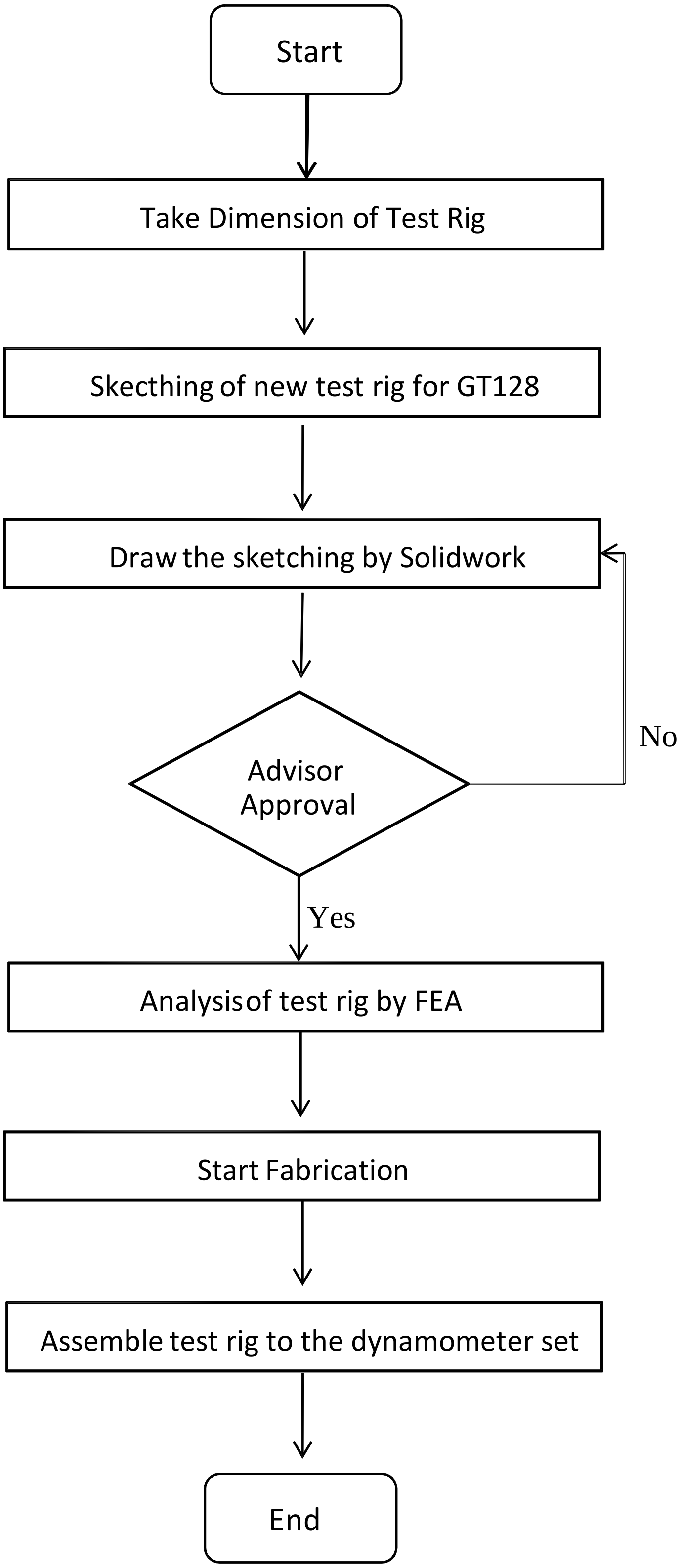

Figure 3.3: Flow Chart of designing New Test Rig GT128