DESIGN AND FABRICATION OF FIRING TEST RIG FOR TWO-STROKE SPARK IGNITION ENGINE

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BORANG PENGESAHAN STATUS TESIS ◆

JUDUL: DESIGN AND FABRICATION OF FIRING TEST RIG FOR TWO-STROKE SPARK IGNITION ENGINE

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MOHD FADHIL BIN RANI

A report is submitted in partial fulfillment
of the requirements for the award of the degree of
Bachelor of Mechanical Engineering with Automotive Engineering

Faculty of Mechanical Engineering
Universiti Malaysia Pahang

NOVEMBER 2008

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project report and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature :

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DEDICATION

I would like to show my expression and gratitude to Allah Subhanahu wa Ta'aalaa whose guidance, help and grace was instrumental in making this humble work become a reality. To my beloved parent, Mr Hj Rani Bin Seman and Pn. Zabariyah Binti Ahmad and to all by sibling and friends. Also to all staff in Faculty of Mechanical Engineering from University Malaysia Pahang especially to my supervisor Mr. Nik Izual Bin Nik Ibrahim.

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ABSTRACT

The two-stroke engine is widely used in motorcycle especially in motorcycle racing and also for the kart engine. The mechanical simplicity of the two-stroke engine gives it great power, and makes it a tempting target for tuning operations. The key to successful design, development and modification is knowledge of the engine's operating principles itself [8]. A firing of engine test rig built specifically for high speed application is design for two strokes spark ignition engine to allow further study and have better understanding of flow mechanism of the engine at high speed condition. This project represents the experimentally testing for two-stroke spark ignition engine and the method of measurement for the engine. The objective of this project is to design and fabrication of firing test rig for two-stroke spark ignition engine. The first step is design and modeling of the engine test rig using the SolidWork 2005 software. Then, after the design have been finalize, the fabrication process will take place to mount the engine and also all the equipment needed during the testing. For fuel consumption measurement, the data will completely using a gravimetric method and for air consumption measurement, the data will be are measuring using the airbox method respectively.

ABSTRAK

Enjin dua lejang telah digunakan dengan meluas dalam motosikal terutama dalam motosikal lumba dan ia juga digunakan dalam enjin kart. Mekanikal yang mudah dalam enjin dua lejang memberikannya kuasa yang hebat dan membuatkan ia mencapai target dalam operasinya. Kunci untuk berjaya dalam mereka, membangun dan memodifikasi enjin dua lejang adalah dengan memahami prinsip operasi enjin dua lejang itu sendiri. Pembinaan tempat untuk menguji prestasi dalam pembakaran sesebuah enjin dalam kelajuan yag tinggi adalah kursus untuk memudahkan kajian di masa hadapan serta permahaman yang mendalam dalam mekanisma pembakaran didalam enjin pada kelajuan yang tinggi. Projek ini memperkenalkan ujian secara experiment untuk enjin dua lejang nyalaan pencucuh dan cara untuk mengukur data bagi enjin ini. Objektif utama untuk projek ini adalah mereka dan membuat tempat menguji enjin dua lejang nyalaan pencucuh untuk kes pembakaran. Langkah pertama adalah menguji enjin dalam kelajuan yang berbeza. Kemudian, data akan diambil daripada alat ukuran yang telah di pasangkan kepada panel dan disambung secara terus kepada DAQ sistem. Untuk pengukuran kadar minyak, data akan diambil sepenuhnya dengan cara graviti dan untuk pengukuran bagi kadar udara, data akan diukur menggunakan cara airbox.

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LIST OF SYMBOL

B	Cylinder bore
N	Engine speed
N_c	Number of cylinder
P	Pressure
P	Power
$\dot{Q}$	Heat transfer rate
R	Gas constant
S	Stroke length
T	Temperature
T_o	Standard temperature
V	Cylinder volume
V_d	Displacement volume
m	Mass
m_a	Mass of air
m_f	Mass of fuel
$\dot{m}$	Mass flow rate
$\dot{m}_a$	Mass flow rate of air
$\dot{m}_f$	Mass flow rate of fuel

n	Number of revolution
q	Heat transfer per unit mass
$\dot{q}$	Heat transfer rate per unit mass
r	Connecting rod length
v	Specific volume
η_c	Combustion efficiency
η_f	Fuel conversion efficiency
η_v	Volumetric efficiency
ρ	Density
ρ_a	Density of air
ρ_f	Density of fuel

LIST OF ABBREVIATION

AFR	Air to fuel ratio
BDC	Bottom dead center
imep	Indicated mean effective pressure
mep	Mean effective pressure
SI	Spark ignition
TDC	Top dead center
WOT	Wide open throttle
DAQ	Data Acquisition System
MIG	Metal Inert Gas
SMAW	Shielded Metal Arc Welding
RPM	Revolution Per Minutes

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

A firing condition for two-stroke engine test-rig have been design and develop to allow a further study and have better understanding about performance and the gas emission of the two-stroke engine test rig [3] [4]. Experiment method is the most reliable method to investigate the cause and effect and to execute parametric engine study on engineering device. The test engine is mounted on the engine casing which gives easiness in storage and portability. The development of the test-rig engine casing needs to use the strong and light weight material like alloy steel and its have to require fewer tools as possible. The casing has to be fitted and assembled as rigid as possible to avoid the casing from loosen because of the vibration occur during the performance testing. The damage also will be effected the experiment result.

1.2 PROBLEM STATEMENT

The principle advantages of the two-stroke engines are high specific power output, mechanical simplicity and low production and maintenance cost. However, these engines have serious drawback, like poor brake thermal efficiency and emission levels of HC and CO. On the previous study [1] [2] [5] [6] [10], these are due to short-circuiting of the fresh fuel air mixture and poor combustion at light load arising due to exhaust gas dilution of the charge. Also it’s not clearly specified the parameter of the two-stroke engine testing [17] [23] [46] [48]. The performance of the engine 2 stroke cannot be clearly discussed. Through this study, the important parameters of two stroke engine testing will be determined.

1.3 OBJECTIVE

The objective of this project is to design and fabrication of firing test-rig for two-stroke spark-ignition engine.

1.4 SCOPES

1) Literature review about two-strokes engine
2) Design and modeling of the engine test rig for firing condition
3) Fabrication of engine test rig for firing engine testing for two-stroke small engine
4) Measurement installation equipment on the test rig for firing condition

CHAPTER 2

LITERATURE RIVIEW

2.1 INTRODUCTION

This chapter will provide about all the data collection done regarding on the project title and based on the fabrication of firing test-rig for two-stroke spark-ignition engine. Because of the title is design and development of new engine test-rig for two-stroke spark-ignition engines, the first step is to study about the project via searching the related literature review about the project and important information is gather. The first topic is about to define the internal combustion engines and then it follows by the basic understanding of the two-stroke engines. Some study about the advantages two-stroke engines over four stroke engines has been carried out to differentiate this kind of engines.

2.2 INTRODUCTION TO INTERNAL COMBUSTION ENGINE

The internal combustion (IC) engine date back to 1876 when Nicolaus A. Otto first develop the Spark-Ignition engine and 1892 when Rudolf Diesel invented the Compression-Ignition engine [1] [4] [5]. Internal combustion engines are used to produce mechanical power from the chemical energy contained in hydrocarbon fuels.

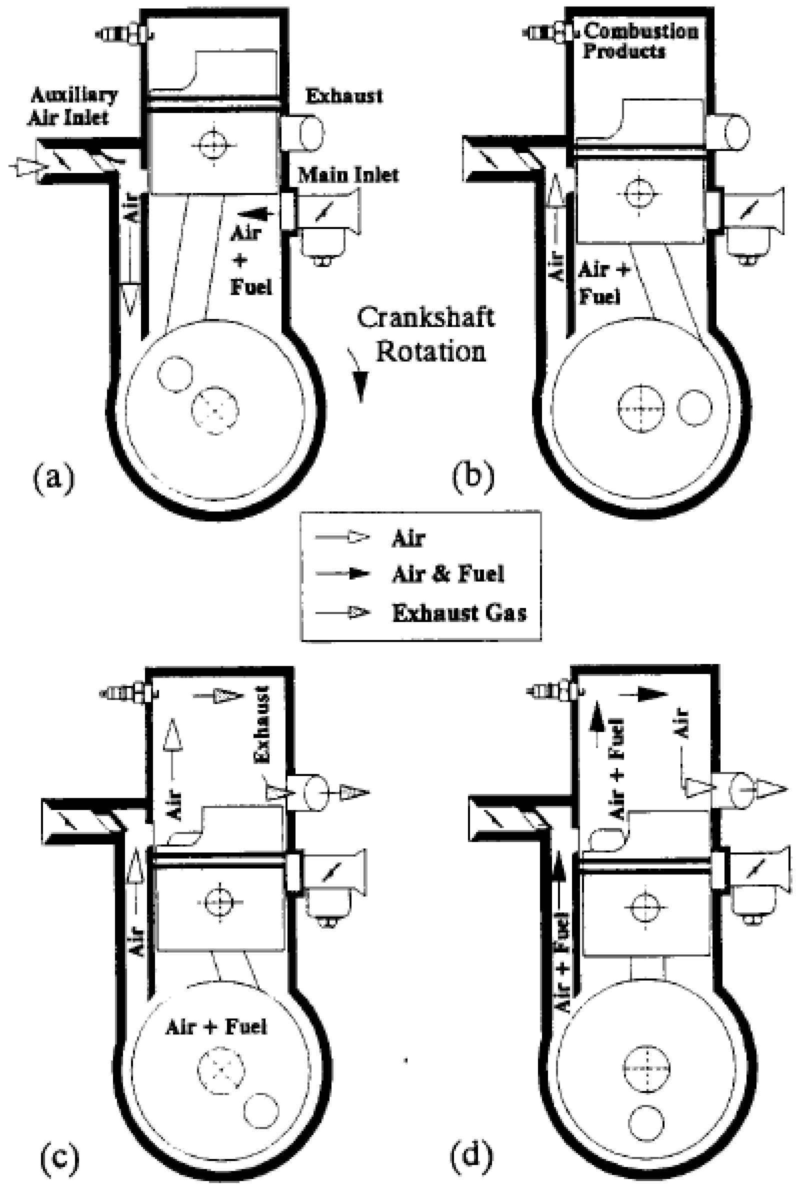
An internal combustion engine is any engine that operates by burning its fuel inside the engine. The most common internal combustion engine type is gasoline powered. Others include those fueled by diesel, hydrogen, methane, propane and many more. Engines typically can only run on one type of fuel and require adaptations to adjust the air/fuel ratio or mix to use other fuels [2] [4]. In a gasoline engine, a mixture of gasoline and air is sprayed into a cylinder. This is compressed by a piston and at optimal point in the compression stroke, a spark plug creates an electrical spark that ignites the fuel. The combustion of the fuel results in the generation of heat, and the hot gases that are in the cylinder are then at a higher pressure than the fuel-air mixture and so drive the piston back down. These combustion gases are vented and the fuel-air mixture reintroduced to run a second stroke [40] [42]. The outward linear motion of the piston is ordinarily harnessed by a crankshaft to produce circular motion. Valves control the intake of air-fuel mixture and allow exhaust gasses to exit at the appropriate times [24] [28].

The combustion in the two-stroke engine depends strongly on the scavenging gas flow. The measurement of scavenging process of internal combustion engines is extremely difficult, and there are few direct method to determined the flow rate of the fresh air into the cylinder to understand the scavenging flow process [5] [7].

2.3 TWO STROKES ENGINES

The cycle as in two or four, of an internal combustion piston engine is defined by how many strokes of different direction must be accomplished to complete one cycle of combustion. One cycle is defined as the time between two ignitions of combustible material. The cycles are often divided into strokes. Each stroke is motion in one direction [3].

In two strokes engines, the cycle is completed in one revolution of the crankshaft [3] [9]. In these engines, the crankshaft is sealed, and the outward motion of the piston is used to slightly pressure the air-fuel mixture in the crankcase. Also the intake and exhaust valves are replace by opening in the lower potion of the cylinder wall. During the latter part of the power stroke, the piston uncover first and exhaust port, allowing the exhaust gases to be partially expelled, and the intake port, allowing fresh air-fuel mixture to rush in and drive most of the remaining exhaust gases out of the cylinder [4].The potential of the two strokes engines has become more and more subject to increasing research work trying to optimize the power-weight ratio as well as the pollution emissions especially with the development of high efficient direct injection system [6] [12] [13]. The conventional two stroke engine operates by inducing the air and fuel into the crankcase and supplies a homogeneous mixture of air and fuel to the cylinder [16]. The principle advantages of these two strokes engines are high specific power output, mechanical simplicity and low production & maintenance cost [3] [15].However, these engines have serious drawbacks, like poor brake thermal efficiency and emission level of HC and CO [5] [13] [38] [49].



(a) Air intake (b) Compression (c) Combustion (d)Exhaust emission

Figure 2.1: Scheme Cycle in 2-Stroke Engine System [24].

2.4 ADVANTAGES AND DISADVANTAGES OF TWO-STROKE ENGINES

2.4.1 Advantages

- Two-stroke engines do not have valves, simplifying their construction [3].
- Two-stroke engines fire once every revolution while four-stroke engines fire once every other revolution. This gives two-stroke engines a significant power boost [3] [4].
- Two-stroke engines are lighter, and cost less to manufacture [3] [33] [47].
- Two-stroke engines have the potential for twice the power in the same size because there are twice as many power strokes per revolution [3].

2.4.2 Disadvantages

- Two-stroke engines don’t live as long as four-stroke engines. The lack of a dedicated lubrication system means that the parts of a two-stroke engine wear-out faster. Two-stroke engines require a mix of oil in with the gas to lubricate the crankshaft, connecting rod and cylinder walls [3].
- Two-stroke oil can be expensive. Mixing ratio is about 4 ounces per gallon of gas will burning about a gallon of oil every 1,000 miles [3].
- Two-stroke engines do not use fuel efficiently, yielding fewer miles per gallon [3].
- Two-stroke engines produce more pollution [5] [13].

2.5 ADVANTAGES OF 2-STROKE ENGINES OVER THE 4-STROKE ENGINES

The main difference between two strokes and four strokes engines is the method of filling the fresh charge and remove the burnt gases from the cylinder [3].The advantages of two strokes engines over four strokes are evident [6]

- A compact size and low weight with respect to engines output and potentially smaller mechanical losses [6].
- Higher engine power per weight ratio will result the smoother torque vs. time profile; smaller flywheel (lower moment inertia) [1]
- Exhaust and intake strokes are removes, thus doubling the number of power strokes per unit time [1]
- Mixing between the two gasses result in inherent exhaust gas recycling and reduction of NO_x emissions [1] [4].
- Simple structure, low production cost, small bulk volume and simple maintenance [1].
- Potential for lower exhaust emissions and superior thermal efficiency, reduced weight and greater compactness [27].
- The inherent double cycle frequency and the low mechanical friction and pumping losses give to the two-stroke engine its qualities of high specific power, compactness, and drive ability and low nitric oxides emissions[21] [27].

Table 2.1: Comparison of Four Strokes and Two Strokes Cycle Engines [3] [25] [27].

Four strokes engines	Two strokes engines
The thermodynamic cycle is completed in four strokes of the piston or in two revolutions of the crankshaft. One power strokes is obtained in every two revolution s of the crankshaft.	The thermodynamic cycle is completed in two strokes of the piston or in one revolutions of the crankshaft. One power strokes is obtained in each revolution s of the crankshaft
Turning moment is not so uniform and hence a heavier flywheel is needed	Turning moment is more uniform and hence a lighter flywheel can be used
Power produced for same size of engines is less, or the same power the engines is heavier and bulkier	Power produced for same size of engines is twice, or for the same power the engines is lighter and compact
Four strokes have valves and valve actuating mechanism for opening and closing of the intake and exhaust valve for opening and closing of the intake and exhaust valves	For the valves, the Four strokes engines have no valves but only port (some two strokes engines are fitted with conventional exhaust valve or reed valve)
Because of comparatively higher weight and complicated valve mechanism, the initial cost of the engine is more	Because of light weight and simplicity due to the absence of valve actuating mechanism, initial cost of the engine is less
Volumetric efficiency is more due to more time for induction	Volumetric efficiency is low due to lesser time for induction
Thermal efficiency is high, part load is better.	Thermal efficiency is power, part load is poor.
Used where efficiency is important like in car, busses, truck, tractor, aero planes and power generation.	Used where low cost, compactness and light weight are important like in mopeds, scooters, and motorcycles

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will explain detail about the methodology from the beginning until the project will be achieved. In order to make the project successfully, the work have to be arrange carefully and its have to pass through the step by step and work by work to make sure the project progress can be done in fluently without any rough error.

3.2 THE FLOW CHART

This project is start with search the literature review about the project and the main important of the project is to determination of the objective. The literature reviews play an important part to give a information about the study case also give a way how to deal with the problem that will face along the project journey. The flow chart is the simplest, compact and the best way to show the overall project methodology and the all the project progress is shown in order to achieve the objective of this project. The overall methodology is explaining based on the flow chart below:

OVERALL METHODOLOGY

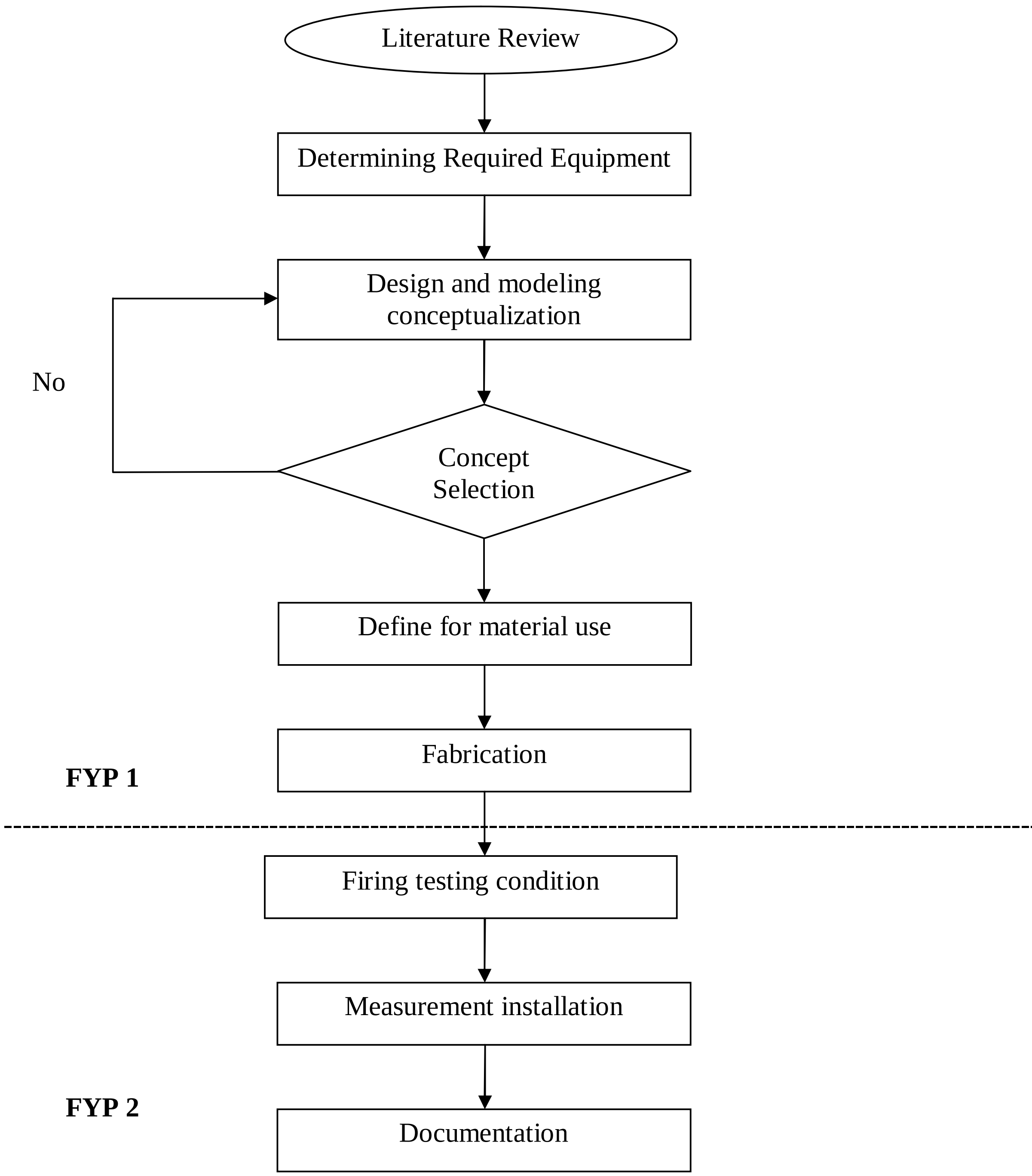


Figure 3.1: Flow Chart of Overall Methodology

3.3 METHOD OF STUDY

3.3.1 Experimental Study for firing condition

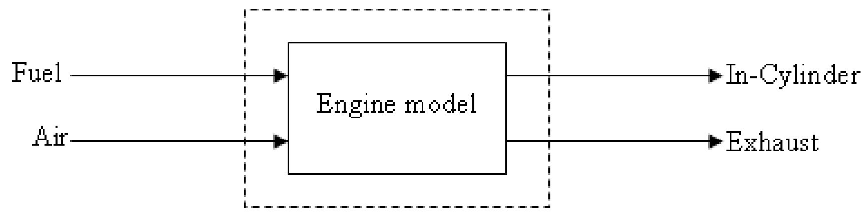


Figure 3.2: Engine Model with Input-Output Parameter [6].

Experiment method is the most reliable method to investigate the cause and effect and to execute parametric engine study on engineering device. Firing measurement in engines at a particular location and engine speed were performed consecutively but in different run with no changes in engine operating parameters [5] [13]. The input to the engine can be classified into two which are fuel and air. In this project, fuel and air usually measured in term of volumetric or mass flow rate and water input represent in the inlet temperature and mass flow rate of the engines cooling system. The output parameter for the engine is the in-cylinder properties and the exhaust gas. The most often measured cylinder properties is the cylinder pressure and the exhaust gas usually measured by taking the exhaust gas composition of the harmful exhaust gas like CO_2, O_2 and NO_2.

Table 3.1: Small Fan Calibration Curve for Use as Load on Small 2-Strokes Engines

Fan speed		**Mean**		**Lower limit**		**Upper Limit**	
		Torque	**Power**	**Torque**	**Power**	**Torque**	**Power**
Hz	**RPM**	**Nm**	**W**	**Nm**	**W**	**Nm**	**W**
10	600	0.17	10	0.13	0	0.21	20
20	1200	0.51	63	0.47	53	0.55	73
30	1800	0.97	183	0.93	173	1.01	193
35	2100	1.25	274	1.21	264	1.29	284
40	2400	1.55	388	1.51	378	1.59	398
45	2700	1.87	528	1.83	518	1.91	538
50	3000	2.22	695	2.18	685	2.26	705

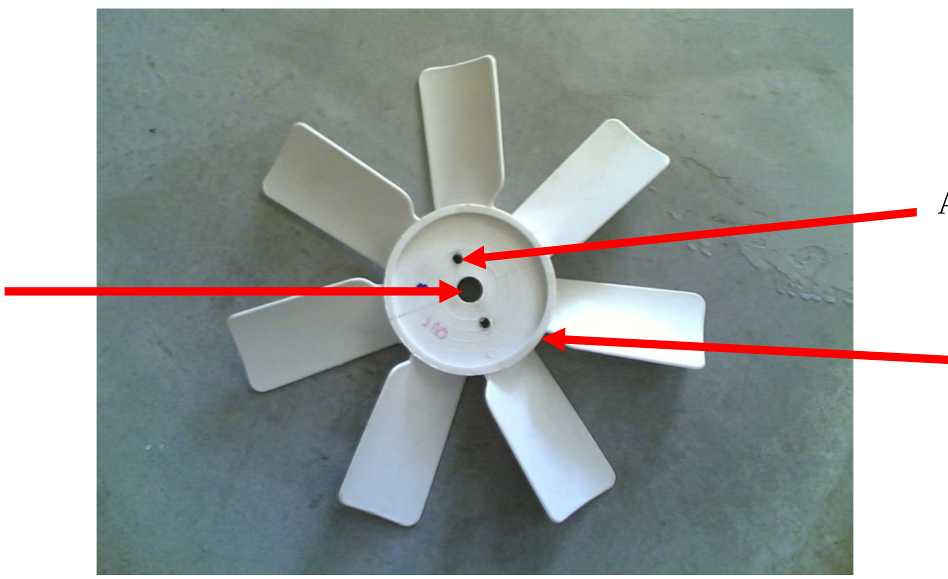


Figure 3.3: Small Fan Used As Load on Small 2-Strokes Engines

Outer diameter : 12.4 cm

Inner diameter : 2.0 cm

Attach diameter : 1.0 cm

3.3.2 Engine Specification

Figure 3.4: Tanaka Engine BG-328A

The engine that test in this project is two-stroke spark ignition engine model 328 A Tanaka Engine. The specifications of engine are shown below [3] [5]:

Table 3.2: 328 A Tanaka Engine Specifications [30] [5]

Parameter	Size/ Feature
Cylinder type	Single cylinder, piston ported
Compression type	Crankcase compression
Displacement	30.5 cm^3
Scavenging concept	Multi port-loop scavenged
Bore x Stroke	36 x 30 mm
Exhaust port opening / closing	101 CA ATDC / 259 CA ATDC
Scavenged port opening / closing	140 ATDC / 220 CA ATDC

3.4 DETERMINING REQUIRED COMPONENT

3.4.1 Pressure Transducer

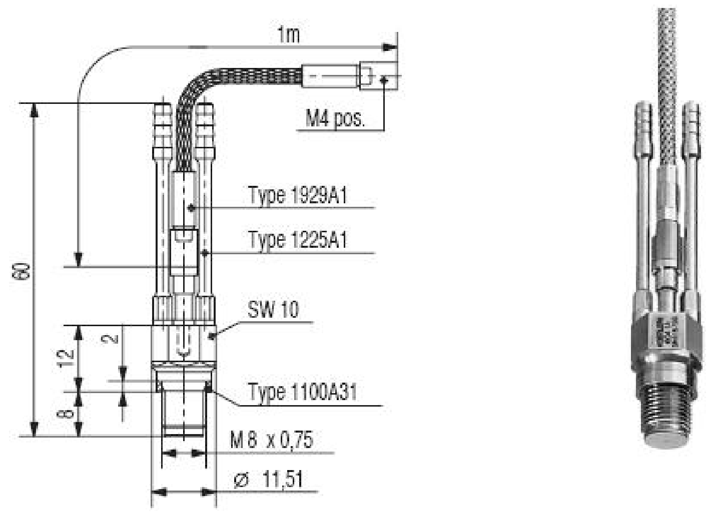


Figure 3.5: Kistler Type 6041A Pressure Transducer [31]

In order to measure the pressure produced in the engines, two different location of pressure transducer have been mounted in the engine system. Cylinder pressure was recorded with a Kistler Type 6041A water cooled pressure transducer is place in the cylinder head at top side.

This pressure measurement was used in analyzing the data and also ad the indicator of the extend of high-pressure gas leakage as the ring material degraded under the high temperature fired engines conditions [12]. To mount the second sensor, the cylinder head was drilled using the computer numerical control (CNC) milling to make a hole for sensor location with a thread size M8 x 0.75mm. This sensor is used to measure data at the intake port which is low range type. The flushed mounting was being applied to minimize the lag in the pressure signal and avoid pipe connecting passage resonance. The Collected of cylinder pressure data at the average over 120 consecutive cycles with a crank angle encoder having resolution of 0.4º CA [5]. The units of pressure are defined through the standard of the fundamental dimension of mass, length and time [28].

Figure 3.6: Pressure Transducer Sensor Type 6041A [5].

3.4.2 Crank Angle Encoder

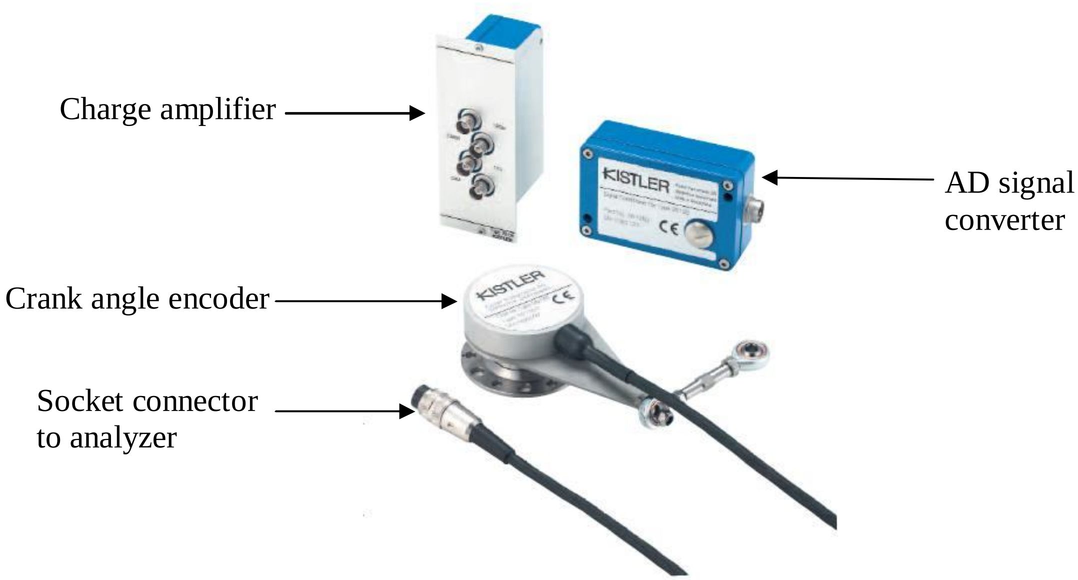


Figure 3.7: Crank Angle Encoder and Data Acquisition Kit [6]

Crank angle that being used is kistler crank encoder type 2613B. It's provided the basis for allcrack-angle-related measurement of internal combustion engines [5].

It is consist of an angle encoder and signal conditioner. The crank angle encoder contains a precision marker disk with a trigger mark and 360 angle marks which is scanned by a transmission photoelectric cell. The speed range of 1 to 20 000 rpm the encoder can be used on a large variety of engines [5][24]. An extremely exact alignment of top dead center of each cylinder to the trigger signal of the encoder is deceived for precious indication (TDC determination) [30]

Table 3.3: Technical specification of crank angle encoder [30]

Kistler Crank Encoder type 2163B		
TTL crank angle signal		
Resolution	o	0,1………..6
Dynamic accuracy		
at 10000 1/min (signal delay)	o	+0.02
TTL trigger signal (TRG)		
Resolution	o	0,1………6
		1……….20000
Speed range	1/min	
Operating temperature range		
Encoder and amplifier	^{o}c	-30…60
Connection flange	^{o}c	-30…60
Power supply		
With stabilized voltage	VDC	5+/-.25
Current consumption	mA	200
With unstabilized voltage	VDC	6……..24
Current consumption	mA	200…..400

Mounting diameter of encoder	mm	69
Encoder weight	g	460
Amplifier dimensions	mm	98 X 64 X 37
Amplifier weight	g	300

3.4.3 Data-Acquisition (DAQ) System

Data-Acquisition (DAQ) System is the portion of a measurement system that quantifies and stores data. Person who read a transducer dial associates a number with the dial position, and record the information in a log book perform the entire task germane to a Data-Acquisition System [12],[13], [29]. Data logging capability was required to recorded pressure and crank angle signals with sampling speed of 9600 bits/second.

The computer based data acquisition system is the SPRCTRUM CA series / NI-6070 card installed on DEWE-5000 and interpretation data transferred to via Excel file [5][30].

Figure 3.8: Data Acquisition System (DAQ)

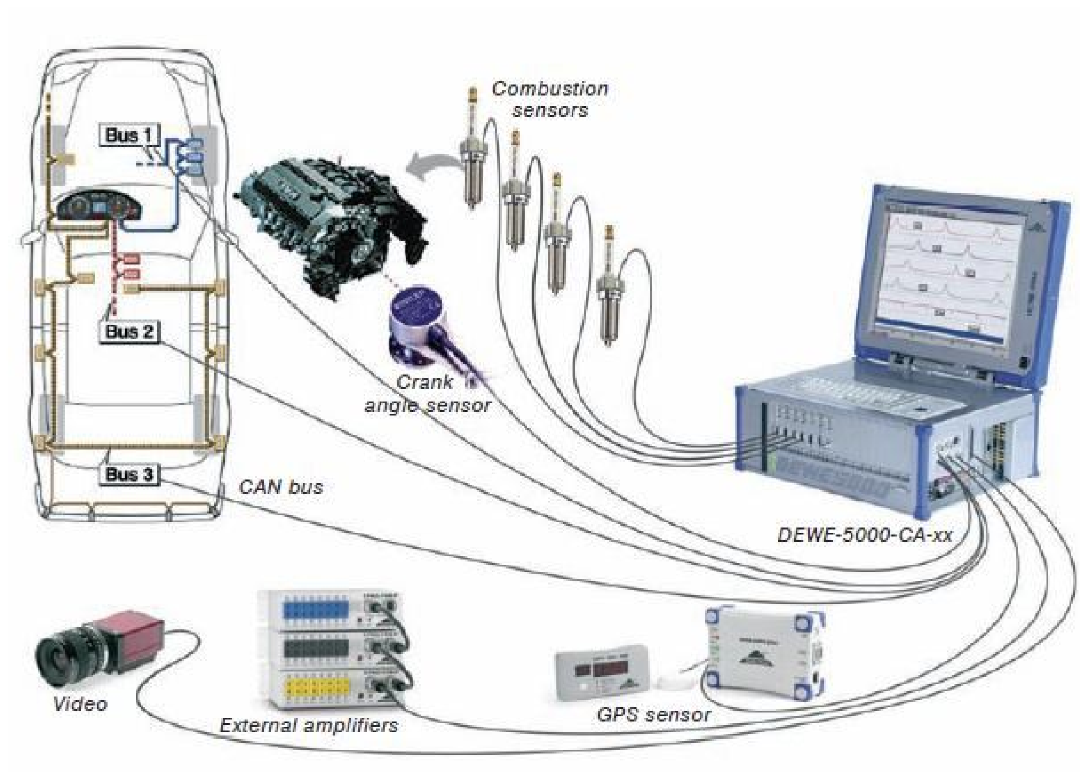


Figure 3.9: Data Acquisition Setup [30]

3.4.4 The Airbox

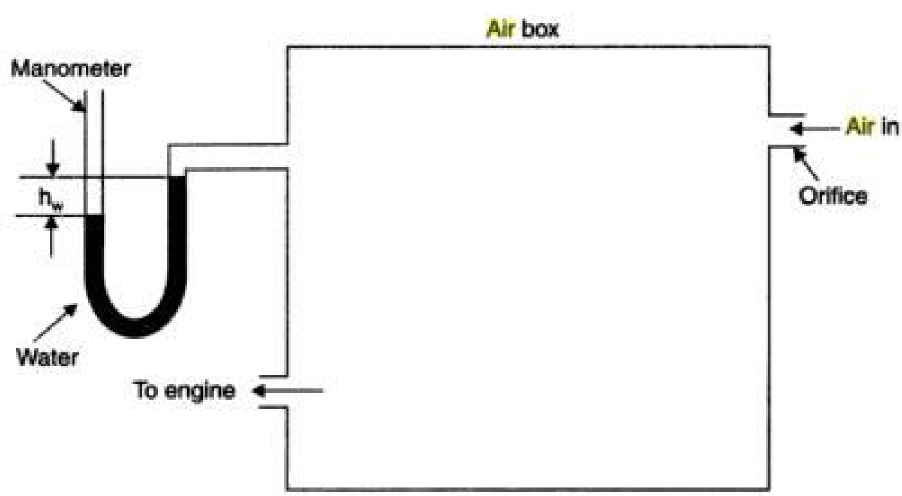


Figure 3.10: Surge Tank with Orifice Position [32]

Minimum desirable of surge tank [32]

$$V_{min} = \frac{417\ x\ 10^6 x\ K^2 x\ d^4}{N_c V_s n^2 min}$$

K	: 1 for 2-stroke and 2 for 4-stroke
Nc	: No. of cylinder
d	: diameter of the orifice
Vs	: swept volume per cylinder
Nmin	: min engine speed at which accurate measurement is required

The minimum desire of surge tank:

$$V_{\mathrm{min}} = \frac{417x10^6\ x\ 1^2 x\ (0.011417)^4}{(1)x\ (3.05362x10^{-5})x(1100)^2}$$

$$= 0.19175\ \mathrm{m}^3$$

3.4.4.1 Determining the Orifice Size

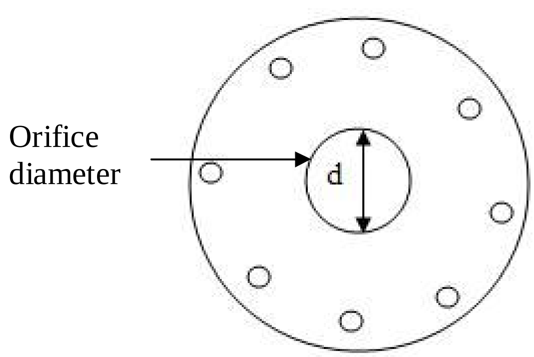


Figure 3.11: Orifice Size of Air Box [6]

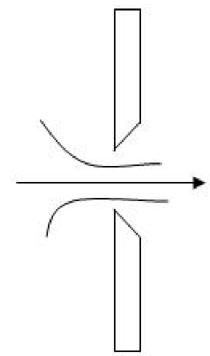


Figure 3.12: Flow through a Sharp Edge Orifice [6]

Table 3.4: Approximates Flow Rates for Orifices [32]

Orifice dia. (mm)	Q (m3/s)	m (kg/s)
10	0.002	0.002
20	0.008	0.009
50	0.048	0.057
100	0.19	0.23
150	0.43	0.51

Swept Volume for engine Tanika BG-328A

$$v_s = \frac{\pi B^2}{4} X\, S \quad [32]$$

B = piston bore

S= stroke

From the engine specification;

$$v_s = \frac{\pi x\,(0.036)^2}{4} X\,(0.03)$$

$= 3.05362 \times 10^{-5}\ m^3$

$= 0.0000305362\ m^3$

The air consumption of an engine calculated by:

$$V = \eta_v \frac{v_s}{k} \frac{n}{60}\ m^3/s \quad [6]$$

η_v= initial sizing of the measuring orifice

Vs= swept volume

So,

$$V = 0.8\ \frac{3.05362\text{x}10^{-5}}{1}\ \frac{7000}{60}\ \ m^3/s$$

$$= 0.00285\ m^3/s$$

From the table 5 and by intersection, suitable orifice size:

$$= 11.42\ mm$$

3.5 DESIGN, MODELING AND CONCEPT SELECTION

The design and conceptualization for engine test-rig two-stroke spark ignition engine for firing condition has been drawing in SolidWork software. The rough concept and the assembly arrangement have been drawn based on the mounting dimension of the engine test rig.

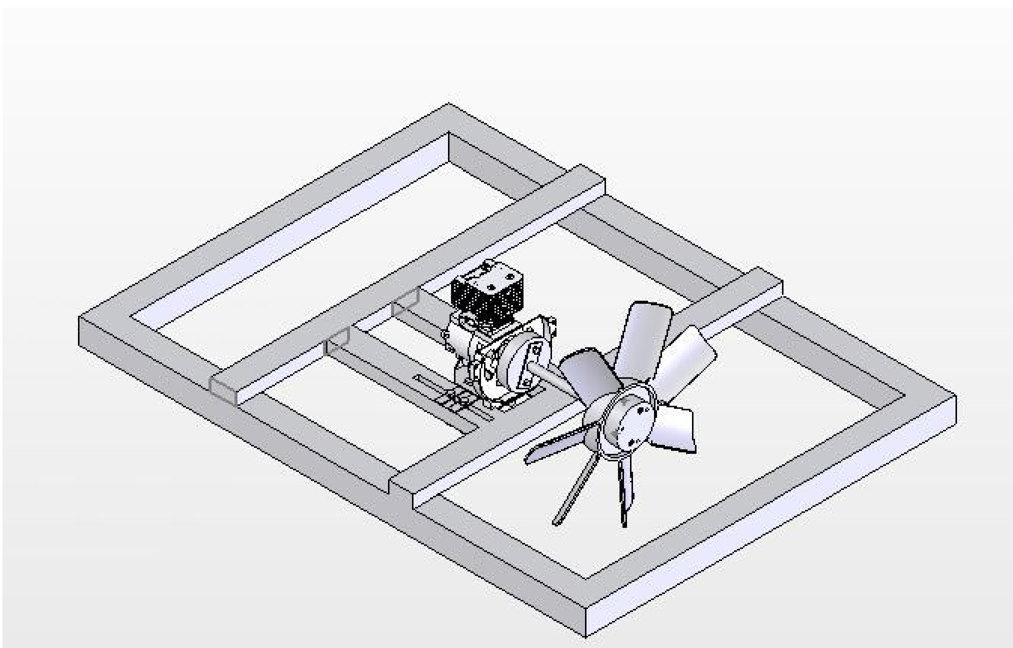


Figure 3.13: Engine Base Concept Using Solidwork Software 2005

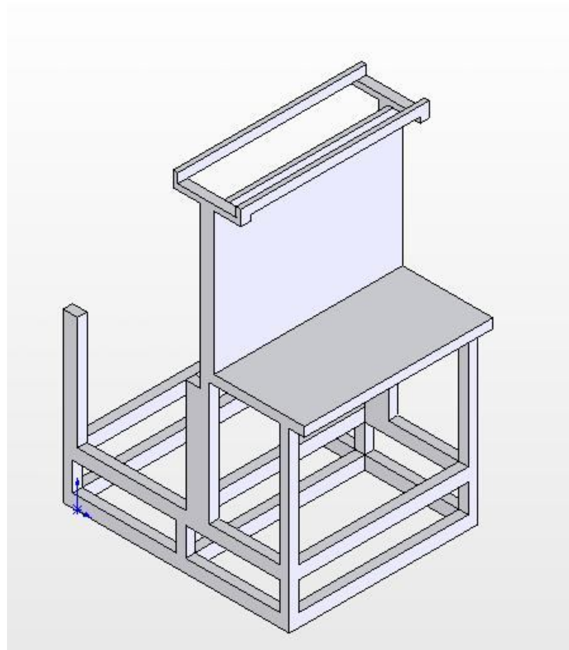


Figure 3.14: Engine Test Rig

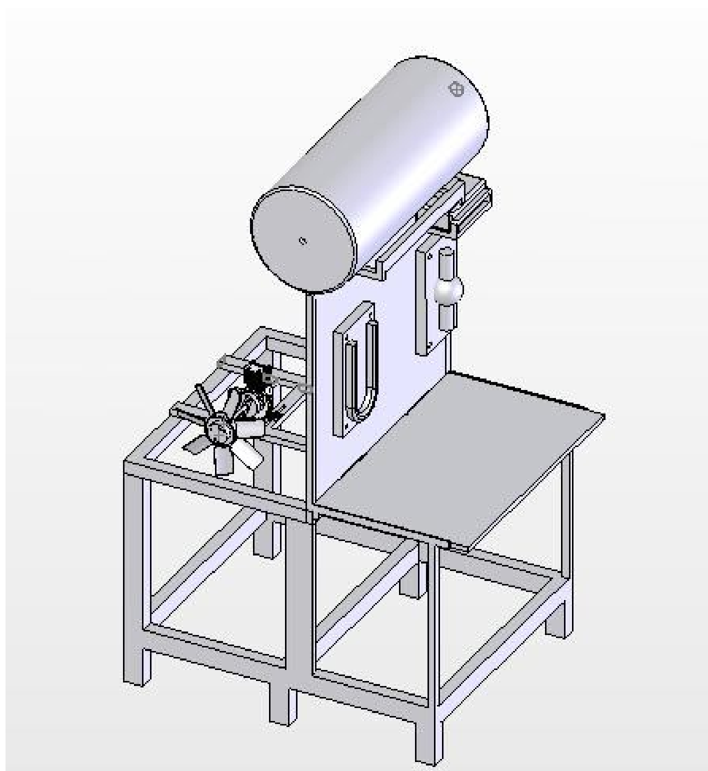


Figure 3.15: Engine Test Rig for Firing Condition

3.5.1 Fabrication

To fabrication process has take their place when the modeling conceptualization and all the required material needed have been define. This follows the gantt chart and the material selection process is carried out along with the fabrication process.

First of all, a raw material have been define and collected according to the engine condition which it is a small engine. The raw material that been used in this project is project is follow:

Table 3.5: Table of Material

No	Part Name	Material	Quantity	description
1	Engine Stand	Tubular Steel Bar	11	3 x 2 inch
2	Surge Tank Stand	Aluminum Bar	2	1 x 1 inch
3	Surge Tank Holder	Mild Steel Bar	4	2 x 1.5 inch
4	Panel Holder	‘L’ iron	2	3 x 4 inch
5	DAQ base	Plywood	1	19 x 40 inch
6	Hex Bolt	Mild Steel	4	M10 x 50 mm
7	Hex Bolt	Mild Steel	10	M4 x 30 mm
8	Hex Bolt	Mild Steel	2	M6 x 40 mm
9	Washer	Iron	16	M10
10	Washer	Iron	18	M4
11	Air tube	Plastic	3 meter	3cm inner diameter
12	Air tube	Plastic	4 meter	0.7 inner diameter
13	Surge tank	Plastic	1	0.2 m^3

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

The main objective of this project is to design and development of new engine test-rig for two-stroke spark ignition engine. The fired condition has been applied on the fabrication process and the engine location is chosen in a suitable place on the test rig for the easier measurement installation.

The fabrication process takes about three month to finish and another one month for the measurement installation. During the fabrication process, there are several problems have been occurred and yet to be determined but the development work is progressively in schedule. Instead of executing the rig construction, some effort paid to design the engine test rig computationally

The concept of the engine test rig and its major component will provide smoother and easier operation for the firing testing. The entire of the fabrication process is in the laboratory where the entire tool needed to mount this engine test is provided.

4.2 FABRICATED PART

In this project, the main part that needed to be fabricated is engine stand. The function of this engine stand is to mount the engine on it and also to hold the engine while the engine testing is running for firing condition. The space for the engine in wide and the engine is located at the centralized of the engine stand to make it more stable and less vibration during the testing.

The first step is to check all the material that required in this project in the FKM laboratory. All the material that has been defined has been gather at the automotive section for cutting process. All the parameter for the cutting process has been mark on the material.

Figure 4.1: Raw Material for Fabrication

Figure 4.2: Measurement on the Raw Material

The raw material is then been cut out which is the square tubular mild steel bar into a rough dimension with the disc cutter. The materials then grinded with the hand grinder based on the true dimension that have been define on the drawing in the SolidWork software and followed the engine dimension. The holes for the engine to fix to the engine stand are drilled with a stepped drilling method using pillar drill and drill bit. The step for drilling is start with the small drill bit that is 3 mm diameter, 6 mm and lastly 8 mm holes.

Figure 4.3: The Disc Cutter

Figure 4.4: Cutting the Raw Material

The position of the engine has to be considering because a fan will be attach to the engine as a load during the testing. The engine will test in a different speed and the mounting engine has to be strong enough to hold its fixed position to give the precious data.

After all the material has been cut out, it will go to the welding process. The welding that been use is MIG (Metal Inert Gas) welding and the welding process take about one month to finish all the joint on the test rig component. During the welding process, the angel for all the material is really important in order to make sure the test rig is stable enough to hold the engine during the testing. Because of lack angel measurement on the engine test rig, vibration will occur while the engine is running and the DAQ system cannot provide the true data from the crank angel encoder.

DAQ system is one of the components for the engine test rig but it doesn't have to be discussing on this chapter because the fabrication process is not involved on the DAQ system. It was the standalone component and directly connects to the sensor on the cylinder pressure transducer and crank angle encoder to give the reading from the signal of the sensor. The signal is transmitted to DEWE-5000 combustion analyzer via flexible wire.

The shaft from the engine to the fan also has to be fabricated. The shaft is 17.50 cm long and the holes for the fan is 0.8 cm. the length of the shaft is really important because it will effect the rotation of the fan and the torque that will produce from the engine to the shaft. The crank encoder holder that attach to the fan also have been fabricated from a aluminum bar using a milling machine. The thickness of the crank encoder holder is really important in order to make sure the fan is not collided with the crank encoder which can damage the crank encoder. The thickness of the crank encoder holder also will effect the reading because if the engine is carried too much torque on it. Te dimension of the crank angle encoder holder have been showed in the appendix section.

Figure 4.5: The Fabricate Part for the Engine Test Rig

4.3 ASSEMBLY THE TEST RIG

In this chapter the assembly process go trough in two types of assembly process which is permanent assembly and temporary assembly. The permanent assembly is referred on the assemblies that do not allowed to disassembly after the part is joined together and the temporary assembly is the part that can disassembly back after the joint for the further study.

After all the dimension and drawing of the engine test rig component has done in the SolidWok software 2005 and all the fabricated part has been finish fabricated, it go through the assembly process. Here all the detail information like a mounting dimension and the parameter of the test rig component from the SolidWork software 2005 is been applied on the assembly process. The view from the SolidWork 2005 gives the full dimension to make the assembly process easier. The physical dimensions are illustrated in appendix later.

For the main frame of the engine test rig, most of the material that contributed this engine test rig process are assemble by permanent assembly that be done by welding process. The function of this engine test rig is to stand the engine and hold it tight during the testing process. The welding for this part is done by using Metal Inert Gas (MIG) welding which is most suitable welding method in order to joint the parts with tack welding such as joining the angle bar to the main frame. To assemble the airbox stand, the welding method that been use is Metal Arc Welding (SMAW). This is because SMAW is the welding method that relatively thicker filler rod used in this system which is suitable to joint the different metal together and here its use for joint the aluminum bar and the mild steel bar.

Figure 4.6: The Engine Test Rig

When mounting the engine to the engine test rig, the assembly required is temporary assembly which is bolt and nuts are used to fix the engine onto the engine test rig. Between the nut and the bolt, the washer is been used to provide a height adjustment and also act as vibration absorber while the engine is running.

Form the previous study, the location of the engine has to be correct because all the measurement data from the sensor that connect to the engine and to the DAQ system is in limited space due to the length of the sensor wire. The location of the carburetor at the engine also has to be considered because the air from the airbox is directly connected to the engine. Wrong side location of the carburetor and the airbox will give a hard connection on it.

Figure 4.7: Engine Mounting On the Test Rig

4.4 MEASUREMENT TESTING INSTALLATION

4.4.1 Measurement of Air Consumption

From the previous study [6], the simpler method of measuring air consumption involves drawing the air through some form or measuring orifice. The calculations for the orifice size is been determine on the previous chapter and the measurement of air consumption for this project is completed by using conventional differential method of orifice plate meter. The manometer is built with 0.7 inner diameters tube and directly connects to the 0.5 tube tapping on the surge tank surface about D/2 after the orifice plate meter.

The pressure drop across the orifice meter is measured using inclined manometer and the pressure drop theoretically limited to 125 mmH_2O (0.012 bar) [6] [32]. Estimation of the pressure drop also can be done for the know value of flow velocity using empirical relation in the equation.

Figure 4.8: The Inclined Manometer

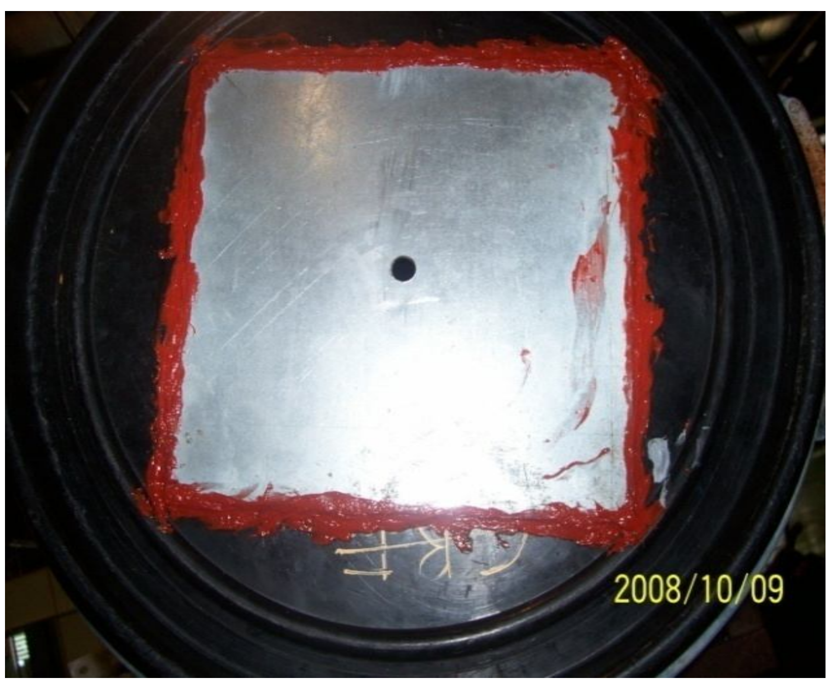


Figure 4.9: The Orifice

Figure 4.10: The Tube Connection from Airbox to the Carburetor

Figure 4.11: The Connection from the Airbox to Carburetor

4.4.2 Fuel Measurement

Fuel flow measurement is accomplished using the gravimetric method where the rate of consumption of specific volume of fuel is recorded. The fuel measurements are built with 0.7 cm diameter and directly connect to the fuel tank. The fuel must be high enough to make sure the gravimetric method can be applied where the fuel can flow down to the engine and by pass a fuel measurement tube.

Figure 4.12: Fuel Measurement Installation

4.4.3 Pressure Measurement

The measurement for the combustion process can be done by using a combustion pressure sensor. From the previous study [5], the cylinder pressure that been use in this project is Kristler Type 6041A water cooled pressure transducer mounted in the cylinder head and use a water as a cooling system while engine is running. This sensor was used to measured cylinder pressure and it was flush mounted in the cylinder head.

The next sensors are mounted at the intake port and scavenge port of the engine which is in low range. The usage of combustion pressure sensor is made simpler with the integration of Dewetron CA 5000. A computerized based combustion analyzer.

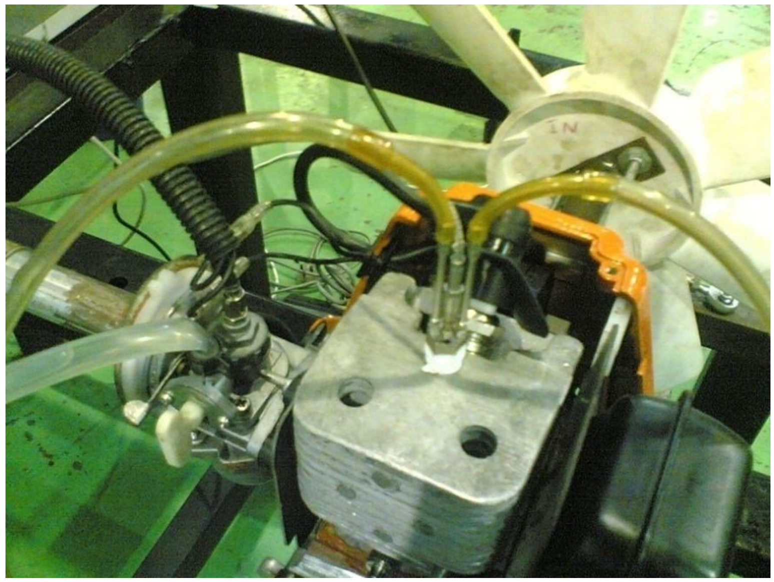


Figure 4.13: The Pressure Transducer Mounted On the Cylinder Head

Figure 4.14: The Pressure Sensor Located At Intake and Scavenge Port

4.4.4 Crank Angle Encoder

The location of the crank angle encoder is attached at the fan that has been used as a load during experiment. The shaft have been fabricated to connect the engine to the fan and the also for the crank angle encoder holder. The function of crank encoder in this project is to measure the speed of the engine and to detect the crank angle position proportional to the pressure sensor.

Figure 4.15: The Crank Angle Encoder Position

4.4.5 Engine Control and Data Acquisition System (DAQ)

When the engine is testing, it's required an equipment to control all the data that want to be measured form the engine. All engine control and data acquisition were perform using DEWE-500 support by software DEWE-CA series system. All the sensor and crank angle encoder is directly connect to the DAQ system at certain of speed.

Figure 4.16: The DAQ System on the Panel Board

4.5 FULLY ASSEMBLY OF ENGINE TEST RIG FOR FIRING CONDITION

After doing a fabrication and measuring installation, the fully assembly and experimental setup of engine test rig for two-stroke spark-ignition engine for firing condition have been completed. A brief test for the engine was been carried out and there was no serious vibration occur during the testing.

Figure 4.17: Complete Assembly of the Measurement Installation

Figure 4.18: Overall Assembly View on Engine Testing For Firing Condition

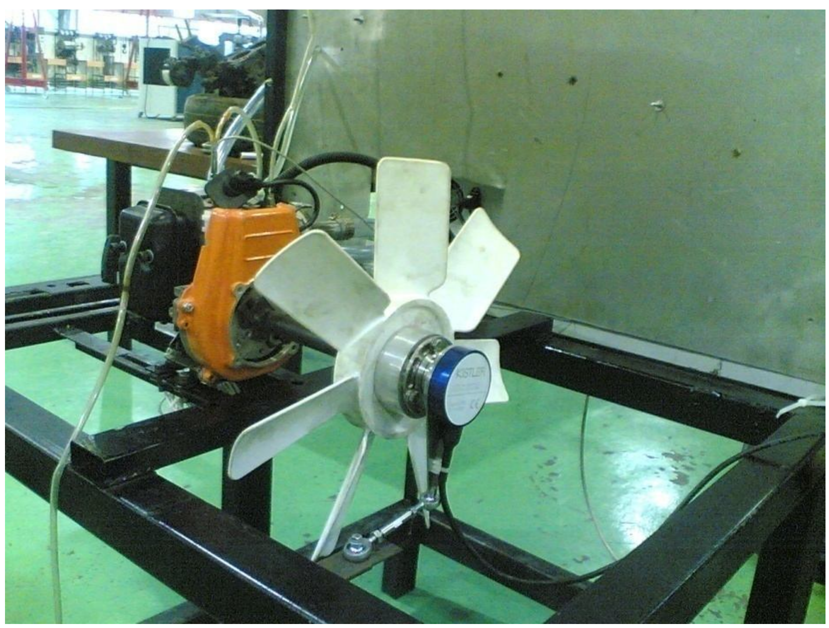


Figure 4.19: Complete Measurement Installation on Testing Engine

4.6 EXPERIMENTAL CONDITION

The major idea and the main objective of this project is to design and development of new engine test rig for two-stroke spark ignition engine for firing condition. The design and development work is put forward to achieve future objective. The concept is important to allow the engine can be running and the data can be measured preciously.

During the firing testing, the engine is target at certain of speed to allow all the data can be measure. The pressure transducer that located at the intake and exhaust port and also the pressure at in-cylinder will takes places to give the measurement data during the combustion process in the engine and cylinder pressure.

The suction of air through the orifice plate at the airbox will give the reading of the air consumption measurement. The air pressure drop across the orifice is measured using inclined manometer which is connected via tube o the tapping on the surge tank. The fuel measurement is accomplished using gravimetric method where rate of consumption of specific volume of fuel is record.

As a fan is rotate when the engine is running, the crank encoder will give the crank angle position proportional to the pressure sensor. The crank encoder directly connected to the DAQ system and the measurement reading can be display on the DAQ system. The collected data is later transfer to excel files for further analysis.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

` Starting from the process of literature review, design, concept modeling, fabrication and lastly measurement installation, this project has generate a new portability engine test rig for two-stroke engine in firing testing and data collection for small two-stroke engine.

5.2 CONCLUSION

The aim of this project is to design and development of new engine test-rig for two-stroke spark-ignition engine and allows data acquisition system to determine the flow rate and fuel consumption from the exhaust at certain RPM. The objective of this project will be achieved through the planning from the beginning until the end of this project. The information about the case study is collected from many source and mostly come from the journal and its gather together in the literature review section. In this project, the engine test rigs had been design and develop for the firing testing condition. Performance of the engine is strongly depending on how well the burnt gases are scavenged from the cylinder volume and at the same time it's replaced with fresh mixture. Improved the scavenging will minimized losses of the fresh charge to the exhaust port through the short-circuiting and engine with premixed charge will be reduced the hydrocarbon emission and fuel consumption. After required information was gather, it was put on the design conceptualization as a reference to completing this project.

5.3 RECOMMENDATION

The performance testing of a small engine two-stroke spark ignition engine for firing condition to determine the true performance of the engine. With all the data measurement equipment that has been installed on this test rig, the data collection method can be measure easily and smoothly. The material that been used on this test rig also can be modified to improved the engine performance testing like cut the propeller shaft to reduce the torque on the engine and the crank encoder holder should be more light. GT power software is one of the engineering software analysis that can measure the performance of the engine preciously there will be a room for improvement of this test-rig by comparing the experiment result with the simulation analysis data like in order to make sure the accuracy of the data.

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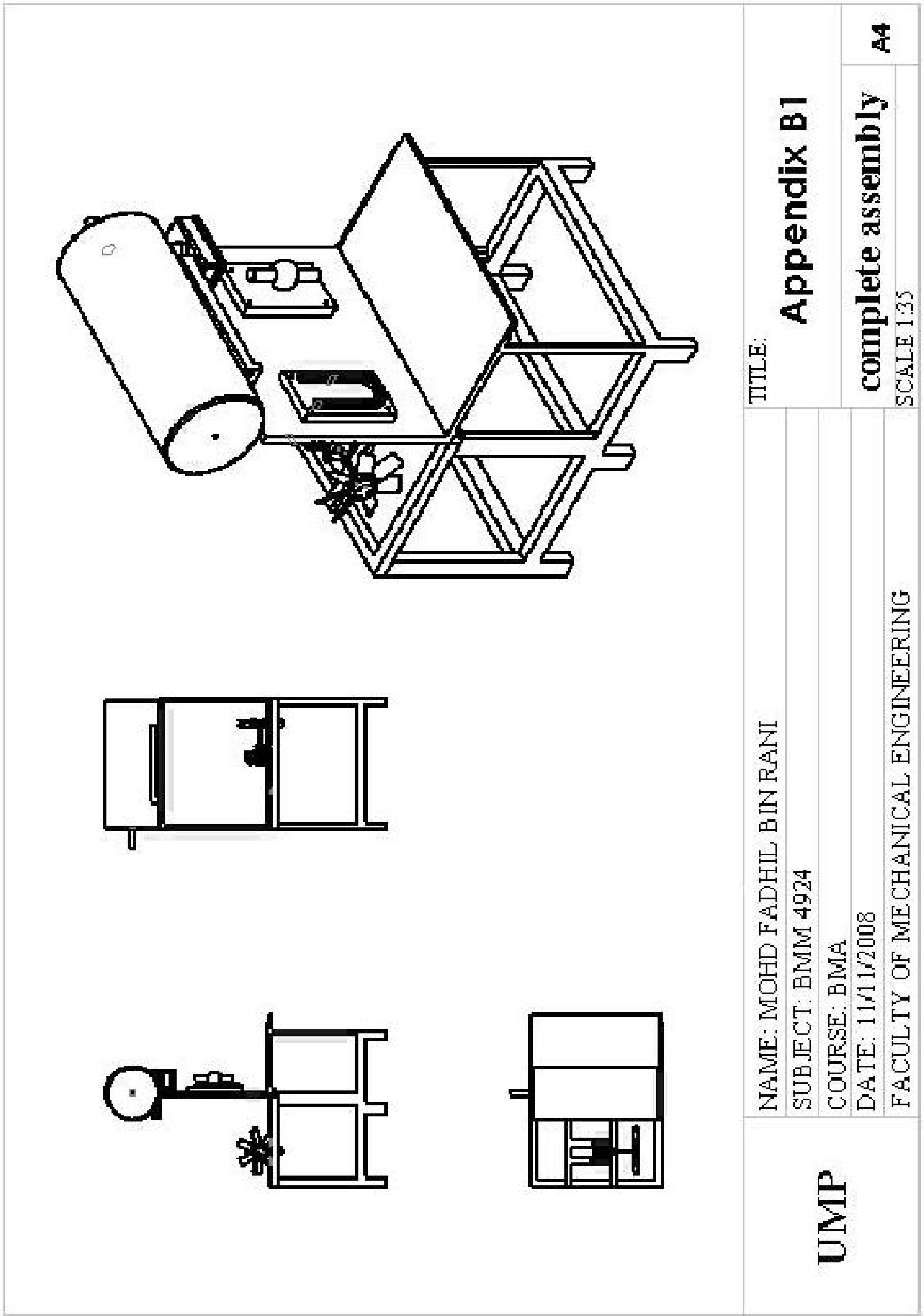
Appendix A: GANTT CHART/ PROJECT SCHEDULE FOR FYP

GANTT CHART FYP 1

	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9	Wk 10	Wk 11	Wk 12	Wk 13	Wk 14	Wk 15
1.0 Proposal Confirmation															
2.0 Define Problem Statement															
2.1 Background Writing															
2.2 Introduction Writing															
2.3 Literature Review															
3.0 Methodology															
3.1 Experimental Stage															
3.2 Test Rig Design (Firing Condition)															

GANTT CHART FYP 2

	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9	Wk 10	Wk 11	Wk 12	Wk 13	Wk 14
4.0 Results														
4.1 Measurement Installation														
4.2 Result Documentation														
5.0 Discussion														
5.1 Discuss Result														
5.2 Recommended Result														
5.3 Future Work														
6.0 Draft & Thesis Properties														
6.1 Draft Writing														
6.2 Full Manuscript Preparation														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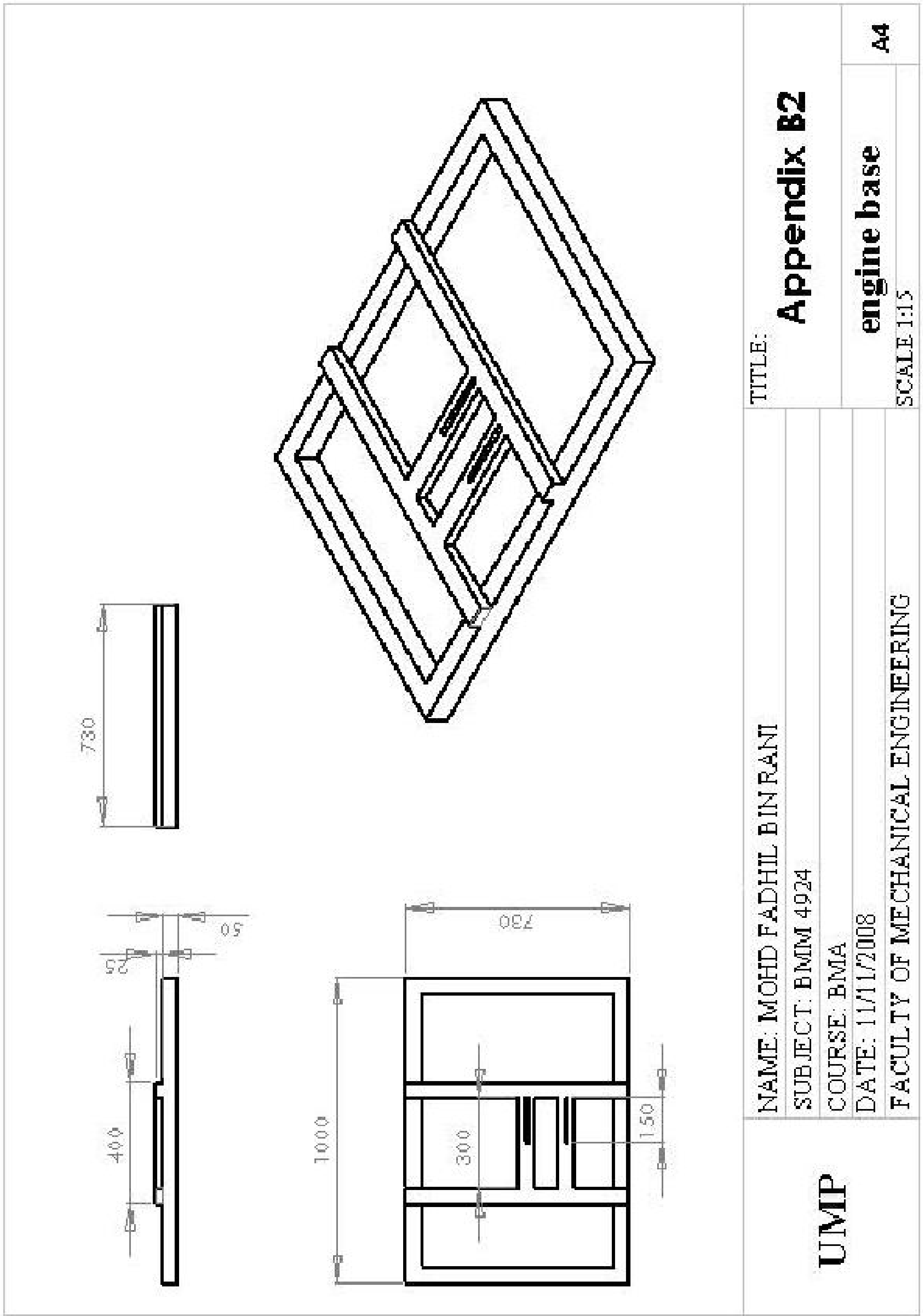
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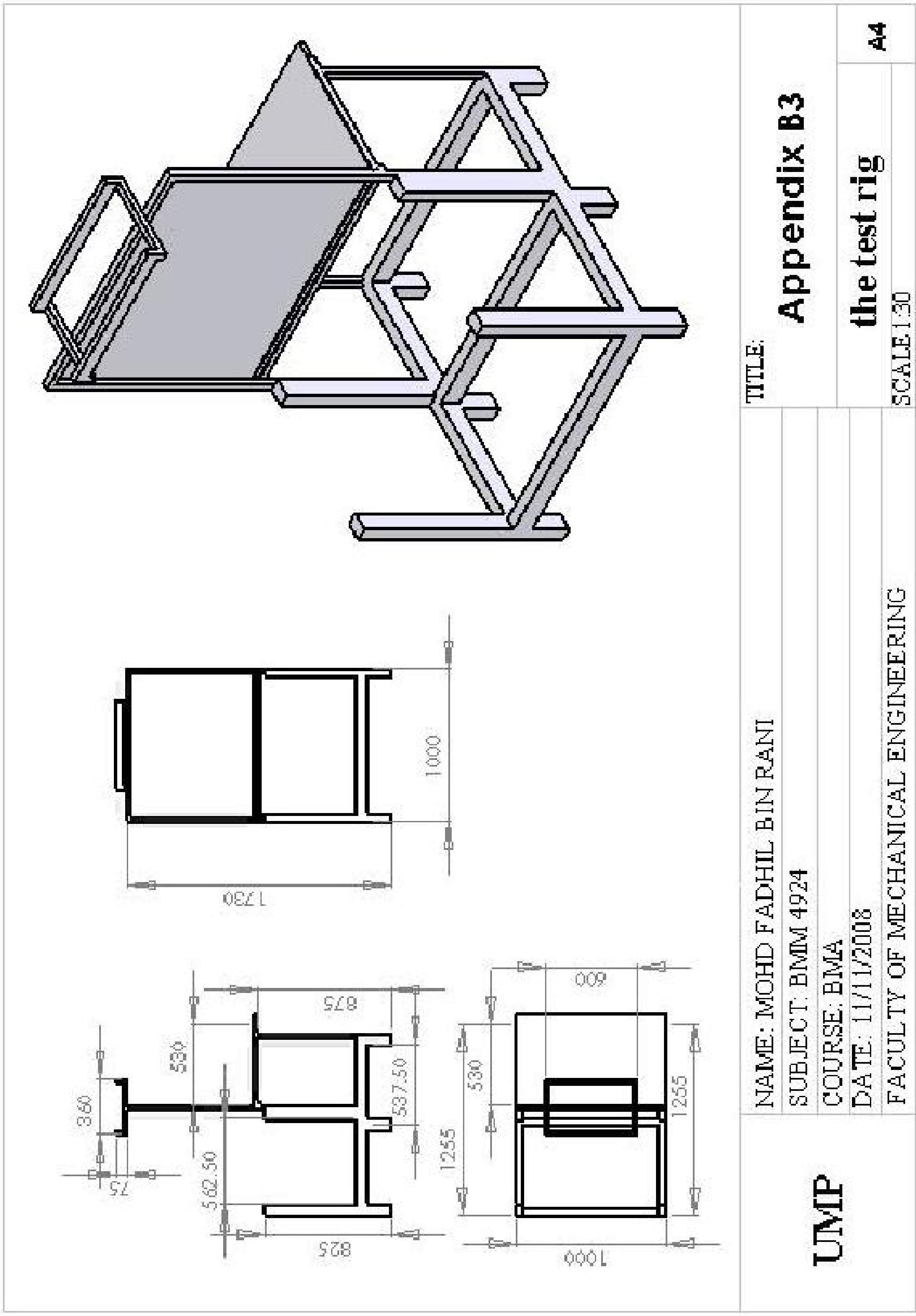
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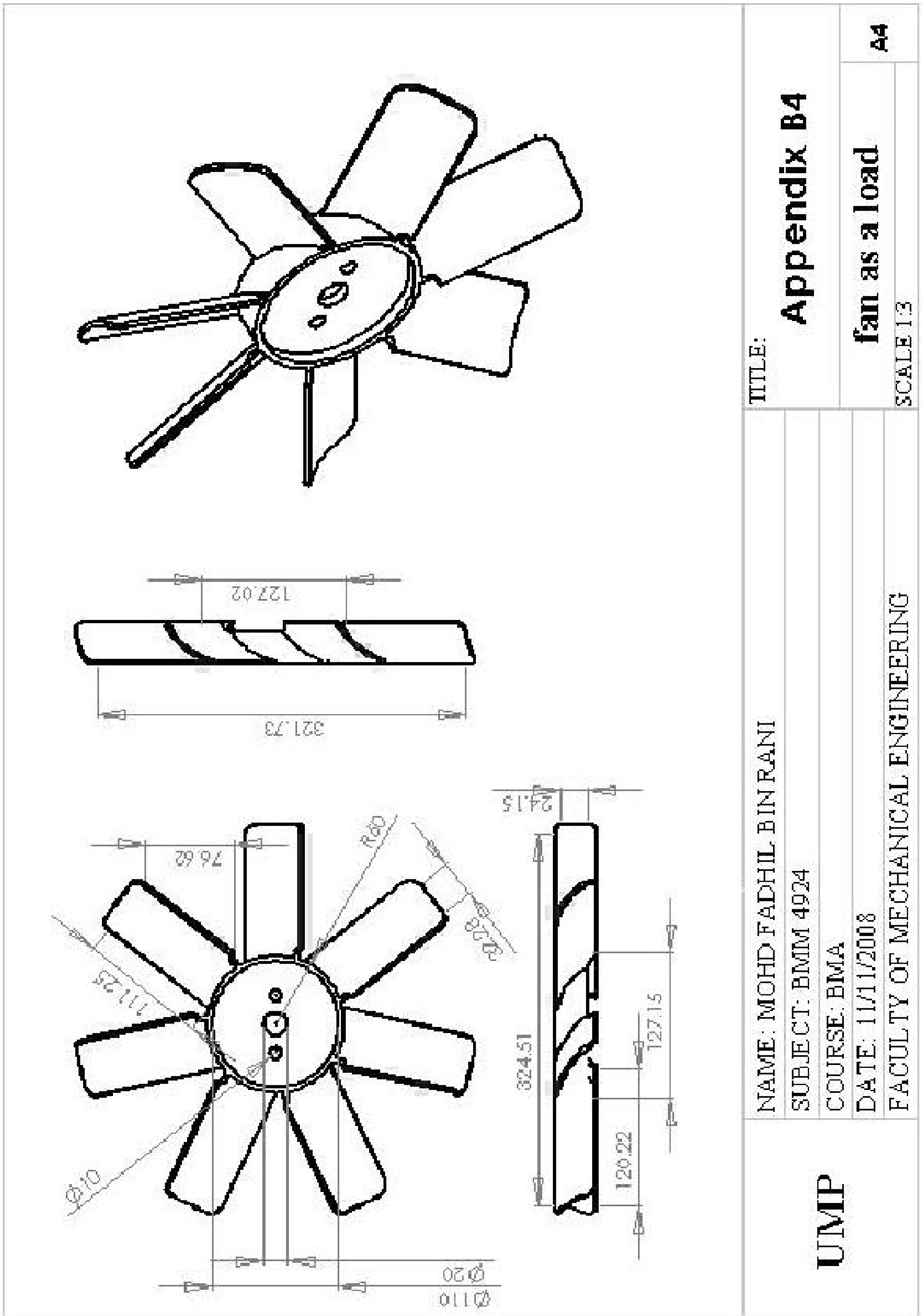
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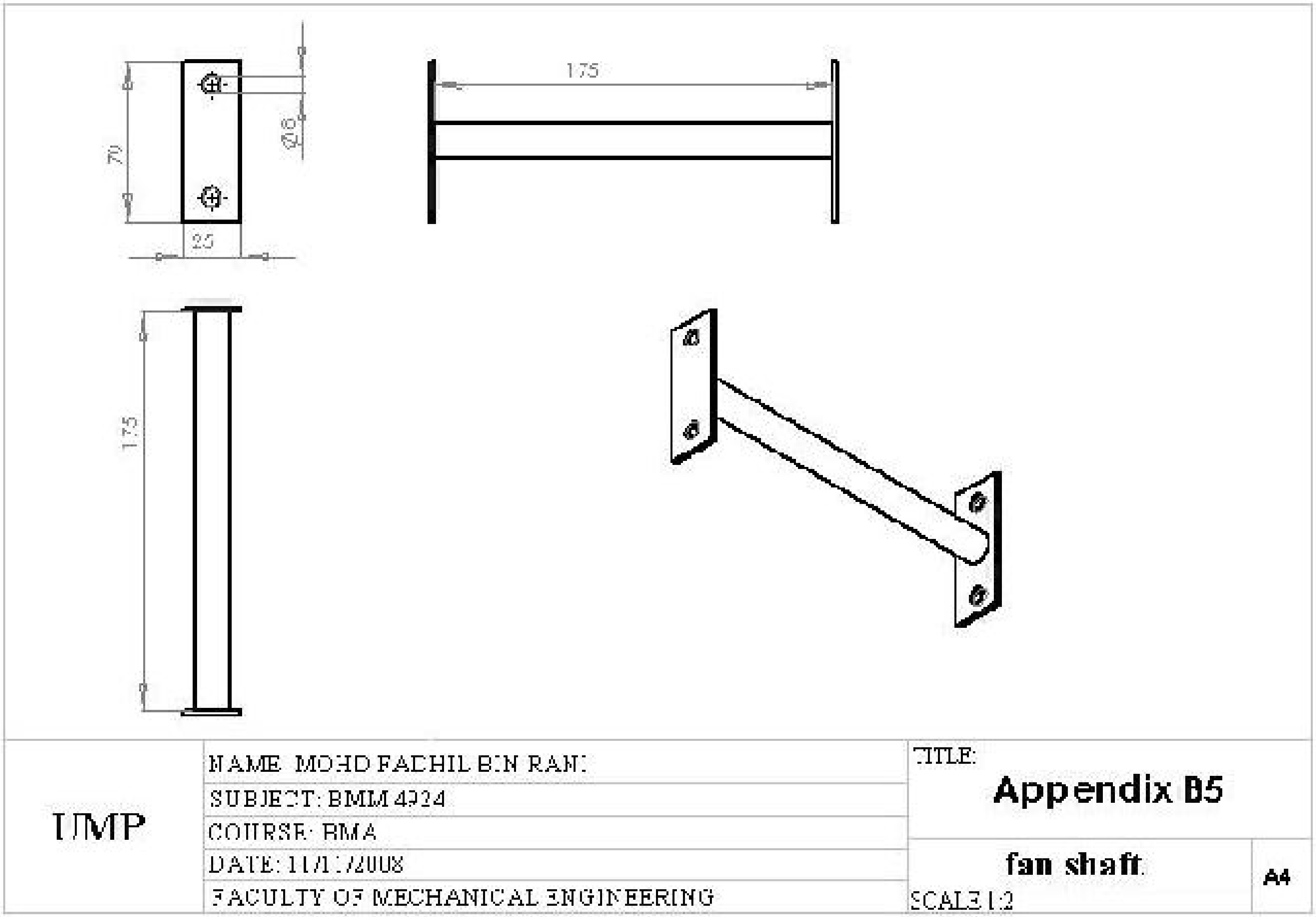

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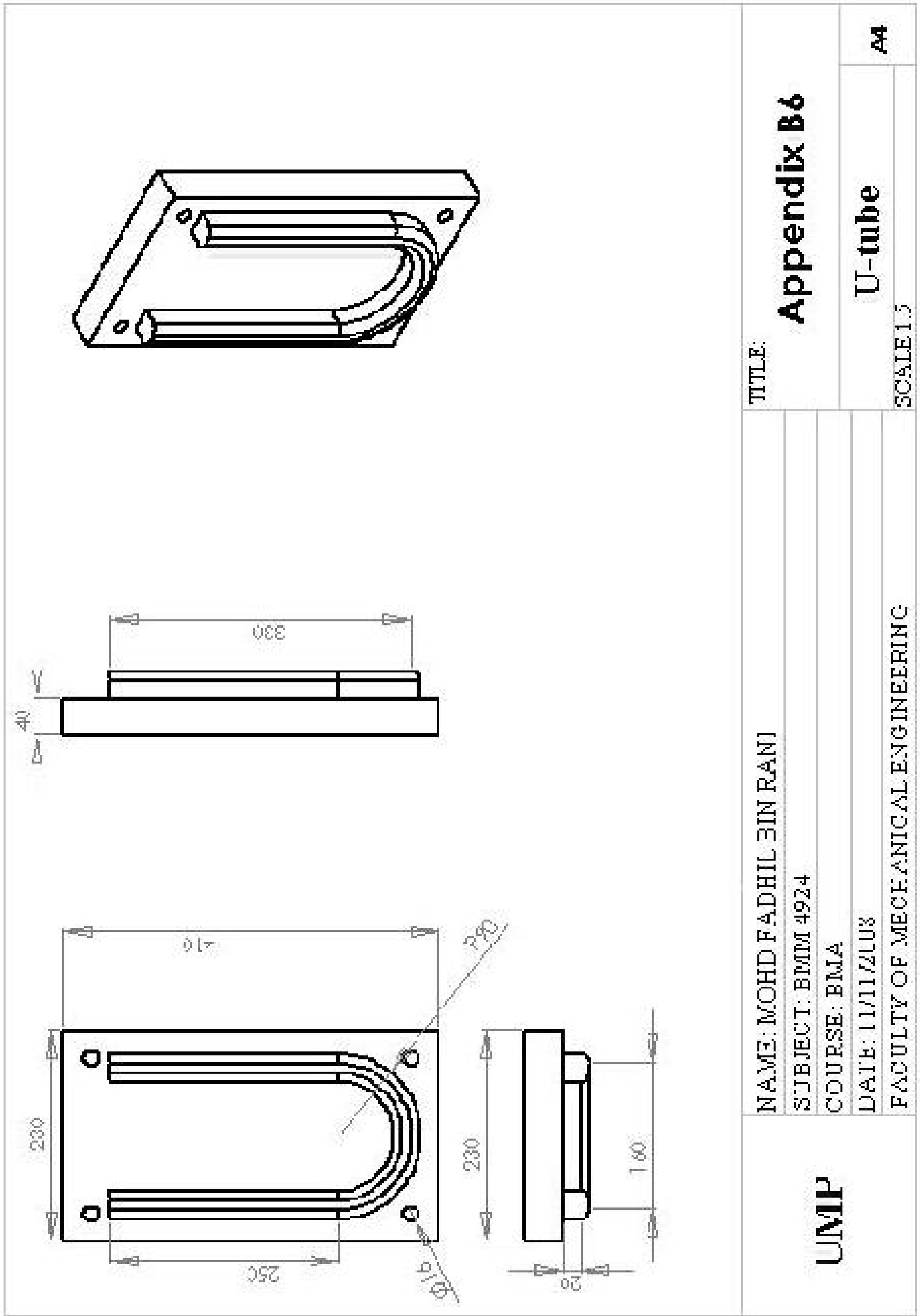
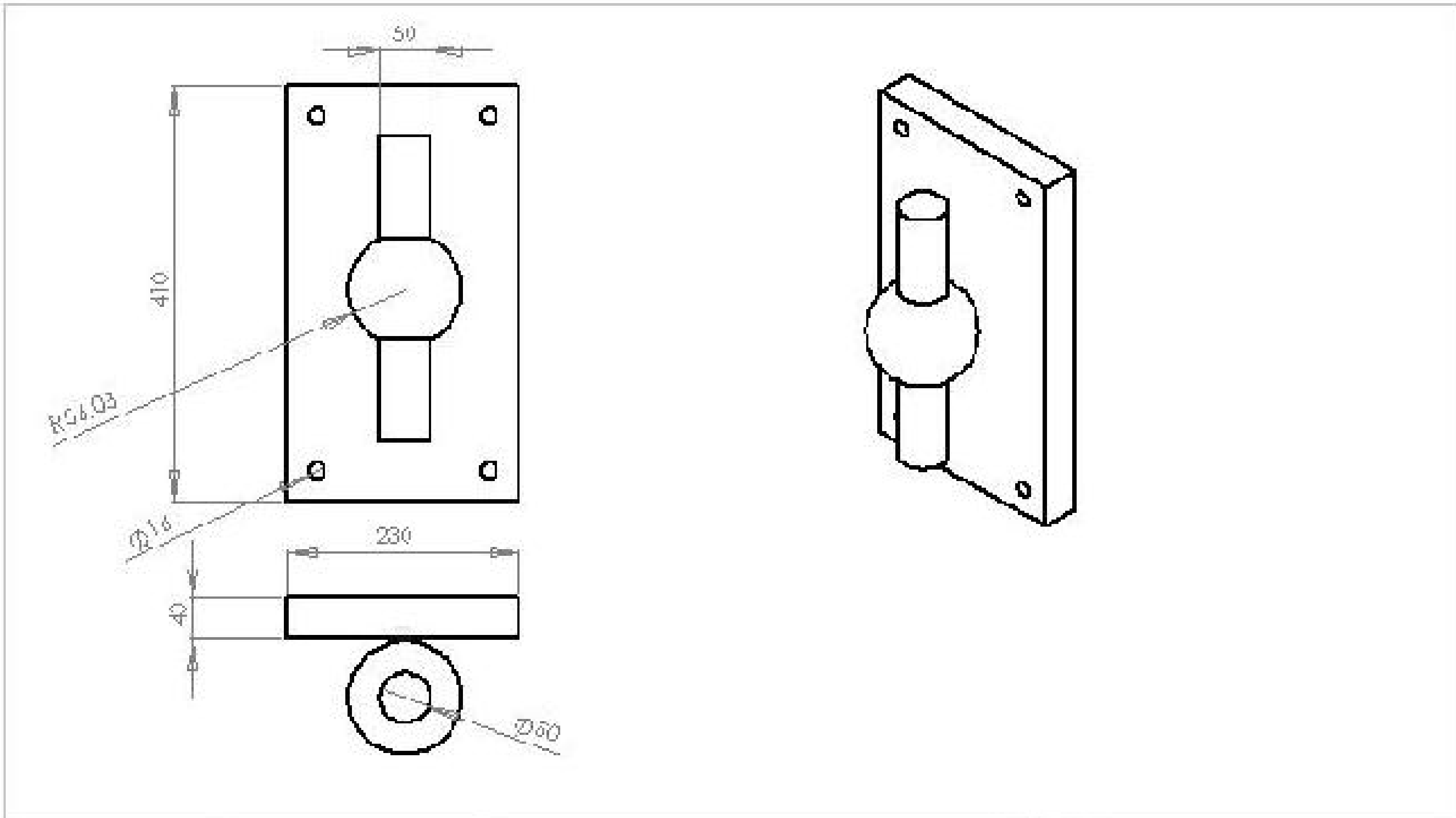
COURSE: BMA
DATE: 11/11/2008
FACULTY OF MECHANICAL ENGINEERING
TITLE:
Appendix B5
fan shaft
SCALE 1:2
A4

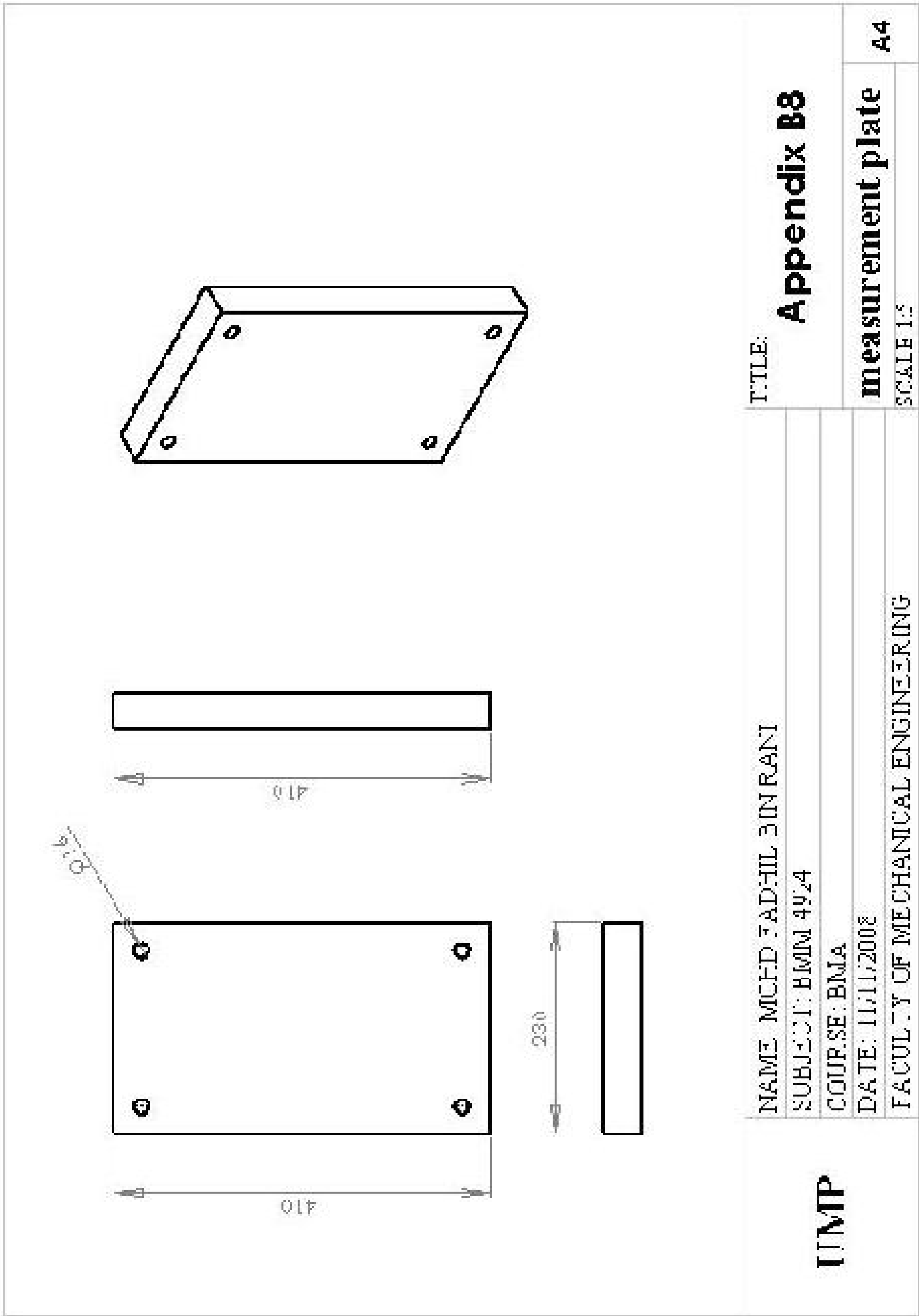

TITLE:
Appendix B6
U-tube
SCALE 1:5
A4
NAME: MOHD FADHIL BIN RANI
SUBJECT: BMM 4924
COURSE: BMA
DATE: 11/11/2008
FACULTY OF MECHANICAL ENGINEERING
UMP
230
410
R90
250
Φ16
230
160
20
40
330



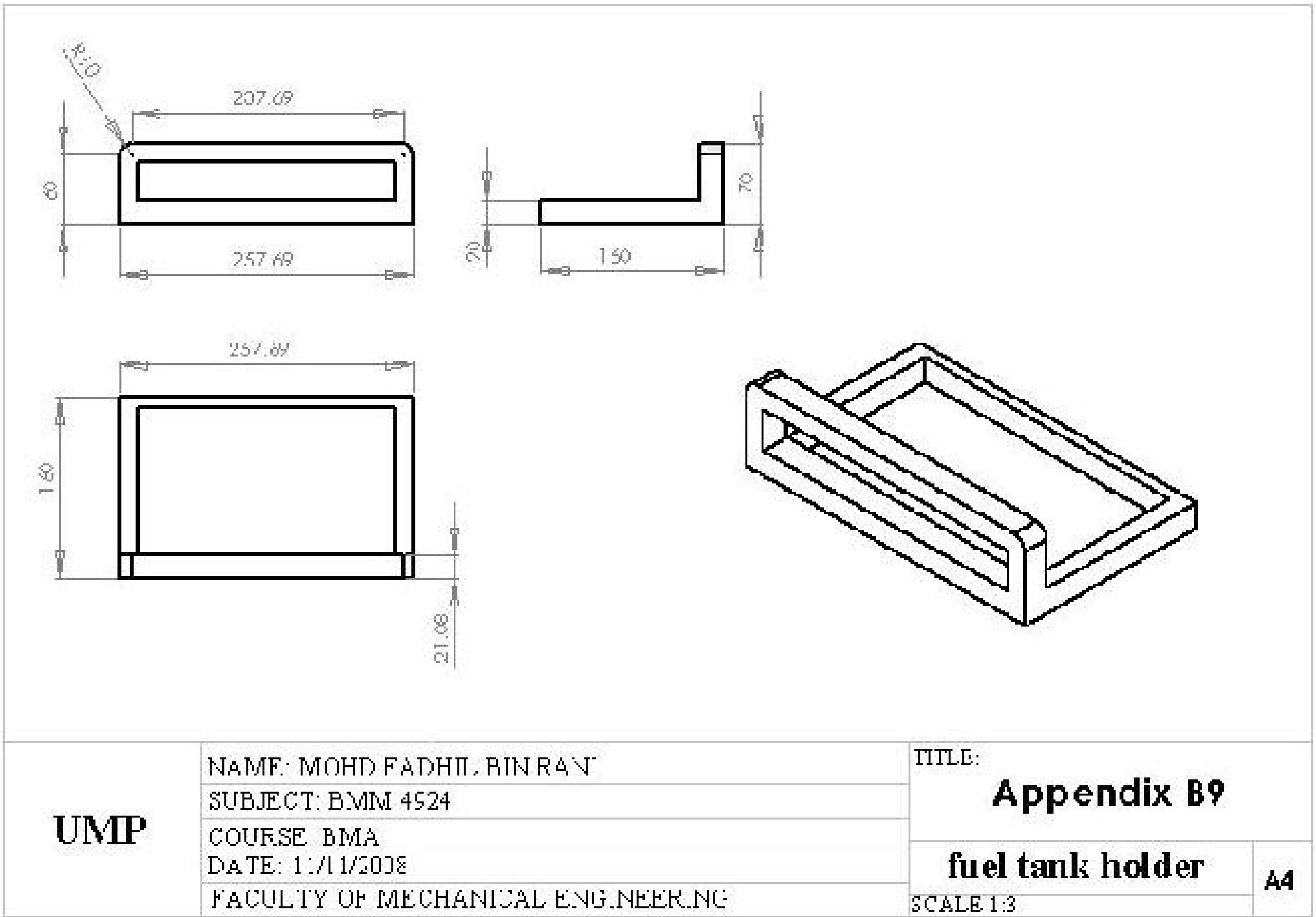
UMP

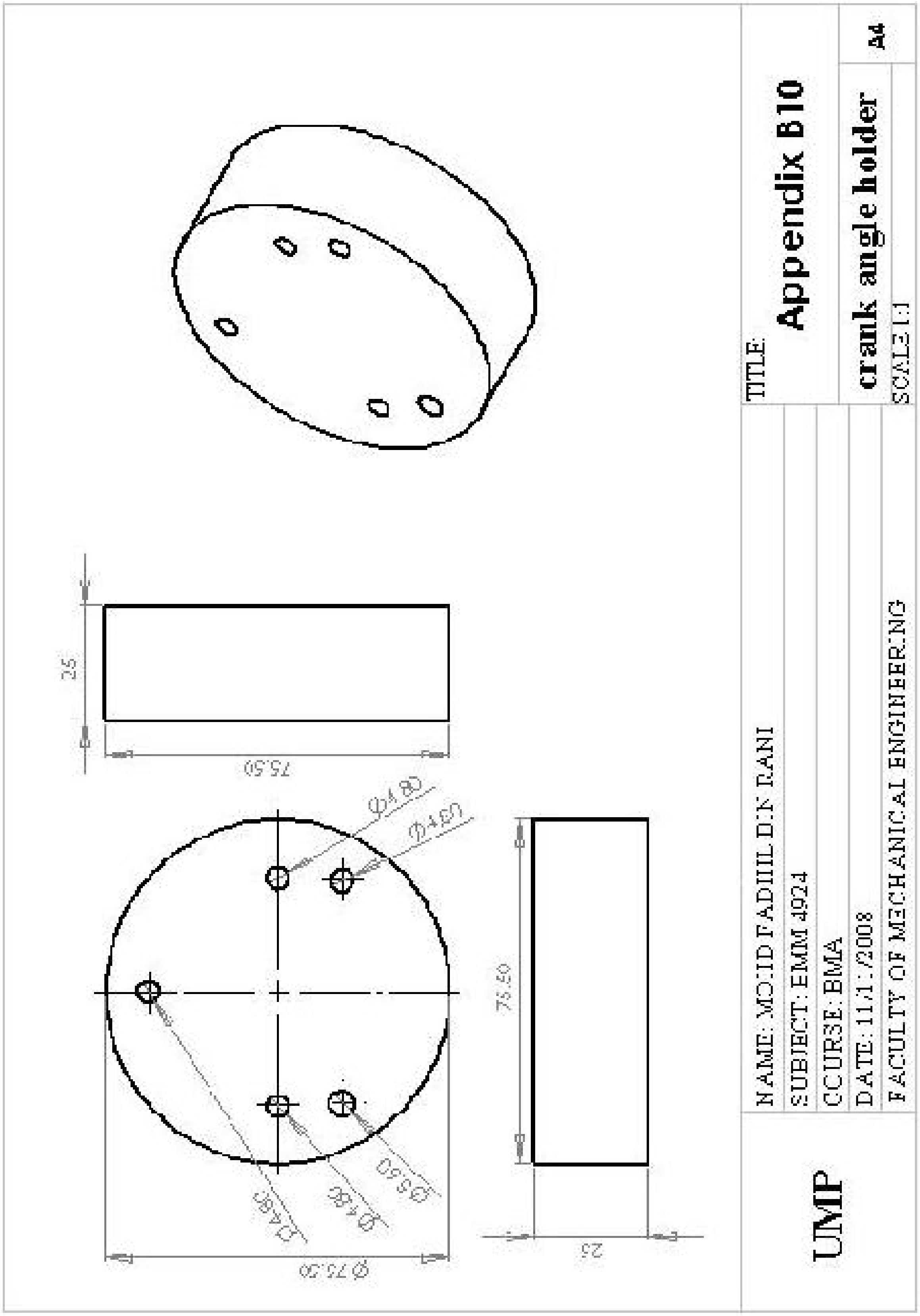
NAME: MOHD FADHIL DIN RANI
SUBJECT: BMM 4924
COURSE: BMA
DATE: 11/11/2008
FACULTY OF MECHANICAL ENGINEERING

TITLE:
Appendix B7
fuel measurement
SCALE 1:5
A4



410
410
230
TITLE:
Appendix B8
measurement plate
A4
SCALE 1:5
NAME: MOHD FADHIL BIN RANI
SUBJECT: BMM 4924
COURSE: BMA
DATE: 11/11/2008
FACULTY OF MECHANICAL ENGINEERING
UMP


R10
207.69
60
257.69
20
150
70
257.69
180
21.08
UMP
NAME: MOHD FADHIL BIN RANI
SUBJECT: BMM 4524
COURSE: BMA
DATE: 17/11/2008
FACULTY OF MECHANICAL ENGINEERING
TITLE:
Appendix B9
fuel tank holder
SCALE 1:3
A4


TITLE:
Appendix B10
crank angle holder
SCALE 1:1
A4
SUBJECT: EMM 4924
COURSE: BMA
FACULTY OF MECHANICAL ENGINEERING
UMP
75.50
25
Ø75.50