Fabrication of New Cylinder Head Concept Model for 4-stroke Motorcycle Engine

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A project report submitted in partial fulfillment of the
Requirement for the award of the Diploma
Of Mechanical Engineering

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University Malaysia Pahang

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SUPERVISOR DECLARATION

I hereby declare that I have read this project report and in my Opinion this project report is sufficient in terms of scope and Quality for the award of the Diploma in Mechanical Engineering

Signature : …….

Supervisor name : EN. ISMAIL BIN ALI

Date : …….

DECLARATION

I declare that this thesis entitled “Fabrication of New Cylinder Head Concept model for 4-stroke Motorcycle Engine”is the result of my own study except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree

Signature : ……

Name : CARL-VENTOLINSON ANAK EMLEY

Date : ……...

DEDICATION

First of all, I would like to show my expression of gratitude to God whose guidance, help and grace was instrumental in making and finish this final year project. I also would like to express my thanks to my supervisor Mr. Ismail bin Ali whose help, guidance and advice me for the whole time during the process in finish this final year project. Without him, this project will not be completed. I also would like to thanks t Mr. Rashidi Bin Maarof whose help, guidance and be my instructor in casting process. Without him the upper piston cannot be casted.

I would also like to thank to my beloved mother and my father, Mrs. Limgime Anak Neggog and Mr. Emley anak Ahua, without them, my pursuit of higher education would not have been possible and I would not have had the chance to study in mechanical course. Thanks a lot to my university and friends too in their support and advice towards this project. Last word from me, thanks to all for your enduring patience and continuous encouragement.

ACKNOWLEDGEMENTS

I would like to express my gratitude and appreciation to all those who gave me the possibility to complete this report. Special thanks to my supervisor Mr. Ismail Bin Ali whose help, stimulating suggestions and encouragement helped me in all time of fabrication process and in writing this report.

I also would like to acknowledge with much appreciation the crucial roll of staff in mechanical laboratory, who gave me a permission to use the machine equipment and giving permission to use the entire necessary tool in the laboratory.

Many thanks go to the lecturer in charge of foundry lab, especially to Mr. Rashidi Bin Maarof who given their full effort in guiding me in achieving the objective as well as their encouragement to maintain my progress in track. My profound thanks to the entire DMM student especially to my friends for spending their time in helping and giving support whenever I need it in fabrication of the upper piston.

ABSTRACT

This project focuses on re-design and fabrication of new cylinder head concept model for a 4-stroke motorcycle engine. The idea of the new cylinder head model was also completed. It's for the purpose of demonstrating the idea of this new concept. It also focuses on re-design the new upper piston for the new cylinder head. The piston based design was from PSM student. The re-design was done for simplifying the fabrication, machining and casting process. To achieve this project objective, this upper piston pattern should be fabricated using casting and machining process. But the dimension changes were done after the first casting work didn't produce the desired product. This project flow must start from study, design, and lastly fabrication process. Before fabricate the upper piston, a study was made for the design based on the original design by Malcolm Beare and study on Modenas 110cc engine system. It is because to study the specification need and maintain the original design. Diploma Final Year Project will cover for the whole last semester, before go to the industrial training to complete this project. This is an individual task and must do by ourselves. This is also one of opportunity to student to show or to apply their knowledge also skill in using manufacturing process and mechanical design software in complete this project. Time management and a good planning also important to make sure the entire plan are in their way. Lastly, discipline needed to complete this project.

ABSTRAK

Mereka bentuk dan mencipta silinder baru untuk sistem enjin motosikal 4-lejang yang adalah merupakan tajuk yang telah dicadangkan oleh pensyarah, En. Ismail Bin Ali untuk dijadikan tajuk untuk subjek Projek Tahun Akhir (PTA). Projek ini hanya memfokuskan terhadap mereka bentuk semula dan mencipta omboh bagi enjin sistem baru. Objektif projek ini adalah untuk mereka bentuk dan menbuat omboh untuk silinder baru. Bagi mencapai objektif projek ini, proses membuat omboh adalah dengan menggunakan mesin pelarik dan mesin "milling". Projek ini perlu dijalankan bermula dari proses analisis bentuk, merekabentuk dan mencipta. Sebelum memulakan proses mereka bentuk dan mencipta piston, sedikit sebanyak mencari maklumat tentang piston rekaan Malcolm J Beare dan sistem enjin Modenas kriss 110cc bagi mengekalkan spesifikasi dan rekabentuk asal omboh. Projek Tahun Akhir diploma ini mempunyai tempoh selama satu smester untuk disiapkan secara individu. Projek ini juga merupakan satu peluang kepada pelajar untuk mengalikasikan semua kemahiran dan pengetahuan dalam pengunaan mesin dan rekabentuk perisian dalam menyiapkan omboh. Pembahagian masa dan jadual yang betul adalah penting untuk memastikan projek in berjalan lancar. Secara keseluruhannya,projek ini memerlukan komitmen dan disiplin dari pelajar untuk menyiapkan projek tahun akhir ini.

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rpm	Revolution Per Minute
mm	Millimeter
cc	Centimeter cube

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND AND PROBLEM STATEMENT

Basically, the purpose of fabricate new upper piston is for the new cylinder head concept for 4 stroke engine system. The new cylinder head concept for 4 stroke also known as 6 stroke cylinder head. The 6 stroke cylinder system was developed in the 1920s. The new engine system been used in Ducatti motorcycle and some of mini helicopter engine.

According to the design of the motorcycle system, none of the motorcycle using a new system that are more to bring benefit. Such as increase the output power, efficiencies and emission reduction in a 4-stroke single-cylinder motorcycle engine.

The new cylinder head concept was designed by the PSM student. The concept ws model completely using solid works. However, in order to further understanding og the concept's working principle, a physical model must be constructed.

In this final year project, the design and fabrication of new upper piston is for the new cylinder head.

1.2 PROJECT OBJECTIVE

- To design the new cylinder head model.
- To re-design the upper piston for first prototype.
- To fabricate the upper piston using casting and machining method.

1.3 PROJECT SCOPE

From the title that has been given, the development of this project must include how to design the mechanical part of machine and how to fabricate the system of this mechanical part. It also needs some knowledge and skill to finish the project. There is some other guide must followed to finish this project.

1.4 PROJECT SCHEDULE

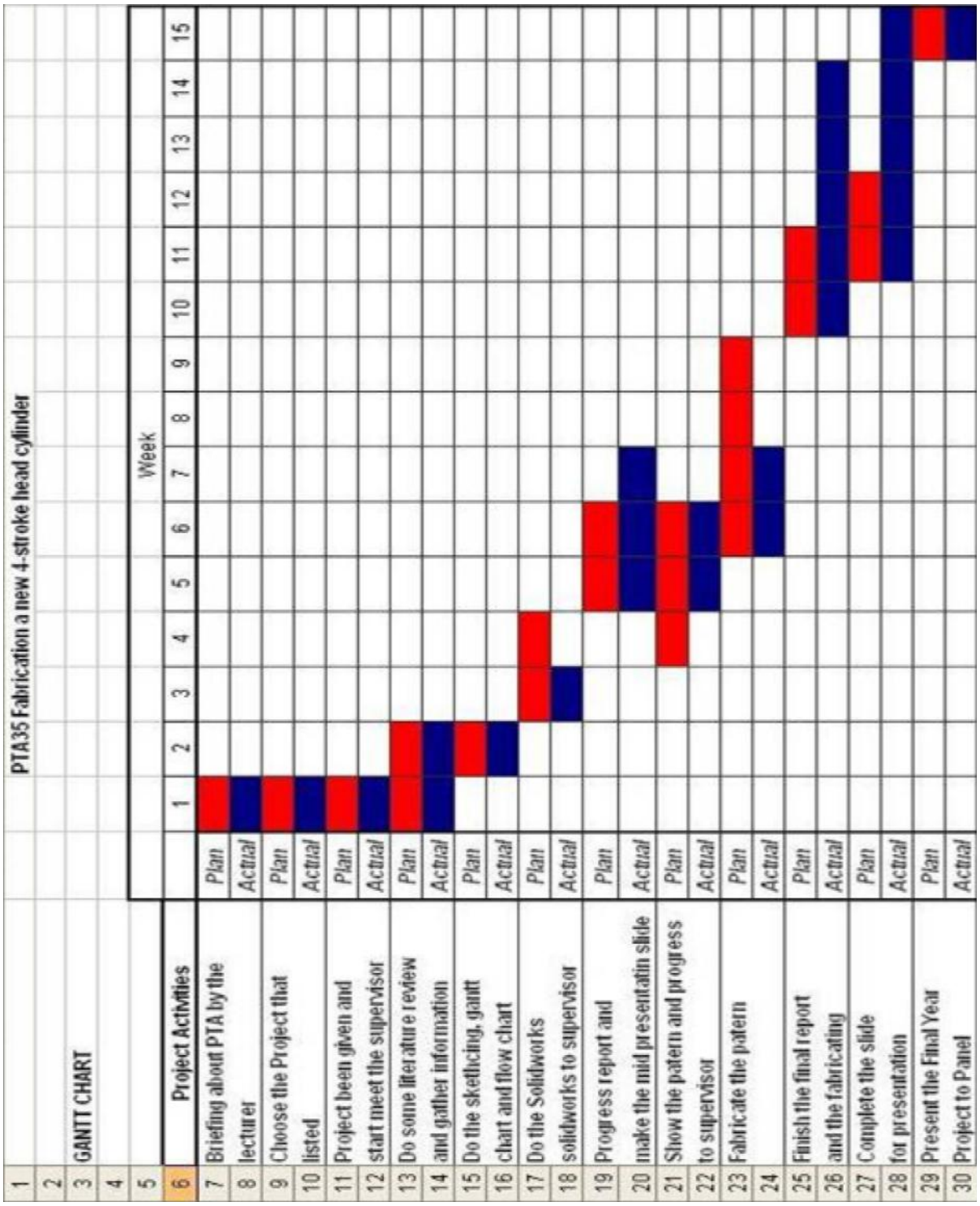


Table 1.4.1: Gantt chart

1.5 FLOW CHART

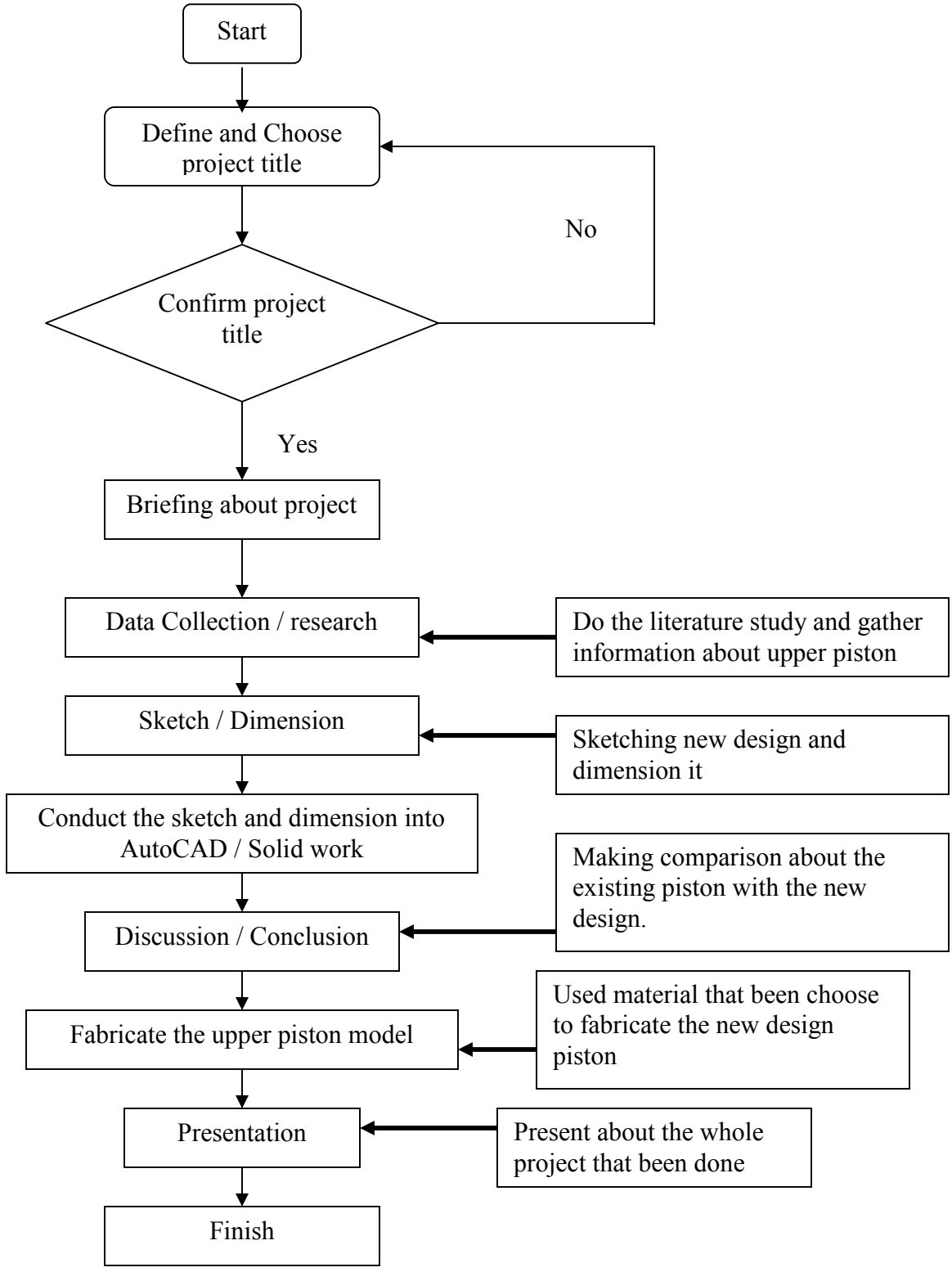


Figure 1.5.1 Project Flow Diagram

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, there will be a short information about the six stroke engine that been invent by Malcolm J. Beare and charge pump engine which invent by Helmut Kottman. It also has the information about the 4-stroke and 2-stroke engine operation.

2.2 HISTORY

2.2.1 Malcolm J Beare six stroke

The term six stroke engine describes two different approaches in the internal combustion engine, developed since the 1990s, to improve its efficiency and reduce emissions.

The Beare head engine developed by Australian Malcolm J. Beare internal combustion engine technology combines a four stroke engine bottom end with a ported cylinder head closely resembling that of a two stroke, thus 4+2= six stroke. The head piston is smaller and has half the speed of the opposing piston. Functionally, the cylinder head piston replaces the valve mechanism of a conventional engine.

Figure 2.0 Beare Piston

- Concept of the design new head cylinder engine was inspired by the BEARE HEAD engine.
- Advantage of this type of engine:
  - power/torque increase of 30%
  - Lower maintenance costs due to less wearing parts.
  - Simpler and less expensive manufacturing and tooling.

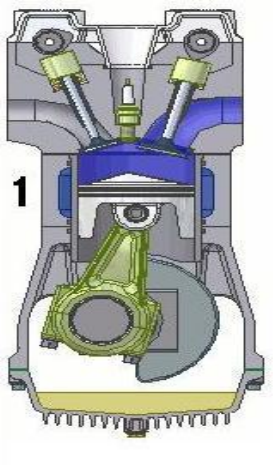
2.2.2 Charge pump by Helmut Kottman

In the charge pump engine system which invent by Helmut Kottman is similar in design to the Beare head. A piston replaces the valve system. The piston will charge the main cylinder and simultaneously regulates the inlet and outlet aperture leading to o loss of air and fuel in exhaust. In the main cylinder, combustion take place every turn as in a two stroke engine and lubrication as in a four stroke engine. With the opposed two pistons, fuel injection will inject the fuel and gas for combustion. It is also possible to charge the working cylinders with one piston charger.

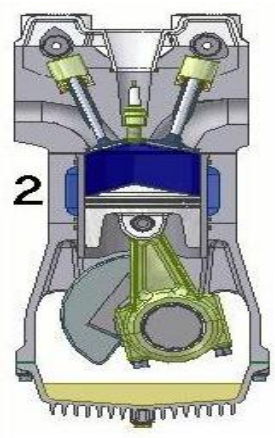
The combination of compact design for combustion chamber will give the engine more torque, more power and better fuel consumption. The less of moving part and design is claimed to lead to lower manufacturing costs and cooling system.
The six strokes are: aspiration, pre-compression, gas transfer, compression, ignition and ejection.

2.3 FOUR-STROKE SYSTEM OPERATION

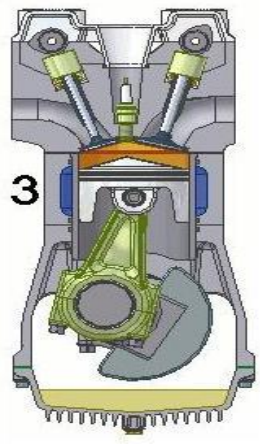
These kinds of engine system most commonly use in all kind of vehicle such cars, trucks, motorcycles, machinery and many others. The stroke is referring to intake, compression, combustion (power) and exhaust stroke that occur during two crankshaft rotations per working cycle of the engine.A four-stroke engine is characterized by four stroke, or reciprocating movements of a piston in a cylinder. (Refer figure 2.3)



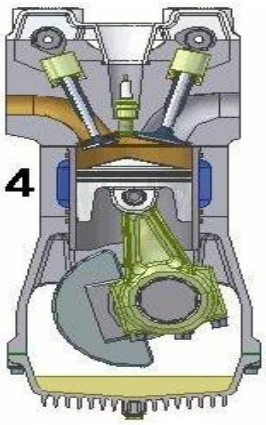
1. Intake (induction) stroke



2.Compression stroke



3. Power stroke

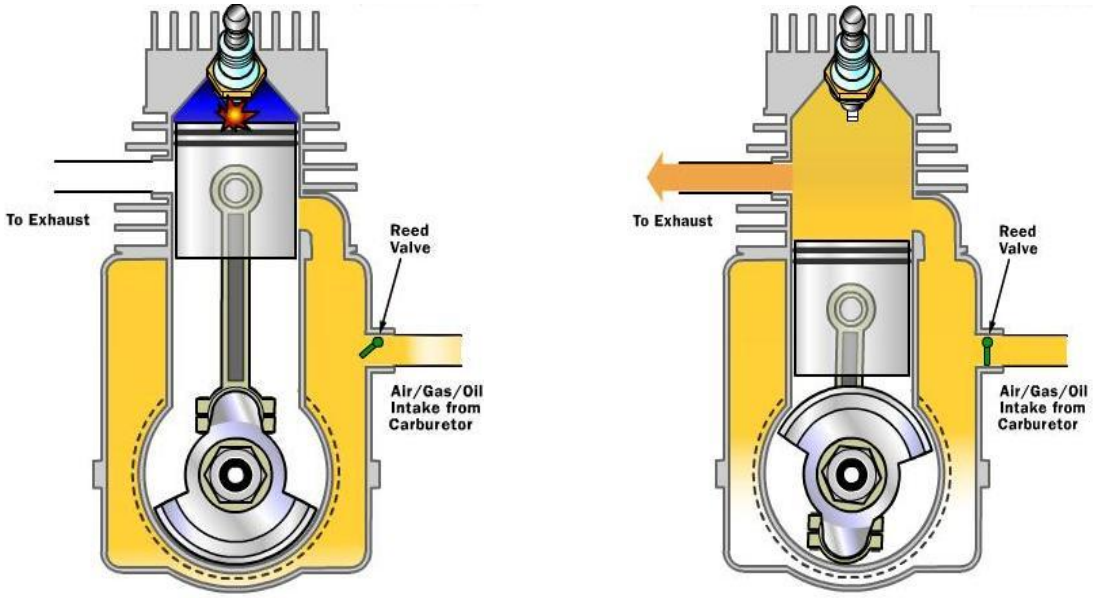


4. Exhaust stroke

Figure 2.3 Four-stroke cycle

2.4 TWO-STROKE SYSTEM OPERATION

The two-stroke engine system operation is differs from the more common four-stroke engine by completing the same four processes(intake, compression, combustion, exhaust) in only two strokes of the piston rather than four. This is accomplishing by using the beginning compression stroke and the end of the combustion strokes to perform the intake and exhaust function. This allows a power stroke for every revolution of the crank instead of every second revolution as in a four-stroke engine. This two-stroke provide high specific power and light weight. Figure 2.4 is show the two-stroke operation:



1. Compression and combustion stroke 2. Intake and exhaust stroke

Figure 2.4 Two-stroke cycle

CHAPTER 3

METHODOLOGY

3.1 MODENAS KRISS 110CC ENGINE SPECIFICATION

The first model national motorcycle, Modenas Kriss have launch by the Modenas in 1996. It being launch in two models which is first model with drum brake on the front and the second model was with disc brake. Engine specifications are listed as:

Figure 3.1 Kriss ii

Max power : 9.0 PS (6.6 kW) @ 8,500 rpm
Max torque : 9.3 N·m (0.95 kgf·m) @ 4,000 rpm
Engine type : SOHC 2-valve 4-stroke single-cylinder, air-cooled
Displacement : 111 cc
Bore x stroke : 53 x 50.6 mm

Compression ratio : 9.0:1

Fuel tank capacity : 4.3 L

Dry weight : About 100 kg

Transmission : 4 speed with automatic centrifugal clutch

Max speed : about 120 km/h

3.2 THE BASED CYLINDER HEAD DESIGN.

The based cylinder head design was simplified from the PSM student design. But the upper piston will be change by put the new design of the upper piston. Figure 3.2 a show the sketching of the cylinder head system. Figure 3.2 b show the explode view of the cylinder head design include the new design of upper piston using solid works.

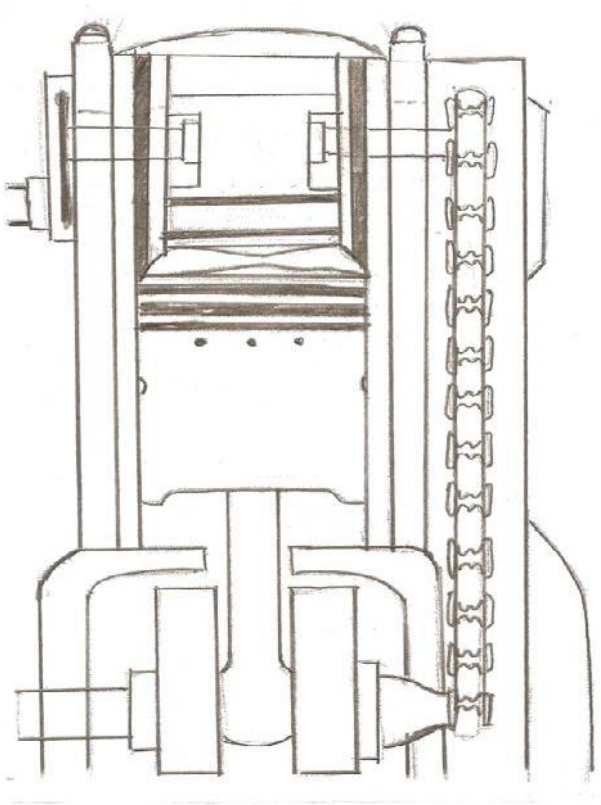


Figure 3.2 a Sketching Cross section

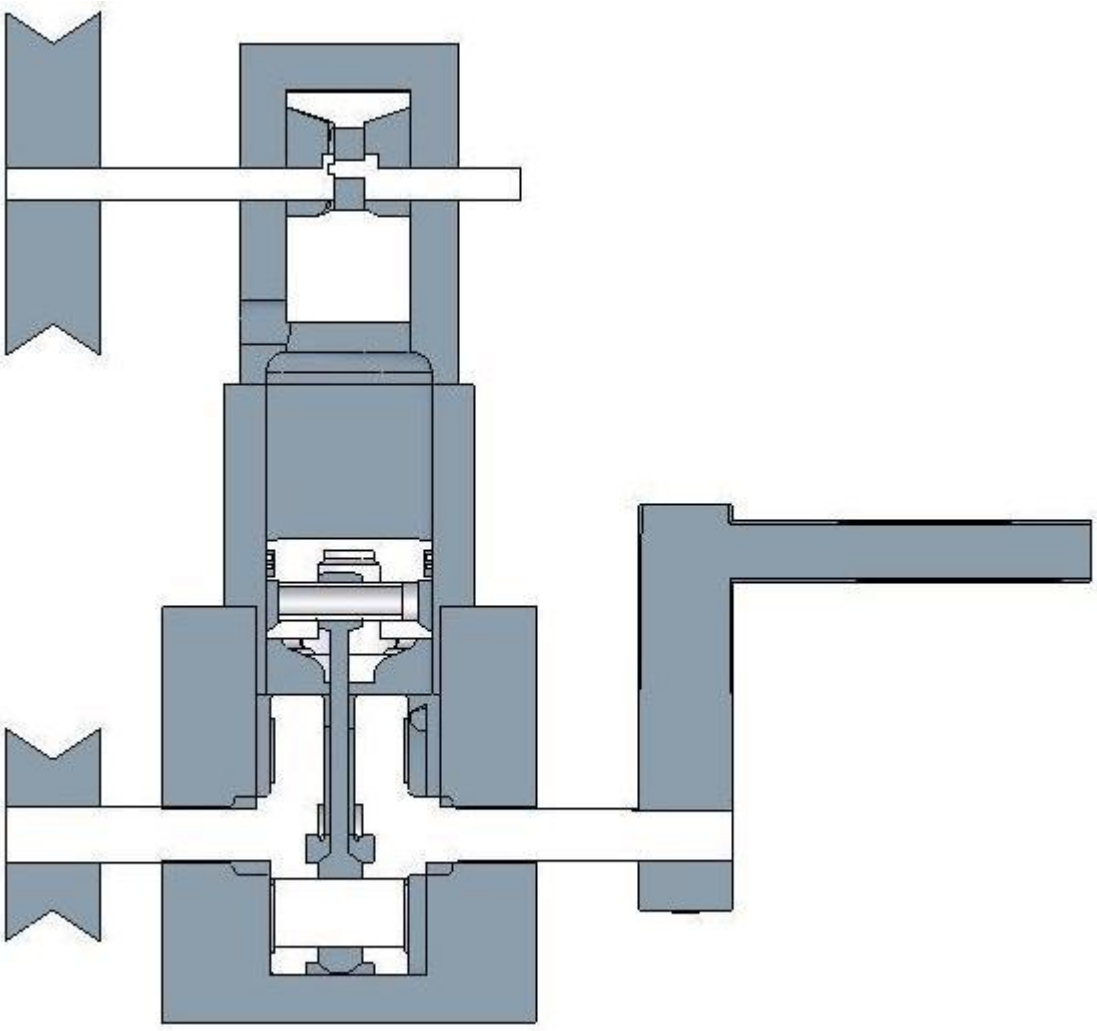


Figure 3.2 b Cross section view

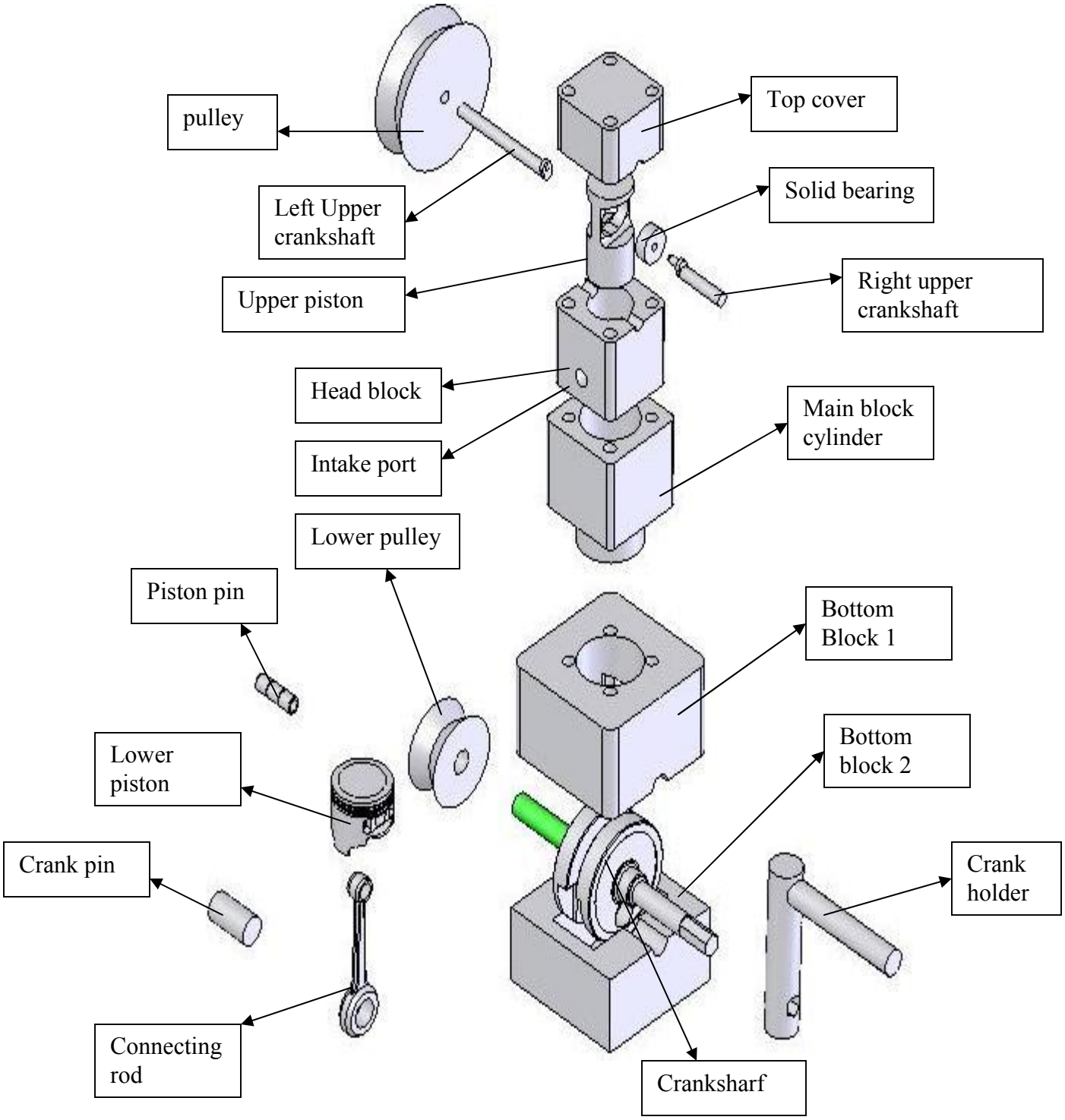


Figure 3.2 c Exploded view

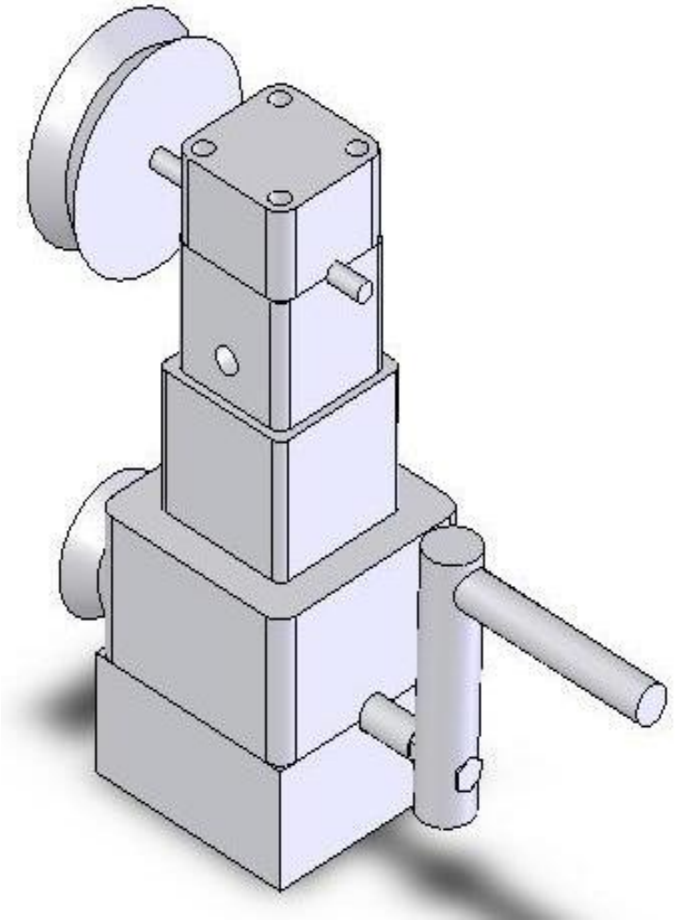


Figure 3.2 d Full Assembly

3.3 UPPER PISTON DESIGN

The design of the upper piston must be compliance with several aspects. The design consideration must be done carefully so that the new design can be fabricate. The aspect that must be considered is:

I. Shape of the piston: The shape should be maintaining the original piston shape.
II. Material: Material availability to fabricate the piston.
III. Dimension: The dimension should be correct so that the bore and stroke value not change.

3.3.1 Design specification

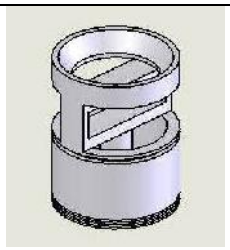
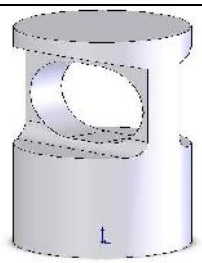
The design specification consideration as follow:

I. Cylinder shape.
II. Material must be light and easy to fabricate.
III. Dimension should be diameter is 40mm and length is 74 mm.

3.3.2 Design selection

The design is must be look like Malcolm J. Beare design and simplified from the design that is bachelor student design by maintaining the real dimension. A little modification on the bearing hole from a rectangle to an oval shape.

3.4 COMPARISON OF THE DESIGN

Malcolm Beare design	Bachelor student Design	New Design
		
Alloy	Aluminum	Aluminum
Have been used in Ducatti engine	First prototype design	First prototype product
Used needle bearing	Used needle bearing	Used ball bearing
Have sliding housing for needle bearing	Have sliding housing for needle bearing	Have oval shape of bearing hole
Complete with piston ring and lubricant hole	Complete with piston ring groove	Doesn't have the piston ring groove

Hollow	Hollow	Solid design
Donie top piston	Flat top piston	Flat top piston

Table 3.3

There is same criteria with all the three design that being design. Which is piston having same shape and design, cylinder shape. The difference only can be seen on the through the bearing hole, solid and not solid design, and the piston ring groove.

3.5 FABRICATION PROCESS

After designing process is the fabrication process. This process is using the raw material and makes the product based on the design and the dimension. Only a several method in fabricate the upper piston such as sand casting, lathe, milling, drilling, filing and finishing. Fabrication process is difference from other piston fabricate term of the quantity scale because of fabrication only make one product. This fabrication is only making the prototype for upper piston. In fabrication of the piston, material that used to fabricate is the aluminum instead of using real material of fabricate the piston which is using alloy. This fabrication just to show shape of the new design of upper piston.

3.5.1 Casting process

In the first fabrication of the upper piston, sand casting were used for fabricate. The fabricate step which start with:

Pattern making:

a) Draw and sketch:
   - Draw and sketch the real dimension on the hard cardboard.

b) Cutting:
   - Cut the shape that been draw on cardboard and cut the polystyrene using polystyrene wire cut.

c) Assembly:
   - Assembly all the part that been cut using glue according to the upper piston design and shape.

Casting process:

a) Sand mixture:
   - Mix the dry sand with a little of water for the sand mold.

b) Pattern buried:
   - Patter will be buried into the sand casting box.

c) Material melting:
   - The aluminum bar will be melt in the casting furnace with constant heat.

d) Pouring melt aluminum:
   - Melt aluminum will be pour into the hole that connect to the pattern in the casting box.

e) Filing:
   - Filing process is to smooth the work piece surface.

f) Finishing:
   - Finishing process is to get the work piece surface clear from bur and chip.

3.5.1 A) Fabrication method

1. **Casting process:**

1.1 Pattern making:

a. Draw and sketch

Draw and sketch by pencil and marker on the card board and polystyrene. (Refer figure 3.5 a)

Figure 3.5 a Draw and sketching

b. Cutting

Cut the polystyrene using the polystyrene wire cut according to the marking. (Refer figure 3.5 b)

Figure 3.5 b Cutting

c. Assembly

Assembly all the part that been cut using polystyrene glue. Complete pattern that been glue. (Refer figure 3.5 c)

Figure 3.5 c Pattern assembly

1.2 Casting process

a. Sand mixture

Dry sand will be mixture with a little amount of water in the mixture machine. (Refer figure 3.5 d)

Figure 3.5 d Sand mixture

b. Pattern buried

The pattern will be buried into the casting box used the wet sand. Then make a pouring hole using PVC pipe. (Refer figure 3.5 e)

Figure 3.5 e Pattern Buried

c. Material melting

The aluminum bar will be melt in the furnace at the certain heat temperature. (Refer figure 3.5 f)

Figure 3.5 f Material melting

d. Pouring melt aluminum

After the aluminum bar melt. The molten aluminum will be pouring in the sand mould. (Refer figure 3.5 g)

Figure 3.5 g Pouring melt aluminum

e. Cooling

After pour the melt aluminum into the casting box. The pattern will be leaving around 10 to 15 minute to get cold and hard. (Refer figure 3.5 g)

Figure 3.5 h Cooling

f. Filing

Filing process will be done after the product been casted.

g. Finishing

Finishing process will be done after the filing using sand paper

3.5.2 Machining Process

In second of fabricate the new upper piston, machining method is been used to fabricate the piston, which is:

a) Cutting
   - Cut the aluminum bar using bend saw according to the length needed.

b) Facing
   - Using the lathe machine to facing to get a flat and smooth surface.

c) Turning
   - Used the lathe machine turning the aluminum bar to get the diameter product.

d) Filing
   - Filing process used files to remove the chip or bur and get the smooth surface and dimension.

e) Finishing
   - Used waterproof sand paper to smoothen the entire piston surface.

3.5.2 A) Fabrication Method

1. **Machining process:**

A. Marking and Cutting process

The fabrication process for the upper piston is start with measuring and marking the aluminum bar long than the dimension needed. It because for the facing process. All the measuring and marking process is done by using measuring tape and marker.

After measuring and marking process, the marked aluminum bar goes to next process, cutting. First put the aluminum bar at the machine clamp. Then clamp the bar and turn on the bend saw to start the cutting process. (Refer figure 3.5 i)

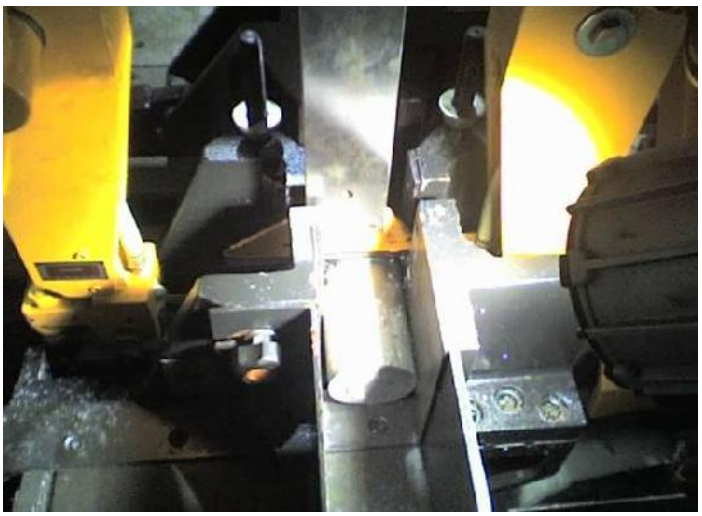


Figure 3.5 i Cutting process

B. Facing and Turning process (Lathe Machine)

First clamp the work piece at the lathe jaw, then set the center point to center the cutting tool. Then set the rpm according to the tool and the material used. Start off by set the zero point to the material so that the dimension will correct. Then start with making the facing process. Facing process is done at the both side of end side aluminum bar.

After get the flat and smooth surface, next is the turning process to get the diameter. Lastly the facing and turning process is done. (Refer figure 3.5 j and 3.5 k)

Figure 3.5 j Facing and turning process

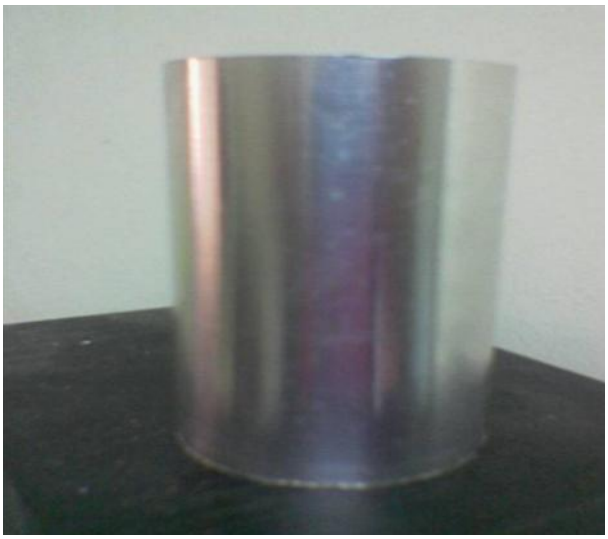


Figure 3.5 k workpiece

C. Facing and Turning process (Milling Machine)

After the facing and turning process by lathe machine, next step is the facing using the milling machine. Before start, the clamp and the tool also have to set to zero point so that

the dimension easy to get and easy to run. Then the set the rpm according to the tool and the material used. Facing process start, facing process is making step by step. (Refer figure 3.5 l)

Feed rate is important to prevent tool and work piece damage. Facing process done in both side. (Refer figure 3.5 m)

Figure 3.5 l Facing process

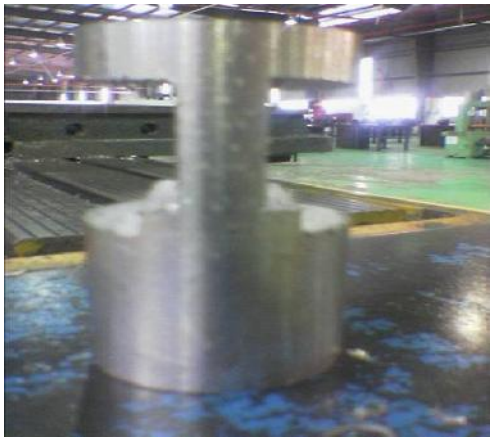


Figure 3.5 m Milling process done

D. Drilling process for bearing slot.

Before making the drill process, sketching for the drill hole to prevent over drill for the hole. It also due to the limited tool for the drilling process at milling machine. (Refer figure 3.5 n and 3.5 o)

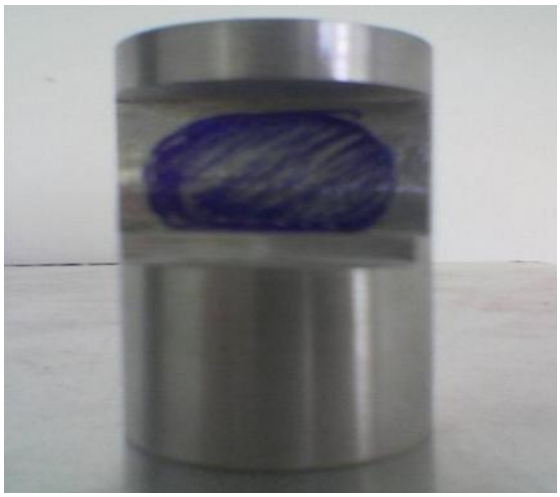


Figure 3.5 n Sketch for drilling process

Figure 3.5 o Drilling process

E. Filing process

Filing process is done to remove the chip and bur. Filing process also does to get the real dimension for the bearing slot. Then filing process is doing at both side of the piston to get the fillet part. (Refer figure 3.5 p and 3.5 q)

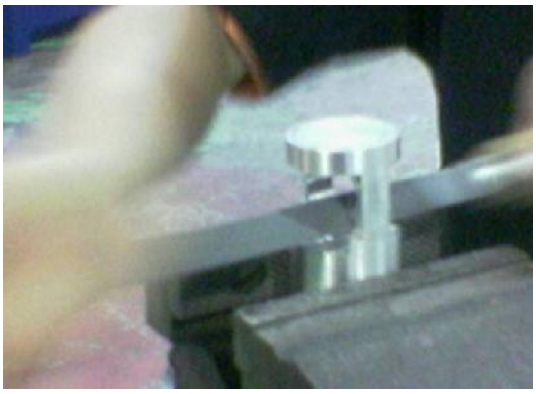


Figure 3.5 p Bearing Slot filing

Figure 3.5 q Fillet filing

F. Finishing process

After all the filing process, the finishing is doing used the waterproof sand paper to smoothen all piston surfaces. It also to get the piston bearing hole are fit for the bearing size. (Refer figure 3.5 r, 3.5 s and 3.5 t)

Figure 3.5 r Middle surface finishing

Figure 3.5 s Bearing slot finishing

Figure 3.5 t Surface finishing

CHAPTER 4

RESULT AND DISCUSSION

4.0 INTRODUCTION

In this chapter, it is mention about the project result after the fabrication process is done, about material properties and about comparison all of the designs that have been design by bachelor student and Malcolm J. Beare. The comparisons are between the design, material used, disadvantage and advantage of the design. There will no testing data because of no testing process been done for the piston. And also about the problem encounter in project progress.

4.1 RESULT

After through all the fabrication process, the new upper piston prototype is not succeed at the first fabrication. However it succeeds fabricate on using the second method which is using machining process. As well as achieve the project objective. Because of the fabrication focus on the prototype making so no testing been done to the upper piston. (Refer figure 4.0 a and 4.0 b)

Figure 4.0 a Casted piston

Figure 4.0 b Machined piston

4.2 DISCUSSION

4.2.1 Casting process.

At first of the fabrication, the upper piston is failed to produce by the sand casting. All this because of the first time of using the casting method in produce the upper piston. Even thought the dimension been increase from original dimension. During the fabrication process, there was technical error on the machine which is furnace cannot run properly so the aluminum bar cannot be melt.

4.2.2 Machining process.

After using the machining process, there is none of error in fabrication process. All the dimension of the design is followed. At the end, the upper piston prototype is succeed been fabricate.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.0 CONCLUSION

As the conclusion, the objective of the project was achieved. The upper piston for new cylinder head concept has been fabricated. The upper piston fabricate by follow all the dimension and specification needed.

5.1 RECOMMENDATION

After finish the project, the upper piston is ready to use as a reference for new design of upper piston. Due to the problem that are facing when fabrication the upper piston. Which is the furnace of the casting machine cannot run properly. In achieve the project objective, the fabrication is used the machining method to fabricate the upper piston. In designing using the new method, the upper piston design can be upgrade by make a place for piston ring and make it hollow piston. And the other part to complete the design also can be fabricated. Due to the limited of time in fabrication, the only part that can be fabricated is the upper piston.

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WEB SITES

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http://en.wikipedia.org/wiki/Six_stroke_engine

Beare Head
http://en.wikipedia.org/wiki/Beare_Head

Modenas Kriss 110cc
http://en.wikipedia.org/wiki/Modenas
Four-stroke engine

http://en.wikipedia.org/wiki/4_stroke

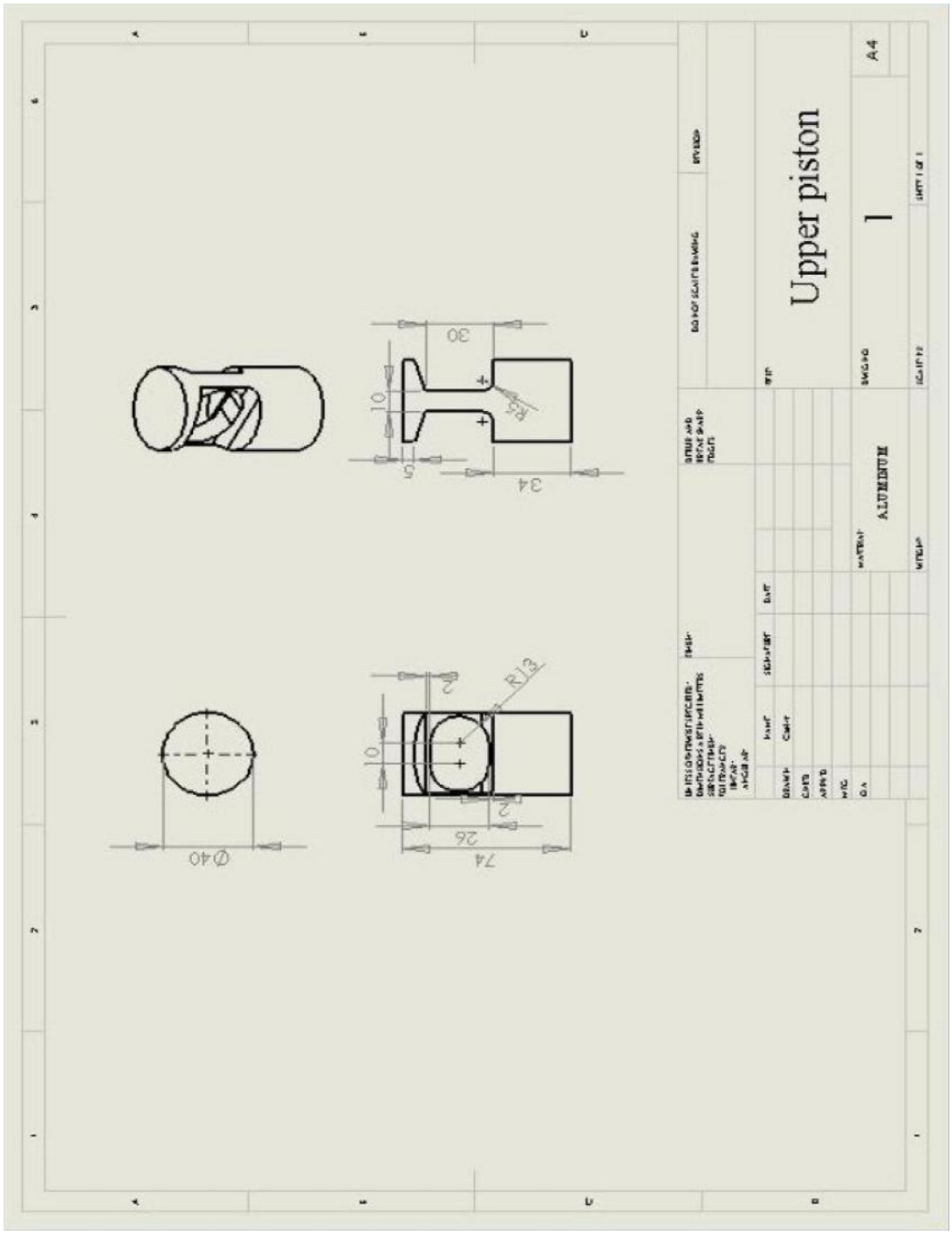
Two-stroke
http://en.wikipedia.org/wiki/2_stroke

Six-stroke
http://en.wikipedia.org/wiki/Six_stroke_engine

Two-stroke system operation
http://science.howstuffworks.com/two-stroke2.htm

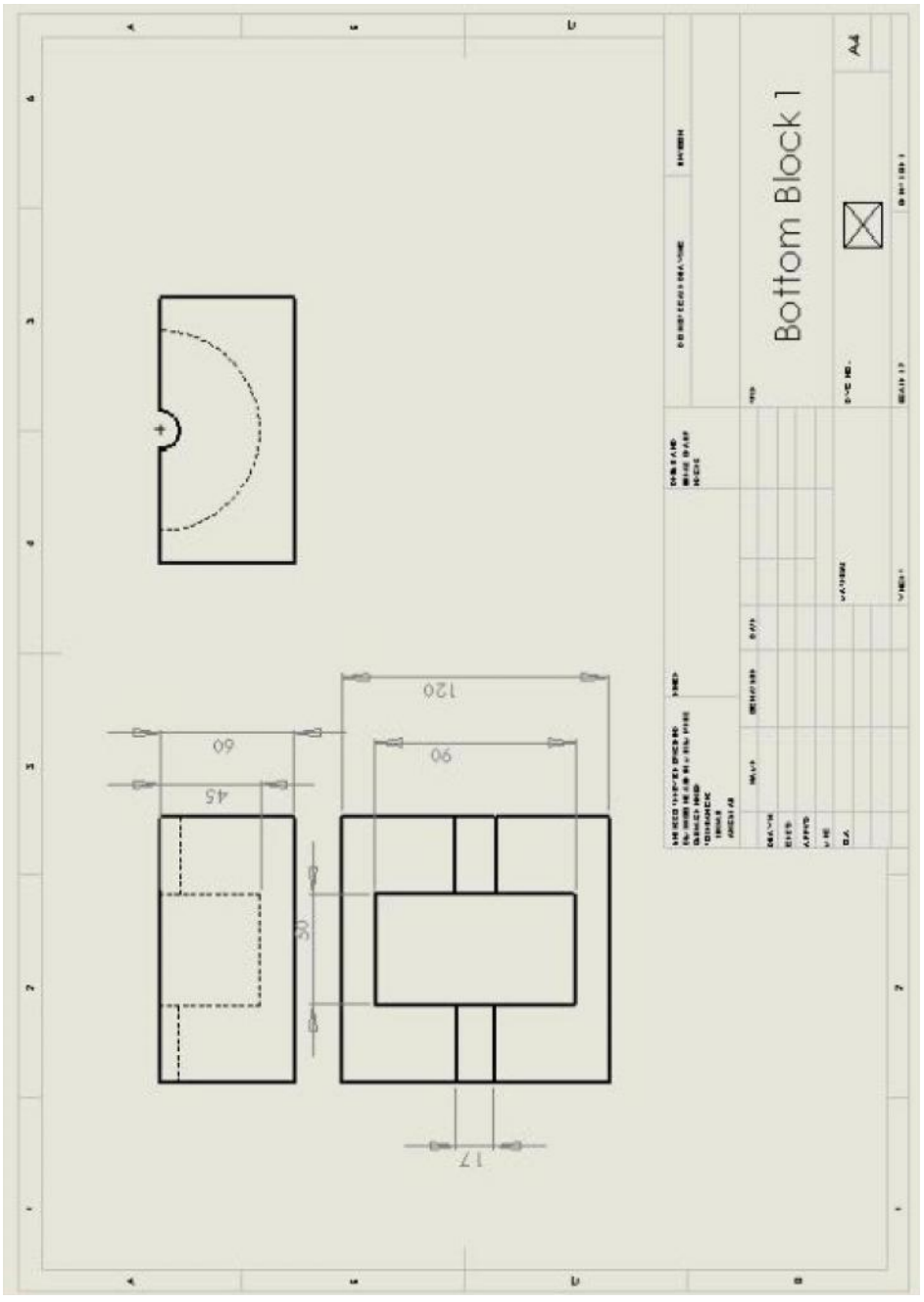
APPENDIX A

UPPER PISTON



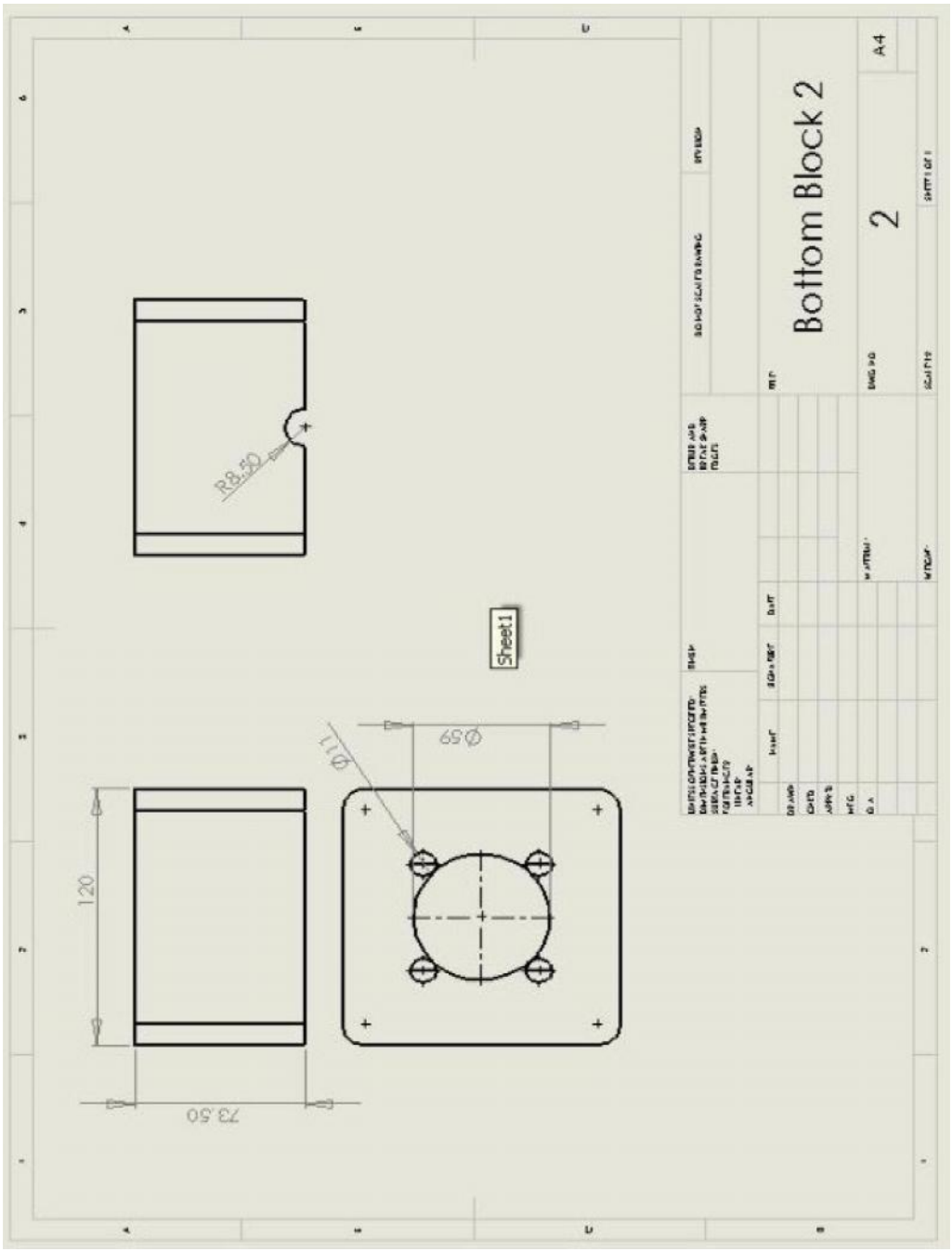
APPENDIX B

BOTTOM BLOCK 1



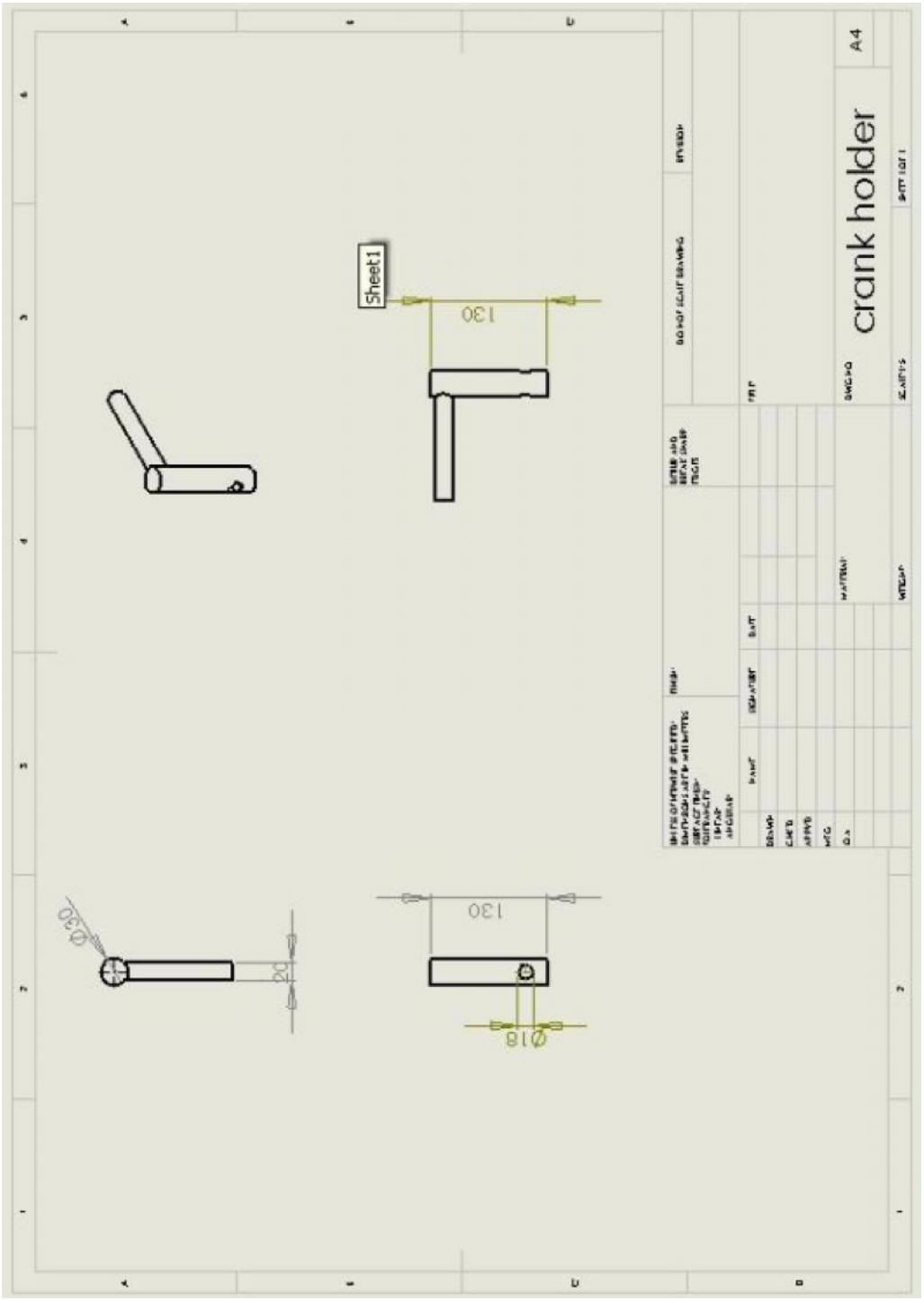
APPENDIX C

BOTTOM BLOCK 2



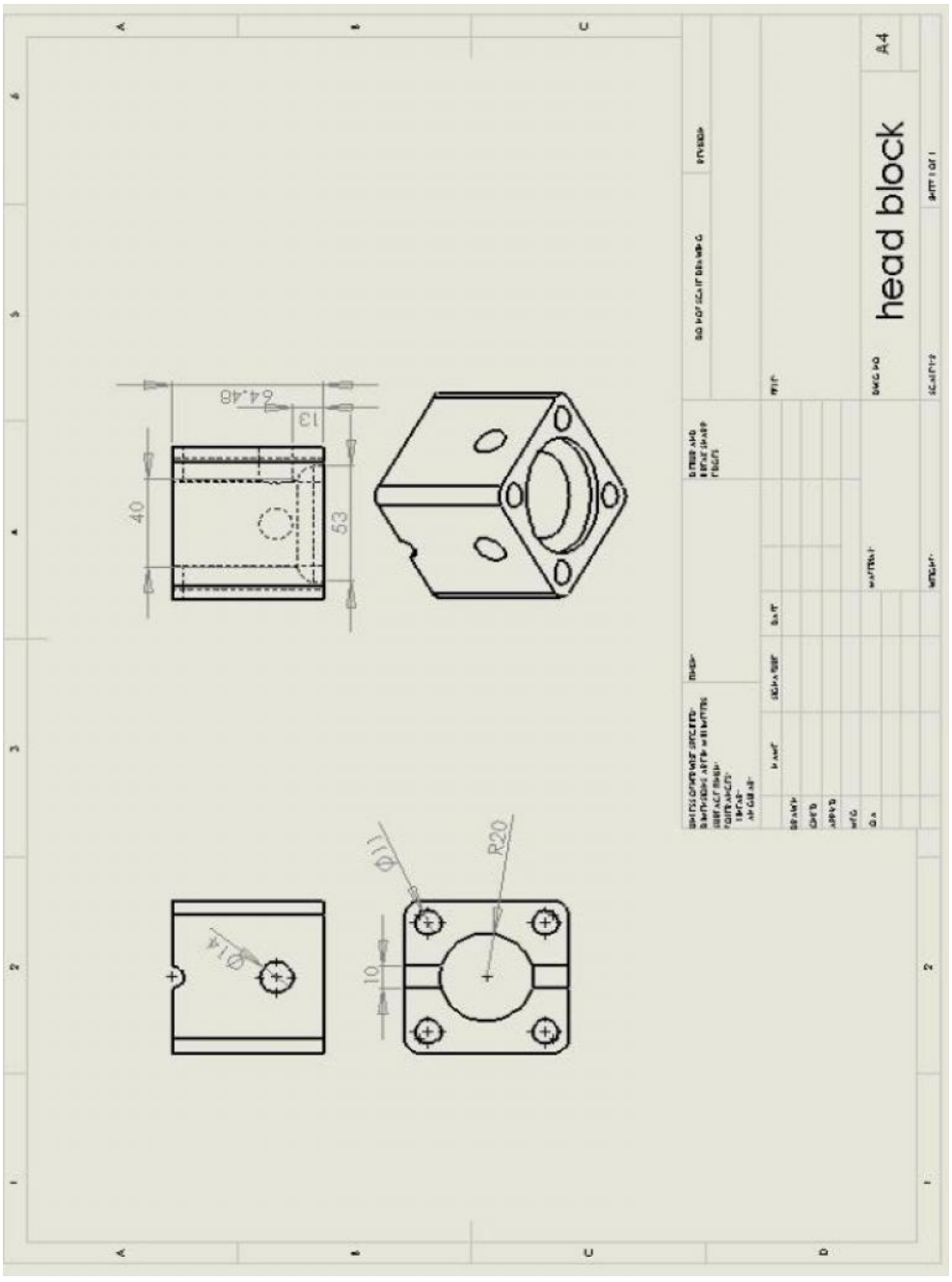
APPENDIX D

CRANK HOLDER



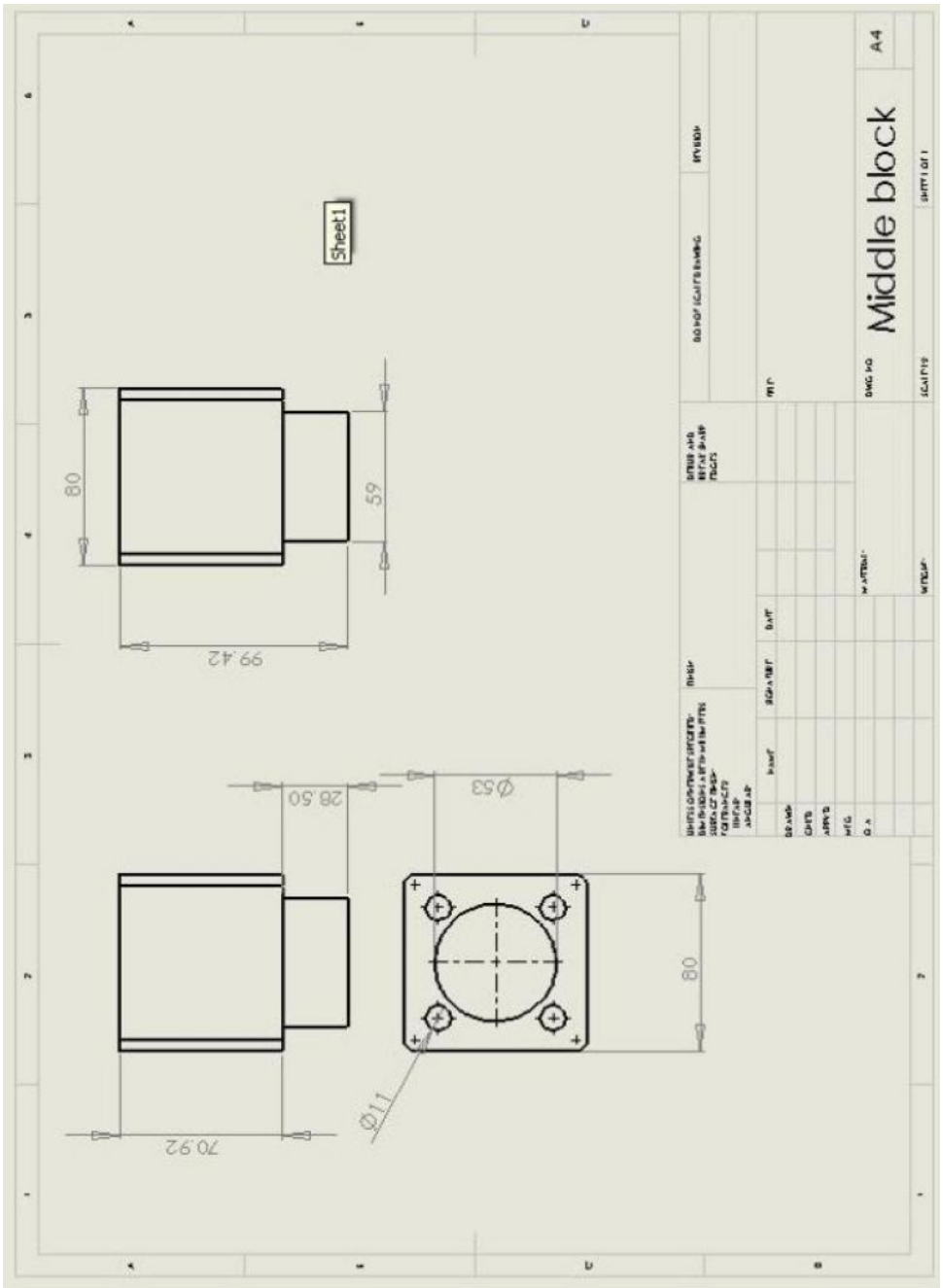
APPENDIX E

HEAD BLOCK



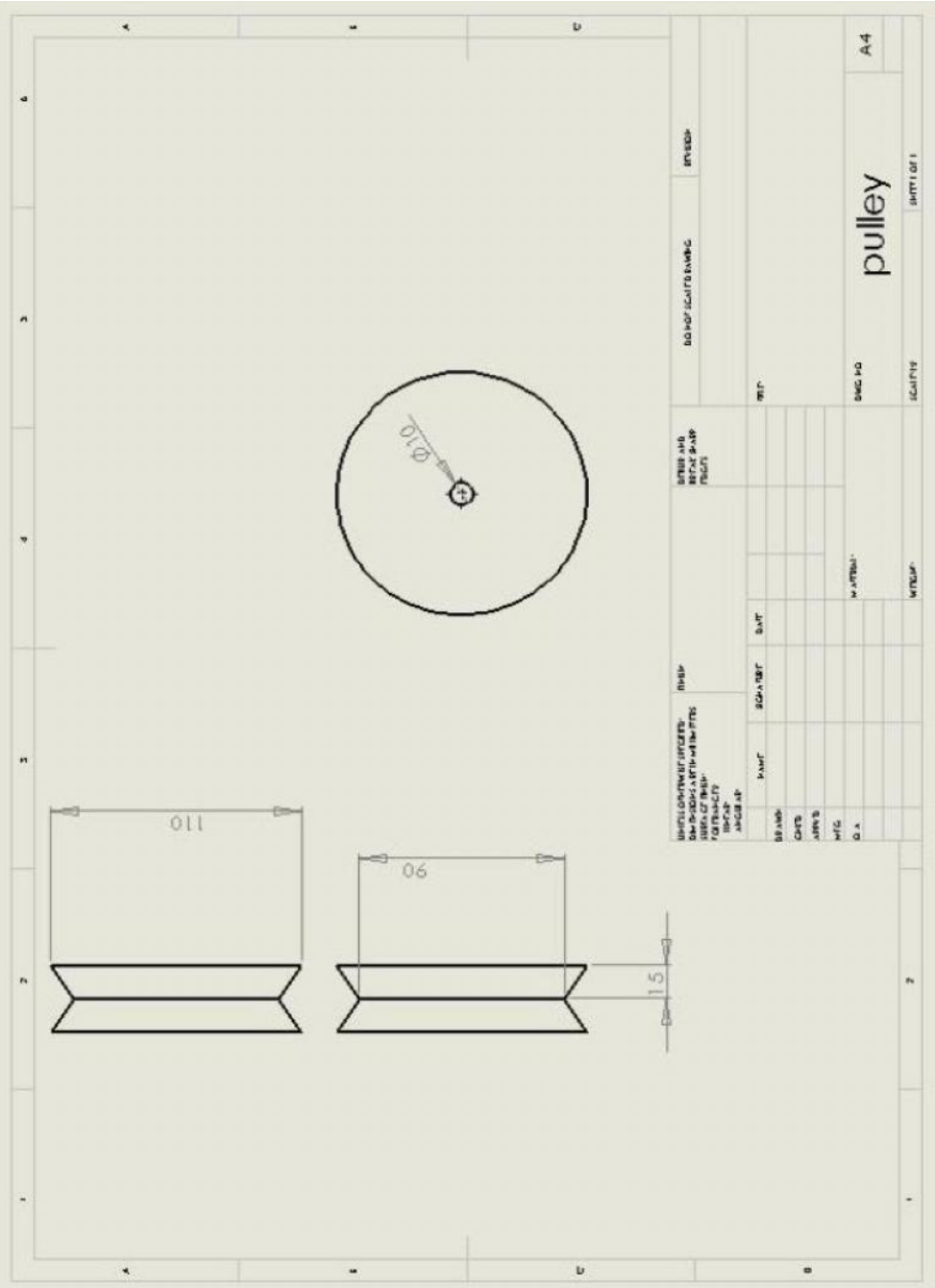
APPENDIX F

MIDDLE BLOCK



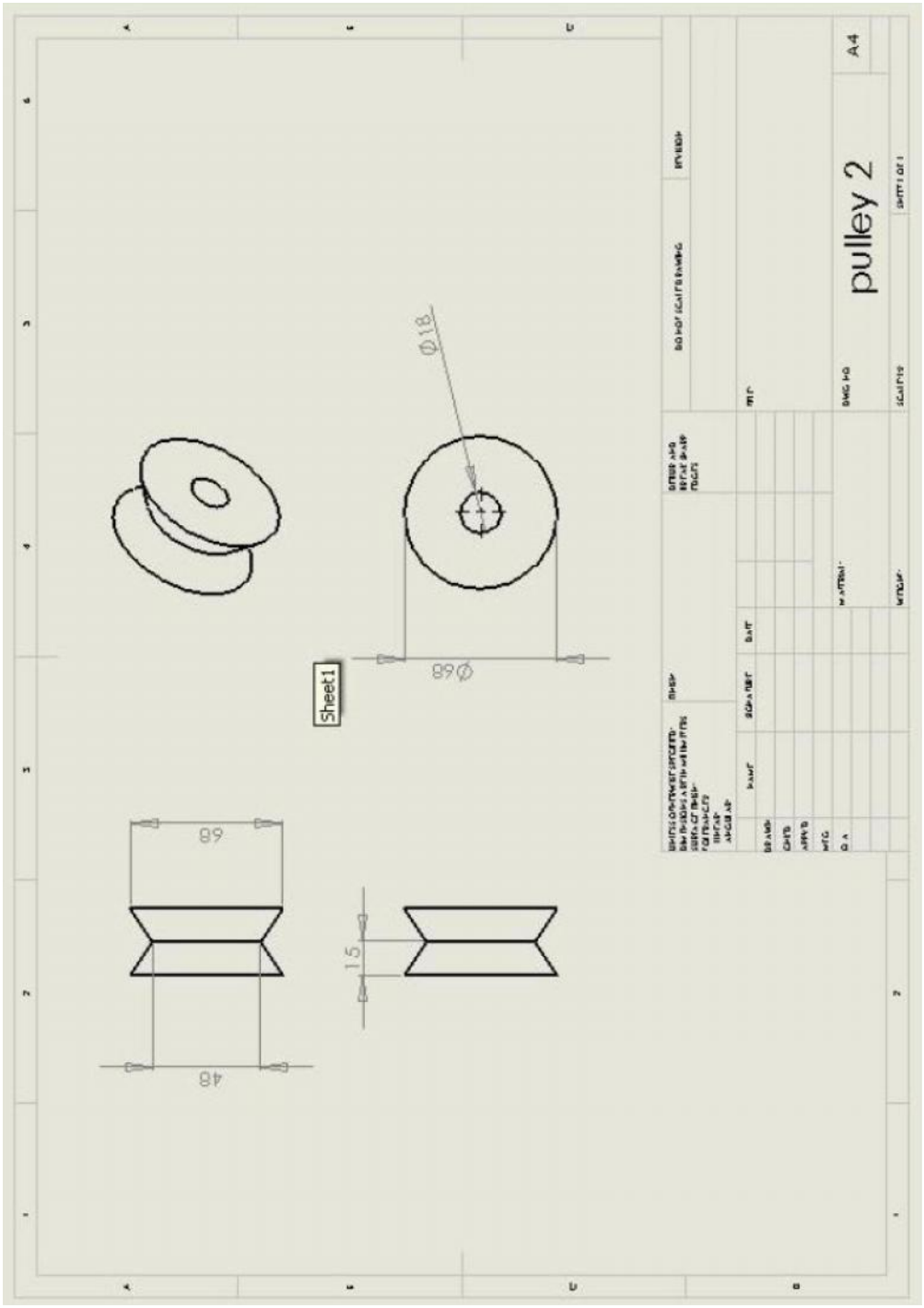
APPENDIX G

PULLEY



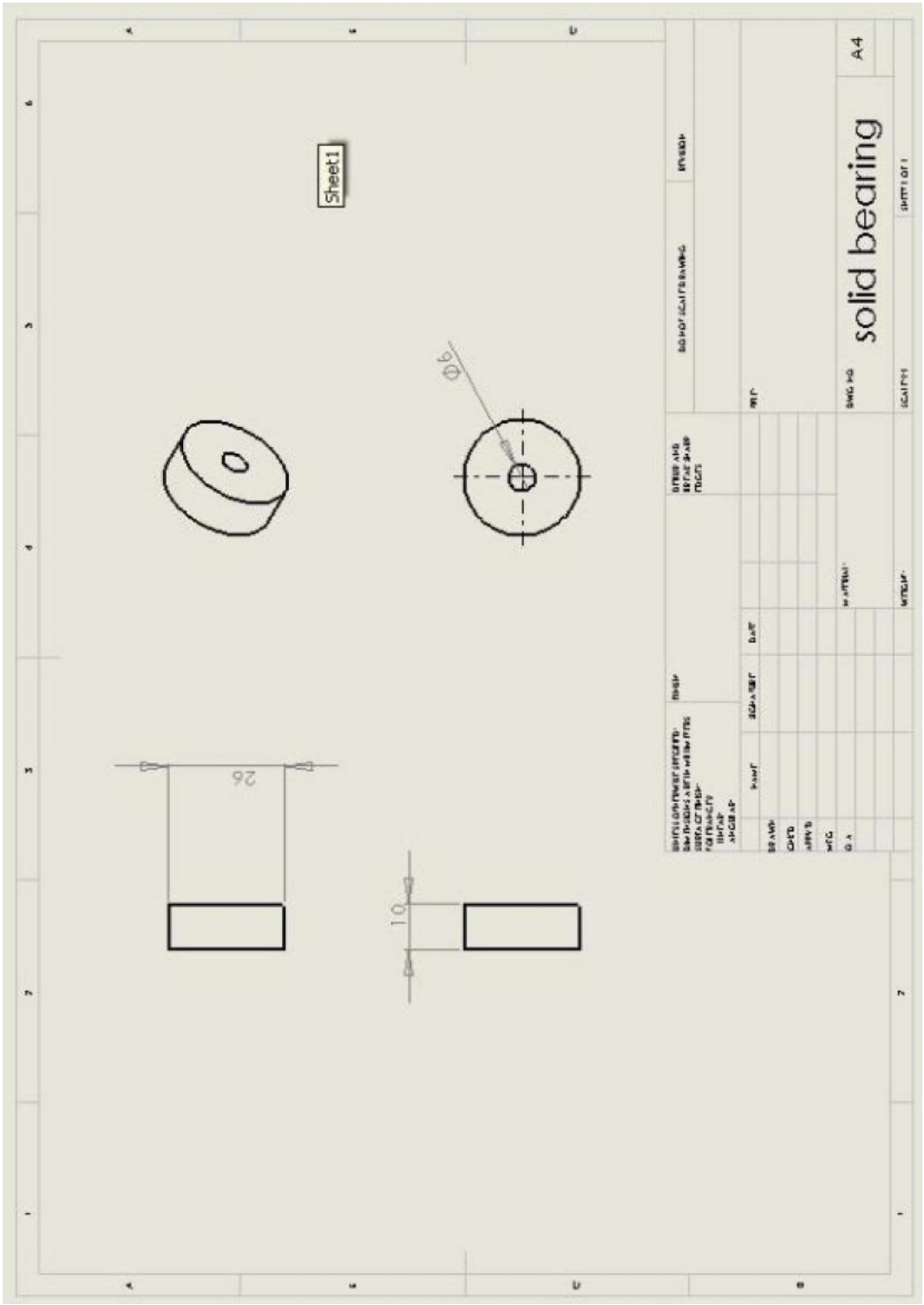
APPENDIX H

PULLEY 2



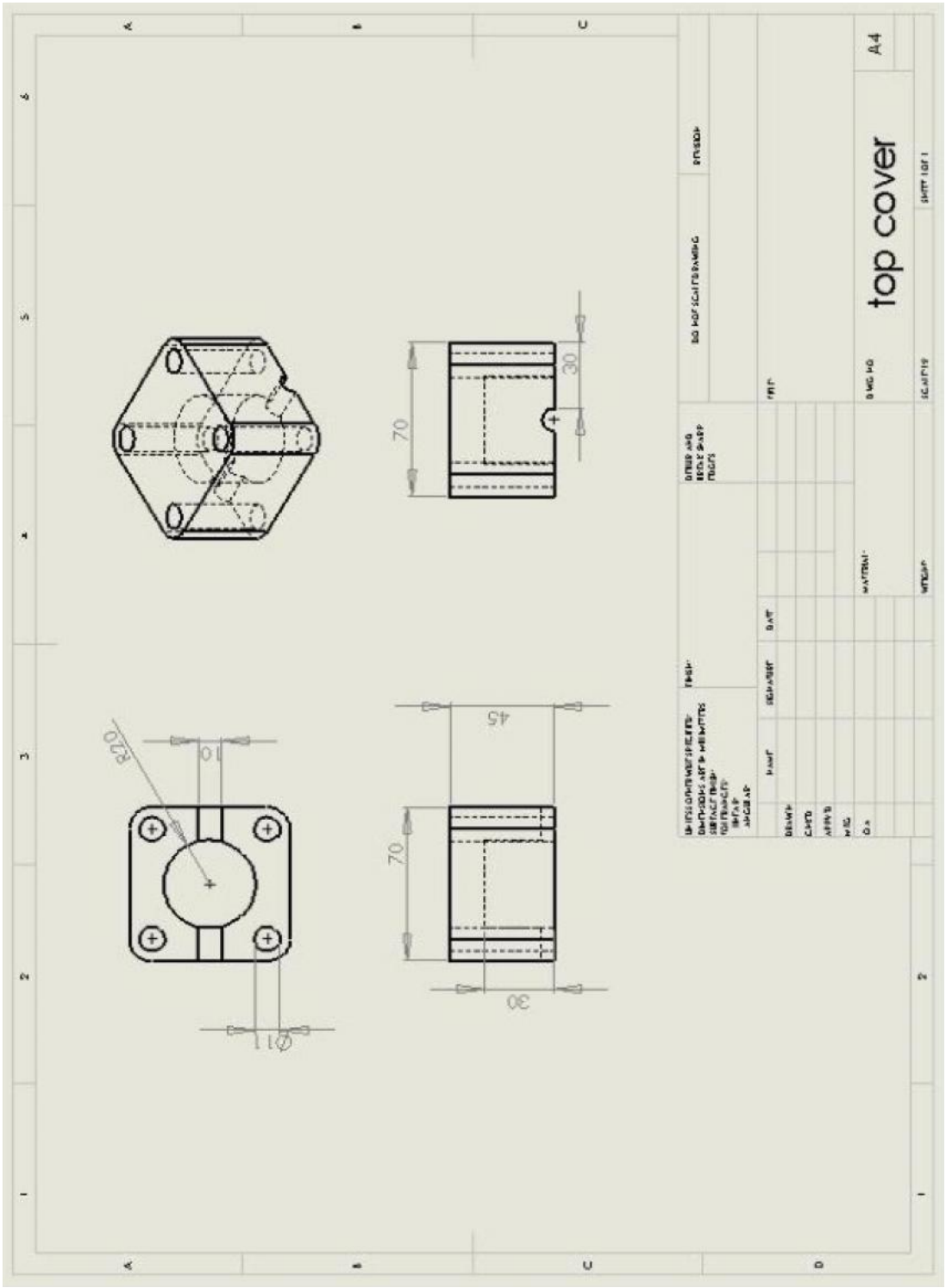
APPENDIX I

SOLID BEARING



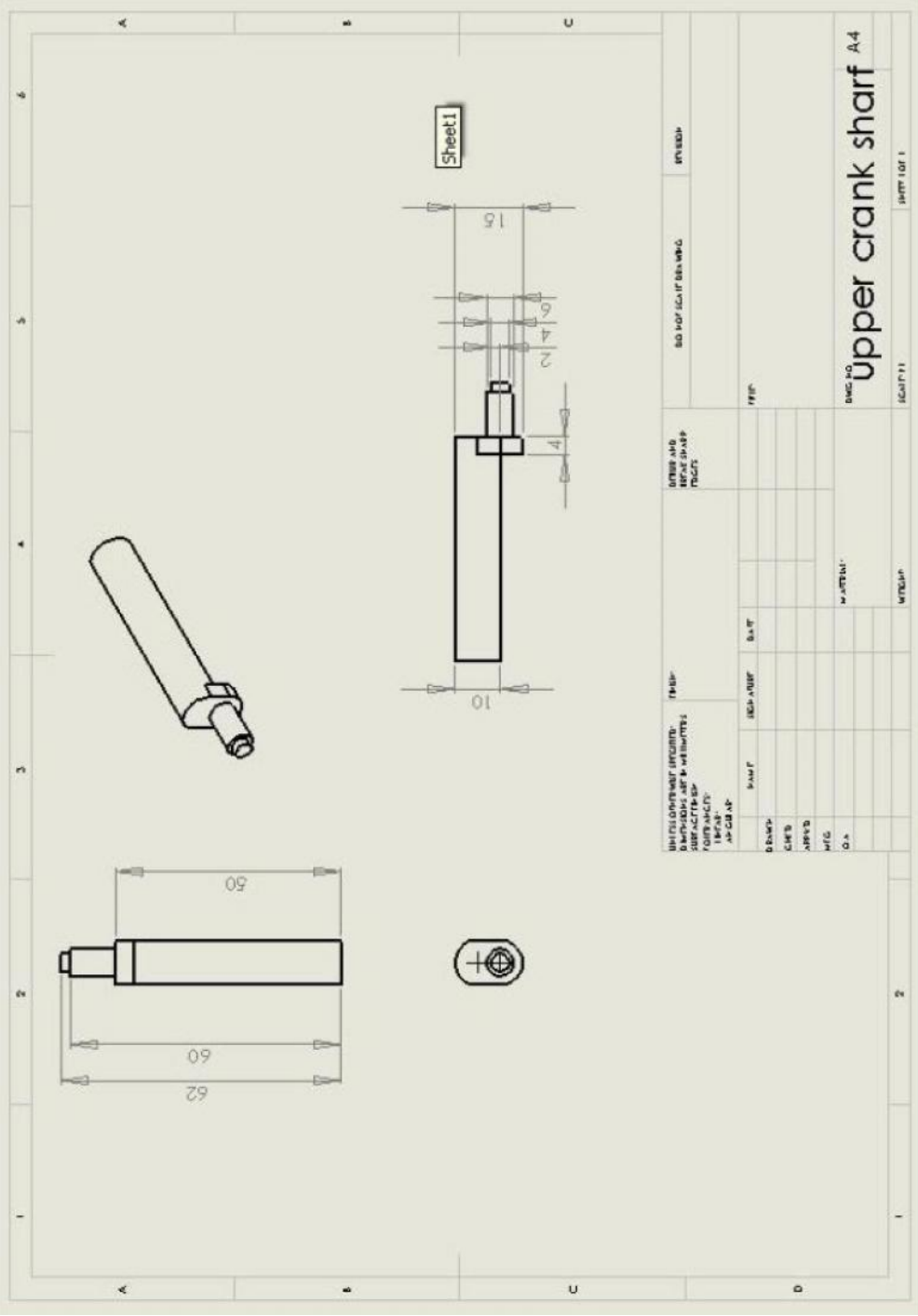
APPENDIX J

TOP COVER



APPENDIX K

UPPER CRANK SHAFT RIGHT



APPENDIX L

UPPER CRANKSHAFT LEFT