DESIGNING AND MANUFACTURE SOLAR TURBINE

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Report submitted in partial fulfillment of the requirements for the award of
Diploma in Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2010

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project report and in my opinion this project is satisfactory in terms of scope and quality for the award of Diploma in Mechanical Engineering.

Signature:
Name of Supervisor:
Position:
Date:

STUDENT 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 concurently submitted for award of other degree.

Signature:

Name:

ID Number:

Date:

ACKNOWLEDGEMENT

Praise to God for His help and guidance that I am able to complete the task of the Final Year Project. I am thankful and grateful to my supervisor, Mr Idris Bin Mat Sahat for his advice and knowledge that he shared in the completion of the project. I appreciate his help for me while I am doing the Final Year Project from week 1 to the day I finished my Final Year Project.

I also would like to thank all my friends who have been really helpful during the course of the conducting the Final Year Project. I also would like to thank laboratory assistants who have help me in sharing knowledge in conjunction with the project that I am conducting.

I sincerely grateful to my parents for they love and sacrifice that they had for me throughout my life and their support for me in all my activities that I have done. I also wanted to that other people who have directly or indirectly help in the completion of my Final Year Project. I sincerely appreciate all your help.

ABSTRACT

This report shows the design and fabrication of a solar turbine. The objective of the report is to develop the procedures to design and fabricate a prototype solar turbine to generate energy. This report also describes the ideas and products of current solar turbines which are available around the world. Design generation is showed and solid three dimensional structures modelling of the solar turbine was developed with computer aided design software. Material selection and the reason behind the selection are shown based on criteria predetermined. Based on the selection, aluminium alloy and mild steel is selected. The result from the testing of the solar turbine shows that the solar turbine able to generate electricity. Ideas of improvement for the solar turbine also provided to further improve the solar turbine.

ABSTRAK

Laporan ini menunjukkan lukisan dan pembuatan turbin solar. Objectif untuk laporan ini adalah untuk menghasilkan prosedur-prosedur untuk menghasilkan lukisan dan pembuatan prototaip turbin solar yang menjana tenaga. Laporan ini juga menerangkan tentang idea-idea dan produk-produk turbin solar yang terdapat di serata dunia. Generasi lukisan telah ditunjukkan dan permodelan struktur-struktur pejal tiga dimensi untuk turbin solar telah dihasilkan menggunakan perisian lukisan bantuan komputer. Pemilihan material dan seba-sebab pemilihan telah ditunjukkan berdasarkan criteria yang telah ditetapkan. Berdasarkan pemilihan tersebut, aluminium aloi dan logam asli telah dipilih. Keputusan daripada percubaan turbin solar tersebut menunjukkan ia mampu menjana tenaga elektrik. Idea-idea pembaikan untuk turbin solar juga diberi untuk improvasi turbin solar tersebut.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This project title is ‘Designing and manufacture Solar Turbine. A solar turbine or also known as solar convection turbine is a product which generates energy with renewable energy source. It uses the concept of air convection to generate energy.

1.2 PROJECT BACKGROUND

This project is about designing and manufacturing a solar turbine. A solar turbine is a renewable energy plant whereby it generates energy by converting kinetic energy from air movement into electricity. Solar turbine uses 3 concepts which are greenhouse effect, buoyancy effect and power generation. The air is heated through greenhouse effect whereby it is heated by sun’s radiation under transparent material (such as glass). Hot air is less dense than cold air thus hot air will rise. This phenomenon is called buoyancy effect. The air then moves upwards, through a channel whereby there is/are turbine(s). The air movement turns the turbine, and the kinetic energy from the turbine is converted by a motor into electric energy.

1.3 PROBLEM STATEMENT

Nowadays, fossil fuel is the main energy source, however it will be depleted. Therefore, a renewable energy source should be applied as alternative energy source. The alternative way is using solar turbine to generate energy.

1.4 PROJECT OBJECTIVE

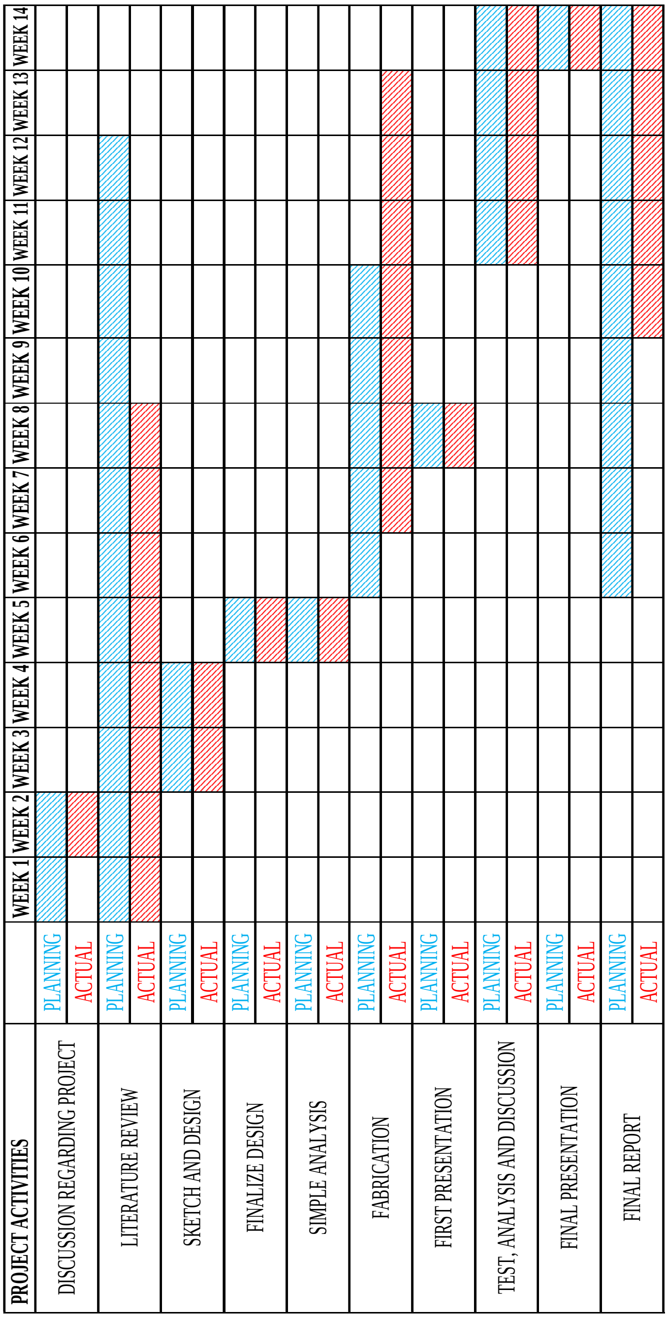
The main objective of this project is to design and fabricate a prototype solar turbine to generate energy based on mechanical engineering method.

1.5 PROJECT SCOPE

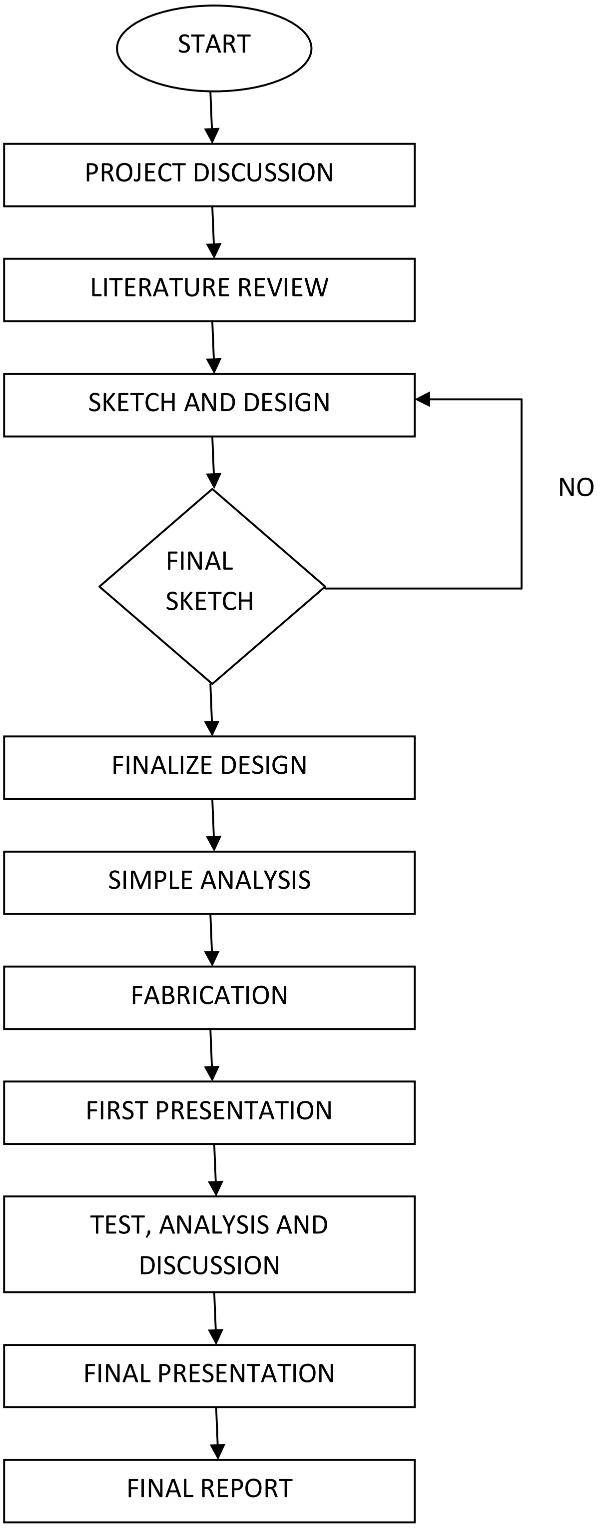
1. To apply all related topics which are learned during the course Diploma of Mechanical Engineering such as industrial design, fluid mechanics and dynamic in product design and efficiency.
2. Final design of the project is illustrated in 3D by using Solidwork software.
3. To manufacture a prototype solar turbine that able to generate electricity.
4. Fabrication of a prototype solar turbine in a small scale.

1.6 GANTT CHART

Table 1.1: Gantt chart



1.7 FLOW CHART



CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE REVIEW

2.1.1 Solar Turbine 1

Solar turbine or Solar Convection Turbine is a turbine which generates electricity by natural convection of fluid by exposing the fluid to sun's heat. When fluid is heated, the density decreases, due to the increase of gaps between molecules. The area which is exposed to heat will become less dense, thus the denser fluid will move downward, causes the movement of fluid. This movement is called convection.

The ideas of producing solar turbine have been circulating among researchers for years starting from the 20th century when a Spanish Colonel called Isidoro Cabanyes proposed it in a scientific magazine but there are few efforts on producing one. One of the ideas came from Dr Alan Williams, a freelance solar energy researcher.

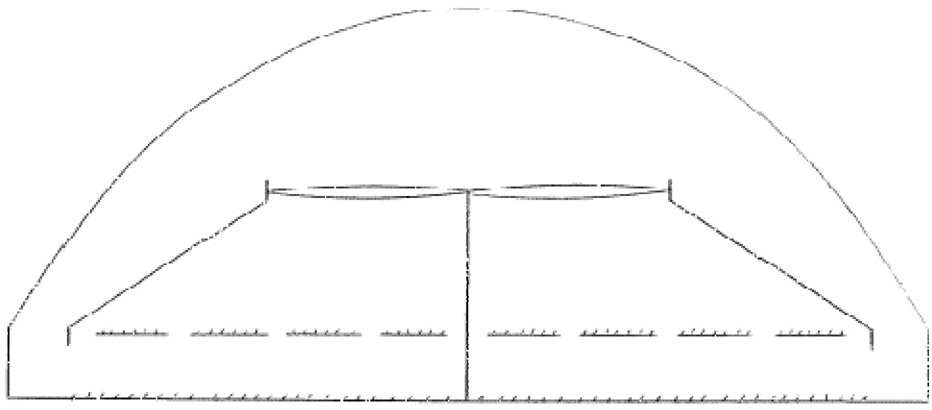


Figure 2.1: Dr. Alan Williams solar turbine idea (Ref. 1)

His idea was to build large sealed ground level solar conductors. The convective energy conversion cycle involved requires no heat rejection and may allow the conversion of solar energy into electricity with very high efficiency. Based on Figure 2.1, the outer dome and inner nozzle are made of transparent material. Inside the dome contains air at atmospheric pressure and is sealed to the ground. The solar absorber is placed above the ground level with substantial gaps to allow air flow. The ground is also covered with solar absorber. A horizontal wind turbine is placed in the center of the dome with its vanes in the throat of the nozzle. The solar absorber acts as a heater warming the air which then rises because of buoyancy effect. The air then flow through the nozzle. The constriction will cause the air to flow in a high velocity. The kinetic energy of the air flow will be taken by the turbine, generating electrical energy. The air then rises to the top of the dome, and eventually cooled, causing it to flow downwards. It will be heated again by the solar absorber. This will cause a cycle, which is called convection.

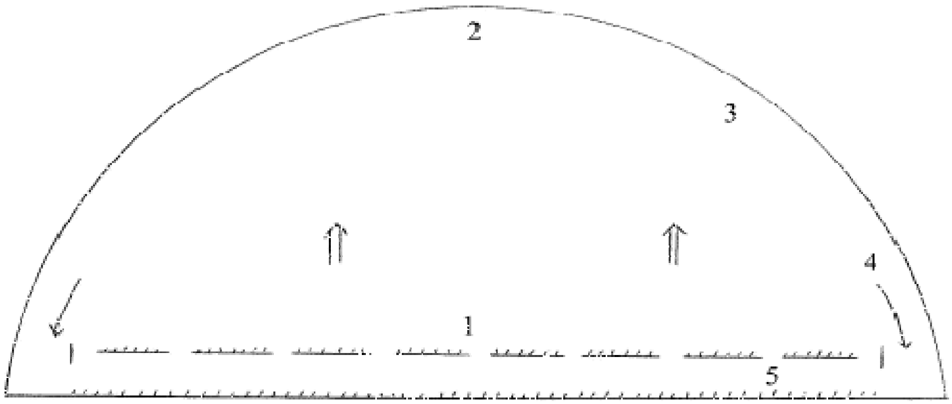


Figure 2.2: The flow of air movement inside the solar turbine (Ref. 1)

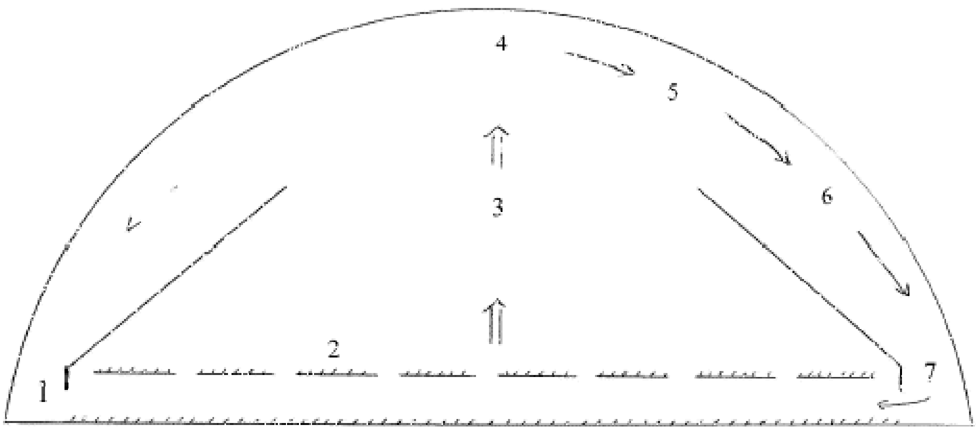


Figure 2.3: The flow of air inside the solar turbine (Ref. 1)

2.1.2 Solar Turbine 2

Secondly is a project lead by Robert J. Rohatensky called Solar Heat Pump Electrical Generation System or SHPEGS. The project is to design and build a system that uses a combination of direct and indirect solar collection to generate electricity and store thermal energy in an economical, environmental friendly, scalable, reliable, efficient and location independent manner using common construction materials. The system is called “Energy Tower”.

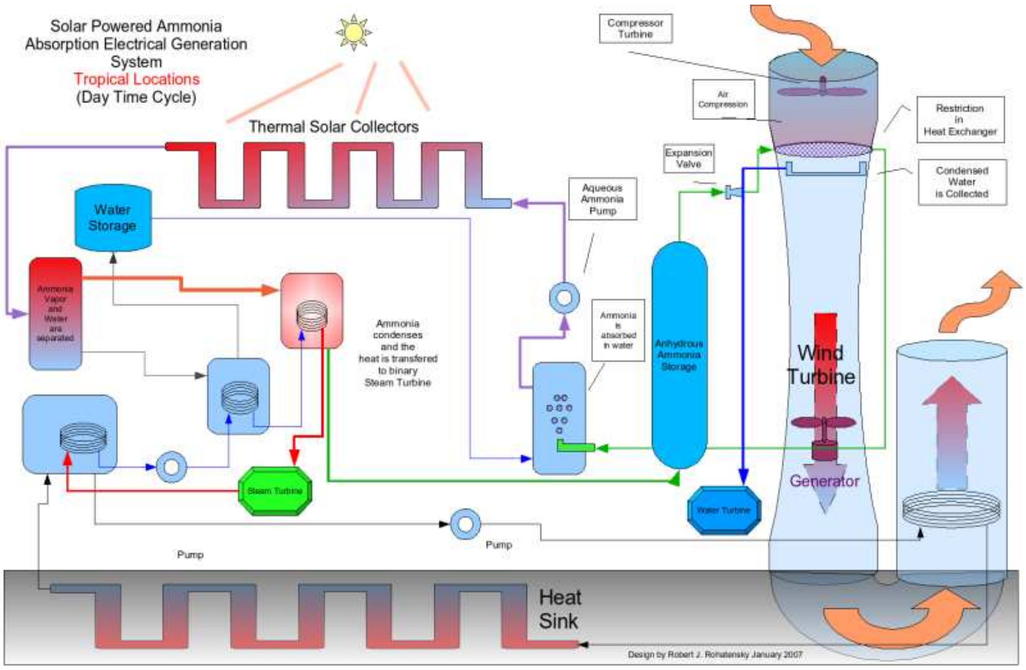


Figure 2.4: SHPEGS illustration (Ref. 2)

The system is divided into two parts, the tower and the thermal solar collectors. The thermal solar collectors absorb heat from the sun directly and warm up the ammonia. In the tower, as hot air enters, it will heat the ammonia. The air then flows to the wind turbine. The kinetic energy will turn into electricity. Excess heat then absorbs by the heat sink and the air then flows out of the tower.

2.1.3 Solar Turbine 3

Third was a prototype, build in 1982 by German Ministry of Investigation and Technology, in collaboration with Spanish Power Company Union Fenosa in the town of Manzanares, Madrid.

Figure 2.5: Manzaranes Solar Tower (Ref. 4)

The medium-scale working model had a height of 195 meters and diameter of 10 meters with a collection area of 46,000 m^2 obtaining a maximum power output of 50kW. The pilot power plant operated approximately eight years, but “encountered severe structural instability close to the tower due to induced vortices”, and was decommissioned in 1989.

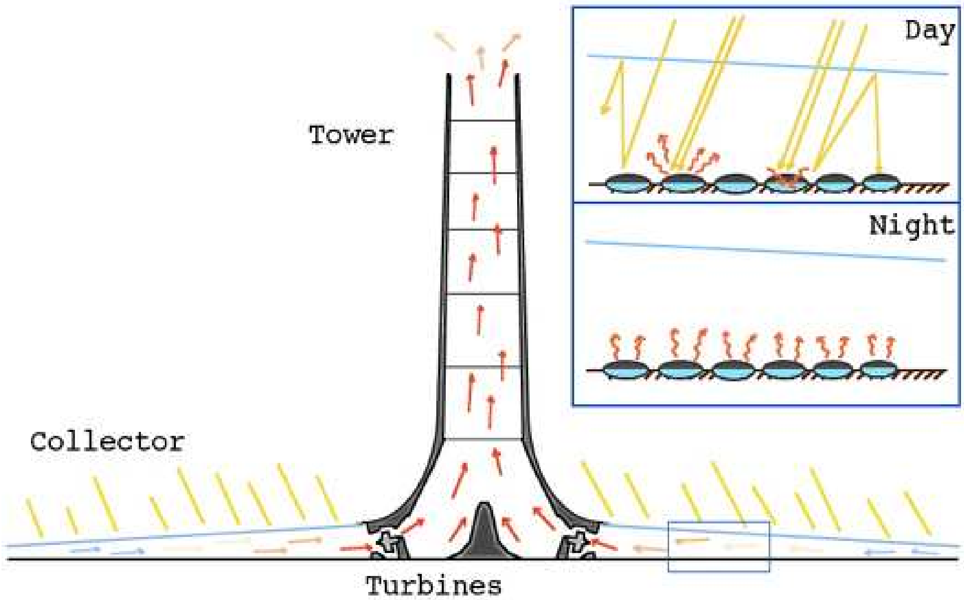


Figure 2.6: Illustration of air flow in Manzaranes Solar Tower (Ref. 4)

The design is based on 3 thermal principles, greenhouse effect, buoyancy effect and air movement drives the turbine to generate electricity. The sun's radiation will heat the air below the glass, in which the heat can't escape and flows towards the chimney. The air flow will turn the turbines, generating electricity. The hot air then continues to rise out of the chimney into the atmosphere.

2.1.4 Solar Turbine 4

Fourth is a project of solar tower in Namibia. The tower will be build with a height of 1.5 km and 280 m wide. The solar updraft towers could potentially produce 400MW of energy, enough to power Windhoek, the nation's capital. The idea was proposed by a company called Hahn & Hahn. The tower also functions as a 37 square km of greenhouse.

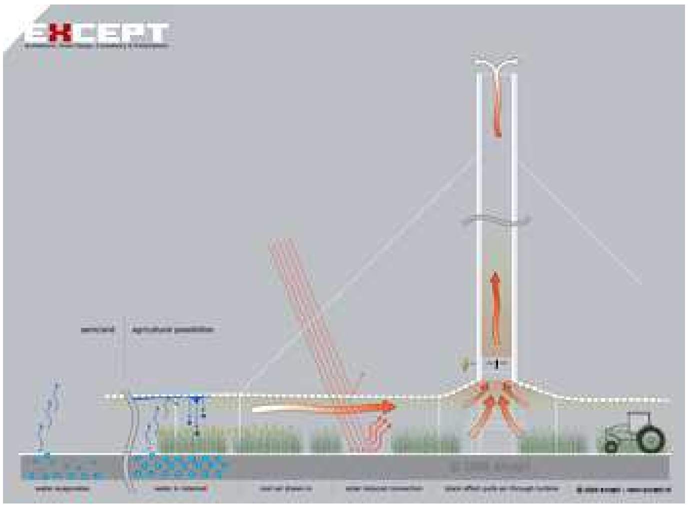


Figure 2.7: Illustration of solar tower in Namibia (Ref. 6)

Similar to the prototype build in Manzaranes, the solar tower generate energy by using sunlight to heat the air within a vast greenhouse situated at the base of the chimney. As the hot air rises, it is funneled into reinforced concrete chimney, driving through series of wind turbines which will generate electricity.

The structure's greenhouse base provides the environment to allow crops to grow, which will then allow the plant to provide energy at night. The water used for crops is heated during the day and transfers this energy at night.

CHAPTER 3

METHODOLOGY

3.1 DESIGN GENERATION

3.1.1 Sketch 1

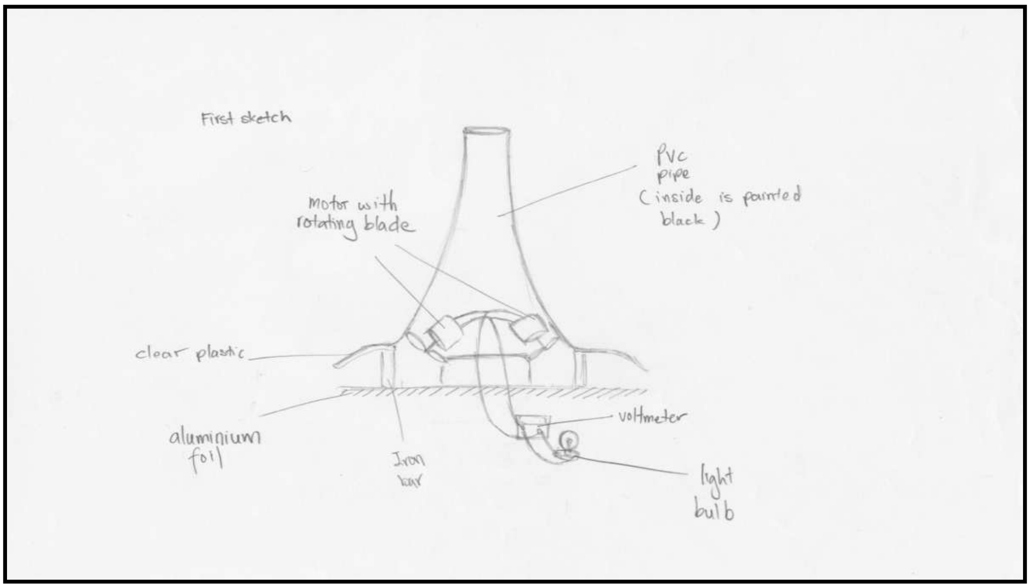


Figure 3.1: First Sketch

3.1.2 Sketch 2

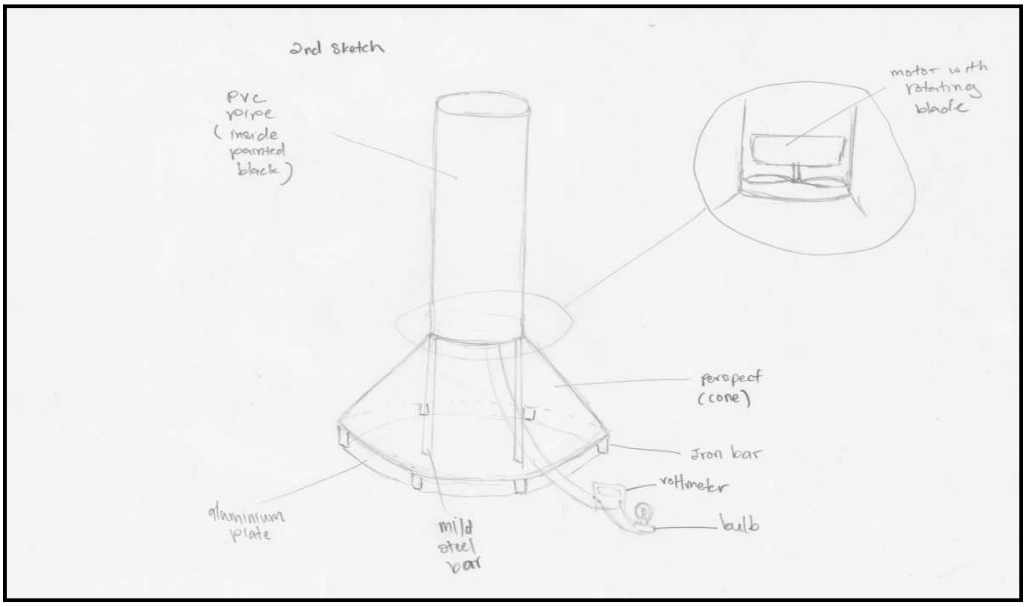


Figure 3.2: Second Sketch

3.1.3 Sketch 3

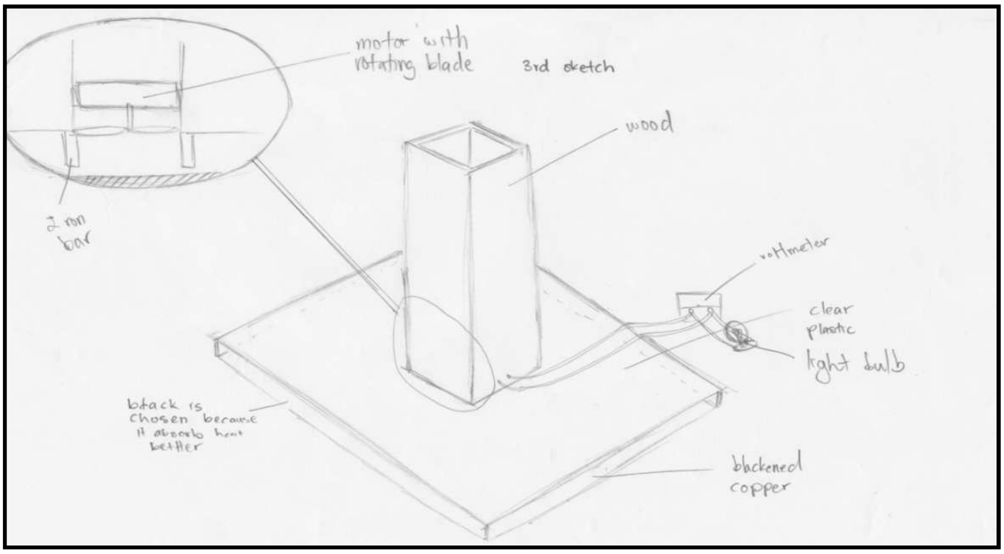


Figure 3.3: Third Sketch

3.1.4 Sketch 4

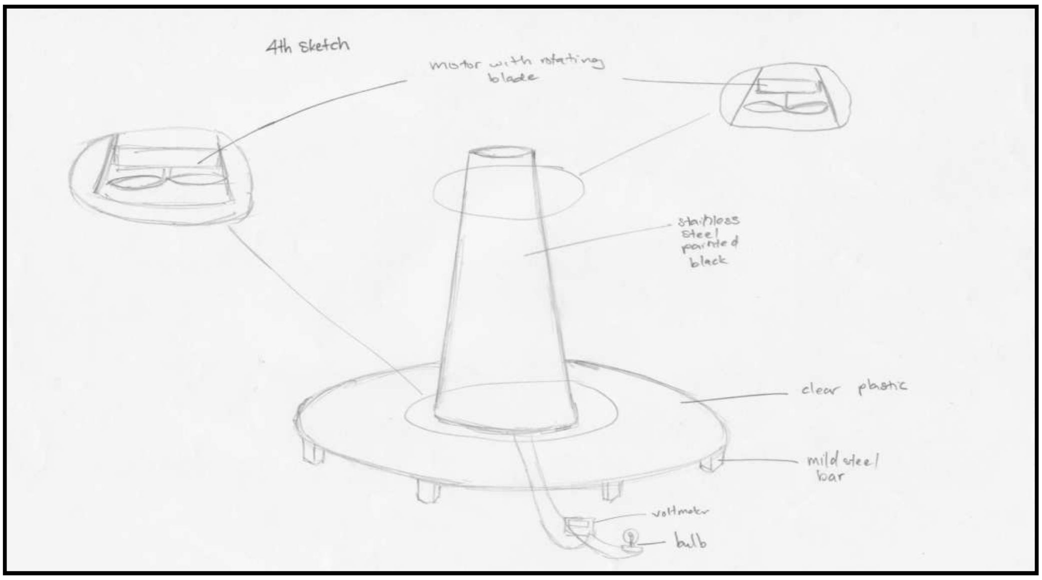


Figure 3.4: Fourth Sketch

3.2 FINALIZE DESIGN

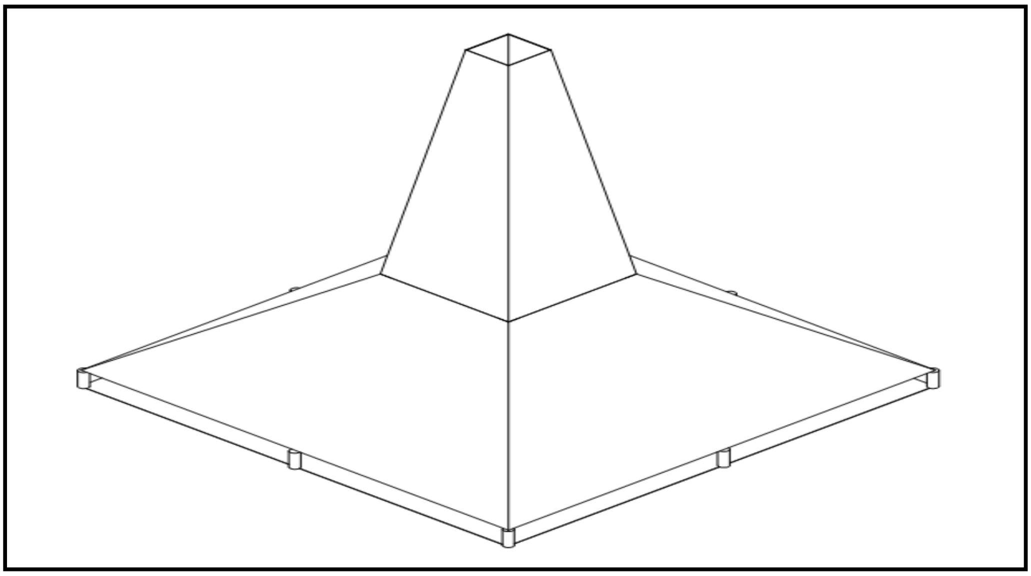


Figure 3.5: Finalize Design

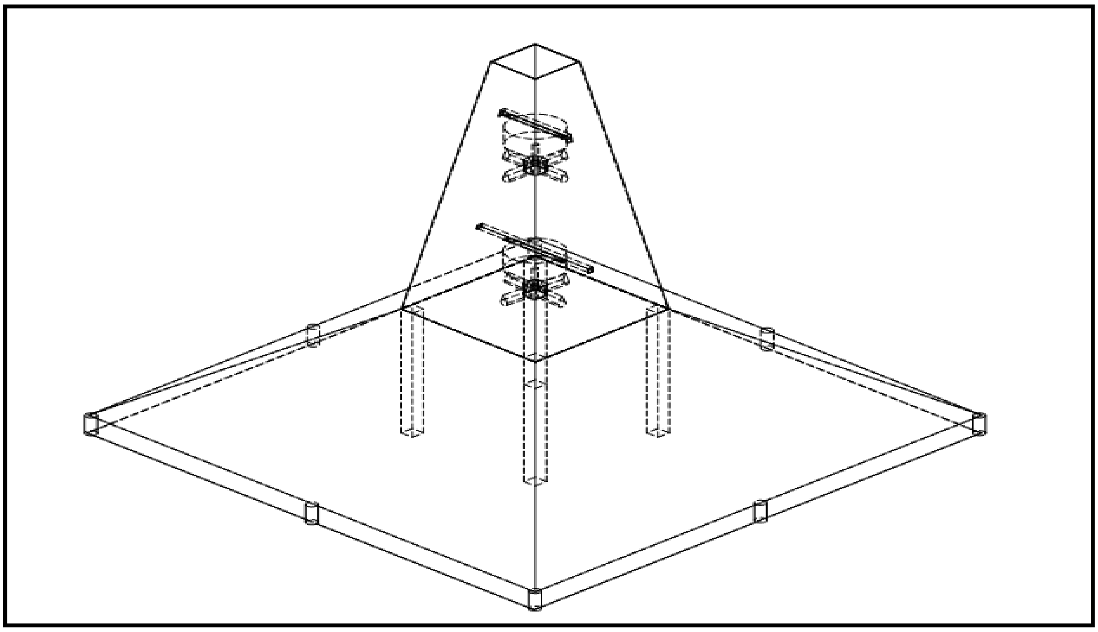


Figure 3.6: Inside-view

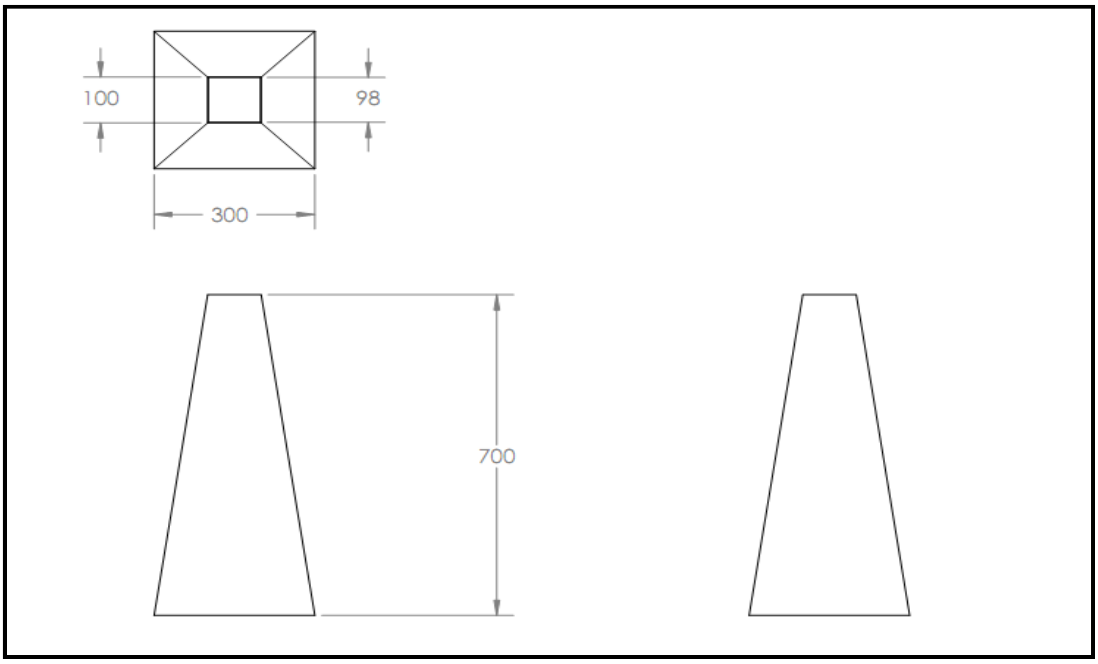


Figure 3.7: Pyramid Tower

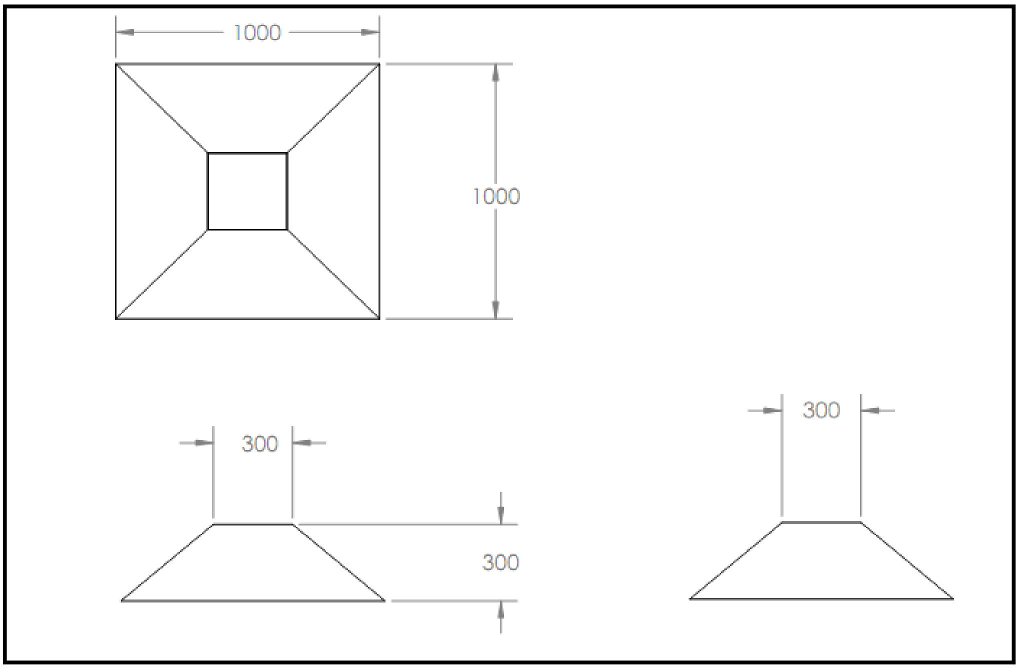


Figure 3.8: Plastic Base

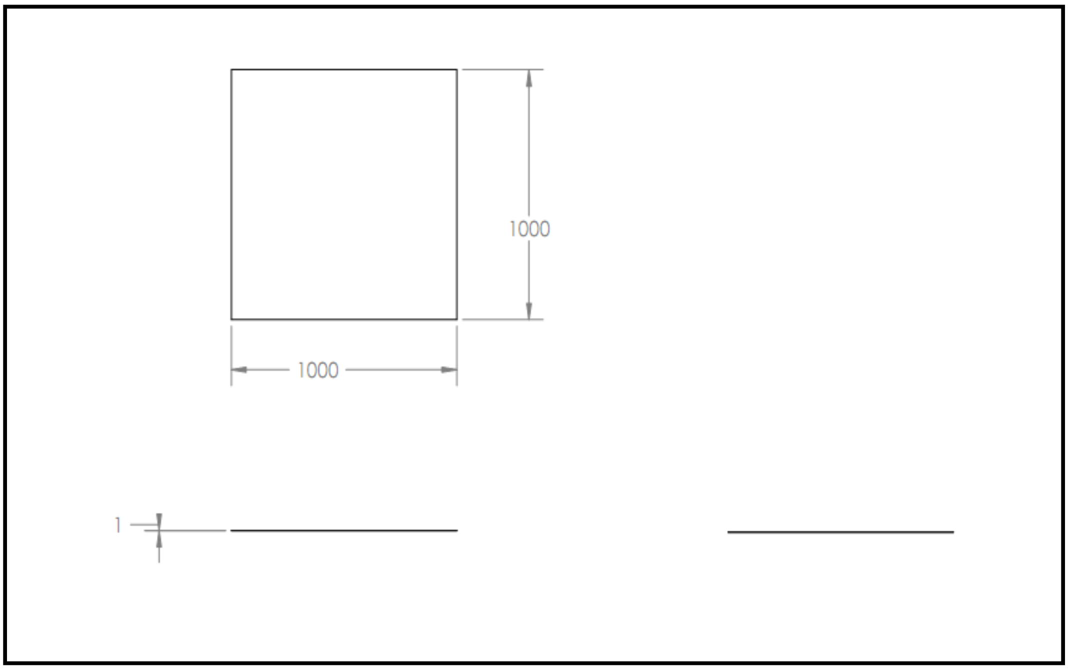


Figure 3.9: Base Plate

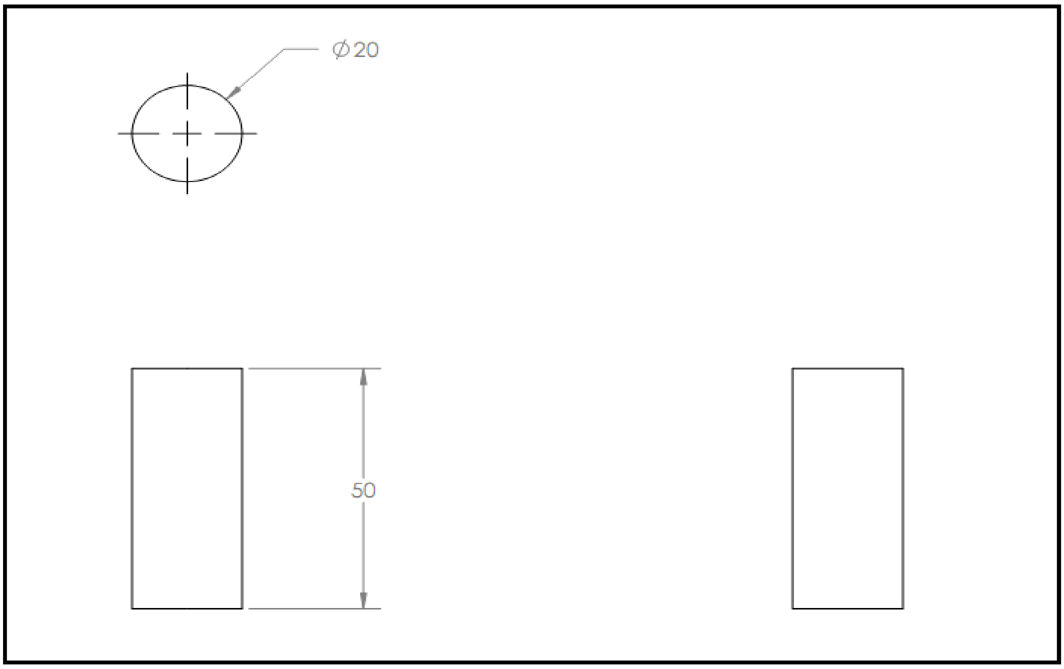


Figure 3.10: Base Stand

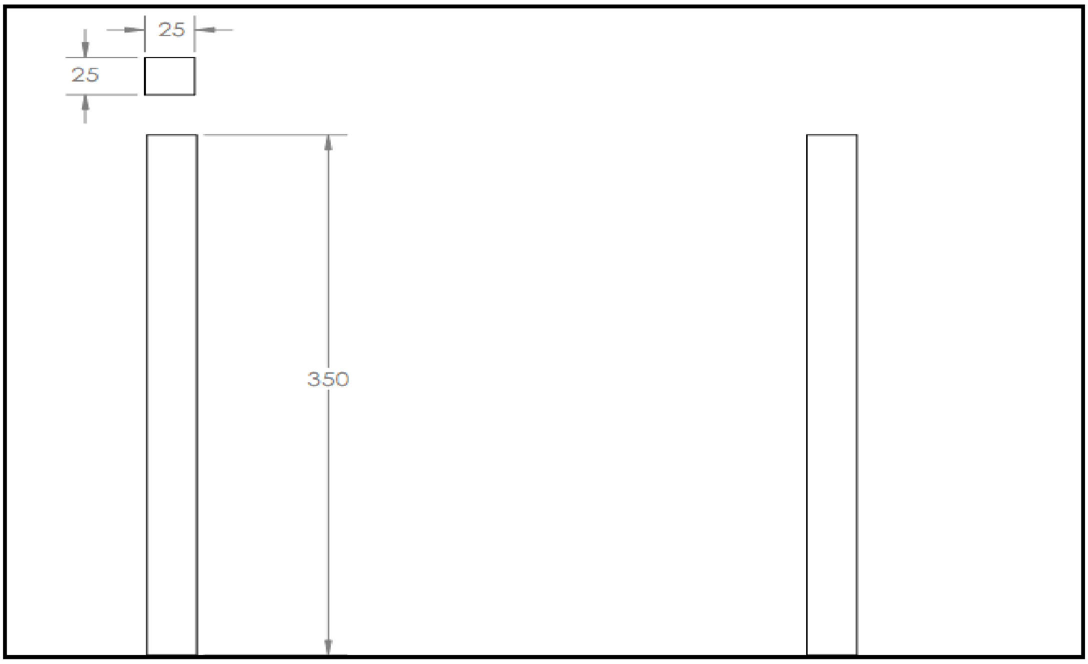


Figure 3.11: Pyramid Stand

3.3 BILL OF MATERIALS

Table 2.1: Bill of Materials

BILL OF MATERIALS			
PARTS	**MATERIAL**	**DIMENSIONS**	**NO.**
PYRAMID TOWER	ALUMINIUM ALLOY PLATE	700mm x 300mm x 1mm	4
PLASTIC BASE	CLEAR PLASTIC	1000mm x 1000mm	1
BASE PLATE	ALUMINIUM ALLOY PLATE	1000mm x 1000mm x 1mm	1
BASE BAR	MILD STEEL HOLLOW ROD	50mm θ20mm	8
PYRAMID STAND	MILD STEEL HOLLOW BAR	25mm x 25mm x 350mm	4

3.4 FABRICATION

There are several fabrication methods that have been applied in the fabrication of the solar turbine such as:

- Cutting
- Bending
- Drilling
- Riveting
- Surface finish
- Project Testing

3.4.1 Cutting

The process of cutting involve in the fabrication of solar turbine is the process of cutting the material which are aluminium alloy plate and mild steel bar into the desired size. The machines which are used during the cutting process are bend saw and pneumatic shearing machine.

Figure 3.12: Cutting of aluminium alloy plate with pneumatic shearing machine

Figure 3.13: Cutting of mild steel bar with bend saw

3.4.2 Bending

The process of bending in this fabrication is the bending of aluminium alloy plate. The machine involve in the process is pneumatic bending machine.

Figure 3.14: Using pneumatic bending machine to bend solar tower

3.4.3 Drilling

The process of drilling in this fabrication is the drilling of aluminium alloy and mild steel bar. The machine involve in drilling is hand drill.

Figure 3.15: Using hand drill to drill holes for rivet

3.4.4 Riveting

The process of riveting is needed to combine the structure of solar turbine which consist of aluminium alloy plate and mild steel bar. The tools involves are riveter and rivet.

Figure 3.16: Using riveter to rivet the solar tower

3.4.5 Surface Finish

The surface finish is not only functioning as to beautify the solar turbine, but also to improve heat absorption. The surface finish is painting the solar turbine with black paint spray.

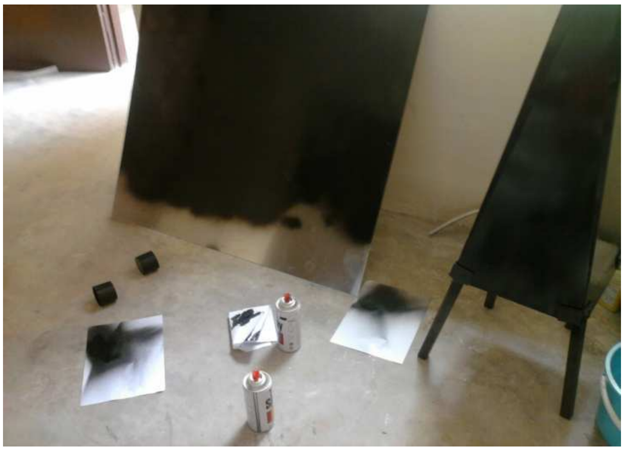


Figure 3.17: Paint spray is used to do surface finish on the tower and base

3.4.6 Project Testing

After the parts are assemble, the project is tested to check the whether electricity is generated from the solar turbine. Multimeter is used to check the amount of volts produced by the dynamo from the solar turbine. There are two tests that are conducted to the solar turbine.

The first test is the test whereby the dynamo and the fan blade are put in front of a fan. The fan faced directly to the fan blade. The dynamo is then connected to the multimeter. This test is conducted to check the capability of the dynamo under strong wind.

The second test is the test whereby the solar turbine is put under exposure of sunlight. The dynamo inside of the solar turbine is connected to multimeter. The solar turbine is left and the highest value from the solar turbine is taken. This test is to check the functionality of the solar turbine.

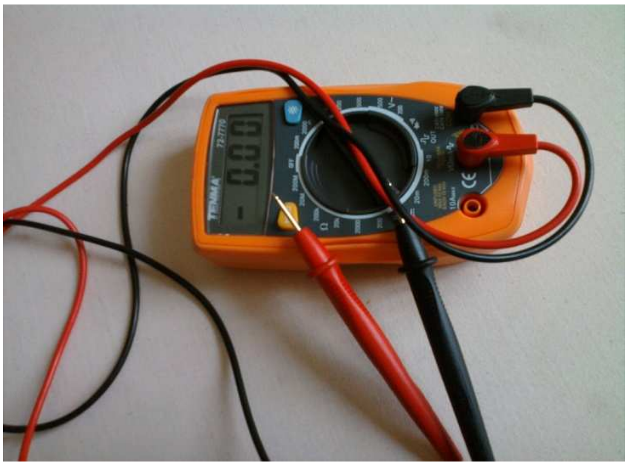


Figure 3.18: Multimeter is used to show the amount of voltage the dynamo produced

Figure 3.19: Multimeter is connected to the solar turbine

CHAPTER 4

RESULT AND DISCUSSION

4.1 RESULT AND DISCUSSION

There were two tests that are conducted to test the dynamo used for the solar turbine. The first test was by putting the dynamo and fan blade to an electric fan. This is to check the maximum volts that the dynamo can produce. The second was a test to check the volts generated when the dynamo equipped to the solar tower.

Figure 4.1: Dynamo attached with fan blade

Figure 4.2: Dynamo attached to fan blade

Figure 4.3: Final product

Table 4.1: Table of Voltage and Current from Electric Fan and Solar Tower

Test No.	Voltage and Current From			
	Electric Fan(Full Speed)		Solar Tower	
	Voltage (volts, v)	Current (milliAmpere, mA)	Voltage (volts, v)	Current (milliAmpere, mA)
1	5.87	476	0.19	73
2	5.68	452	0.23	89
3	5.92	498	0.57	124
4	6.02	520	0.64	148

From Table 4.1, a graph of current against voltage have been made.

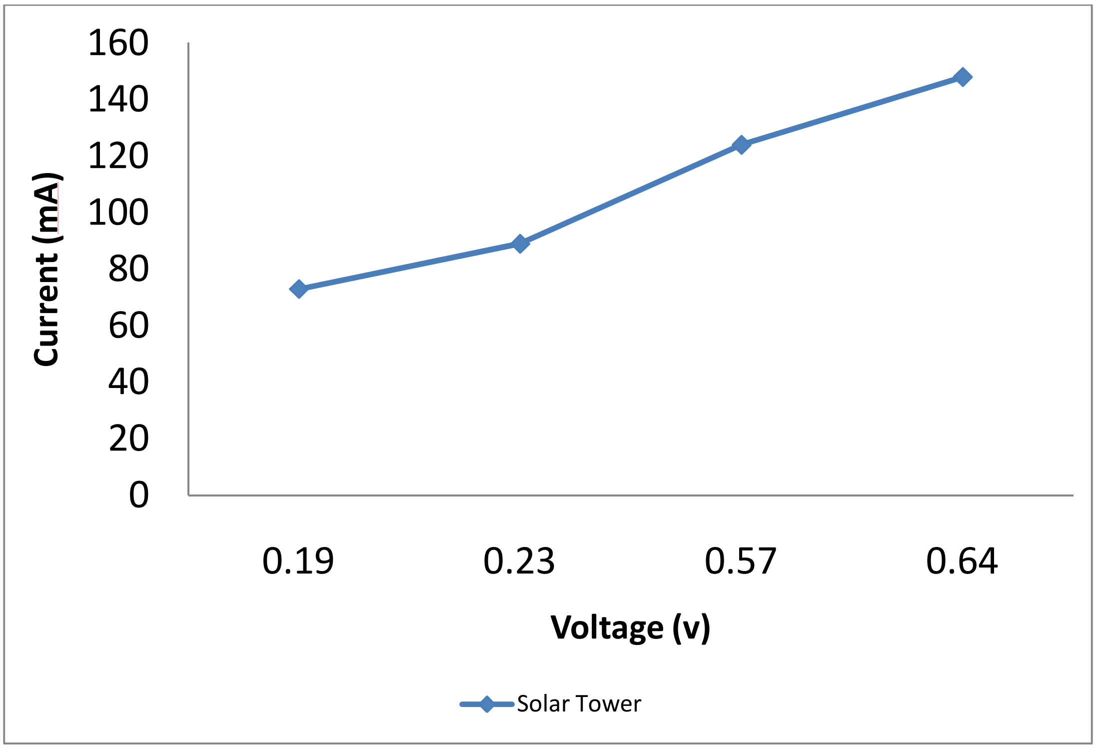


Figure 4.4: Graph of current against voltage of solar tower

From Table 4.1, amount of power can be calculated with the formula P = I x V, which is power equal to current multiply with voltage.

Table 4.2: Table shows the amount of power generated based on the test conducted on solar tower.

Test No.	Current (milliAmpere, mA)	Voltage (volts, v)	Power (watt, W)
1	73	0.19	0.001387
2	89	0.23	0.02047
3	124	0.57	0.07068
4	148	0.64	0.09457

Table 4.1 shows the result taken from the two tests conducted on the dynamo and the fan blade of the solar turbine. Comparison from both tests shows that the air movement created from the solar turbine is insufficient to generate enough electricity to compare with the electric fan. The result can be seen on Table 4.2 whereby the power generated from the solar turbine is small.

From the results taken, the advantages and disadvantages of solar turbine can be identified. The advantages and disadvantages are shown on Table 4.3.

Table 4.3: Advantages and Disadvantages of Solar Turbine

Advantages	Disadvantages
Green Technology (Technology that does not produce pollution)	Can only be used on daylight
Renewable and free energy	Can only be done in a large scale
Cost of power generation is low	Power supplied is not as high as power generated by fossil fuel
Area of greenhouse effect can be transform for agriculture	

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The project is finish and the solar turbine is able to generate electricity. The objective of the project is achieved at the end of design and fabrication. However, the result from the solar turbine was quite poor.

5.2 RECOMMENDATIONS

The solar turbine has its weaknesses which will need to be improved so that the result gained can be optimized.

5.2.1 Material selection

i. Solar Tower

a. For the solar turbine, aluminium alloy is used for fabrication of solar tower. Aluminium alloy are suitable because it has a high heat conductivity which is 2.37 W/cm.K and it is cheap and less dense. However, a tougher aluminium alloy should be used to withstand better.

ii. Plastic Base

a. A better material can be used to achieve better result. Solexx panels and polycarbonate wall are example of material can replace the plastic used in the solar turbine because they have higher insulating value and lower heat loss.

iii. Solar Turbine Base

a. Aluminium alloy plate is used in the solar turbine as the based. However, they are materials which are more suitable as heat absorber. In terms of heat latency and efficiency, water are the best. A container of water as base can increase heat absorption, howerver, it is hard to maintain. Layers of stones and gravel are also among good choice of heat absorber.

5.2.2 Design

i. Solar Turbine Tower and base ratio

a. The solar turbine in the project has an undefined ratio and based on feasibility. However, to produce better result in electricity generation, the area base of the solar turbine must be at least 1000 times bigger than the base of the solar tower. The solar tower height must be increased.

5.2.3 Part selection

i. Motor

a. A dynamo is used as electricity generator in the solar turbine as the wind generated is not strong enough to power a bigger motor. However, with larger size of solar turbine, a better motor is needed. A stepper motor is the best option, as it needs less rotation to generate specific electricity value compare to common motor.

REFERENCES

1. Dr. Alan Williams, Solar Electricity Using Wind Turbines, March 2007, Online, http://www.globalwarmingsolutions.co.uk/solar_electricity_using_wind_turbines.htm

2. Solar Heat Pump Electrical Generation System, Online, http://www.shpegs.org/index.html

3. Solar Updraft Tower, Online, http://en.wikipedia.org/wiki/Solar_updraft_tower

4. Solar Tower, Online, http://www.global-greenhouse-warming.com/solar-tower.html

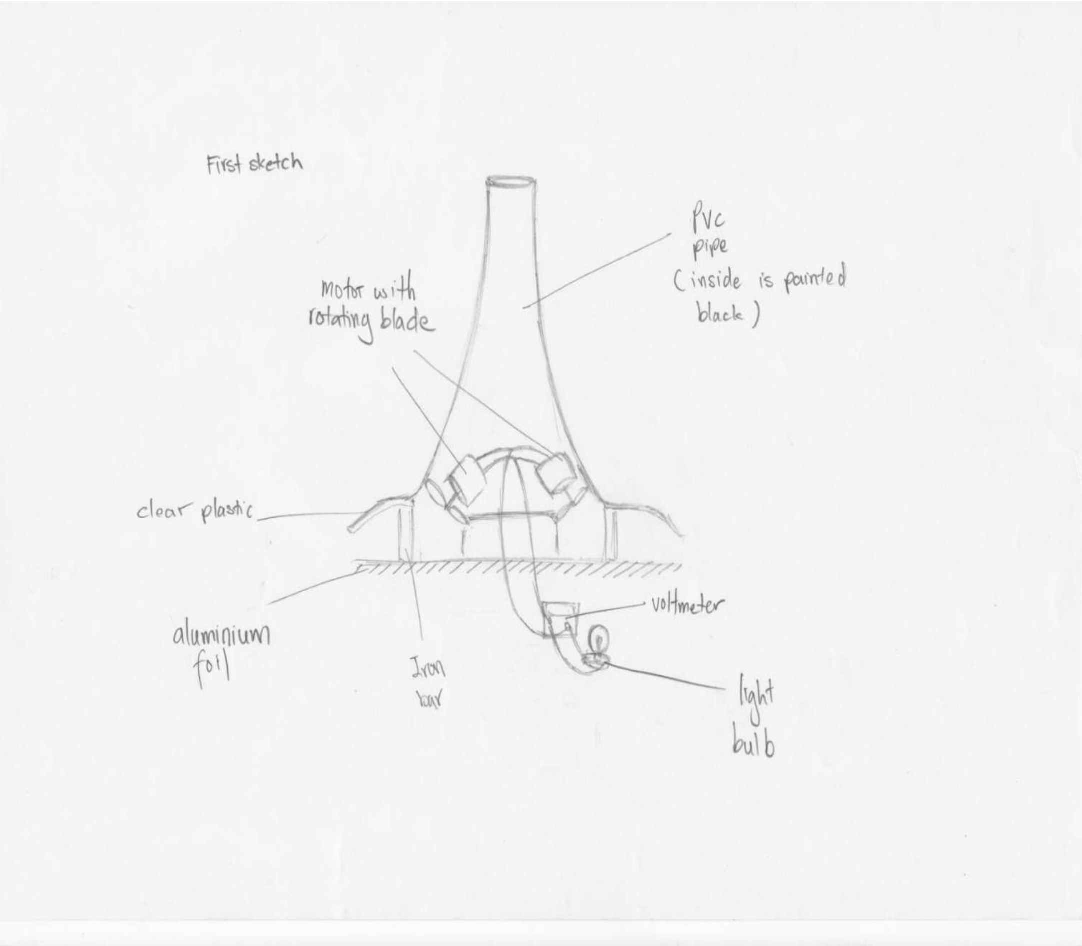
5. Solar Updraft Tower Variations and Research, Online, http://www.except.nl/consult/SolarUpdraftTower/solar_updraft_research.html

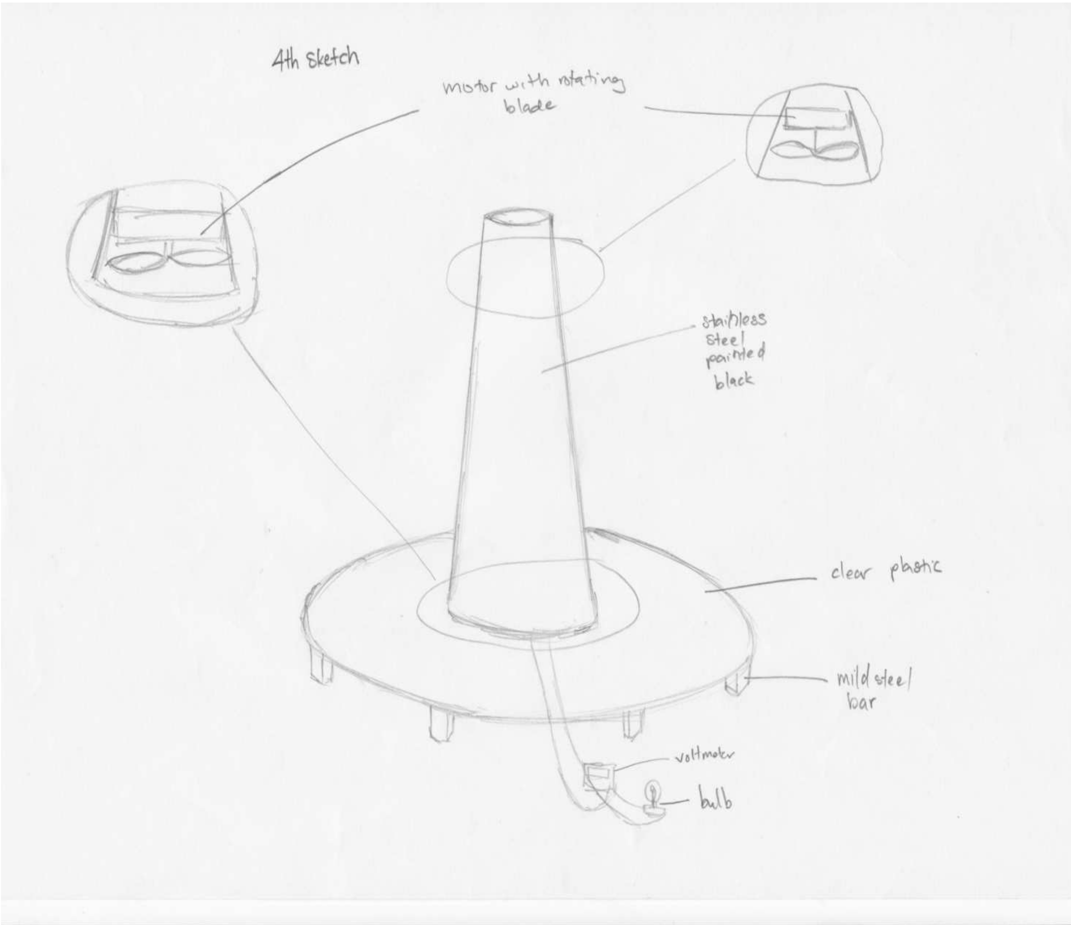
6. Mike Chino, Solar Updraft Towers to Generate Food and Energy, 9^{th} October 2008, Online, http://www.inhabitat.com/2008/09/10/solar-updraft-towers-in-namibia/

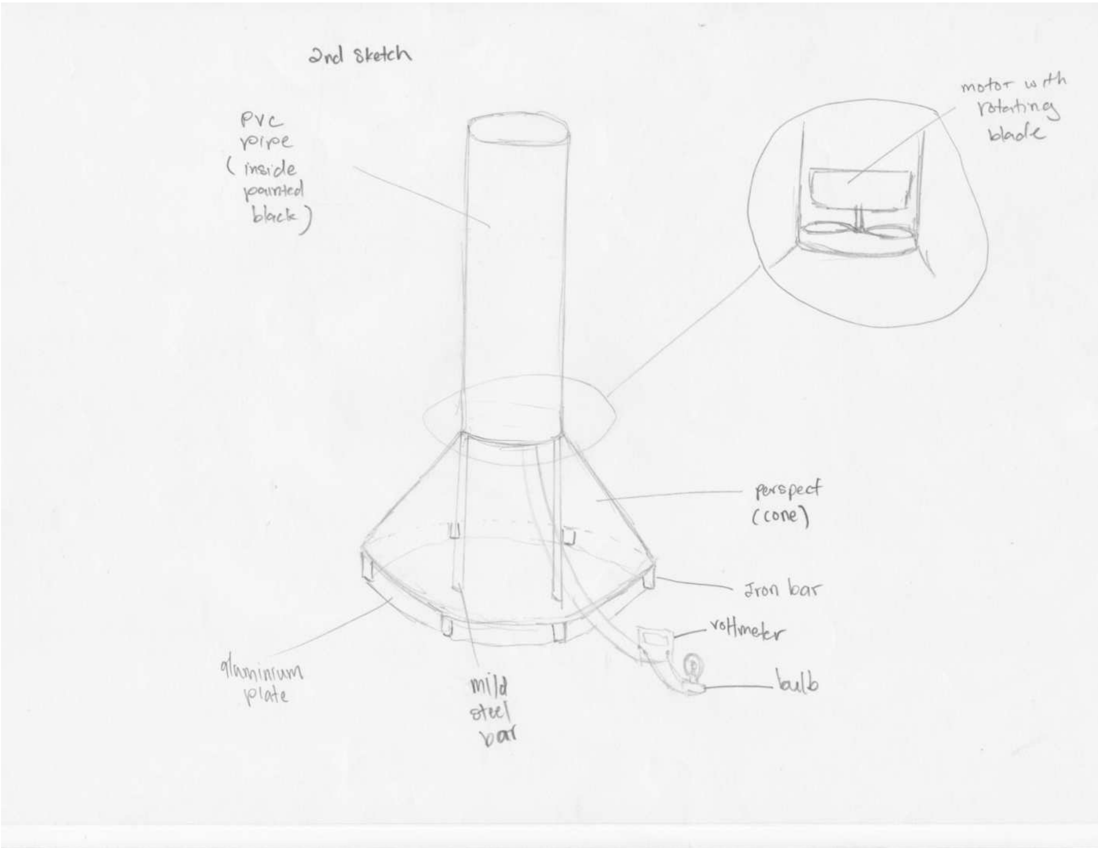
7. Jörg Schlaich, Rudolph Bergermann, Wolfgang Schiel, Gerhard Weinrebe, Design of Commercial Solar Updraft Systems – Utilization of Solar Induced Convective Flows For Power Generation, March 2003

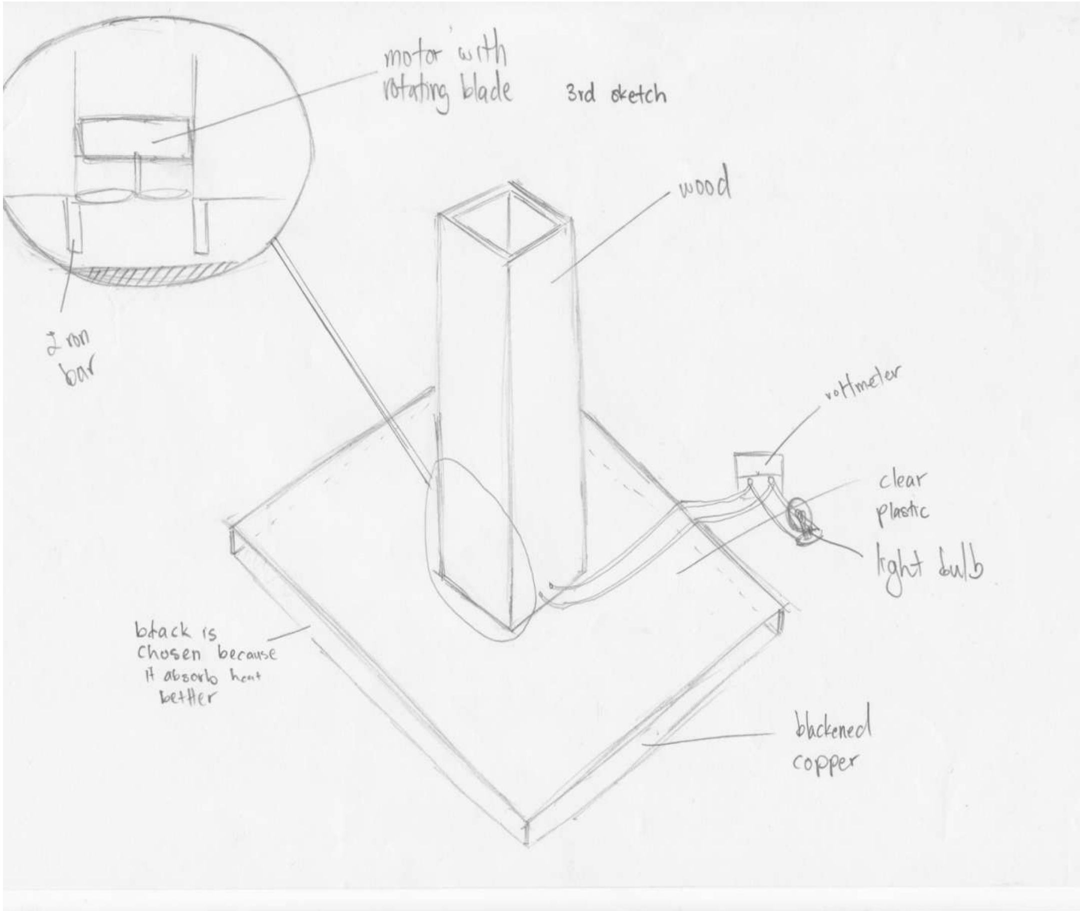
8. Incopera, DeWitt, Bergman, Lavine, Fundamentals of Heat and Mass Transfer, Sixth Edition, March 2006

APPENDICES

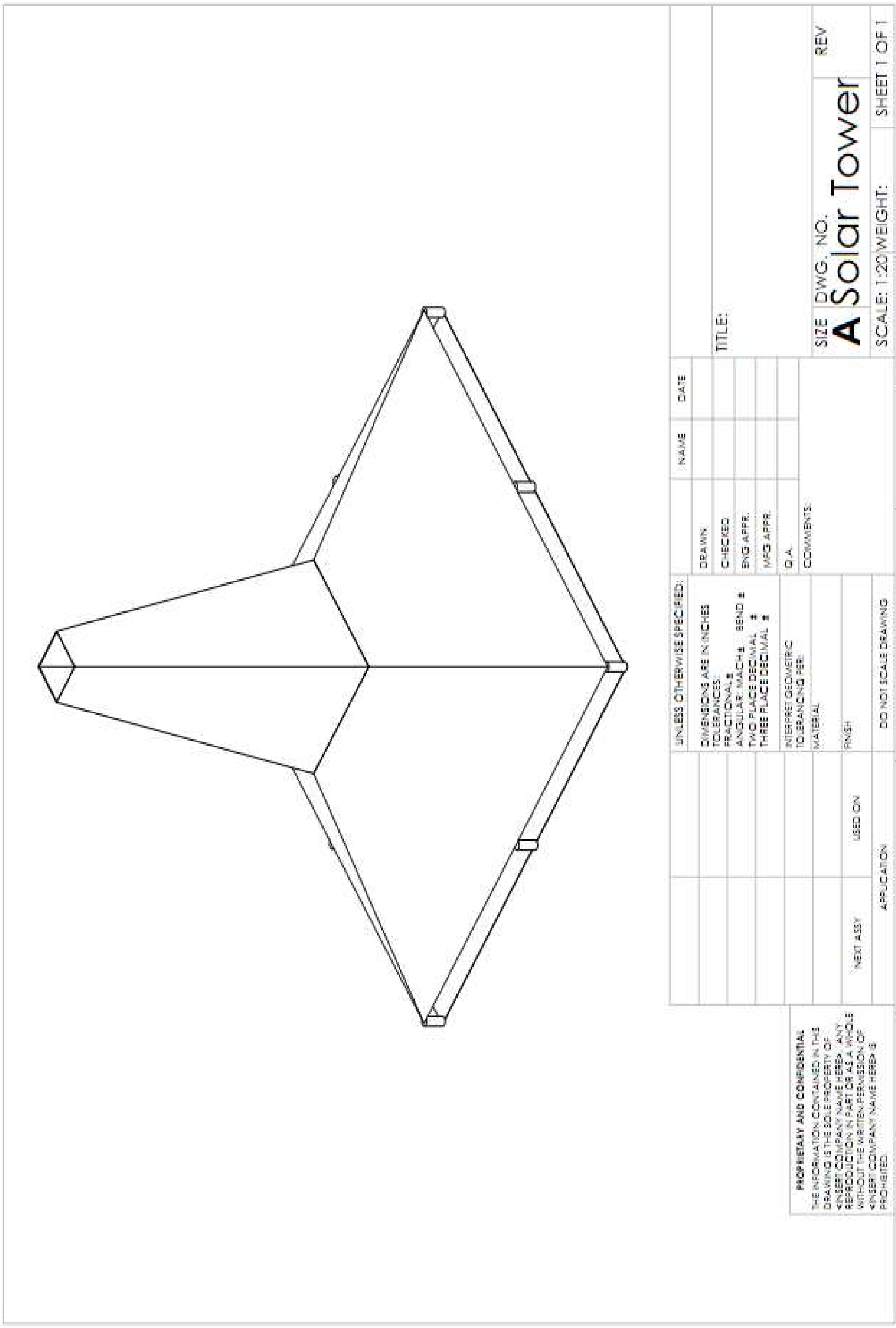

First sketch
Pvc
pipe
(inside is painted
black)
motor with
rotating blade
clear plastic
voltmeter
aluminium
foil
Iron
bar
light
bulb


4th Sketch
motor with rotating blade
stainless steel painted black
clear plastic
mild steel bar
voltmeter
bulb

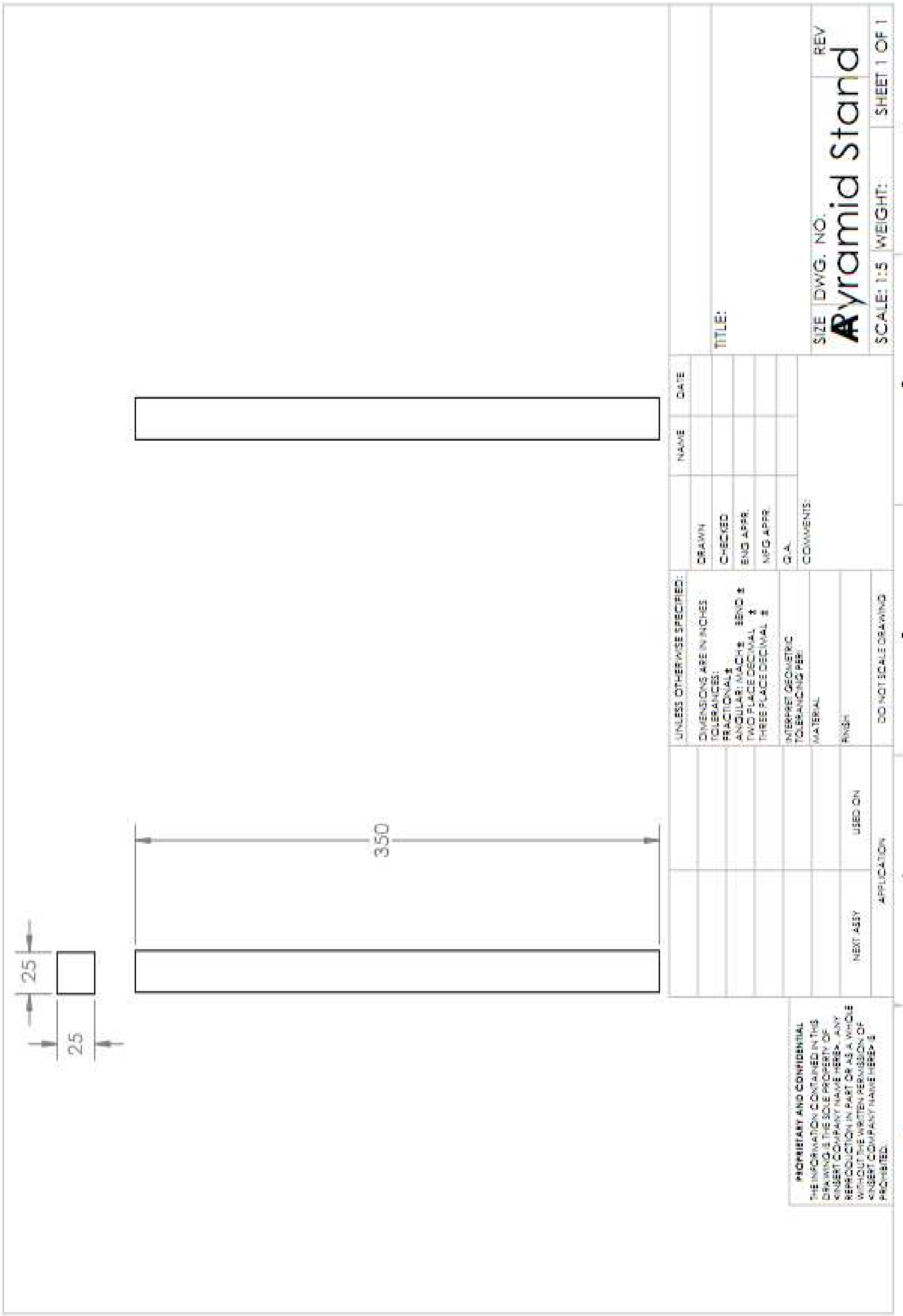

2nd sketch
PVC pipe (inside painted black)
motor with rotating blade
perspect (cone)
Iron bar
voltmeter
bulb
aluminium plate
mild steel bar



motor with rotating blade
3rd sketch
wood
iron bar
voltmeter
clear plastic
light bulb
black is chosen because it absorb heat better
blackened copper



TITLE:
SIZE
DWG. NO.
REV
A
Solar Tower
SCALE: 1:20
WEIGHT:
SHEET 1 OF 1
UNLESS OTHERWISE SPECIFIED:
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL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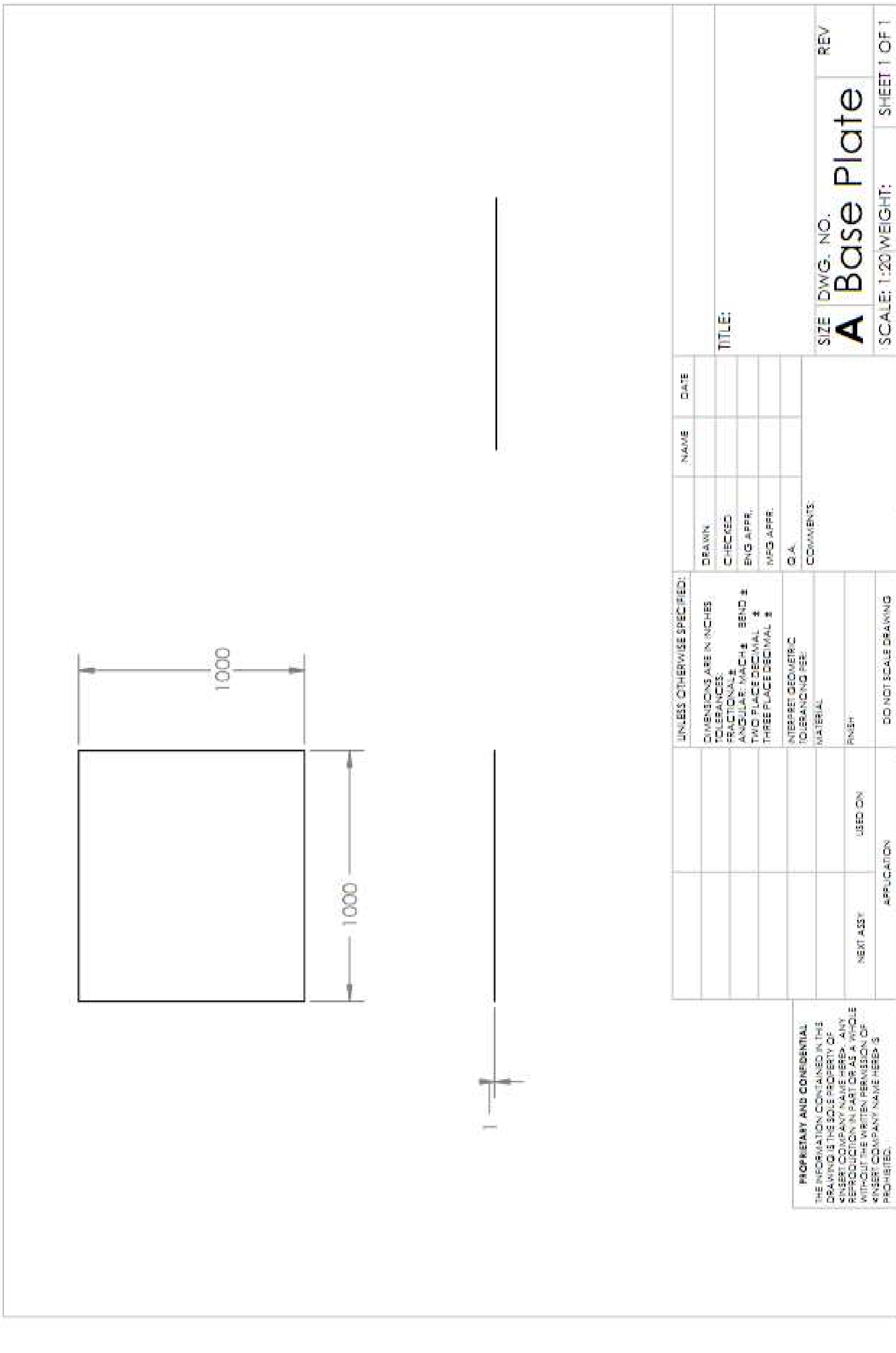
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
MATERIAL
FINISH
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL
TITLE:
SIZE
DWG. NO.
REV
A
Pyramid Stand
SCALE: 1:5
WEIGHT:
SHEET 1 OF 1
1
2
3
4
5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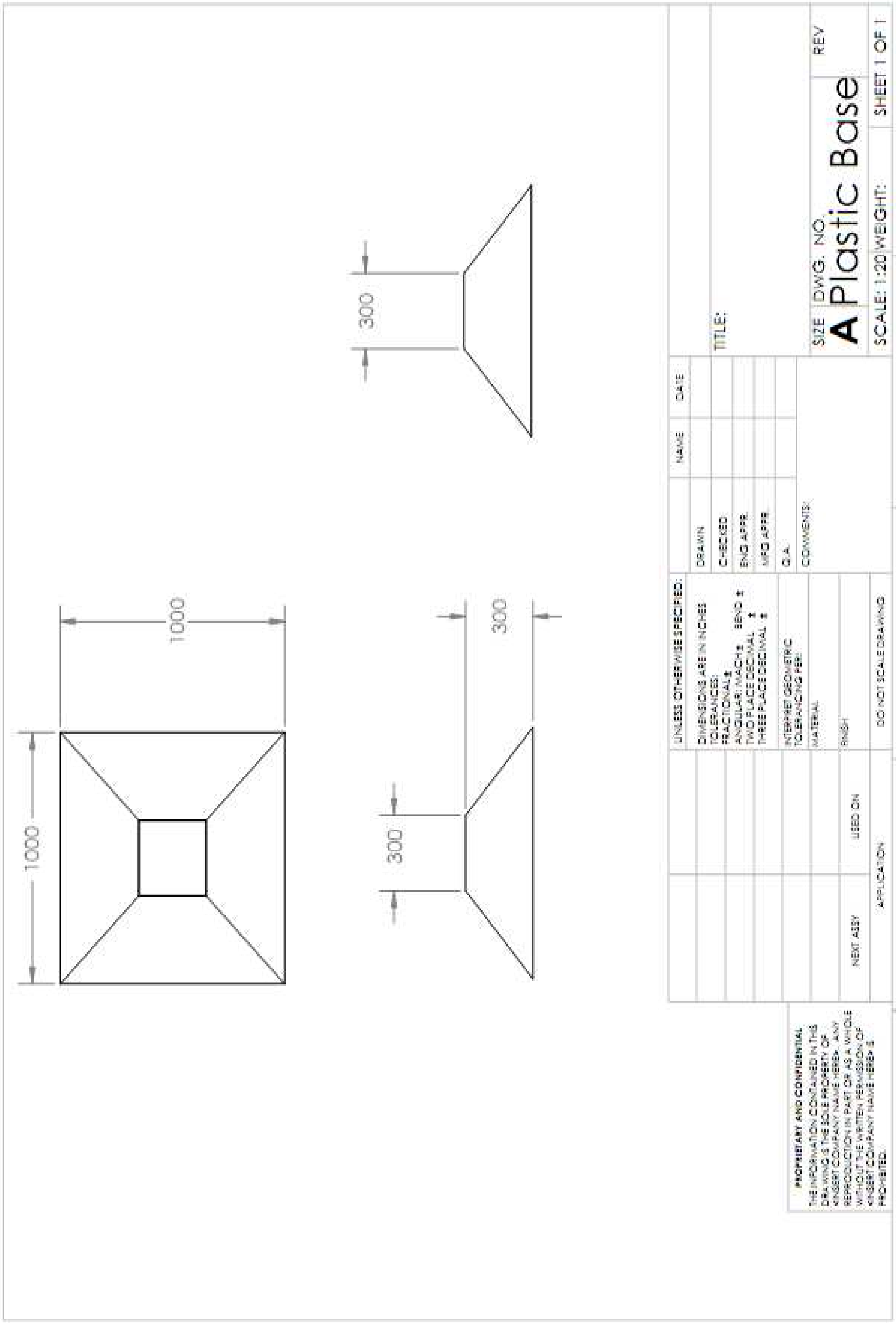
1000
1
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NAME
DATE
TITLE:
SIZE
DWG. NO.
REV
A
Base Plate
SCALE: 1:20
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
1
2
3
4
5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DIMENSIONS ARE IN INCHES
TOLERANCES:
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ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NAME
DATE
TITLE:
SIZE
A
DWG. NO.
Plastic Base
REV
SCALE: 1:20
WEIGHT:
SHEET 1 OF 1
PROPRIETARY AND CONFIDENTIAL
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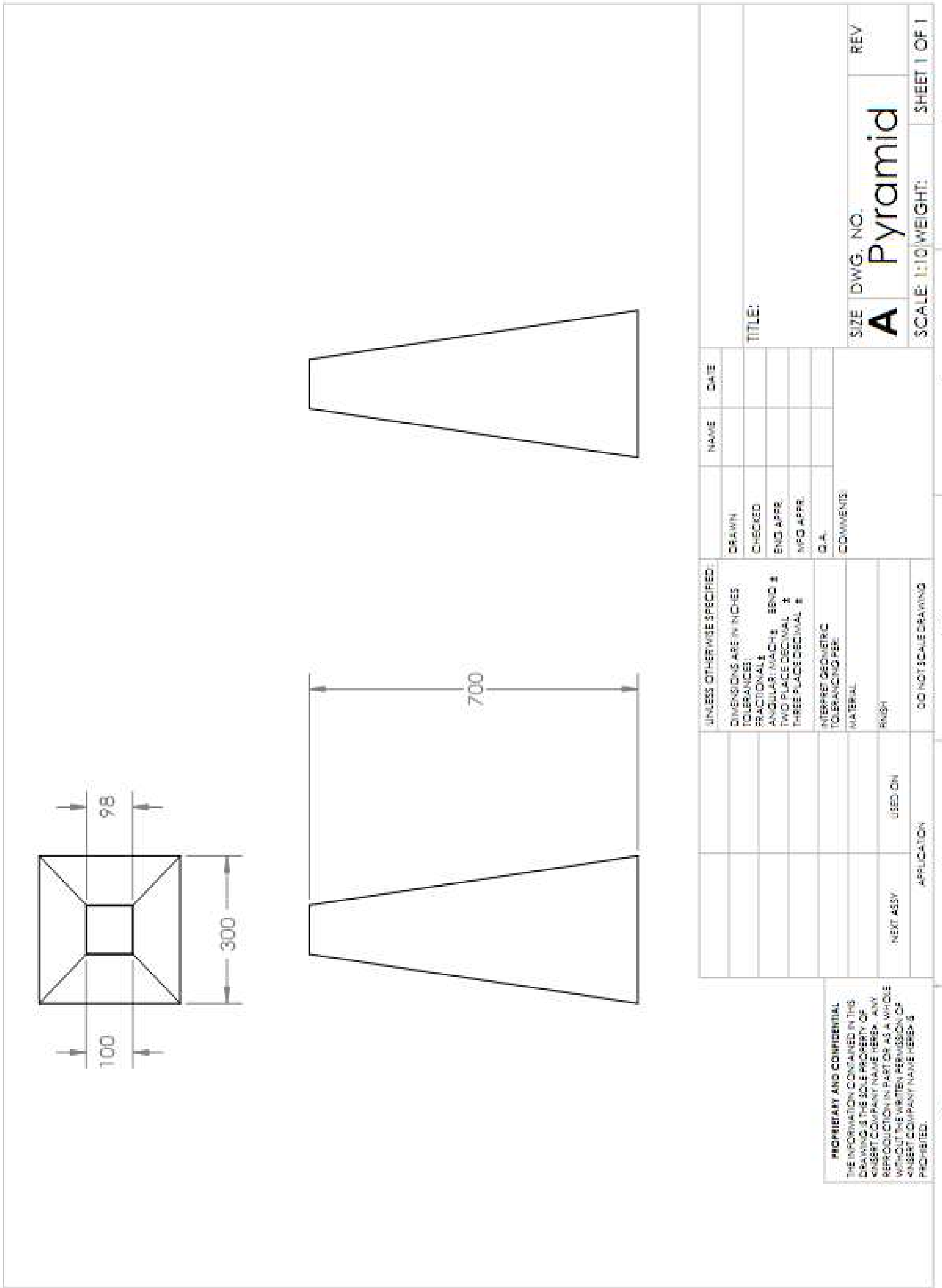
2
3
4
5


98
100
300
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UNLESS OTHERWISE SPECIFIED:
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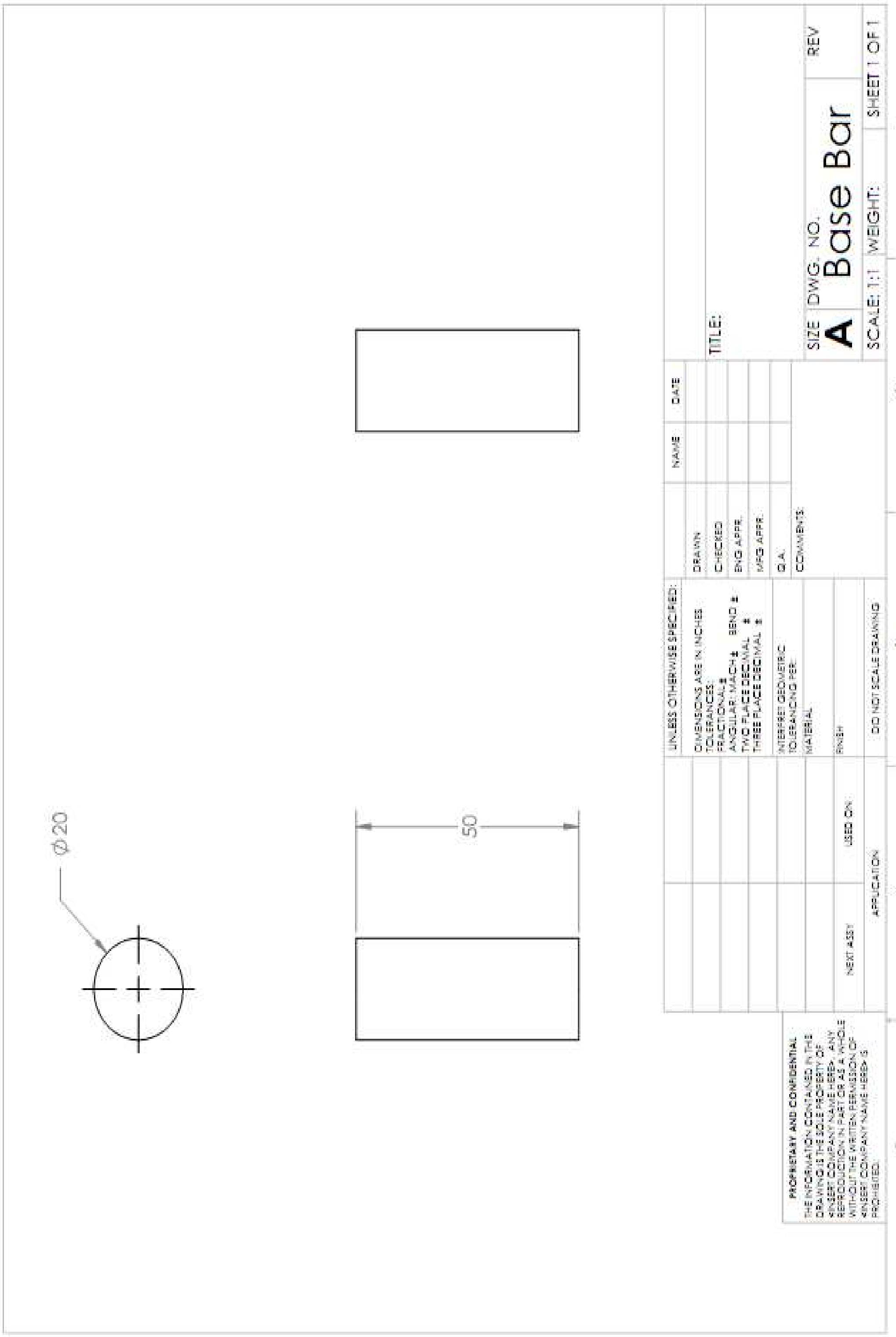
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NAME
DATE
TITLE:
SIZE
A
DWG. NO.
Pyramid
REV
SCALE: 1:10
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL


Ø20
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UNLESS OTHERWISE SPECIFIED:
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NAME
DATE
TITLE:
SIZE
A
DWG. NO.
Base Bar
REV
SCALE: 1:1
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL