DEVELOPMENT OF TEST RIG FOR KNEE PAD

MOHD YUSRI BIN SHAMSUDDIN

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CHAPTER1

INTRODUCTION

1.1 INTRODUCTION

This chapter explained about the objective of the project, project background, project scope, and problem statement than been conducted.

1.2 PROJECT BACKGROUND

In many sporting activities, such as football, cycling, horseback riding and skilling, a knee pad is the only method of protection from sudden impact to the knee. The use of protective equipment such as knee pad is important to prevent knee injuries and reduce the risk of the serious injuries. Not just in sports, knee pad also used in military with the same purpose which is to avoid the knee from injuries. The design of knee pads depends on the types of activities that need to take. Knee pad to be produce must have a high resistant to the force to prevent knee from injuries. Not only knee pads, but all of the protective equipment must have a ability to protect the body from any accident. In order to make sure these protective devices are functional, some of tests must be performed to ensure their effectiveness and quality. Impact testing is the one of the most common method for evaluating the effectiveness of different type and materials used in the manufactured of knee pad. Impact testing was originally developed to determine the fracture characteristics and failure of raw materials under high strain rates.

1.2 PROBLEM STATEMENT

Nowadays, the knee pad is commonly used to prevent knee defect and reduce the risk of the serious injuries during exercises. So, selection of the right knee pad and the quality is very important. The quality of knee pads can be classified into many categories which are the type of material, ergonomic consideration and the safety and performances. But the most important criteria that must have in knee pad are how long it can protect the knee from injured. Because of that, we developed the knee pad test rig for analyze the performance during sporting activities.

1.4 OBJECTIVE

Objective is a specific result that a person to achieve for the project. Usually, an objective may be easier to measure. The objective of this project is to design and fabricate a simple knee pad test rig that used a minimal cost and can be handled by less skill workers.

1.5 SCOPE

i. Operate using pneumatic system
ii. Light weight than other test rig and portability
iii. Knee position between 90^0 or 180^0
iv. Applied load around 50N ~ 100N

CHAPTER2

LITERATURE REVIEW

2.1 INTRODUCTION

In order to come out with the good design, some review should be made to generate the idea for the concept design. This step very important to avoid the incoming design is similar to existing product in the market. It also to make sure the design of this product is suitable with the current situation. In this chapter, the reviews are based on the existing products and also from the ergonomic consideration for knee pad test rig. Therefore, the research must be done to obtain all the information available and related to this test rig.

2.2 TYPE OF KNEE TEST RIG

2.2.1 The Kansas knee simulator

The dynamic Kansas knee simulator can apply dynamic loading to a knee joint. Load is applied using 5 hydraulic actuators coupled with a 5 axis controller. A vertical load is applied at the hip to simulate the body weight of the subject. The hip is free to flex and extend and translate vertically. Each of the axes can be controlled in displacement or load control. This knee simulator used to evaluate the performance of total knee replacement component.

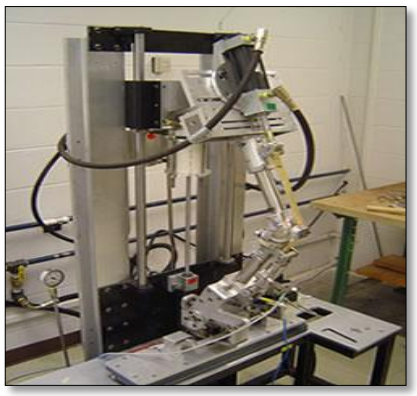

Figure 2.1: The Kansas knee simulator

Source**:** http://www.engr.ku.edu

2.2.2 The muscle loading rig

The muscle loading rig can load the muscle of the hamstrings and the quadriceps invidually in their anatomic direction. The knee can be moved in certain angle of flexion either manually or through a motor hooked. This test rig can determine the effect of each head of quadriceps and hamstrings on both patellofemoral and tibiofemoral kinematics. It also can identify the consequences of different muscle weakness on the knee motion.

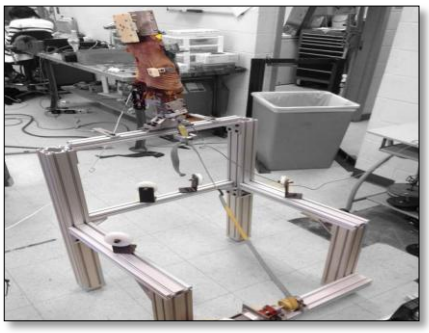

Figure 2.2: The muscle loading rig

Source: http://www.engr.ku.edu

2.2.3 Tibiofemoral testing rig

The objective of test rig is to measure the effect of kneeling on tibiofemoral contact. There is three condition of kneeling condition which is nonkneeling, double-stance kneeling, single-stance kneeling at flexion angles of 90°, 105°, 120°, and 135°. There are two parameters that will be measure by this test rig. One of the parameter is contact area and the second parameter is pressure. By the way, the design of this test rig is quite difficult and complex. Furthermore, it may occur a high cost of manufacture.

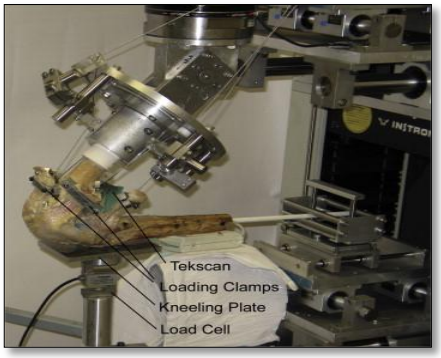

Figure 2.3: The knee joint testing rig

Source: http://www.sciencedirect.com

2.2.4 Impact test rig

The impact test rig required a low cost of manufacture and can be handled by less skill workers. It was to drop a weight in a vertical direction, with a tube or rails to guide it during the "free fall." the weight and height of load can be manipulated in order to get a different result of testing the impact energy will be calculated to dianalyzed. Nowadays there was no way to measure impact velocity, so engineers had to assume no friction in the guide mechanism. Since the falling weight either stopped dead on the test specimen, or destroyed it completely in passing through, the only results that could be obtained were of a pass/fail nature.

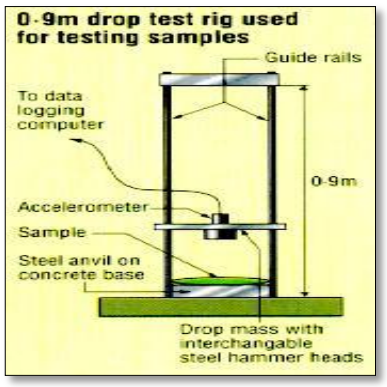

Figure 2.4: Impact test rig

Source: http://www.shelleys.demon.co.uk

2.2.5 Biomechanical knee testing rig

A biomechanical knee testing rig is developing for investigating the kinematics and kinetics of cadaveric human knee-joint. This action occurs during the human knee is bend into a certain angle. This test rig may potentially be used to investigate the effect of ligament injury, post-surgical ligament reconstruction, and evaluating implant designs in terms of its resulting knee kinematics and load distribution.

Figure 2.5: Biomechanical Testing rig

Source: http://www.medgadget.com

2.2.6 Tibia Test jig

Knee mounted in testing jig at 30° flexion, with pressure sensors inserted in the medial and lateral compartments. Load is applied by displacing the femur downward. The tibia is free to rotate and translate normally under load.

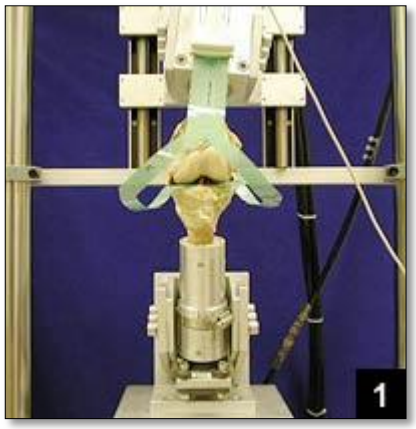

Figure 2.6: Tibia test rig

Source: http://www.healio.com

2.3 TYPE OF MATERIAL

2.3.1 Aluminium

Aluminium is categorized as a metal. It has a unique and unbeatable combination of properties that make it into a versatile, highly usable and attractive construction material. There are many advantages of aluminium and one of the advantages is corrosion resistance. Aluminium is naturally design with a protective oxide coating and is highly corrosion resistant. Aluminium also is a very light metal with a density one third that of steel which is 2700 kg/m^3.

Figure 2.7: Aluminium block

Source: http://en.wikipedia.org/wiki/Aluminium

2.3.2 Steel

Steel is the iron alloy that containing sentences value of carbon. Steel is a hard ductile and malleable solid and its better than iron. Higher amount of carbon make the steel more fluid and castable. There are many types of steel such as high-carbon steel, mild steel, stainless steel, high speed steel, cobalt steel, and aluminium steel.

Figure 2.8: Steel bar

Source: en.wikipedia.org/wiki/Steel

2.3.3 Woods

Wood is an organic material. It transfers water and nutrients to the leaves and other growing tissues and has a support function which is to enabling woody plants to reach large sizes. Wood has many advantages which is, good thermal insulator, not carry an electric charge and it us an easy material to use for decorative work.

Figure 2.9: Wood

Source: Richards Williams Blog

2.3.4 Plastic

Plastic material is consisting of synthetic or semi synthetic organic solids that are mouldable. Plastic are typically organic polymers with high molecular mass but they often contain other substances. There are two types of plastic which is thermoplastic and thermosetting polymers. Thermoplastic is the plastic that cannot recyclable and cannot be melt. Thermoset is the type of plastic that can be melt and take shape once after they have solidified.

Figure 2.10: Thermoplastic

Source: en.wikipedia.org/wiki/Steel

2.4 WELDING

Welding is a material joining process that involves two or more parts. The parts are coalesced at their contacting surfaces by suitable application of heat and pressure. The melting material quickly cool down and it permanently bonded. Many different energy sources can be used for welding such as gas flame, an electric arc, a laser, and friction. Welding can be perfume in different environments, including open air, under water and outer space. The different location surely can give a different risk to the welding process. There are many incidents occur during the welding process such as burns, electric shock, eye damage, poisonous fumes, and overexposure to ultraviolet light.So, the detail safety precaution must be taken in

order to avoid the entire incident during the welding process. By the way, this process can have many advantages which are provide permanents joint, most economical in terms of material usage and high joint strength. There are two common types of welding process that is used in industry, arc welding and MIG welding.

Figure 2.11: Welding process

Source: www.welding.com.my

2.4.1 MIG welding

MIG (metal inert gas) or as it even is called GMAW (gas metal arc welding) use an aluminium alloy wire as a combined electrode and filler material. Shielding is done by flooding the arc with a gas. Bare wire is fed continuously and automatically trough the welding gun. There are two types of gases that usually use for shielding include inert gas (argon and helium) and active gas (carbon dioxide).inert gas is use for aluminium alloys and stainless steels, while active gas use for low and medium carbon steel. GMAW has significant advantages over SMAW (sheet metal arc welding) in terms of arc time, because the electrode does not need to be change. Other advantages of MIG welding are no slag removal required, higher deposition rate compared to SMAW, and good versatility.

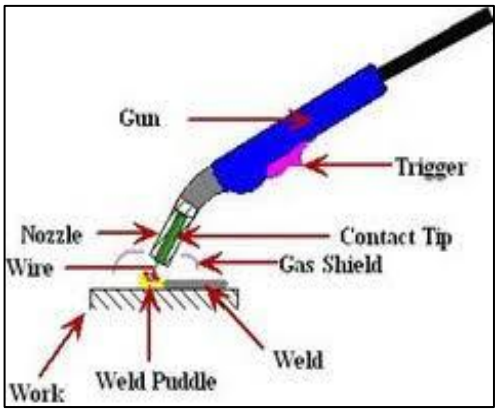

Figure 2.12: MIG welding

Source: www.welding.com.my

2.4.2 Arc welding

Arc welding is categorized under fusion welding. It is a type of welding that use power supply to create an electric arc Coalescence of metal in arc welding is achieved by the heat from an electrode and the work piece. Electric energy from the arc produces temperature of 5500^0C to melt any metal. There arc two types of electrode use in arc welding, consumable and non-consumable electrode. Consumable electrode is usually use in shield metal arc welding (SMAW), gas metal arc welding (GMAW), flux-core arc welding (FCAW), and submerged arc welding (SAW).while non consumable electrode is use in gas tungsten arc welding (GTAW) and plasma arc welding (PAW).

Figure 2.13: Arc welding process

Source: www.welding.com.my

2.5 DRILLING

Drilling is an operation to create a round hole at the workpiece. Drilling is performed with a tool called drill bit. Drill bit is a rotating tool that has two cutting edges and has different size and type. Drilling process is performed using a machine known as “drill press” that can be seen in figure 2.13.Drilling is occurs in many various operations such as reaming, taping, counterboring, countersinking, centring and stop facing. All this operation has a specific drill bit and different drilling method.

Figure 2.14: Drill Press Machine

Source: Lab FKM (2012)

2.6 GRINDING

Grinding is one of the abrasive machining processes. It removes material by action of hard, abrasive particles in form of bonded wheel. This process usually use in finishing operation because it is able to produce extremely fine surface. There are many factors that effecting surface finish in grinding process such as abrasive grain sizes, wheel structure, and cutting velocity. The smaller grain size yield, the better surface finishing required and increasing the cutting speed also will improve the surface finish. For wheel structure, more dense structure will produce better surface finish.

Figure 2.15: Hand Grinder

Source: the fabricator.com

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter discuss about the information and data that related and fabrication process for this project. Concept generation is a description of technology, working principles and the form of product. . A concept of product usually expressed to sketching or as a three dimensional model and its must be include the explanations.

3.2 DESIGN

3.2.1 Concept Generation

Design Concept 1

Figure 3.1 shows the isometric view of concept design 1 and table 3.1 shows that the advantages and disadvantages design concept 1.based on table 3.1, design concept 1 have a more disadvantages which is low stability, low strength, and hard to assemble.

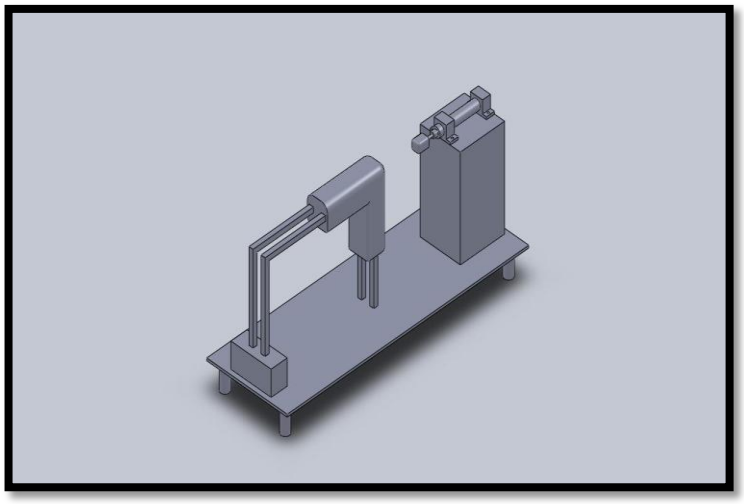

Figure 3.1: Design concept 1

Table 3.1: Advantages and disadvantages design concept 1

ADVANTAGES	DISADVANTAGES
Light weight	Low stability
Low high	Low strength
	Hard to assemble

Design Concept 2

Figure 3.2 shows the concept design 2 and table 3.2 shows the advantages and disadvantages of design concept 2.design concept 2 have a good stability than design concept 1.it also required low manufacturing cost and simple machining process.

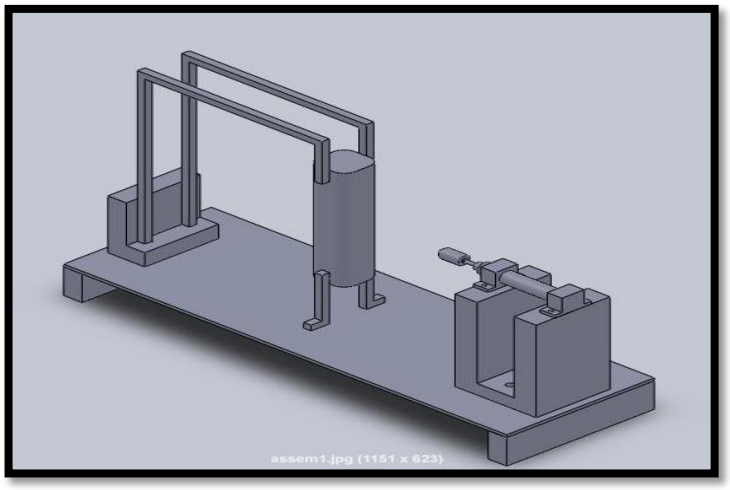

Figure 3.2: Design concept 2

Table 3.2: Advantages and disadvantages design concept 2

ADVANTAGES	DISADVANTAGES
stability	Hard to assemble
Low manufacturing cost.	Low durability
Simple machining process.	

Design Concept 3

Figure 3.3 shows the design concept 3 with high stability and durability design. But this design may occur high manufacturing cost, heavy weight and hard to assemble. The advantages and disadvantages of design concept 3 are shows in table 3.3.

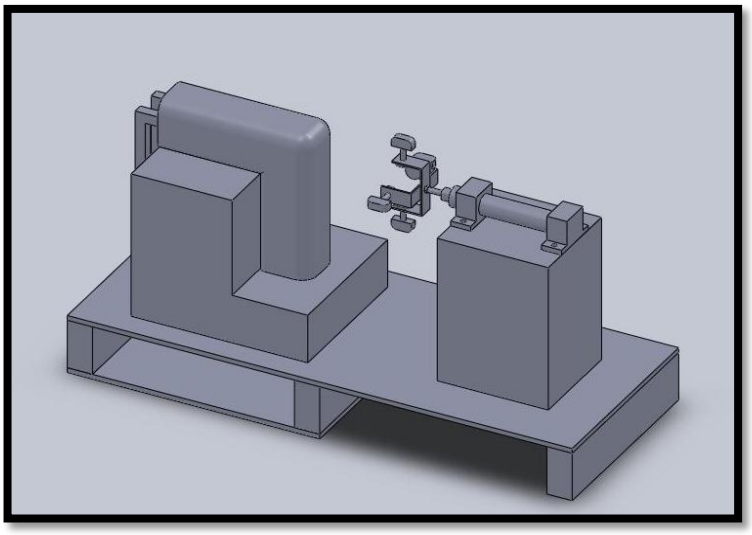

Figure 3.3: Design concept 3

Table 3.3: Advantages and disadvantages design concept 3

ADVANTAGES	DISADVANTAGES
High stability	heavyweight
High durability	High cost
	Hard to assemble

Design Concept 4

This design has many advantages than other concept design. The model of knee can adjustable and it required a simple machining process. Design concept 4 also has a light weight compare to others design concept. Figure 3.4 show the design concept 4 and table 3.4 shows the advantages and disadvantages of design concept 4.

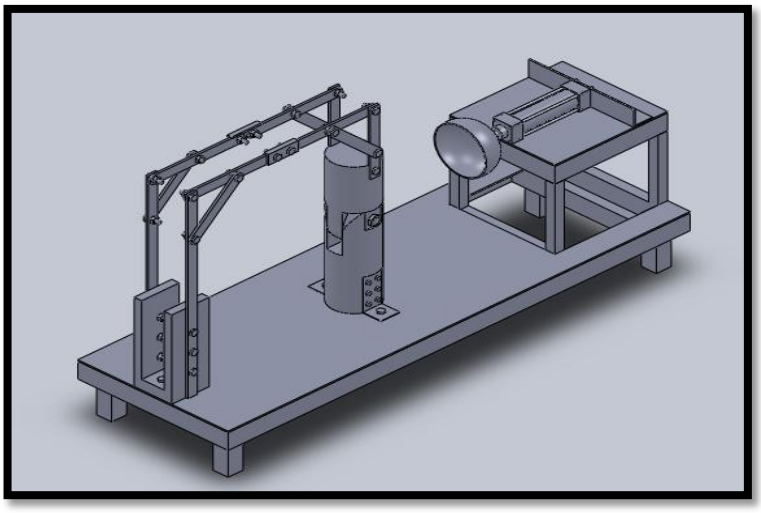

Figure 3.4: Design concept 4

Table 3.4: Advantages and disadvantages design concept 4

ADVANTAGES	DISADVANTAGES
light weight than others design	
Simple design	
Adjustable knee	
Simple machining process required	
Easy to manufactured	
Easy to assemble	

Design Concept 5

Figure 3.5 shows that the design concept 5 and table 3.5 shows the advantages and disadvantages design concept 5.based on table 3.5,this design need more time in fabrication because it require the complex machining process.

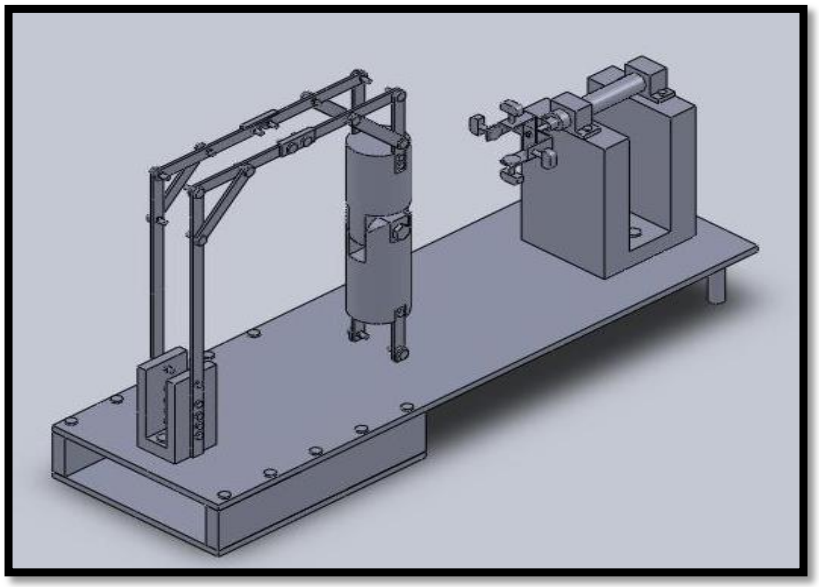

Figure 3.5: Design concept 5

Table 3.5: Advantages and disadvantages design concept 5

ADVANTAGES	DISADVANTAGES
Adjustable knee	More time in fabrication
High stability	Complex machining process
Portability	
Durability	

3.2.2 Concept selection

In order to choose the final design, concept selection method must be done by list down all the important criteria that must have at the product. Based on this method, the entire concept must be rank from 1 to 5, where 1 is bad and 5 is excellent. Table 3.6 shows the concept selection method.

Table 3.6: Concept selection criteria

Selection criteria	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5
Stability	**1**	**3**	**5**	**5**	**5**
Knee adjustable	**1**	**1**	**1**	**5**	**5**
Easy to assemble	**4**	**1**	**2**	**5**	**3**
Low cost	**2**	**3**	**1**	**5**	**4**
Low weight	**3**	**4**	**1**	**5**	**3**
Durability	**2**	**2**	**4**	**3**	**3**
Portability	**4**	**4**	**3**	**4**	**3**
Total	**17**	**18**	**17**	**32**	**26**

Notes/plot: 1(bad) – 5(excellent)

3.2.3 Finalize concept

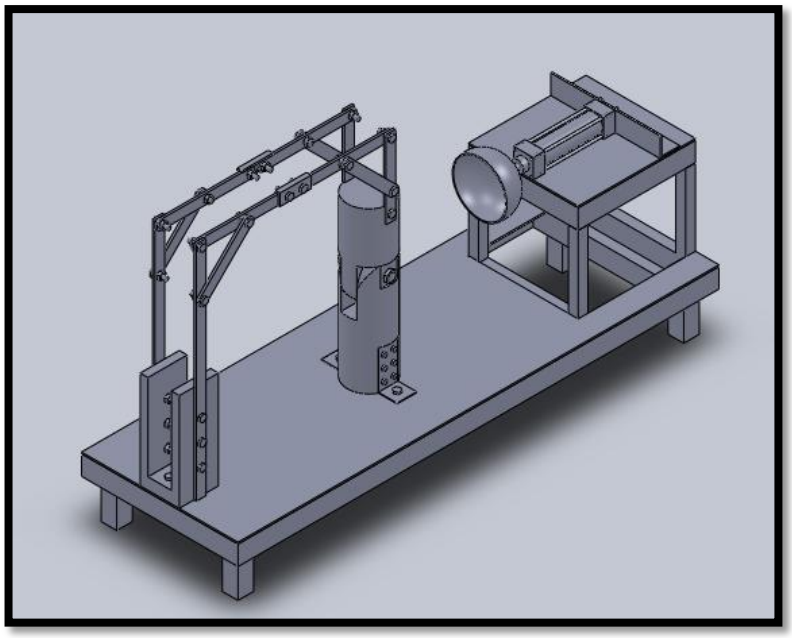

Figure 3.6: Final design or design concept 4

Based on the concept selection table, concepts 4 in figure 3.6 score the highest rating numbers which is 32 scores. Therefore, concept 4 is the best concept to be producing.

3.3 MATERIAL SELECTION

Table 3.7 shows the bill of material for each part as labelled in figure 3.7.

Table 3.7: Bill of materials

No.	Part	material	dimension	Quantity
1	Body 1	Aluminium plate	L-1230mm x W- 400 mm x t-4mm	1
2	Body 2	Aluminium plate	L-300mm x W-280mm x t-4mm	1
3	Body 3	Steel hollow bar	25mmx25mm L-200mm	1
4	Body 4	Steel hollow bar	L25mm x W 50mmx h-5000mm	1
5	Body 5	Mile steel	L-570mm x W-25mm x t-6mm	1
6	Body 6	Aluminium bar	100mm x 100mm x h -250mm	1
7	Body 7	Aluminium angle bar	L280 mm x W -50mm x h 50mm	1
8	Body 8	Lebam wood	r-55mm x L -410mm	1

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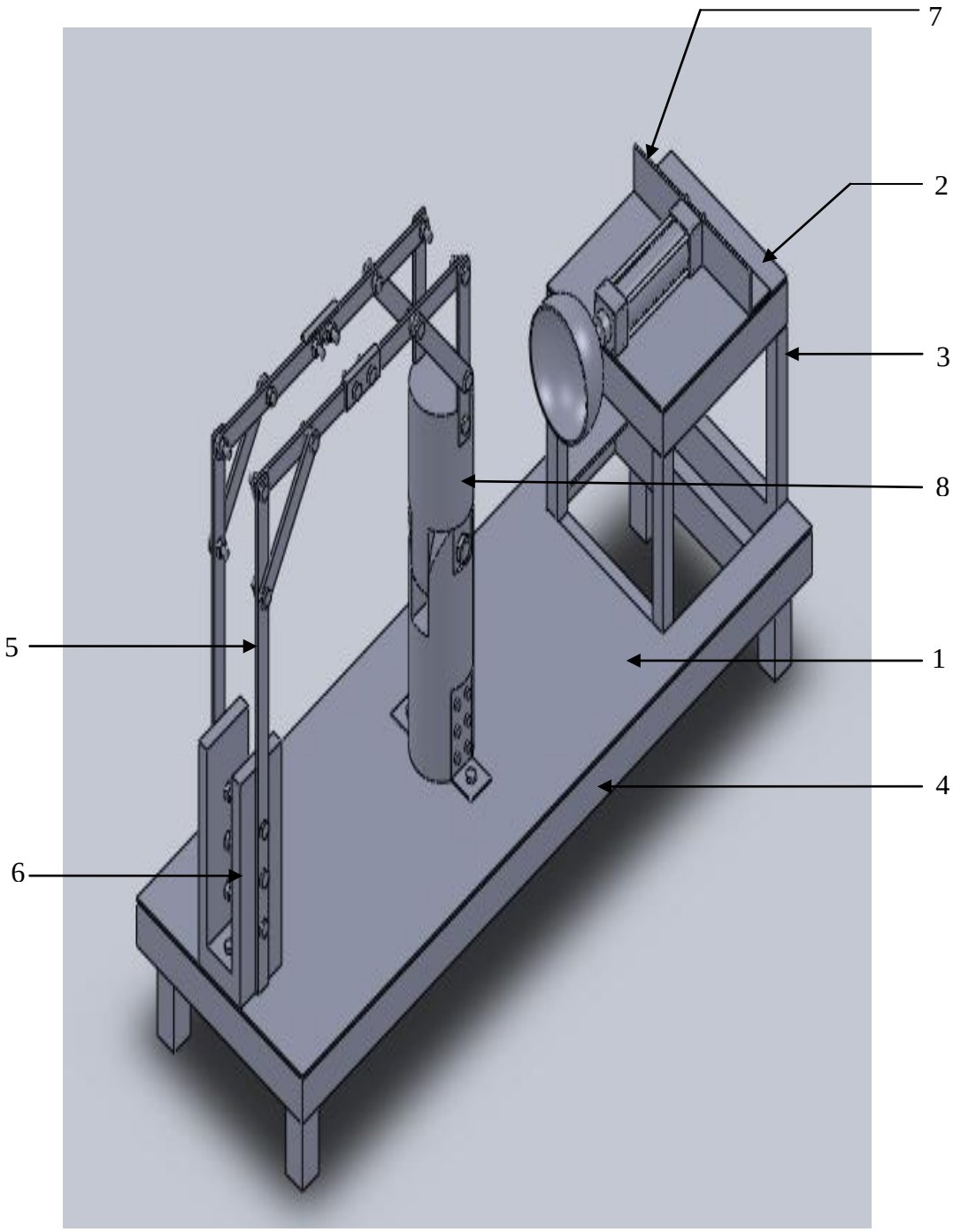

Figure 3.7: Final product

3.4 FABRICATION

After the final design has been selected, the fabrication process will be conducted by using the material. This process must follow the final design which consists of detail dimension. Fabrication process is different than manufacturing process in term of production quantity. Fabrication process is a process to make only one product than manufacturing process that focus to large scale production.

3.4.1 Fabrication flow

(i) Phase 1 - marking and measuring
(ii) Phase 2 – cutting
(iii) Phase 3 – welding
(iv) Phase 4 – drilling
(v) Phase 5 – fastening
(vi) Phase 6 – wiring
(vii) Phase 7 - finishing

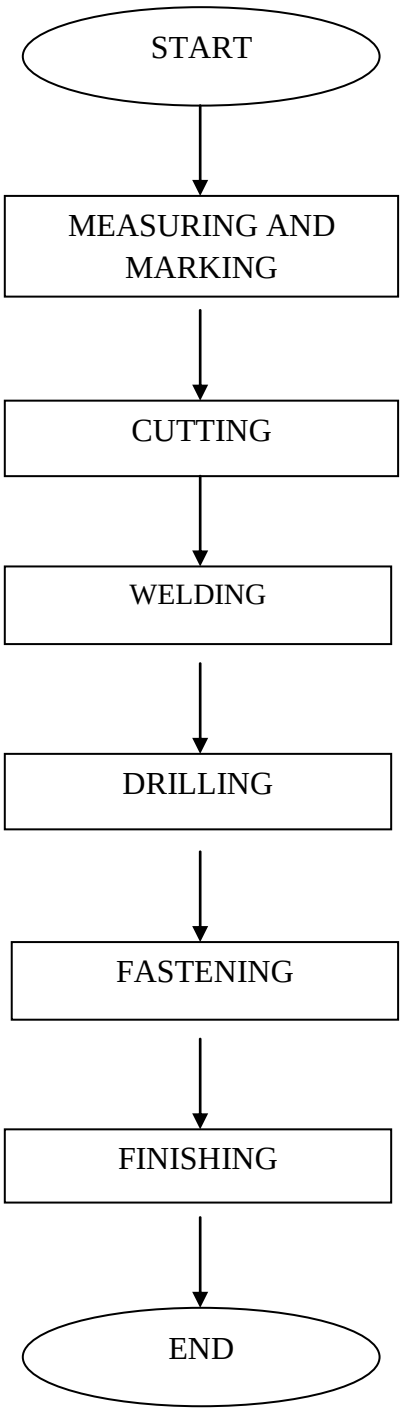

Figure 3.8: Fabrication flow chart

3.4.2 Fabrication process

In order to make the product into the actual size, fabrication process is needed. Figure 3.8 shows the fabrication flow chart for this product. The fabrication process starts from measuring the raw material until it is finish as a desired product. The process involves are:

3.4.2.1 Measuring and marking process

The material needs to measure into a desire dimension based on the design specification. Next, all the measured materials need to be marking for further processing. This process is conduct by using the measuring tape and steel marker. Figure 3.9 show the measuring process and figure 3.10 shows the marking process.

Figure 3.9: Measuring process

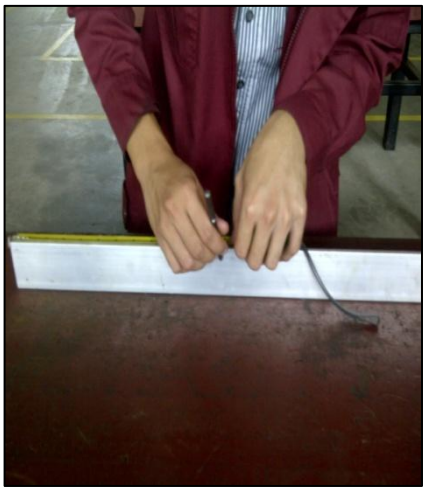

Figure 3.10: Marking process

3.4.2.2 Cutting process

The marked materials were cut into a desire quantity and shape by using the cutter and cutting machine. This process must be done carefully in order to get the desired shape of material.

Figure 3.11: Cutting process

3.4.2.3 Welding process

Some of the part of product is joined by using an arc welding. This process is quietly dangerous. So, some of the safety equipment must be consider avoiding from unexpected incident.

Figure 3.12: Welding process

3.4.2.4 Drilling process

The drilling process is needed to make a hole for further process. Size of drill bit must be suitable for the size of bold to avoid this process is repeated.

Figure 3.13: Drilling process

3.4.2.5 Fastening process

The purpose for this process is to joint or hold the different part of material. Bold and nut is used for this product as a fastener device.

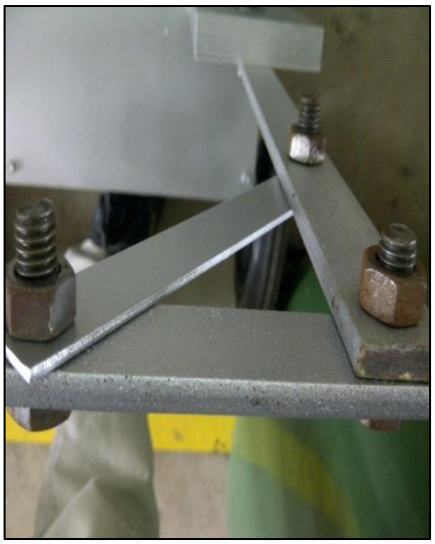

Figure 3.14: Fastening process

3.4.2.6 Finishing process

At the last stages of fabrication process, finishing must be done to give a smooth and safe surface using grinding machine, fisted and followed by painting process.

Figure 3.15: Fisted

CHAPTER 4

RESULT AND DISCUSSION

4.1 FINAL PRODUCT

The final products in several views are shown in figure 4.1 and 4.2 below

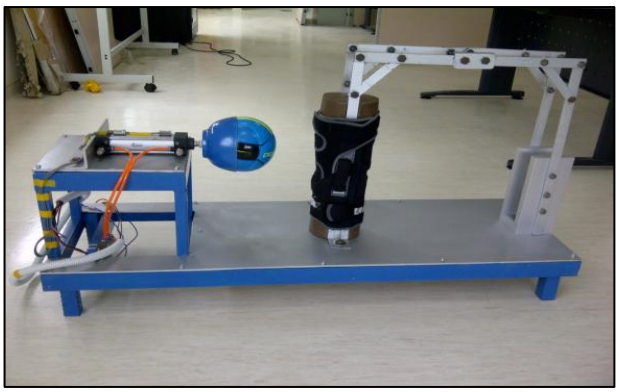

Figure 4.1: Final product with knee pad.

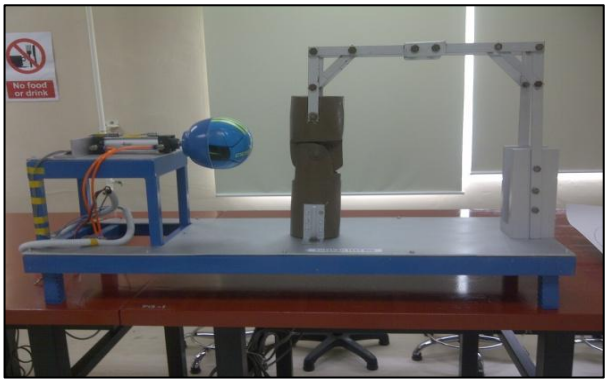

Figure 4.2: Final product without knee pad

4.2 PODUCT ADVANTAGES AND FUNCTION

4.2.1 Pressure control

Pressure is very important to this test rig in order to give the impact force to the knee pad. So, by using the double acting actuator, the pressure can be control in order to manipulate impact force.

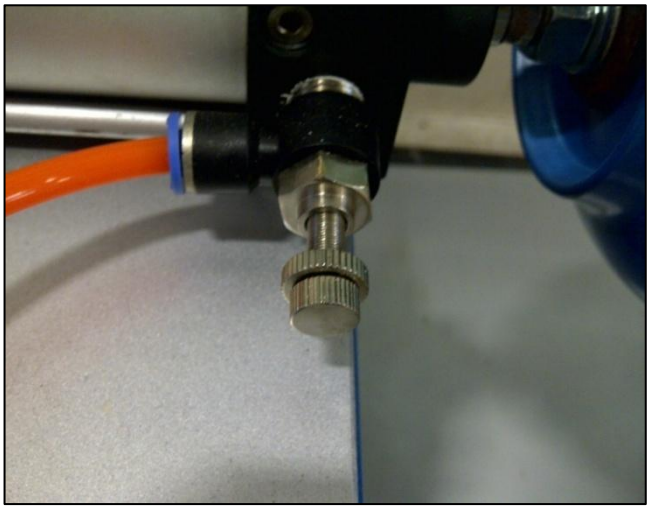

Figure 4.3: pressure control valve

4.2.2 Knee adjustable

The model of knee for this project is designed can be adjustable into 90^0 and 180^0. The purpose of this design is to give a real condition of human knee. Figure 4.4 show the knee in 90^0 position and figure 4.5 show that the knee in 180^0 condition.

Figure 4.4: 90^0 positions

Figure 4.5: 180 positions

4.2.3 Adjustable distant of actuator

The distance actuator and knee can be adjusted in order to manipulate impact force. The force is actually inversely proportional with the distance. So, when the distance decreases, the impact force will decrease.

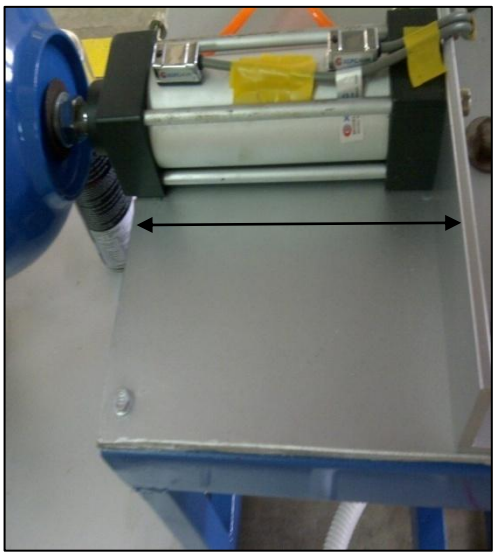

Figure 4.6: Movement of actuator

4.2.3 Using PLC (programmable logic control)

By using this system, the flow of cylinder can be controlled or can be set at the certain time or number. All the system must be draw in ladder diagram in figure 4.8 and transfer to PLC in figure 4.7

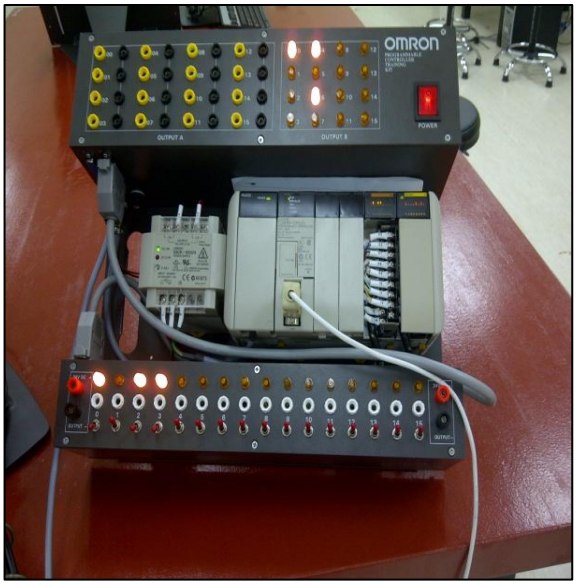

Figure 4.7: PLC

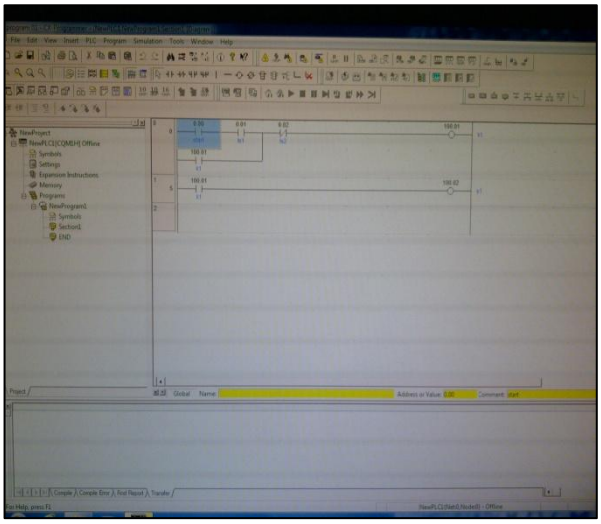

Figure 4.8: Ladder diagram

4.3 PRODUCT ANALYSIS

4.3.1 Stress Analysis

The stress analyses have been tested to the parts of knee by using COSMOSX simulation. The loads that have been applied are 10 N using uniform distribution. The stress analyses result shows in figure 4.9 and figure 4.10. For figure 4.9, the minimum stress is 17.6 N/m^2 and the maximum stress is 112819.9 N/m^2, while figure 4.10 shows the minimum stress is 92 N/m^2 and the maximum stress is 11080.8 N/m^2.

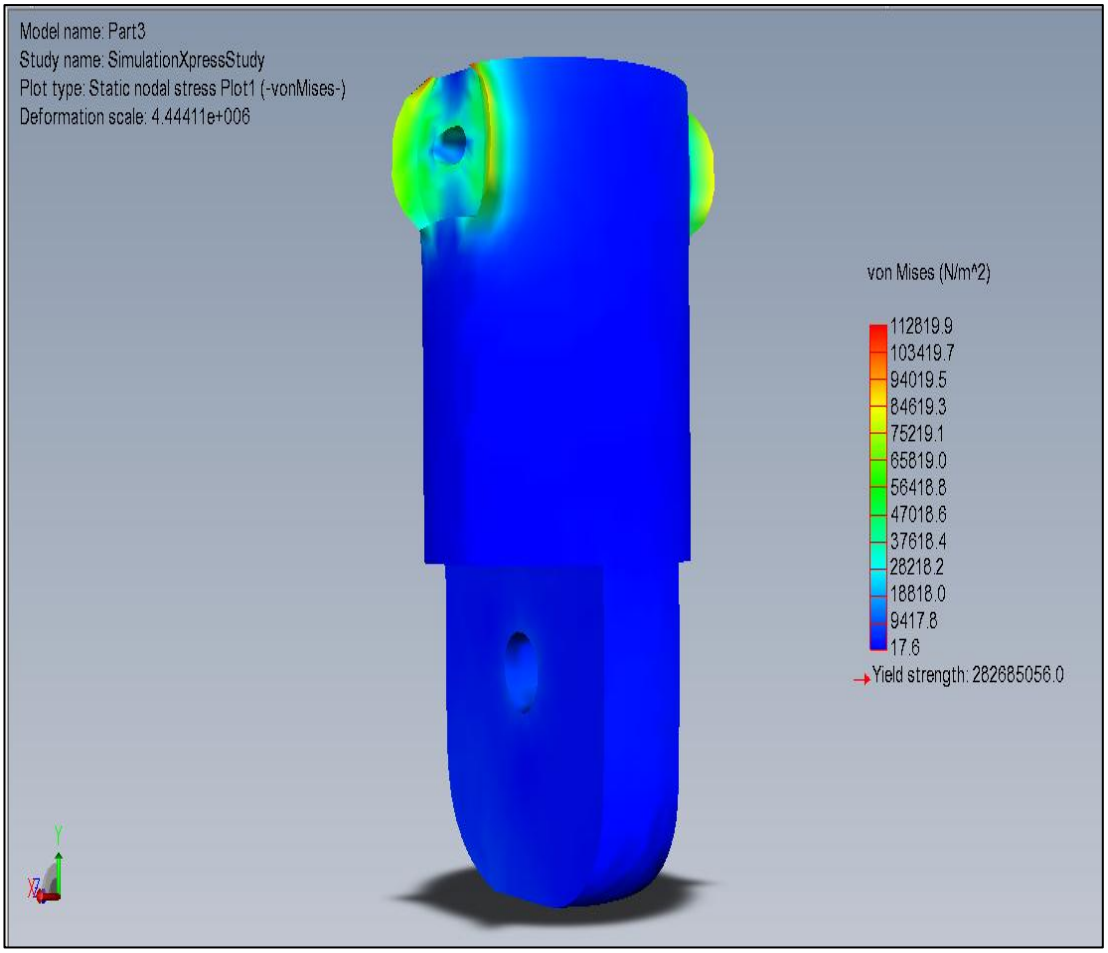

Figure 4.9: Stress analysis result for part 1

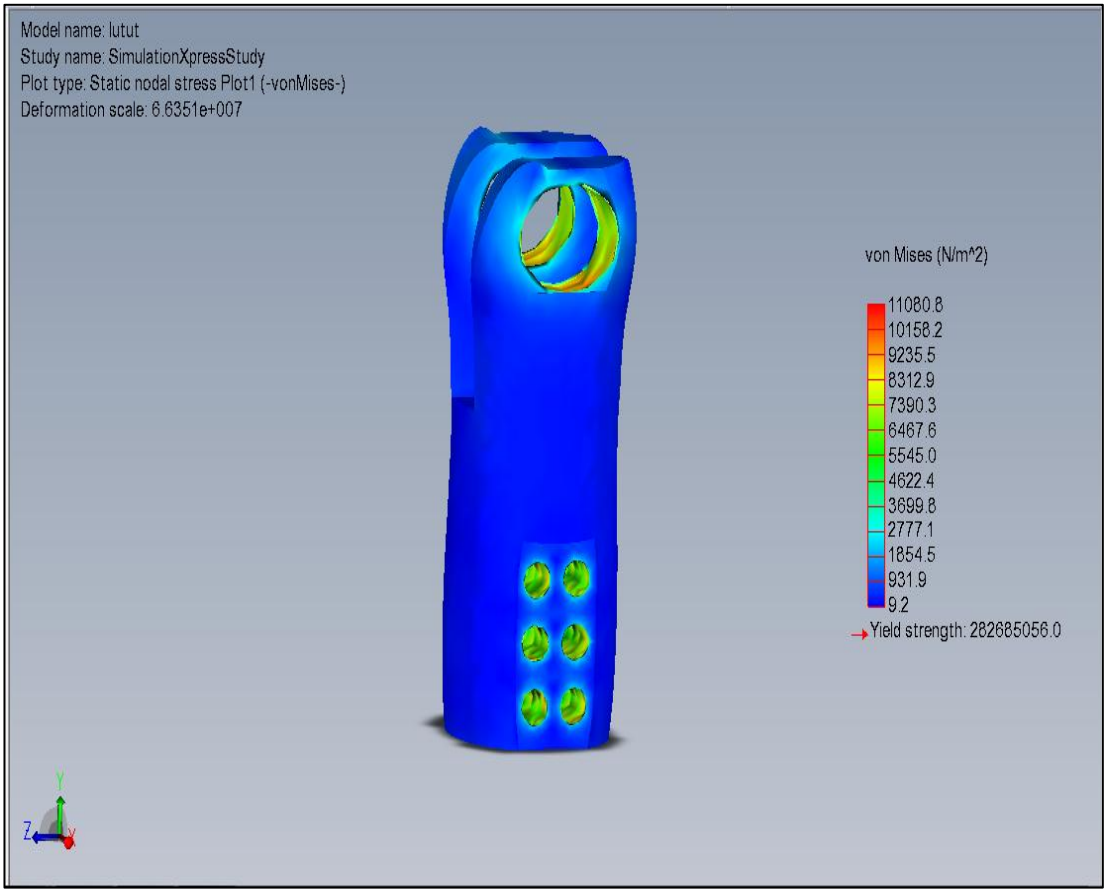

Figure 4.10: Stress analysis result for part 2

4.3.2 Displacement analysis

The displacement analysis has been tested to the parts of knee by using COSMOSX simulation. The loads that have been applied are 10 N using uniform distribution. The displacement analysis result shows in figure 4.11 and figure 4.12.

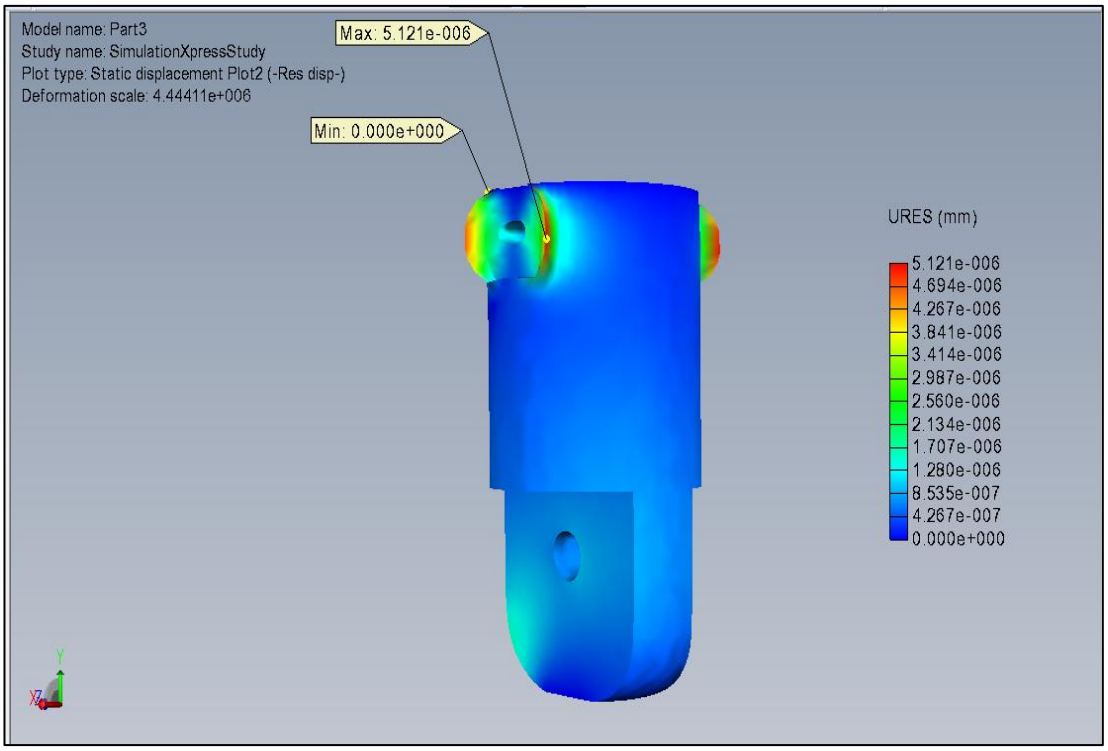

Figure 4.11: Displacement analysis result for part 1

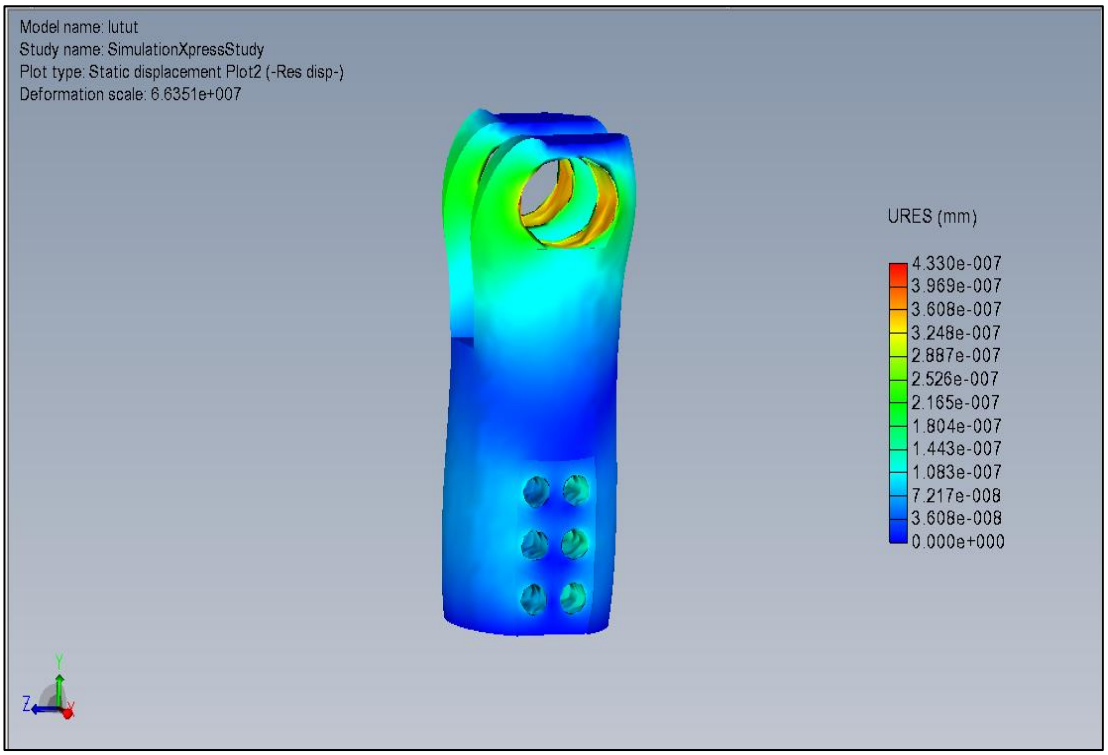

Figure 4.12: Displacement analysis result for part 2

4.4 DISCUSSION

In this project, several observations have been done with respect to the fabrication of the knee pad test rig. The outcome knee pad test rig was achieve the objective of this project. All the component or part of this product can function in good condition for example the actuator can function in difference level of pressure and knee can be able to withstand pressure below 8312.9 N/m^2.

However, this knee pad test rig was too heavy according to the unsuitable material used in the fabrication process. Mild steel bar was perfect in strengthness, but the weight of this material makes this metal not suitable with the knee pad test rig. Besides that, this material can be corrosion if it surface exposed with oxygen and water. The painting method can be used to prevent this problem.

CHAPTER 5

CONCLUSION AND RECOMENDATION

5.1 CONCLUSION

As a conclusion, this project has practice and gives more knowledge about many mechanical properties such as machining and many others material during the fabrication process. Besides that, we also can gain knowledge about the material type, structure and others else. This product also has produces to make an improvement compare to other knee pad test rig that had been exist in the market. The development of this test rig can help the student to study about the effect of impact force at the certain protective equipment. The final year project is very important because it can make our self more discipline and punctual. Overall, this project achieves all the objectives that have been list down previously.

5.2 RECOMENDATION

The recommendations can improve this product in the future:

(i) All the material should be resistance to corrosion in order to make sure this product is function properly.

(ii) The model of knee can be adjust or bend into more than two angle.

(iii) The material that is used for knee should be change with another material such as aluminium.

REFERENCES

a) http://en.wikipedia.org/wiki/Knee_pad

b) www.info.sciverse.com/sciencedirect

c) http://en.wikipedia.org/wiki/Steel

d) http://en.wikipedia.org/wiki/Welding

e) http://en.wikipedia.org/wiki/Aluminium

f) http://en.wikipedia.org/wiki/Wood

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h) http://www.sciencedirect.com

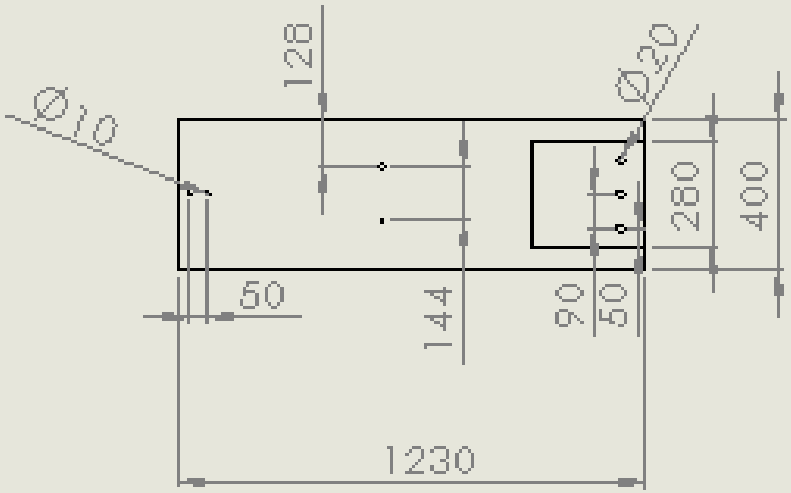
i) http://www.shelleys.demon.co.uk

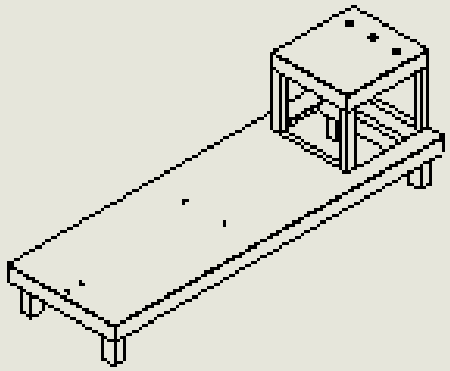
j) http://www.medgadget.com

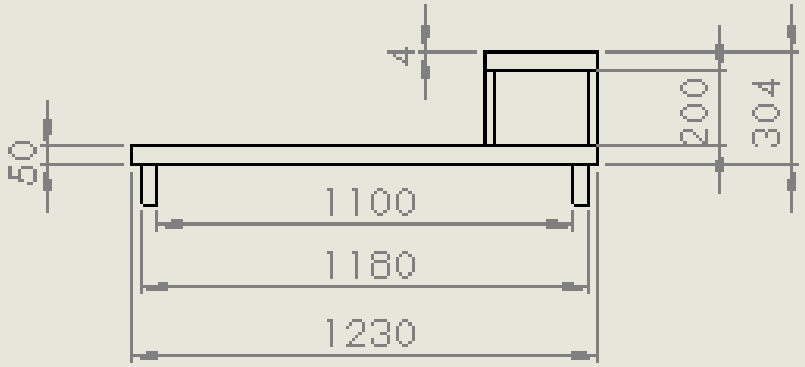
k) http://www.healio.com

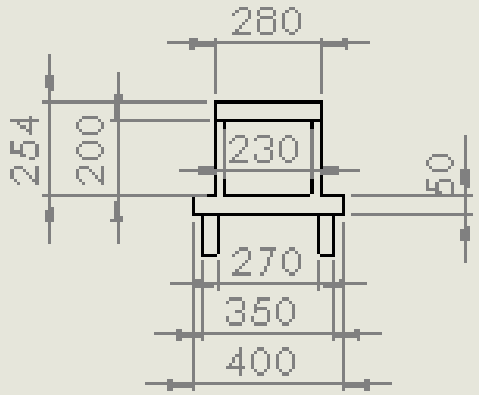
APPENDIX

DRAWING









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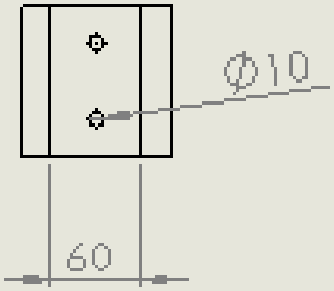

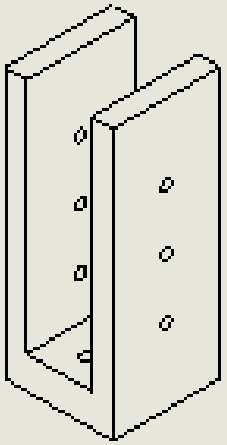

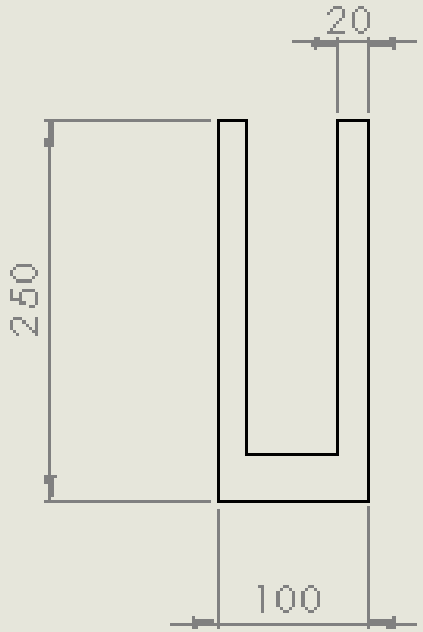

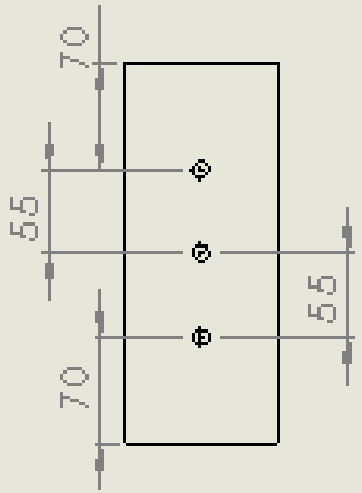

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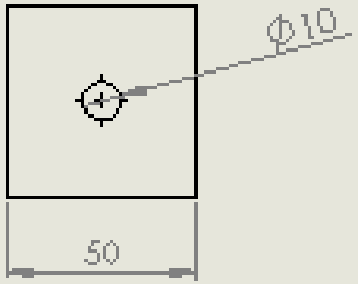

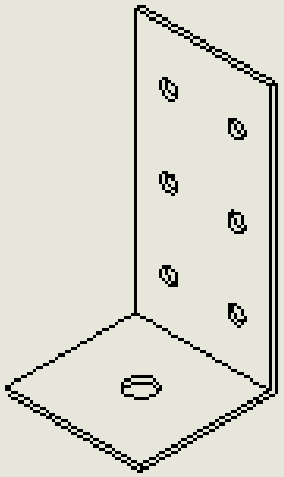

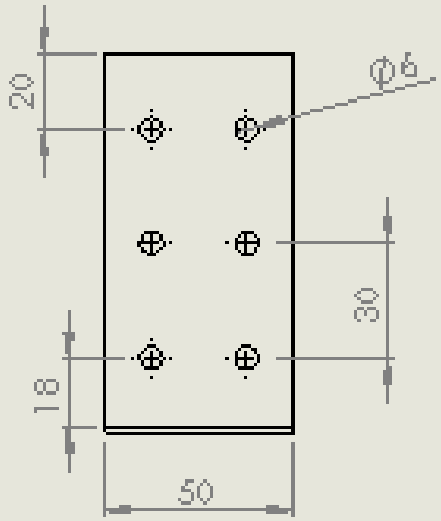

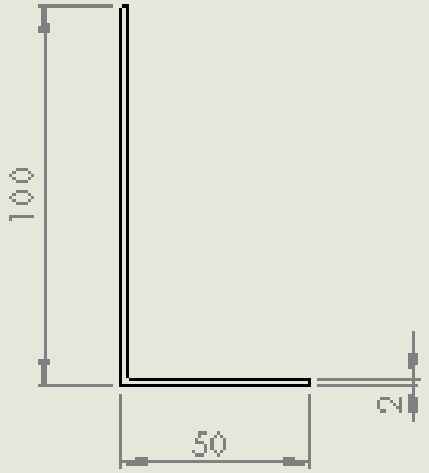

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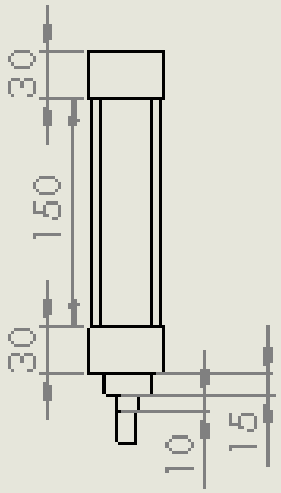

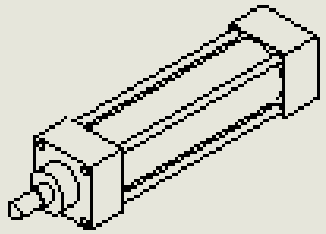

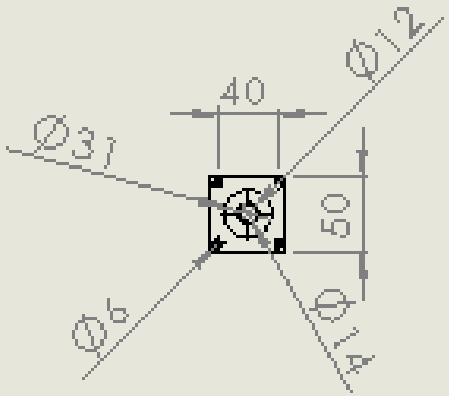

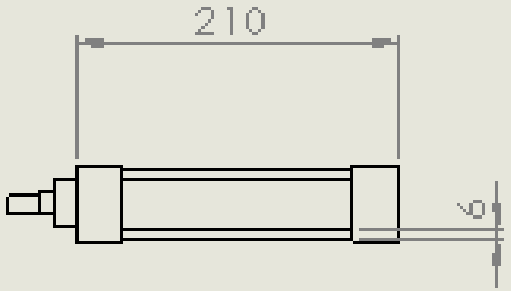

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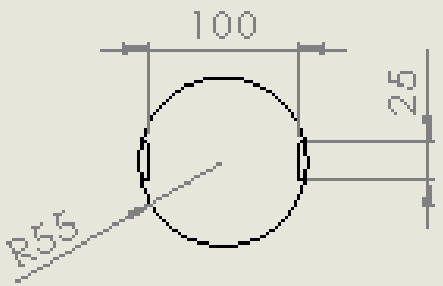

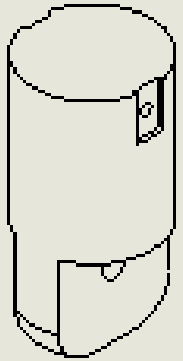

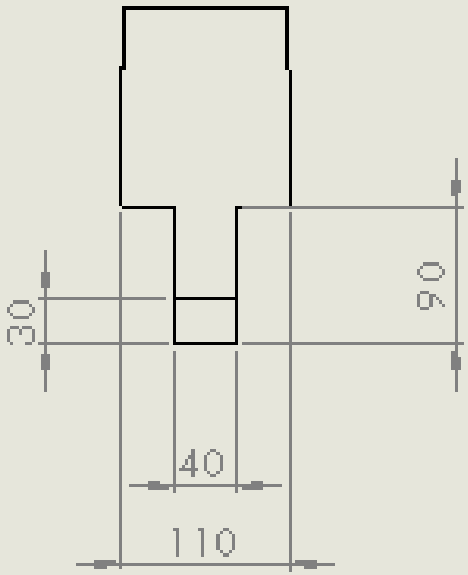

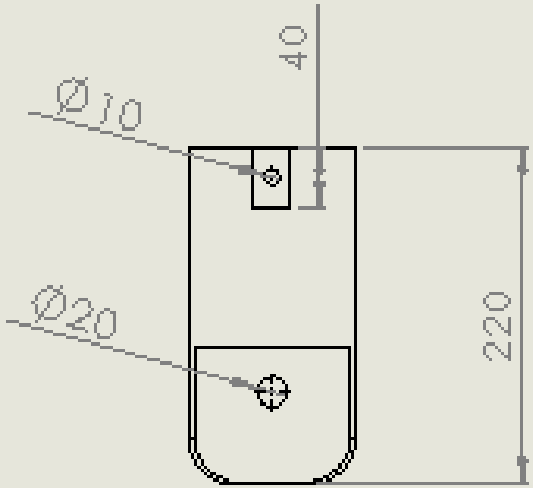

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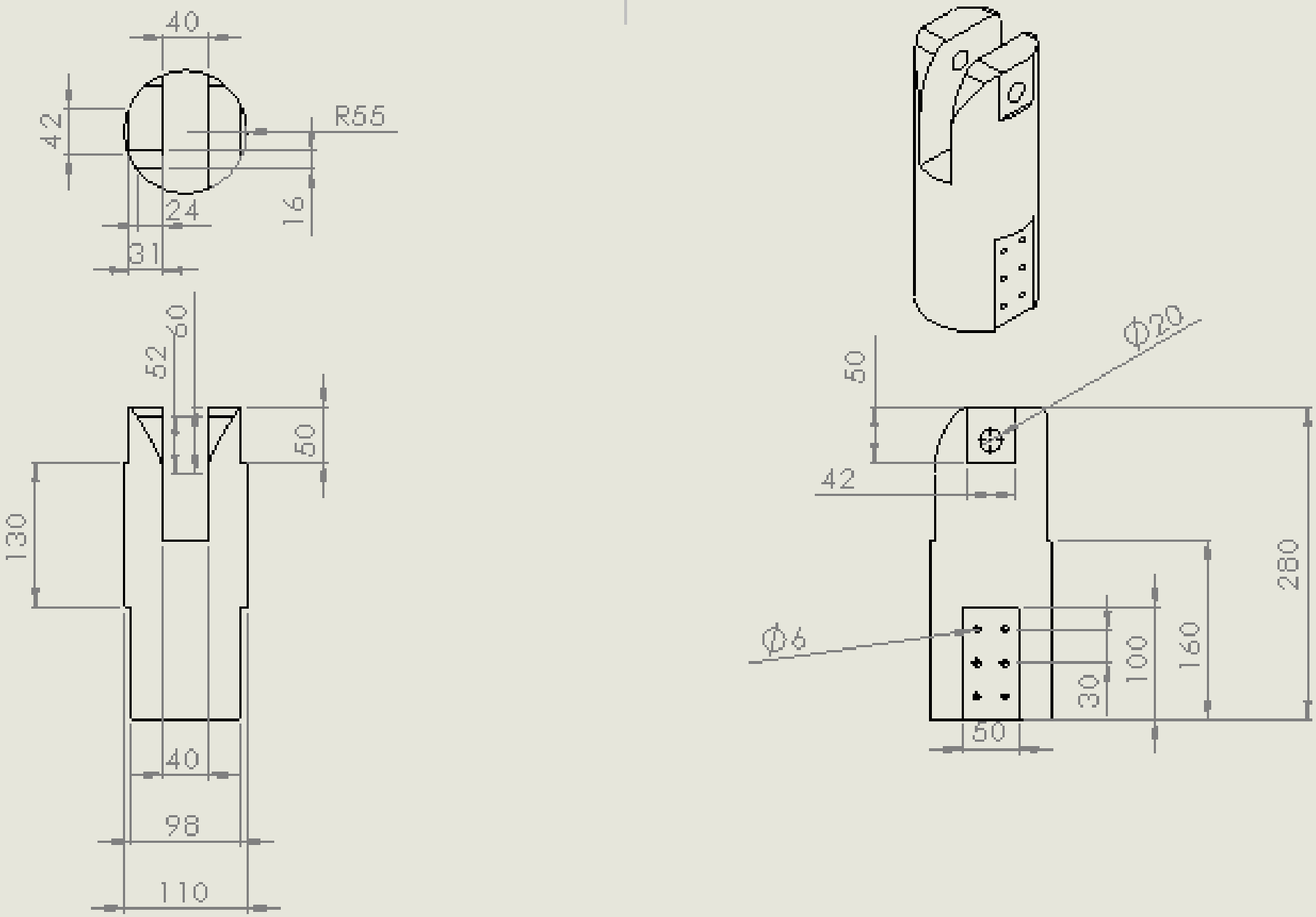

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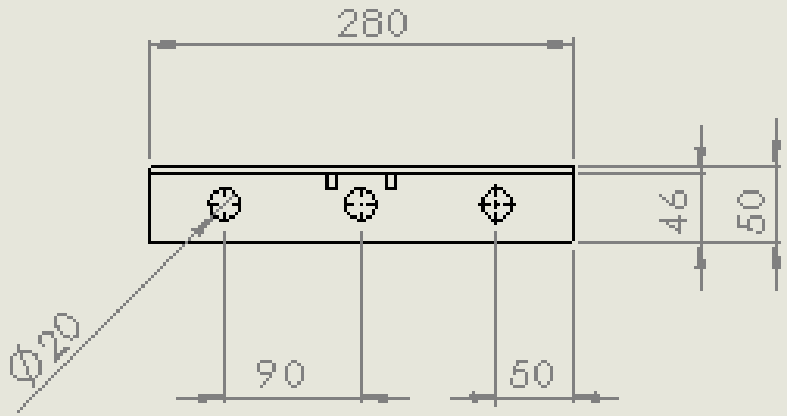

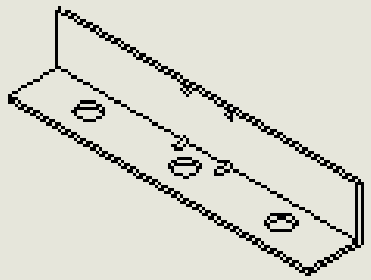

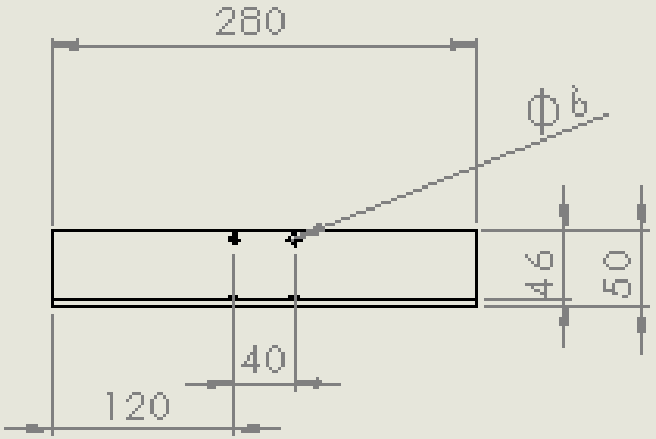

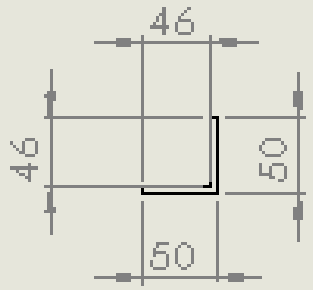

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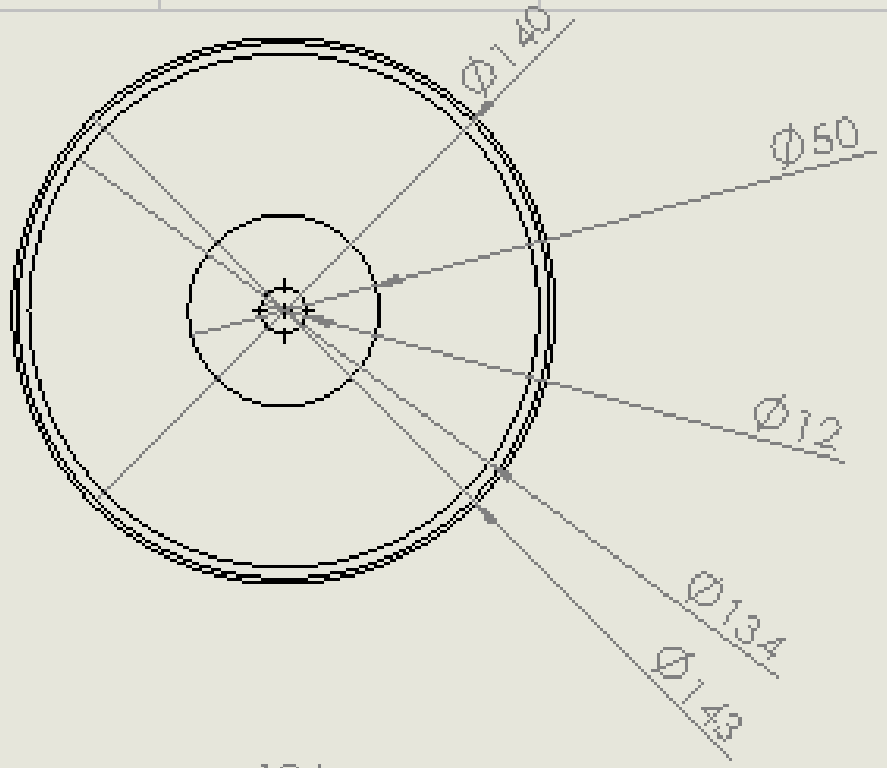

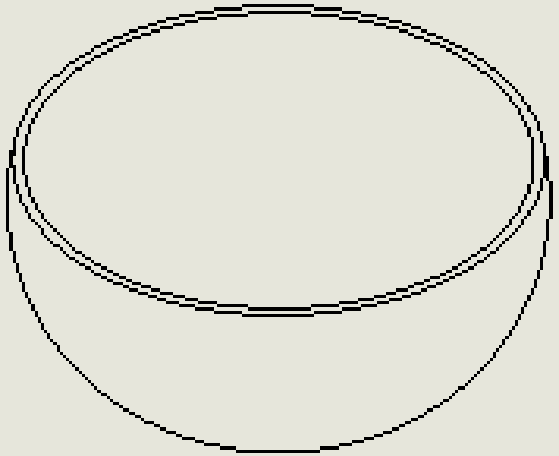

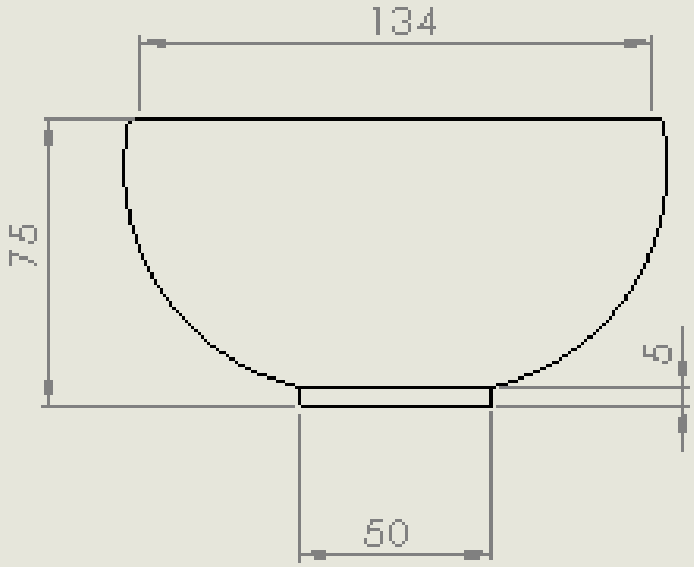

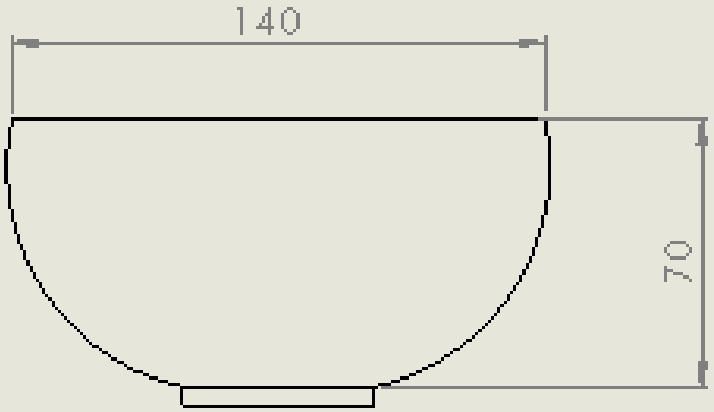

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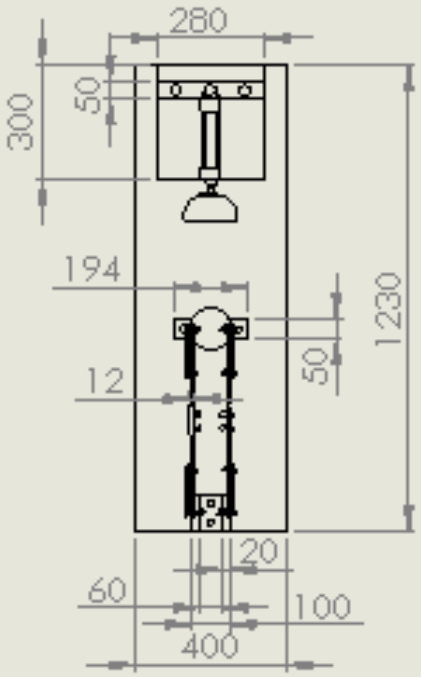

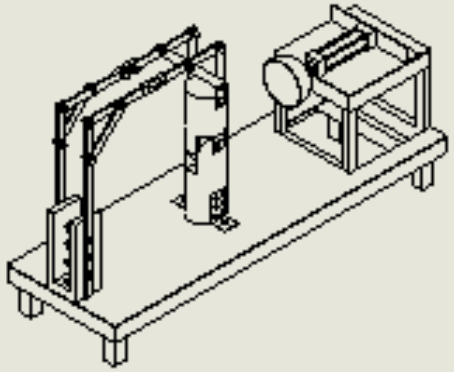

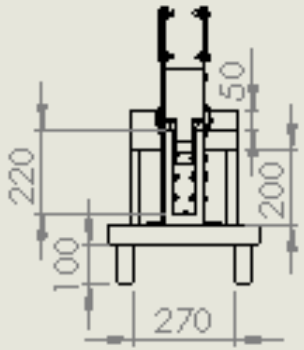

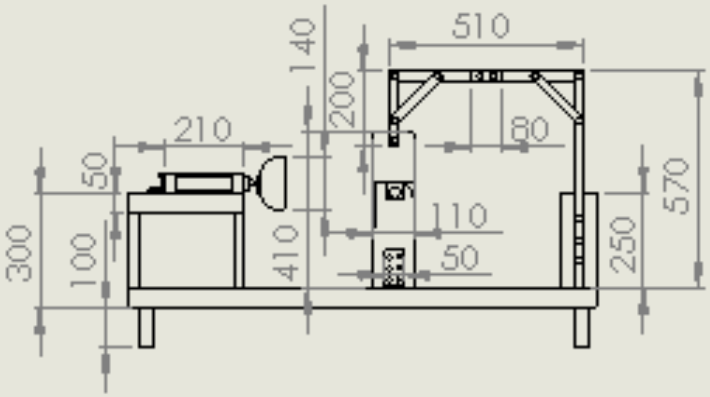

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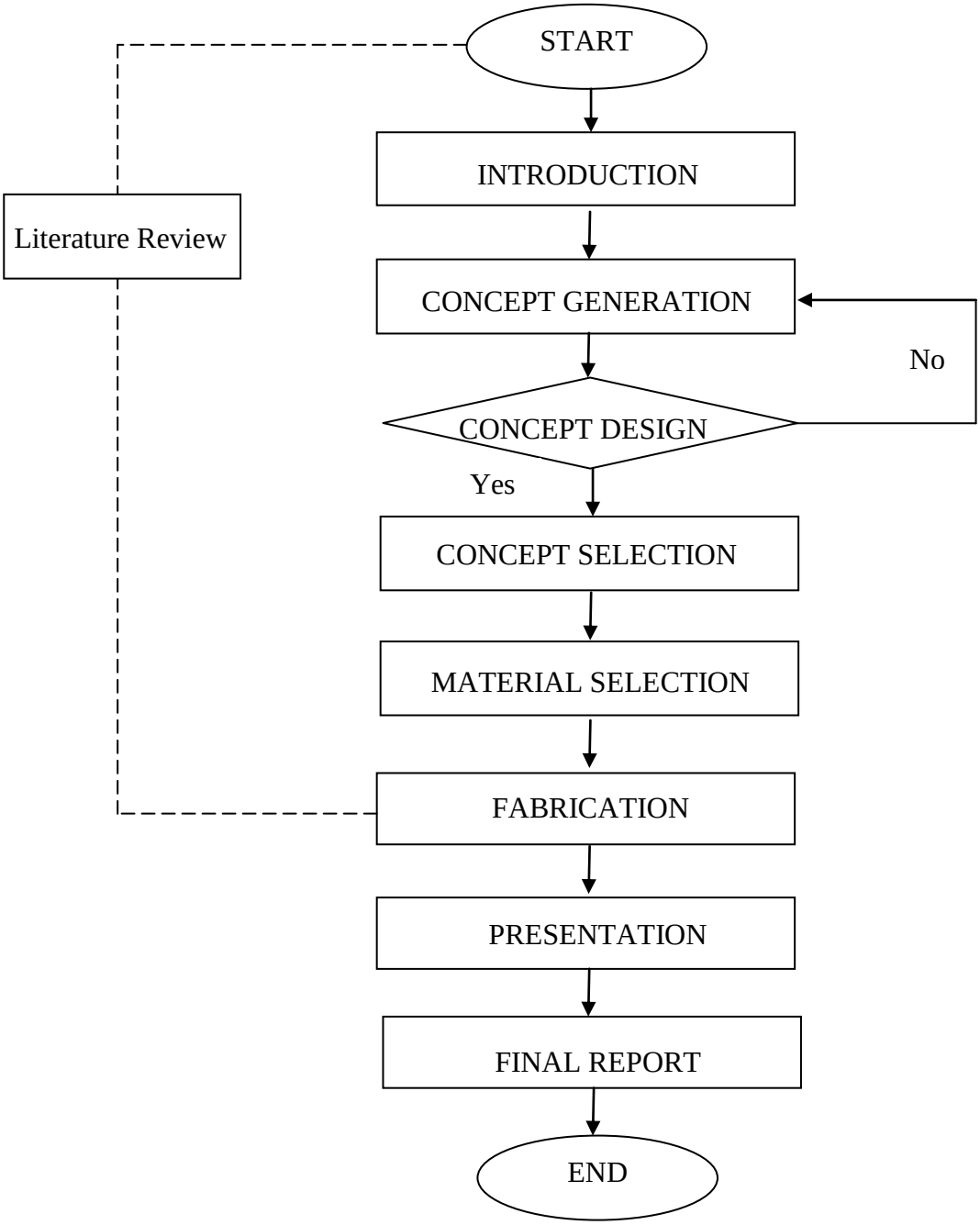
PROJECT FLOW CHART



GANTT CHART OF PROJECT

WEEKS / ACTIVITIES		1	2	3	4	5	6	7	8	9	10	11	12	13	14
DISCUSSION REGARDING THE PROJECT	Plan														
	Actual														
LITERATURE REVIEW	Plan														
	Actual														
CONCEPT DESIGN	Plan														
	Actual														
FINALIZE DESIGN	Plan														
	Actual														
PREPARING MID PRESENTATION	Plan														
	Actual														
MID-PRESENTATION	Plan														
	Actual														
FABRICATION	Plan														
	Actual														
PREPARING FINAL PRESENTATION	Plan														
	Actual														
MAKING REPORT	Plan														
	Actual														
FINAL PRESENTATION	Plan														
	Actual														
SUBMITION FINAL REPORT	Plan														
	Actual														

PROJECT GUIDELINES

(To put knee pad on the knee)

a. Pull out the bold and nut as shows in figure 5.1

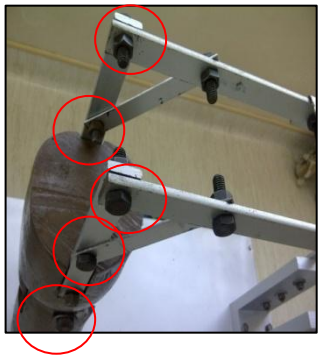


Figure 5.1: Test rig without knee pad

a. Lift up the knee and put the knee pad. After that, put back the bold and nut as show in figure 4.9.

Figure 5.2: test rig with knee pad

(To setup the test rig)

a. Make sure knee pad is already put at knee.
b. Transfer the lather diagram to plc.
c. Connect the solenoid to air compressor by using the cable tube.
d. Connect the wire to plc system and ready to test

TYPICAL YIELD STRENGTH

Material	Yield strength (MPa)	Ultimate strength (MPa)	Density (g/cm^3)
Structural steel ASTM A36 steel	250	400	7.8
Steel, API 5L X65 (Fikret Mert Veral)	448	531	7.8
Steel, high strength alloy ASTM A514	690	760	7.8
Steel, prestressing strands	1650	1860	7.8
Steel Wire			7.8
Steel (AISI 1060 0.6% carbon) Piano wire	2200-2482 MPa		7.8
Stainless steel AISI 302 - Cold-rolled	520	860	
Cast iron 4.5% C, ASTM A-48	276	200	
Titanium alloy (6% Al, 4% V)	830	900	4.51
Aluminium alloy 2014-T6	400	455	2.7
Copper 99.9% Cu	70	220	8.92
Cupronickel 10% Ni, 1.6% Fe, 1% Mn, balance Cu	130	350	8.94
Brass	approx. 200+	550	5.3
Tungsten		1510	19.25
Glass		50 (in compression)	2.53

E-Glass	N/A	3450	2.57
S-Glass	N/A	4710	2.48
Basalt fiber	N/A	4840	2.7
Marble	N/A	15	
Concrete	N/A	3	
Carbon Fiber	N/A	5650	1.75
Spider silk	1150	1200	
Silkworm silk	500		
Aramid (Kevlar or Twaron)	3620		1.44
UHMWPE	23	46	0.97
UHMWPE fibers (Dyneema or Spectra)		2300-3500	0.97
Vectran		2850-3340	
Pine Wood (parallel to grain)		40	
Bone (limb)	104-121	130	
Nylon, type 6/6	45	75	
Rubber	-	15	
Boron	N/A	3100	2.46
Silicon, monocrystalline (m-Si)	N/A	7000	2.33
Silicon carbide (SiC)	N/A	3440	
Sapphire (Al_2O_3)	N/A	1900	3.9-4.1
Carbon nanotube (see note above)	N/A	62000	1.34

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LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

e	Strain	
σ	Stress	(N/m^2)
E	Young's Modulus = σ /e	(N/m^2)
y	Distance of surface from neutral surface	(m)
R	Radius of neutral axis	(m)
I	Moment of Inertia	(m^4)
Z	Section modulus = I/y_{max}	(m^3)
M	Moment	(Nm)
W	Total load on beam	(N)
F	Concentrated force on beam	(N)
S	Shear Force on Section	(N)
L	Length of beam	(m)
x	Distance along beam	(m)

LIST OF ABBREVIATIONS

AL	Aluminium
AISI	The American Iron and Steel Institute
ASTM	American Society for Testing and Materials
CAD	Computer Aided Design
MIG	Metal Inert Gas Welding
PPE	Personal Protective Equipment
PLC	Programmable Logic Control
SMAW	Shielded metal arc welding
UMP	Universiti Malaysia Pahang

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project 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 : MOHD AZRUL HISHAM BIN HJ. MOHD ADIB
Position : LECTURE
Date :

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 diploma and is not concurrently submitted for award of other diploma.

Signature :
Name : MOHD YUSRI BIN SHAMSUDDIN
ID Number : MB10035
Date :

ACKNOWLEDGEMENTS

Foremost, this final year project will not be completed without the guidance of my supervisor, Encik Azrul Hisham bin Mohd Adib who inspired and advice me from the beginning of this project with patience. His encouragement and work enthusiasm motivated me to hurdle all the obstacles on completing the project. He has shared valuable information in the relevance of project study field and provided me with helpful ideas and reference sources.

I also would like to express sincere gratitude to my friends,Ahmad Shawal bin Mohd Amin,Mohd Rosyazwan Hanif bin Ishak and Hafizuddin bin Ismail for support and the ideas to generated the concept design. They also give me valuable information and help to fabricate some part in this project.

Last but not least, my family that helps me to overcome the entire problem during the fabrication of this project. A deepest appreciation to my brothers,Mohd Affandi bin Shamsuddin and Mohd Hanapi bin Shamsuddin because of the helps in fabrication of this test rig. Allah S.W.T giving me the strength to continue running despite at one time I was like giving up, Alhamdulillah.

ABSTRACT

This is project is about to development the test rig for knee pads. The purpose of this project is to improve the performance of knee pad, automatically will increase the safety of the product. Finished components can have very different impact performance depends on the material that have used to create it. The application of pneumatic system is using for this test rig in order to get the impact force. By using this system, impact force can be manipulated into a different level. This system also can constant the time impact in order to get a more accurate data to analyze. Finished knee pad must be test with test rig whether it can work as expected. The use of light and toughness material is applied in order to develop this test rig that have capability and performance as well as to reduce the cost of the project. This project has gives more knowledge about the mechanical properties and machining process. Besides that, it can help student to study about impact force at the certain protective equipment especially knee pad. The design and fabrication of this knee pad test rig hopefully can be reference to develop a larger and more complex design knee pad test rig in future.

ABSTRAK

Projek ini membentangkan tentang pembangunan rig ujian untuk pad lutut. Tujuan projek ini adalah untuk meningkatkan kualiti pad lutut dan secara tidak lansung dapat menjamin keselamatan produk. Komponen yang telah siap mempunyai kualiti dan prestasi yang berbeza bergantung kepada bahan yang digunakan dalam pembuatan produk tersebut.Sistem pneumatik telah digunapakai pada rig ujian ini untuk menghasilkan daya impak. Dengan penggunaan sistem pneumatik ini,daya impak dapat dimanipulasikan kepada tahap yang berbeza mengikut keperluan. Sistem ini juga membolehkan masa hentamam disekatakan bagi mendapatkan keputusan ujian yang tepat untuk dianalisis. Pad lutut yang telah siap dan besedia untuk dipasarkan mestilah diuji terlebih dahulu bagi memastikan ia berfungsi seperti yang diharapkan. Penggunaan bahan yang ringan dan kukuh adalah sangat penting dalam penghasilan rig ujian ini di samping dapat mengurangkan kos projek. Projek ini telah banyak memberi pengetahuan dalam ciri-ciri mekanikal bahan dan proses pemesinan.di samping itu,ia akan membantu pelajar untuk mengkaji tentang daya impak kepada alat perlindungan terutamanya pad lutut.Pengahsilan rig ujian pad lutut ini diharapkan dapat menjadi perangsang untuk pembangunan rig ujian yang lebih kompleks pada masa akan datang.