CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter presents the methodology process of mini fatigue tensile machine. All of this will cover by the explanation based on methodology to make project complete and achieve the objective. Journal articles were used as references and to gather information to support the result of the data. These journal articles help in the form of improvements as well as give advantages in studying more about the design. The main purpose of this design is all about fatigue tensile process. Fatigue tensile can be figured when the material or specimen are getting force with repeatedly. To evaluate the result, the design wasanalyzedusing software such as Ansys and CATIA. According to the design, this design were sketched using software such as CATIA or UGNX 6.0 software. All of the componentswere identified based on specification design. Each of the components need to be evaluated their characteristic and function as well for proper design sketching. Furthermore, this design was figured by the Pugh method table. Pugh method was used to help in differentiate characteristic between the designs that had been sketches. Before the design was start analyzed, fatigue process was identified first in order to know the process on mini fatigue tensile machine. There were three stages on fatigue failure that were identified which are initiation crack, crack growth, and final fracture. When fatigue occurs repeatedly,the structures of the specimen were damaged and crack will start spread rapidly. For this reason, cyclic graph formed if the process continues with repeatedly.

After the entire project was evaluated, this design was sketched using UGNX 6.0 software. The entire componentswere sketchedaccording to their dimensional and specification that had been figured. This design were simulated and analyzed using Finite Element Analysis in order to obtain the stress cyclic loading after done sketching. The methodology is summarized as a flow chart as shown in Figure 3.1.

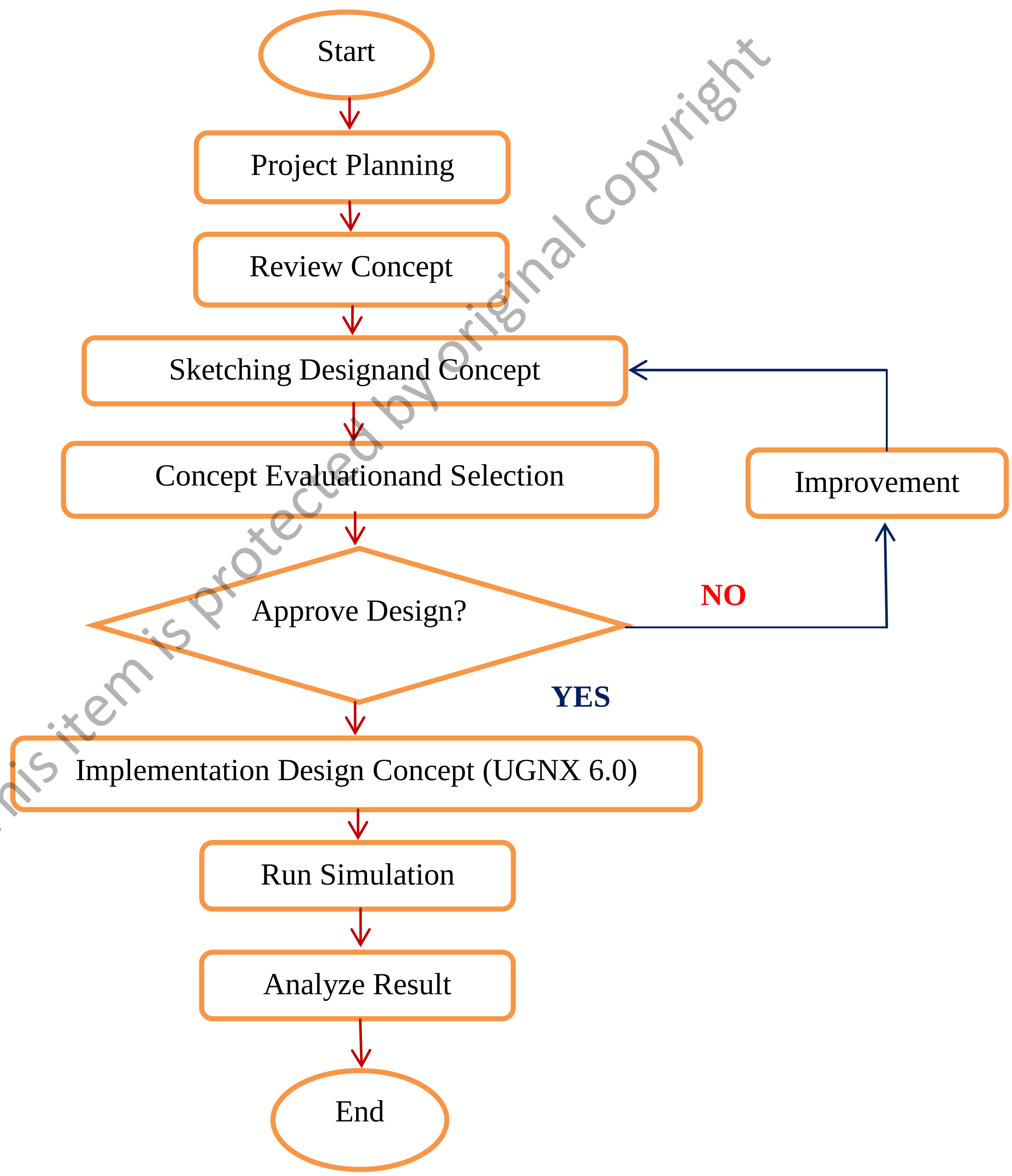


Figure 3.1: Flow Chart.

3.2 Concept Design Theory

Design concept was figured as an idea to solve the design problem and the function as well. After reviewing journal and all references, the concept design had been chooses with three concepts by sketching with different designing. Three of this machines have different function as well and still operate to make a fatigue process. The design was implemented by using UGNX 6.0 software. This design was designed with a mini size for easy maintenance process and use. Motor are the main function of mini fatigue tensile machine because fatigue cannot be occur if the design operate manually. Motor is the main function on design concept because each of rotation motor will make fatigue occur while process.

Moreover, there are several types of motor that are suitable for this machine and one of the motors is high torque machine as it will be applied more load when fatigue process happened. The gripper is also one of important part interiors in tensile fatigue mini because it functions as holder of the specimen. The gripper was used with the suitable specimen where it does not reach the maximum level of load gripper. Besides that, bearing slider functions to help the movement of gripper while machine operates. The use of slider will be shown in concept design three.

Apart from that, this machine was designed according to the concept that had been chosen to achieve the objective. Besides that, this machine also was operated as fatigue tensile process to achieve the objective of report.

3.3 Design and Concept Selection

Concept selection will be known as evaluating or generate the idea for the customer demand or other criteria make new products and improvement based on strategy. Besides that, it also will compare between strength and weakness of material. There are three stages on selection concept design which are evaluating consumers' need, develop product design specification, and generate many of concepts. Concept design was determined as comparison design and decision making of the concept design. There are two types of comparison which are absolute and relative. Absolute was defined as compare directly with target based on criteria and on the other hand relative will compare other criteria by defined it.

3.3.1 Criteria of the project

According to the objectives, the size of the machine should not be too large and suppose to make more space when place it. The purpose for designing this mini machine is to test on a small specimen so that it can ease students when handling the machine. In fact, mini machine also gives more advantage becauseit is not too costly based on the selection of specification. There are some criteria of this project which are:

1. Mini size – The size of design should be maximum 30cm × 26cm × 15cm for mini size.
2. Efficiency – Comparison of what is actually produced or performed with what can be achieved with the same consumption or resources.
3. Low cost – Range of price should be RM800 to RM2000.
4. Reliability – Yield strength of material need to be high than maximum value of Von Misses Stress.
5. Precision data – Based on theoretically calculation to form a cyclic loading graph.

All of these criteria werefor the concept selection. Thus, these criteria were applied on designing concept where to choose the better concept designing.

3.3.2 Sketching Concept

Concept 1 shows about the function and their criteria to make design function as fatigue occurrence. This concept used an electronic device for controller motor. All figuresillustratetheir function and process of fatigue tensile.

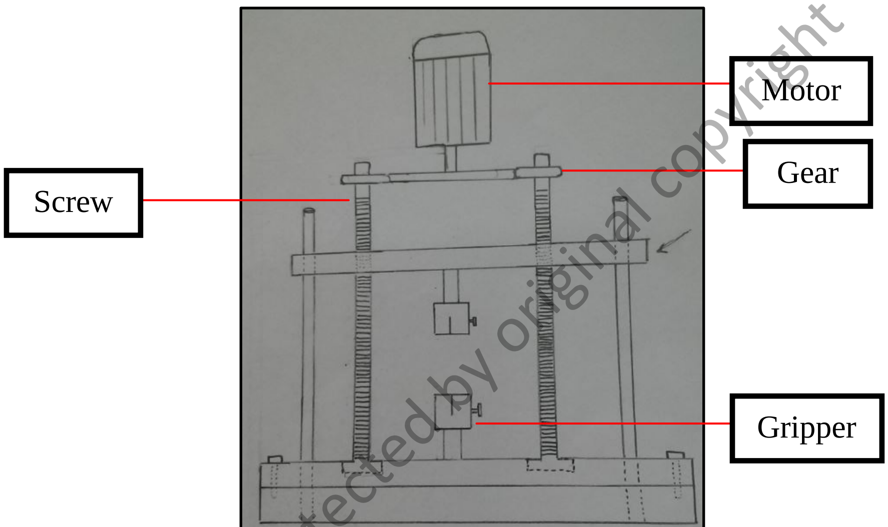


Figure 3.2: Concept 1.

Figure 3.2 illustrates theconcept of using motor and gears to make rotational screw. The main parts of this concept are screw where the screw rotates by driven gears and motor. Gears function as guide of the screw to rotate. Top of gripper was move upward and downward when motor start rotates. This concept needs to use an electronic controller to set gripper moving up and down to make fatigue tensile test. The criteria of this concept are shown on Table 3.1 which has different concept chosenfor each criterion.

Table 3.1: Criteria of Concept 1.

Criteria	Concept (Yes or No)
Mini size	No
Efficiency	Yes

Low cost	No
Reliability	Yes
Precision data	Yes

Figure 3.3illustratesthe function of fatigue tensile where this concept used hammer as the main process to apply force on it while processing.

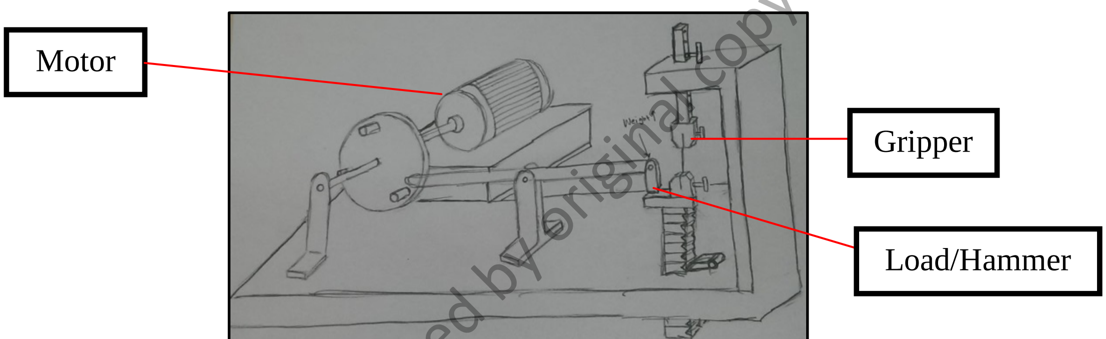


Figure 3.3: Concept 2.

Motor will start to rotate and hammer will move upward and downward with appliedforce on surface gripper. Force on hammer was depending on the weight of the hammer. This design used motor as the repetition process. All criteria were analyzed on Table 3.2 based on their function. The concept is chosen based on specification that fulfills the criteria.

Table 3.2: Criteria of Concept 2.

Criteria	Concept (Yes or No)
Mini size	Yes
Efficiency	No
Low cost	Yes
Reliability	Yes

Precision data	No

Figure 3.4 shows the function of fatigue tensile on concept 3. This concept process is more likely a piston process. The gripper will move upward and downward such a piston motion.

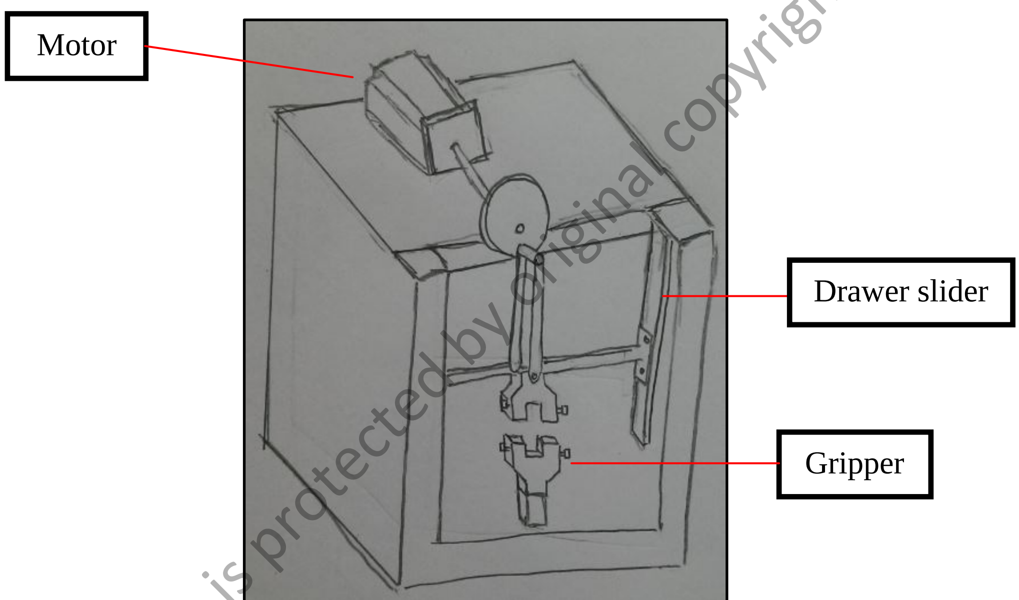


Figure 3.4: Concept 3.

This concept functionedwhenthe motor was started to rotated on a circular plate. The top of gripper moved upward and downward by rotating plate and get support by bearing slider to move it smoothly. Table 3.3 shows the best concept that had been chosen based on their criteria.

Table 3.3: Criteria of Concept 3.

Criteria	Concept (Yes or No)
Mini size	Yes
Efficiency	Yes

Low cost	Yes
Reliability	Yes
Precision data	No

Figure 3.5 shows the process of fatigue tensile. This concept operated as the piston motion in which the left of gripper was moved horizontally to make the fatigue occurred on specimen.

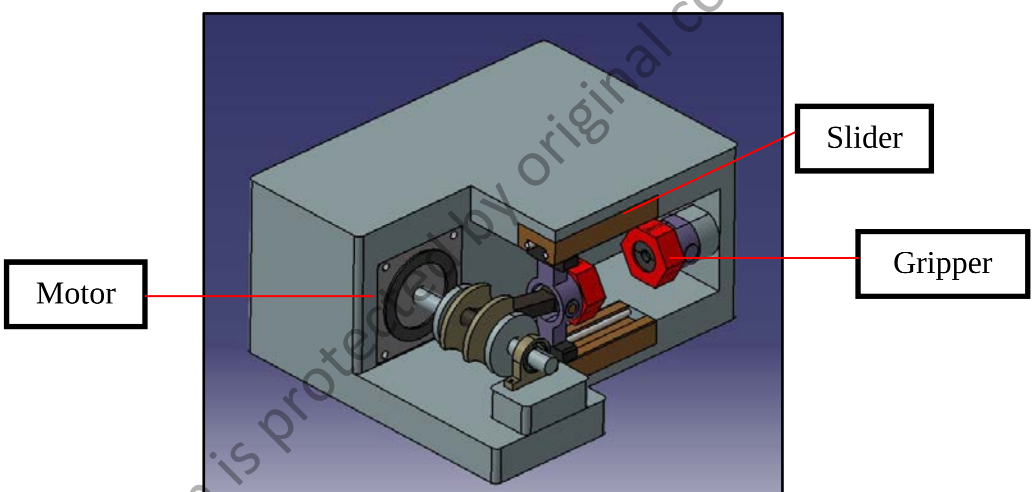


Figure 3.5: Concept 4.

The gripper pulled along 30mm of specimen for each cycle to applied fatigue process.Left gripper moved horizontally by supported moving bearing slider. The specimen were tested based on the maximum yield strength of the machine that was pulled.Table 3.4 shows the best concept that had chosen based on their criteria.

Table 3.4: Criteria of Concept 4.

Criteria	Concept (Yes or No)
Mini size	Yes

Efficiency	Yes
Low cost	Yes
Reliability	Yes
Precision data	Yes

3.3.3 Pugh method

Pugh method shows the evaluated design concept for the concept selection according to their criteria. Table 3.5illustrates the Pugh method for each concept. Based on Pugh method concept, the design of concept is chosen based on highest total value.

Table 3.5: Pugh Method.

Concept alternative				
Criteria	Concept 1	Concept 2	Concept 3	Concept 4
Mini size	-	+	+	+
Efficiency	+	-	+	+
Low cost	-	+	+	+
Reliability	+	+	+	+
Precision data	+	-	-	+
Total –	2	2	1	0
Total +	3	3	4	5

❖ YES (+) NO (-)

3.3.4 Concept Selection

Based on concept selection, concept 4 is the best concepts which propose the mini fatigue tensile machine. The concept selection had been figured by using Pugh method based on total value for each criterion. The concept was chosen by the highest total value from selection of criteria. Figure 3.6 shows the concept selection had been chosen based on their ranking methods.

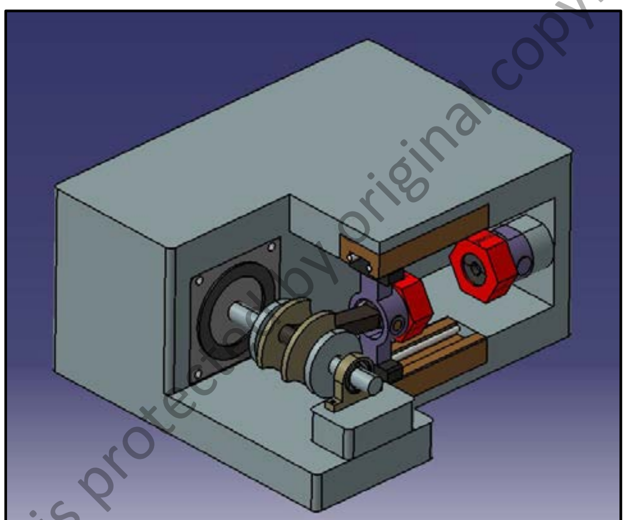


Figure 3.6: Concept 4.

3.4 Machine Component

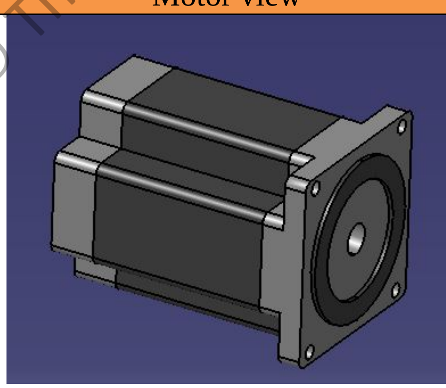
There are several types of components on designing concept 4in which ithas different functions. This component has all specifications that fulfilled the concept design function.

3.4.1 Stepper Motor

Stepper motor is defined as an electrical energy that is transferred to the mechanical energy in order to make the shaft or spindle of motor rotates. Figure 3.7 showsthe type of stepper motor that was used. The advantage of using stepper motor are good acceleration and stability with precise rotation. It is also easy to setup and low cost compared to servo motor. Motor was placed at the top of the frame body. Table 3.6illustratesthe motor specification:

Figure 3.7: Stepper Motor[11].

Table 3.6: Motor Insertion.

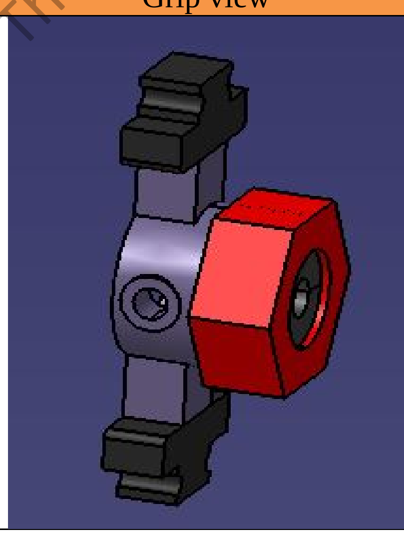
Motor view	Specifications
	Type: NEMA 34 Torque: 9.2 N.m. Weight: 2400 g Phase current: 6.3 A Phase inductance: 3.3 mH

3.4.2 Mechanical Screw Grip

Screw grip was functioned as holder of the test specimens with simple and efficiently. These grips only can use for smaller specimens such as, threads, fabric, soft material, films, and thin sheet materials. Figure 3.8 showsthe type of grip that was used on this design. These grips are ease to use manually and it is an adjustable grip using screw. These grips was placed at the center of the machine in order to grip the specimen. Table 3.7depicts the specification of screw vise grip:

Figure 3.8: Screw Grip[18].

Table 3.7: Grip Insertion.

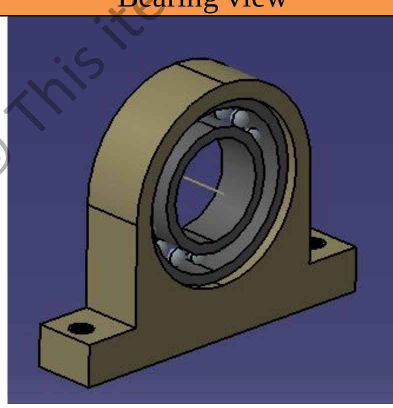
Grip view	Specifications
	Type: Screw grip Maximum load: 0.44 kN Diameter of specimen: 10 mm Material: Steel Material of specimen: Thread, fabric, soft material and thin material.

3.4.3 Bearing

The function of bearing was relative to the movement where its function is to decrease friction occurs on part. It is also was used as a support, guide, and hold another part while operate. Figure 3.9 showsthe type of bearing that was applied on the design. Based on concept design, this bearing will be function as hold the shaft while motor rotates. The specifications of the bearing can be depicted in Table 3.8:

Figure 3.9: Bearing[19].

Table 3.8: Bearing Insertion.

Bearing view	Specifications
	Outer diameter: 16mm Inner diameter: 6.5mm. Material:Stainless steel and ceramic balls

3.4.4 Plate

These parts will function while rotating motor operates. These plates are connected with the shaft from motor. Moreover, it hasan adjustable diameterin order to make fatigue testing. Plate was placed at the center of shaft motor. Figure 3.10illustrates the type of plate that was used on design. This plate was fabricated with using milling machine to make such design as on Table 3.9.Table3.9depicts a specification of round plate that had been designed and fabricated:

Figure 3.10: Plate [20].

Table 3.9: Plate Insertion.

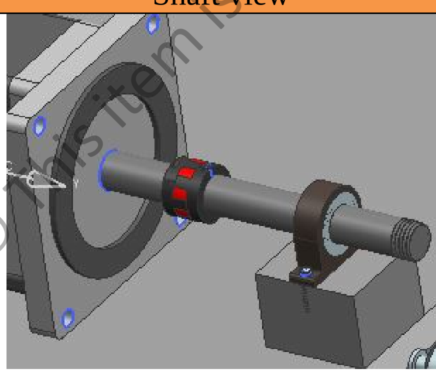
Plate view	Specifications
	Diameter: 65mm Width of the plate:5mm. Material: Steel Durability: Good in corrosion.

3.4.5 Shaft

Shaft can be defined as long cylindrical bar that will connects to coupling from stepper motor. Shaft rotated when the motor transmit the power. Shaft also functioned as a handle of any tools or equipment while the machine operates. Figure 3.11illustrates the type of shaft that been in market with their specification. Table 3.10shows specification of shaft:

Figure 3.11: Shaft[21].

Table 3.10: Shaft Insertion.

Shaft view	Specifications
	Diameter:13.5mm Length: 88mm Material: Steel

3.4.6 LGB65 Rail Slider

This slider functioned as a holder of the gripper. It movedhorizontally with supported by ball bearing.Figure 3.12 shows type of LGB65 rail slider that was design for a small space with lightweight. Table 3.11 shows the specification of LGB65 rail slider:

Figure 3.12:LGB65 Rail [13].

Table 3.11: LGB65 RailInsertion.

Drawer view	Specifications
	Material:Solid aluminium body and chrome plated hardened steel. Maximum load capacity: 400 kg Closed length: 150 – 3000mm Width: 43mm

3.5 Finite element analysis of crank slider mechanism

The analysis that had been used is static analysis in general structural analysis by using CATIA software. Figure 3.13 shows parts to make an analysis to define the maximum force at critical area. Thickness of the parts is important to assure the design is safely. The maximum force that had been apply is 613.33 N. The analysis will be making on crank and pin. Figure 3.14 shows the component part of mini fatigue tensile on assembly drawing. In addition, explode drawing on Figure 3.15 shows bill of material for each part on design.

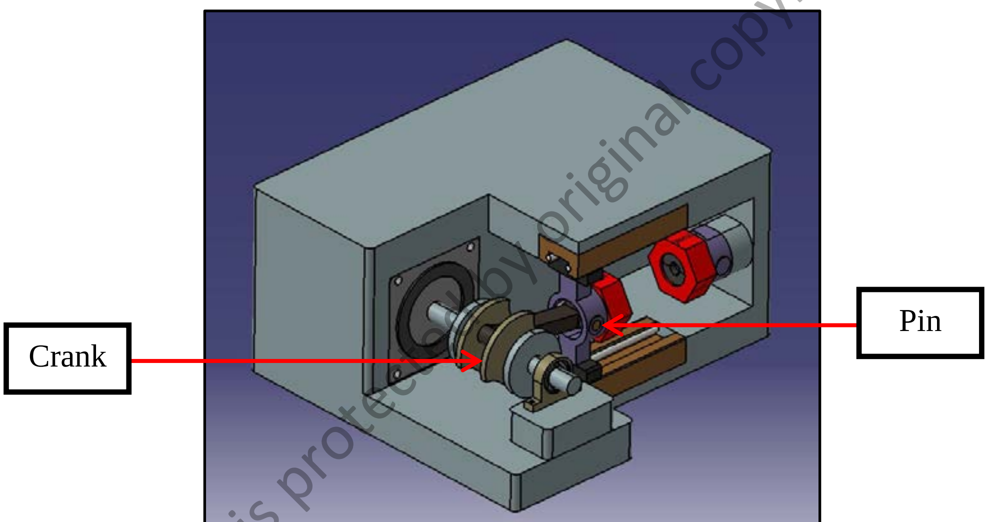


Figure 3.13: Example of part to analysis.

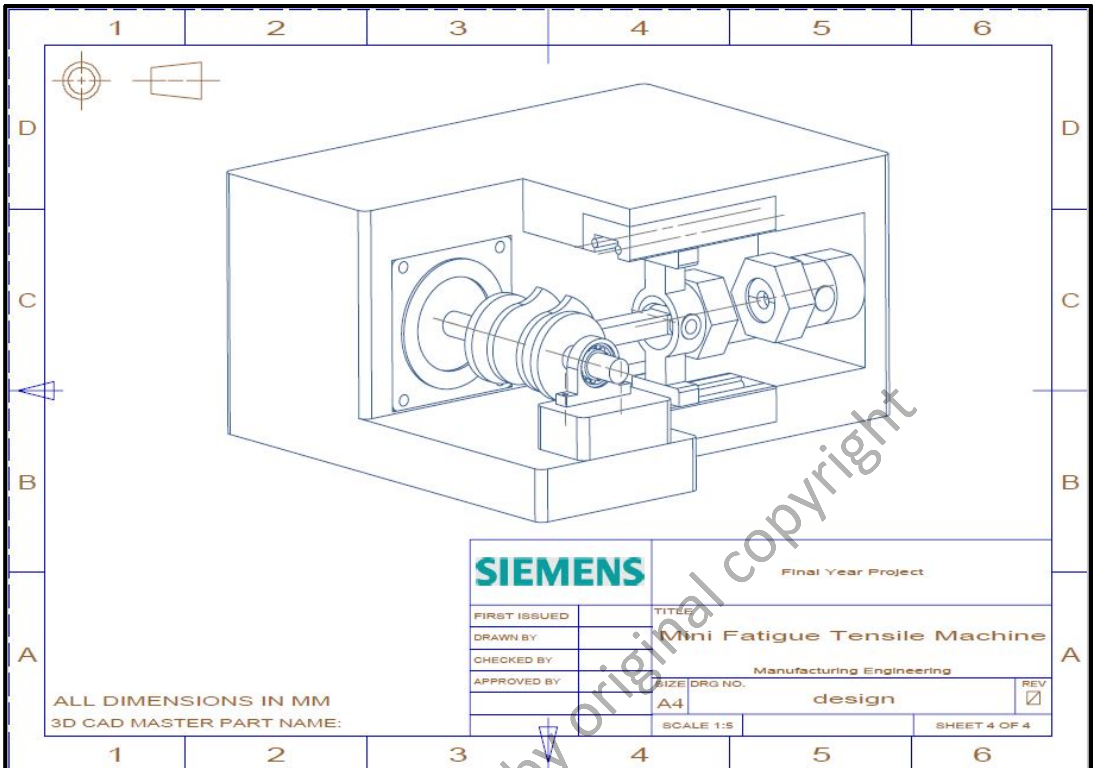
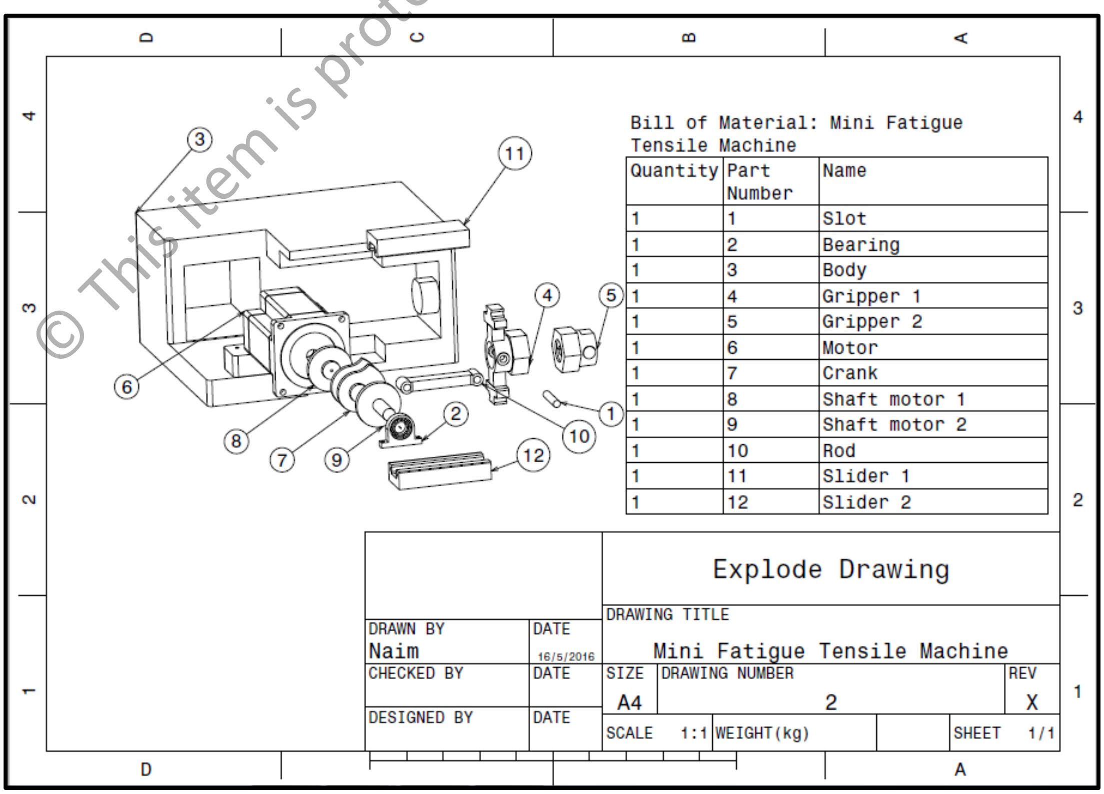


Figure 3.14: Assembly Drawing.



Bill of Material: Mini Fatigue Tensile Machine

Quantity	Part Number	Name
1	1	Slot
1	2	Bearing
1	3	Body
1	4	Gripper 1
1	5	Gripper 2
1	6	Motor
1	7	Crank
1	8	Shaft motor 1
1	9	Shaft motor 2
1	10	Rod
1	11	Slider 1
1	12	Slider 2