UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ANALYSIS OF FLOATING PUMP PLATFORM USING FINITE ELEMENT ANALYSIS

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Design) with Honours.

by

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FACULTY OF MANUFACTURING ENGINEERING

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **DESIGN AND ANALYSIS OF FLOATING PUMP PLATFORM USING FINITE ELEMENT ANALYSIS**

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I hereby, declared this report entitled "Design and Analysis of Floating Pump Platform using Finite Element Analysis" is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design) with Honours. The member of the supervisory committee is as follow:

Signature	:	______________________
Supervisor Name	:	EN. TAUFIK
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ABSTRACT

Floating pump platform is the devices that helping the fire services to hold the pump extinguisher when extinguish the fire burning out of town. The fire tragedy has steadily increased over the past few years making Floating Pump devices become more attractive than ever. Due to the increasing such tragedies the value of Floating Pump device has become the most important needs when handling the fire. This project presents the new portable platform that provides the application of handling, supporting, and clamping the floating pump securely during the operation. The platform consists of base, pump holder and pump support. The material used for this project Polyethylene (PE) however, the rapid prototype has been developed for the project presentation purpose. In addition, the simulation showed the use of computer software such as MSc Nastran/Patran and ANSYS CFX in order to analyze the three dimensional finite element simulations. Safety factor has been determined as safety parts. As a result, the comprehensive of stress tensor and displacement of floating pump platform is discussed.

Keyword: Platform, Floating Pump, Fixtures, Finite Element Analysis

ABSTRACT

Pelantar pam terapung adalah satu alat untuk membantu perkhidmatan bomba untuk memegang alat pemadam api ketika memadamkan kebakaran di kawasan luar bandar. Tragedi kebakaran meningkat dengan tetapnye selepas beberapa tahun menghasilkan alat pam terapung yang menjadikannya lebih menarik dari sebelumnya. Sepertimana yang kita sedar, nilai alat pam terapung menjadi keperluan yang lebih penting ketika mengendalikan kebakaran bergantung kepada peningkatan seperti tragedi kebakaran. Jadi, dalam Projek Sarjana Muda (PSM), satu pelantar mudah alih untuk alat pam terapung direka dan di majukan. Projek ini membentangkan satu pelantar mudah alih yang mempunyai aplikasi seperti mudah dibawa, dpt menahan pam itu daripada terjatuh dan memegang pam itu supaya selamat ketika menjalankan operasi. Pelantar ini terdiri daripada tapak, penahan pam dan pemegang penahan pam. Bahan yang digunakan untuk membuat alat pelantar yang sebenar adalah PE, walaubagaimanapun, prototype yang dibina untuk persembahan projek dibuat dengan menggunakan mesin rapid prototyping. Secara tambahannya, simulasi yang digunakan oleh pengisian computer adalah MSc Nastran/Patran dan ANSYS CFX untuk menganalisis simulasi 3D finite element. Faktor keselamatan telah dipastikan sebagai bahagian-bahagian yang selamat. Secara keseluruhannya, ketegangan dan pegerakan pelantar pam terapung telah dibincangkan secara mendalam untuk membolehkannya beroperasi dengan baik.

Keyword: Pelantar, Pam Terapung, Fixtures, Finite Element Analysis

DEDICATION

For my Dearest Mom and Dad, Thanks for all support which has been given

ACKNOWLEDGEMENT

This is the Author's first application project. At the beginning of this project, the Author has faced some difficulties on the planning phase. Fortunately, due to some valuable guidance and lots of helpful advises and hints from lecturers, friends and all those involved in the project development, the Author has finally able to complete this project successfully.

First, the Author would like to thank Mr. Taufik who is my project supervisor, for giving guidance, advice and comments throughout the project completion. He provided sufficient guidelines that allow the Author to complete this project successfully.

Then, the Author would also like to thank Mr. Kanicen and others that involved, that plays very important role by giving some valuable recommendation and suggestions. Author feels gratitude for all the encouragement and supports, from the start until the end of the project.

Finally, the Author would like to express grateful to the fire brigade who spent some times to give information about their services. They had provided the Author with valuable information that allowing the Author to get some direction and ideas on how actually the Floating Pump device works. All the suggestions, opinions and resources they gave helps the Author to start and end it with much better improvement.

Millions Thanks,
Fara Adillah Binti Che Idris

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LIST OF ABBREVIATION

ABET	- Accreditation Board of Engineering and Technology
CADD	- Computer- Aided Design and Drafting
CAD/CAM	- Computer-Aided Design/Computer-Aided Manufacturing
CFD	- Computational Fluid Dynamics
CFX	- Advanced Computational Fluid Dynamics
DFSS	- Design for Six Sigma
FDM	- Fused Deposition Modeling
FEA	- Finite Element Analysis
FEM	- Finite Element Method
HOQ	- House of Quality
PE	- Polyethylene
QFD	- Quality Function Deployment
SME	- Subject Matter Expert
VOC	- Voice of Customer

CHAPTER 1

INTRODUCTION

1.1 Background of study

In the challenging world now, many of the standard and custom skid and trailer pumping modules with features designed to meet the demanding applications. It is also varying in size and capability from small open design to custom trailer pumping modules. This is really needed in cold harsh working environment and in extremely hot environment as well as airport, nuclear sites and others industrial locations.

In this project, the platform should be design using the FEA and product design methodology. FEA means finite elements analysis which is a computer simulation techniques used in engineering analysis. It uses a numerical technique called the finite element method (FEM). There are many finite element software packages, both free and proprietary. Development of the finite element method in structural mechanics is usually based on an energy principle such as the virtual work principle or the minimum total potential energy principle. From the engineering side, the finite element analysis originated as the displacement method of the matrix structural analysis, which emerged over the course of several decades mainly in British aerospace research as a variant suitable for computers.

While Product design can be defined as the idea generation, concept development, testing and manufacturing or implementation of a product (physical object or service). Product Designers conceptualize and evaluate ideas, making them tangible through a product in a more systematic approach. The role of a product designer encompasses many characteristics of the marketing manager, product manager, industrial designer and design engineer. The term is sometimes equated with industrial design.

1.2 Problem Statement

In this world now, it is very important to have an easy and faster fire services if the burning flame happen out of the town and far inside the forest. The problem is how to find the best design for the floating pump platform which has the applications of holding, supporting and clamping the pump securely during the operation of the pump. The problems also included how to design the new platform for floating pump which have is lightweight and easy to carry to everywhere.

1.3 Project Objectives

The objective of this design document is to explain the design details and to bring out the design approach of providing the proposed solution that caters to the requirements of users that able and want to deploy the technology of floating pump device. The proposed solution would be a portable device to manage and provide services to all the users into fire fighting. The device will be designed and developed that will allows users to get hands-on. In this project, the Author tasks includes two model and study forced cases in a solution and to study how the current solution will benefits with the new development of the floating pump device platform.

The aims of this project are:

a) To design and develop a better portable platform device that emphasis portability and ease of use.
b) To investigate the design parameters of the portable platform for fire services.
c) To analyze the application of fixture system on portable platform using FEA.

d) To design the prototype of a portable platform.

1.4 Scope of project

This project is to design a new platform for the fire service system using the FEA and Product design methodology. The three dimensional simulation analyses that are done to analyze the part of the platform are MSc Nastran/Patran and ANSYS CFX10. The purpose of this project is to study the application of the holding, supporting and clamping the pump securely during the pump operation. The portable pumps that are choose as a guide and references for this project is from the Hale's brand. The floating pump which has been choosing is limited to the Hale's brand and Fry Float only. The product for presentation is done using the Fused Deposition Modeling (FDM) machine which is the Rapid prototyping machine at the AMC. The material that are used to produces the prototype is ABS.

1.5 Importance of Project

It is now time for current floating pump technology to take a further step into upgrading and adding from less effective technology to the use of the latest technology that available to increase the efficiency and affectivity. As we know, there are many devices available with the same purposes, different designs, different styles, and different method of use. However, not all the devices have the right objectives to meet customers' needs and therefore, it all heading to less effective of fire fighting that mostly result of failure. Thus, the shortcomings, there are room to improve by overcoming the shortcoming in those devices. The proposed solution will exist to make sure customers' requirements and goals achieved and to produce a solution that emphasis portability and ease of use that will guarantee the efficiency and affectivity of the floating pump device.

1.6 Limitation of current design

Currently, most floating pump devices still practice the traditional old technology of fire fighting method. This method is not as effective like it used to be those days. First, it consumes a lot of energy, wasting time, and poor chances of getting the fire from destroying. These devices mostly still do not take the opportunity that exists in this high technology market to expand the device into better performance.

Apart from that, when it comes to time factor and availability, not all devices will be able to perform at the required level of portability. This is because most of the devices does not come with the features of ease of use and has the mobility needs.

The Author did some observation by going to existing suppliers and encountered that there are many rooms for improvements. It the site itself, after went through to some of the suppliers, the Author found out that there are a lot of weaknesses that will makes the floating pump devices not up to the current technology and standards.

1.7 New Ideas

More with less seems to be the mission impossible for a student to design preferable solutions for the customers. Addressing more flexibility in the concepts, portability, increase efficiency and effective solution to handling fire is something which proper plans and high skills are needed. Caught between a rock and a hard place, the Author face a greater challenge. Yet they are finding way to produce Floating Pump platform device that adequate the features like portability, ease of use, improve technology that will increase the performance during fire fighting.

A solid foundation and sharp handling are needed when planning, designing and implementing, so that useful improvements can be obtained. These will go through to a lot of upgrading process. The solutions proposed will be focusing most on the customers' needs to produce and provide them a better service with simplest, easiest and trusted solution. This can be done by improving critical area that has been discussed earlier. The simple and effective system is very much preferable to the available of the technology. The design of this solution will be based on the limitations and some problems that the Author have encountered when the Author personally tried to use some of the current devices and came out with some new ideas that the Author believe will benefits for all. The Author has the confident all the new ideas will at least bring some improvements and satisfaction for those going to use the solution in the future.

The proposed ideas are:

a. To expand the current technology used to latest technologies available in the market.
b. To increase the efficiency of the current devices that offers customers with more effective solution.
c. To design and develop a solution that deploys the features like portability and ease of use.
d. To reduce the cost of labors, where not much manpower needed to handle the device.
e. To make customers feel convenience, where the availability of latest technology is an alternative attraction for firefighting devices.

1.8 Schematic of project

Chapter 1:

This chapter describes about the background of the study, project problem statement, objective of the project and the scope of the study.

Chapter 2:

This chapter is explained about the some literature reviews related to the study which includes the description of the portable platform, floating pump, proposed the application of the fixture system which is holding, supporting and clamping the pump securely, Solidworks 2005, rapid prototyping machine (FDM), MSc Nastran/Patran and ANSYS CFX10.

Chapter 3:

On this chapter, the methodology and the process flow consists of the detail design will be conducted. It also briefly explains about the concept selection with respect to the customer needs.

Chapter 4:

This chapter includes the result of the analysis and the data presentation. The result is carried out using the MSc Nastran/Patran and ANSYS CFX10. It also include the result of the prototype which using the FDM machine.

Chapter 5:

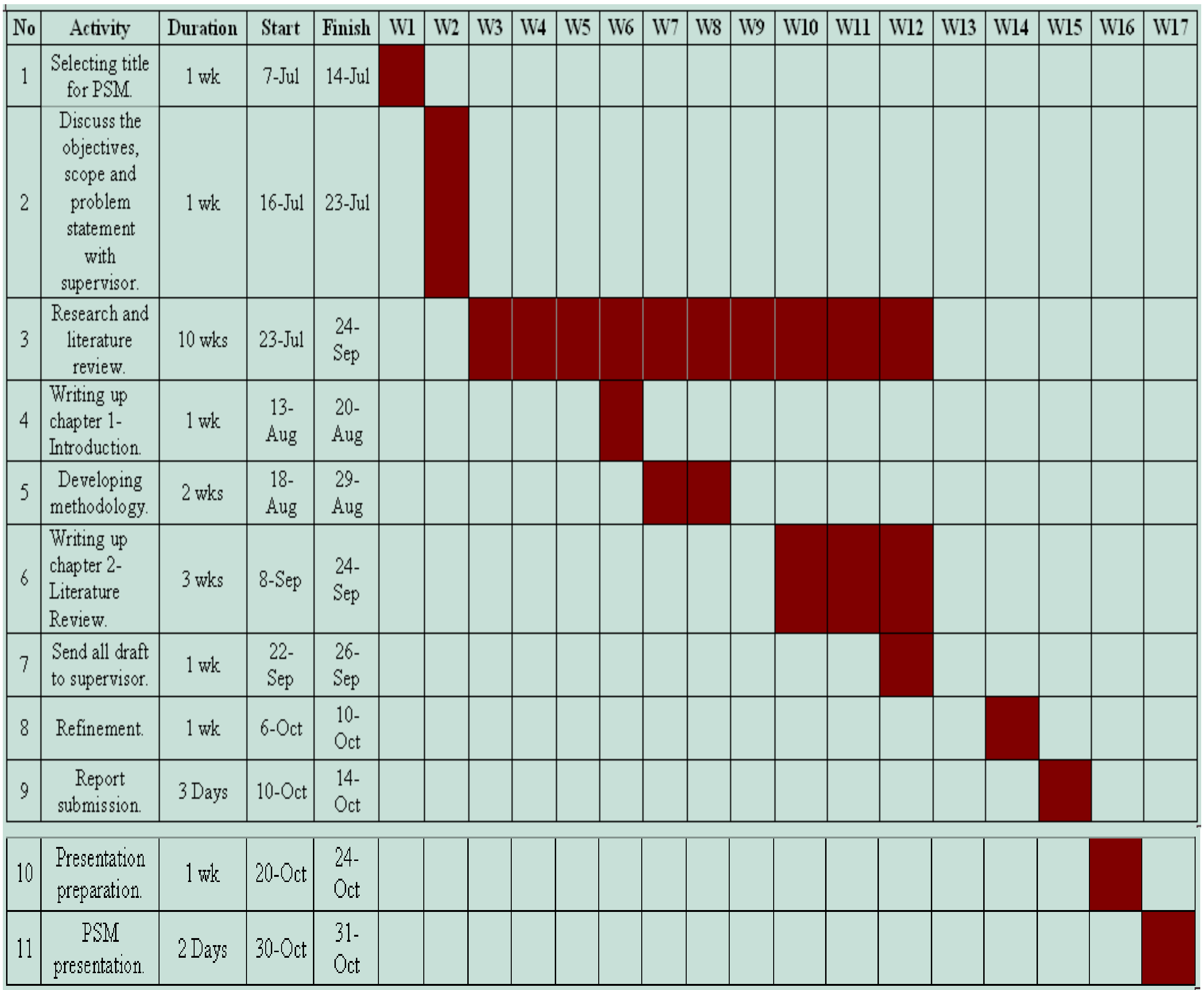
This chapter provides a general discussion on the design, the result of the study, stressing the significance and implications of the findings of the study.

Chapter 6:

This chapter is makes the conclusion on the study includes the suggestion for the future study as well.

1.9 Gantt Chart

Gantt chart has been built to give a visual presentation of the schedule of the project flow. It shows the general sequence of the project activities. Gantt chart is as well as a very useful tool to assist in tracking and monitoring the project progress. Figure 1.1 shows the Gantt chart of the PSM 1 while figure 1.2 shows the Gantt chart for the PSM 2.



No	Activity	Duration	Start	Finish	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17
1	Selecting title for PSM.	1 wk	7-Jul	14-Jul																	
2	Discuss the objectives, scope and problem statement with supervisor.	1 wk	16-Jul	23-Jul																	
3	Research and literature review.	10 wks	23-Jul	24-Sep																	
4	Writing up chapter 1- Introduction.	1 wk	13-Aug	20-Aug																	
5	Developing methodology.	2 wks	18-Aug	29-Aug																	
6	Writing up chapter 2- Literature Review.	3 wks	8-Sep	24-Sep																	
7	Send all draft to supervisor.	1 wk	22-Sep	26-Sep																	
8	Refinement.	1 wk	6-Oct	10-Oct																	
9	Report submission.	3 Days	10-Oct	14-Oct																	
10	Presentation preparation.	1 wk	20-Oct	24-Oct																	
11	PSM presentation.	2 Days	30-Oct	31-Oct																	

Figure 1.1: Gantt chart of PSM 1

No	Activity	Duration	Start	Finish	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19
1	Design Parts	2 wks	06-Jan	19-Jan																			
2	FEA Software	4 wks	20-Jan	16-Feb																			
3	Prototype using FDM machine	4 wks	04-Feb	27-Feb																			
4	Analysis Results(Nastran)	6 wks	24-Feb	03-Apr																			
5	Analysis Results(ANSYS)	2 wks	29-Mar	10-Apr																			
6	Discussion	4 wks	04-Mac	25-Mar																			
7	Conclusion	4 wks	24-Feb	23-Mar																			
8	Report Draft Submission	2 days	02-Apr	03-Apr																			
9	Refinement	2 wks	08-Apr	15-Apr																			
10	Report Submission	1 day	19-Apr	19-Apr																			
11	Presentation Preparation	3 wks	13-Apr	1-May																			
12	Presentation	4 days	5-May	7-May																			

Figure 2.2: Gantt chart of PSM 2

CHAPTER 2

LITERATURE REVIEW

In this section, some literature review will be highlighted which are related to the study. Literature review is a research or studies that finding the results from the reference sources such as journal, book, electronic media, patent and Internet.

In this chapter 2, the topics that includes are the researches bout the floating pump, Quality Function Deployment (QFD), Solidwork 2007 and the existing design of the floating pump platform. It also mention about the software that are used in Finite Element Analysis (FEA) which is ANSYS CFX and MSc Software Nastran/Patran 2005, the product design and the fixture system that are used in this product which consists of holding, clamping and supporting the pump securely during the pump operation. It also reviews about the rapid prototyping machine which is FDM machine.

Floating pump platform develop a need of consumer that wanted to extinguish the burning fire out of the town and give the fire system more efficient and effective.

2.1 Floating pump

According to Anonymous (N.D.) the floating pumps are ideal for pumping from a standing body of water such as a dugout, pond, lake or a stream. The pump is mounted on a floating platform and secured in place by either an anchor or lines to shore.

Pumps are designed especially for the fire services to be highly portable and easy to use. Able to draft in as little as four inches of water, they can be easily used with alternative water sources such as streams, lakes, or pools. They are designed for easy maintenance with a tough long lasting outer shell. The Fyr Flote is a lightweight, portable centrifugal pump mounted on an unsinkable, high-strength polyethylene float with dual carrying handles and a splash suppression collar.

A high-volume model (20FV-C8) and a high-pressure model (20FP-C8) meet most every pump need in as little as four inches of water. The weight just 49 pounds, the Fyr Flote stores easily in most truck compartments. It includes an automatic recoil starter, a spark arresting muffler, and an engine over speed control switch (Anonymous, 2006).

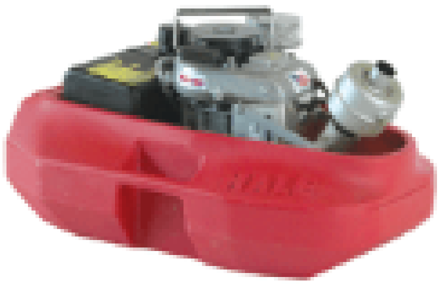


Figure 2.1: Fyr Flote pump (Anonymous, N.D.)

The new Super Chief has a unique design specially engineered for the fire service. The pump and engine assembly detach easily from the float. The float folds in half for convenient storage in most apparatus compartments. The Super Chief is the pump to count on when you cannot count on hydrants. It is easily used with alternative water sources such as streams, lakes, ponds, or pools. The Super Chief requires only three inches of water to draft (Anonymous, 2006).

The Super Chief delivers a flow of 420 GPM (1590 LPM) with one discharge port or a maximum pressure of 50 PSIG. The Super Chief can also throw a stream of water more than 90 feet for direct firefighting capabilities.

- Float assembly folds in half for easy storage in truck compartments
- Engine and pump assembly quickly detaches from float.
- The entire lightweight package easily transports and allows carriage by two people
- Pump output exceeds 420 GPM/1590 LPM
- Ideal for drafting from ponds, streams, lakes or pools. The unit operates in only three inches of water

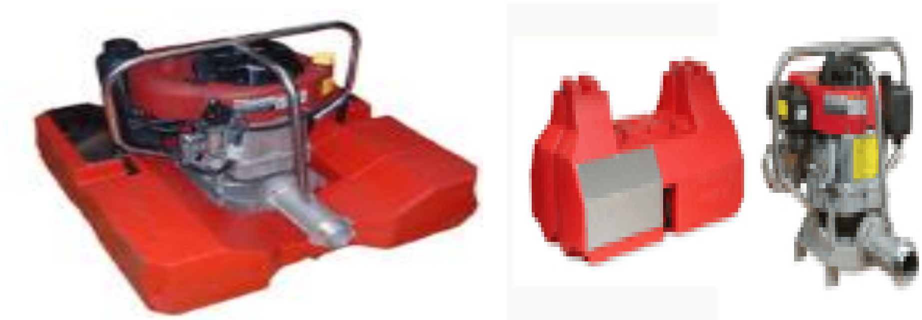


Figure 2.2: Super chief floating pump (Anonymous, N.D.)

H. Alfred Eberhardt and Paoli, Pa. (1985) explained that the floating portable pump is constructed of a float defining a well for containing water, a centrifugal pump supported on the float with its impeller shaft extending vertically and with its suction inlet combustion engine arranged to drive pump impeller.

A wave powered pumping system including a floating platform and a plurality of floats hinged about the periphery of the platform. A double acting piston pump is provided on the platform for each float, with the float driving the piston of the pump utilizing both upward and downward movements of the float in a variable stroke operation.

Leonard C. Tharaldson (1977) said that the nozzles for water jets may be carried on the platform below the water line to provide positioning and/or propulsion forces for the platform. In one embodiment, the platform is free floating; in another embodiment, the platform moves up and down with the swells and has a telescoping pipe anchor.

Anonymous (N.D.) stated that the floating pump gives you the flexibility of high volume and moderate pressure never before available in a floating pump. This lightweight pump (only 120 lbs.) has easily carried by two men through even the roughest terrain. Its compact design (20"H x 30"W x 32½"L) allows you to store it in most standard size compartments.

The pump and engine are secured together on the float in an arrangement such that the engine causes rotation of the pump impeller to cause the pump to draw water from the well through its suction inlet and discharge water from the pump discharge.

Louis B. Evans. Hasting & Harold A. Berglund. (1969) explained that the pump is mounted on independent shock mounts so that the vibration from the engine will not in any way loosen the mounting of the pump and engine or damage the float itself. The provision of fins on the exhaust pipe casting is to help cool the exhaust and protect the plastic float from high exhaust temperature.

2.2 Quality Function Deployment (QFD)

Quality function deployment (QFD) was developed by Yoji Akao in 1966 in Japan when the author combined his work in quality assurance and quality control points with function deployment used in Value Engineering. Mr. Akao described QFD as a "method to transform user demands into design quality, to deploy the functions forming quality, and to deploy methods for achieving the design quality into subsystems and component parts, and ultimately to specific elements of the manufacturing process."

QFD is designed to help planners focus on characteristics of a new or existing product or service from the viewpoints of market segments, company, or technology-development needs. The technique yields graph and matrices. QFD has been used by several corporations and organizations.

QFD is applied in a wide variety of services, consumer products, military needs such as the F-35 Joint Strike Fighter, and emerging technology products. The technique is also used to identify and document competitive marketing strategies and tactics (see example QFD House of Quality for Enterprise Product Development, at right). QFD is considered a key practice of Design for Six Sigma (DFSS) as seen in the referenced roadmap (Yoji Akao, 1994). It is also implicated in the new ISO 9000:2000 standard which focuses on customer satisfaction.

QFD translates the customer requirements which are voice of the customer into the design requirements which is the voice of the engineer. QFD has helped organizations like 3M, Ford Motor Co. and AT&T improve customer satisfaction, reduce product development time, and reduce start-up problems.

Some practitioners believe that QFD is the House of Quality, a matrix for mapping the voice of the customer into the voice of the engineer. Some practitioners call any matrix a House of Quality. Depth of analysis is the most significant difference in the formats. A QFD application using only the customer demanded qualities and the organizations performance measures such as quality characteristics and design requirements has very little depth (Anonymous, N.D.) .

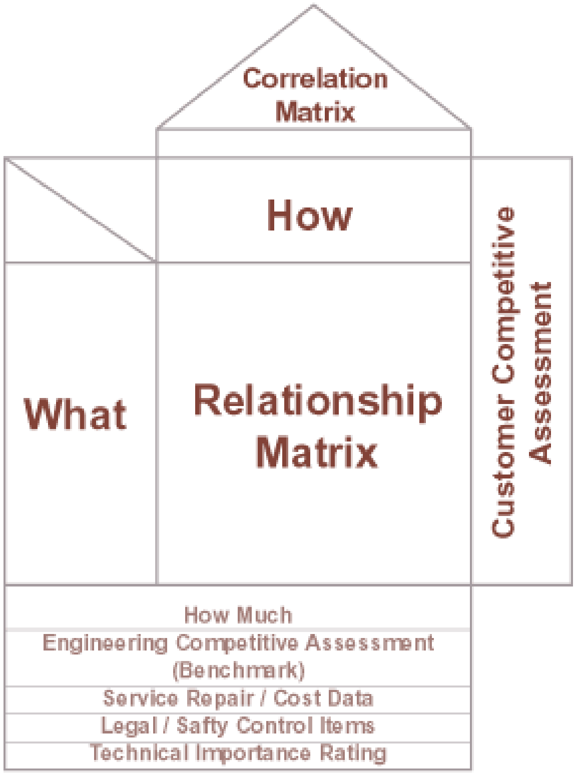


Figure 2.3: House of Quality (Anonymous, 1995)

According to Anonymous (1995), Quality Function Deployment (QFD) is a one method of product development where the product or process is directed from the Voice of the Customer (VOC) through the development of requirements, specifications design feature development, process selection and process control.

The QFD process utilizes a series of matrices which are linked as the product/service development process progresses. This cascade of customer wants into requirements and eventually process controls is accomplished by evaluating each level by walking through rooms which have specific functions. These rooms are carefully entered and exited by a team of Subject Matter Experts (SME) with relationships, rankings and expected measures and metrics. The rooms are situated in such a way that the method has been given the name the House of Quality.

The first matrix of the QFD process typically takes the very non technical Voice of the Customer (VOC), scientifically ranks the importance of these wants, needs and desires and links technical "How To" to the wants, needs, and desires. Each "How To" is translated or cascaded into Measures and Metrics for measuring success.

The organizing framework for the QFD process is a planning tool called the "house of quality" which been simplified in the Figure 2.3. Working as a team, design engineers and marketers first establish critical customer attributes for the product (Anonymous, N.D.). These attributes become the rows of the central matrix of the house of quality.

The team may group attributes into broader categories in order to simplify planning and analysis. The second step is to establish the critical design parameters that drive system performance (in measurable terms and directly linked to customer attributes). In the example such are number of teeth, lubricant, tooth thickness, and manufacturing precision. The third step is to fill in the body of the central matrix. Each cell represents a potential link between a design parameter and a customer attribute. This "relationship matrix" indicates both the direction and strength of the relationship.

The fourth step focuses on customer perceptions of the company's existing product as compared to its competitors. This may give insight into market problems and opportunities. The fifth and last piece of analysis is the interaction or relationship between design parameters. In the cells of the "roof" matrix is indicated the strength and direction of the interrelationships among design parameters.

2.3 SOLIDWORK CAD

SolidWorks is a 3D mechanical CAD (computer-aided design) program that runs on Microsoft Windows and was developed by SolidWorks Corporation. SolidWorks is a parasolid-based solid modeler, and utilizes a parametric feature-based approach to create models and assemblies. Parameters refer to constraints whose values determine the shape or geometry of the model or assembly.

Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent. Design intent is how the creator of the part wants it to respond to changes and updates. For example, you would want the hole at the top of a beverage can to stay at the top surface, regardless of the height or size of the can. SolidWorks allows you to specify that the hole is a feature on the top surface, and will then honor your design intent no matter what the height you later gave to the can. (Anonymous, N.D.)

Features refer to the building blocks of the part. They are the shapes and operations that construct the part. Shape-based features typically begin with a 2D or 3D sketch of shapes such as bosses, holes, slots, etc. This shape is then extruded or cut to add or remove material from the part. Operation-based features are not sketch-based, and include features such fillets, chamfers, shells, applying draft to the faces of a part, etc. screen shot captured from a SolidWorks top down design approach.Building a model in SolidWorks usually starts with a 2D sketch (although 3D sketches are available for power users). The sketch consists of geometry such as points, lines, arcs, conics (with exception to hyperbola), and splines.

Anonymous, N.D stated that the dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity, and concentricity. The parametric nature of SolidWorks means that the dimensions and relations drive the geometry, not the other way around. The dimensions in the sketch can be controlled independently, or by relationships to other parameters inside or outside of the sketch. SolidWorks pioneered the ability of a user to roll back through the history of the part in order to make changes, add additional features, or change to sequence in which operations are performed. Later feature-based solid modeling software also copied this idea.

In an assembly, the analog to sketch relations are mates. Just as sketch relations define conditions such as tangency, parallelism, and concentricity with respect to sketch geometry, assembly mates define equivalent relations with respect to the individual parts or components, allowing the easy construction of assemblies. SolidWorks also includes additional advanced mating features such as gear and cam follower mates, which allow modeled gear assemblies to accurately reproduce the rotational movement of an actual gear train.

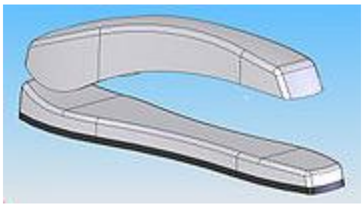


Figure 2.4: Example of the solidwork design

2.4 ANSYS CFX

ANSYS CFX software delivers powerful computational fluid dynamics (CFD) technology for simulations of all levels of complexity. As one of the many computer-aided engineering (CAE) tools available within the ANSYS Workbench platform, ANSYS CFX takes advantage of data and information common to many simulations.

This begins with common geometry: Users can link to existing native computer-aided design (CAD) packages as well as create and/or modify CAD models in an intuitive solid modeling environment. Complementing the common geometry model is a suite of meshing tools, designed to ensure easy generation of the most appropriate mesh for the given application. ANSYS CFX tools then guide the user through the setup of operating conditions, selection of materials and definition of models (Anonymous, 2008).

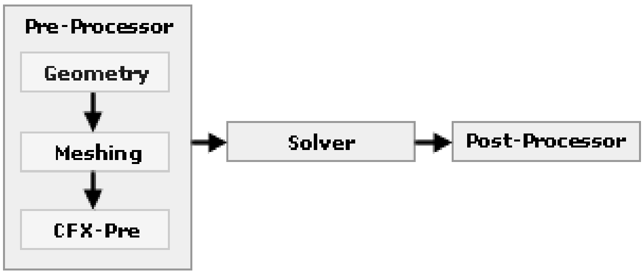


Figure 2.1: Schematic of the pre-processor (Anonymous. N.D.)

According to Anonymous (N.D.) the ANSYS CFX post-processor is a powerful graphical and quantitative post-processing tool that allows users to quickly extract useful information from ANSYS CFX. Its intuitive user interface makes it easy to use even for the casual user. As well as the standard interactive mode, the post-processor will also easily execute post-processing session files in batch mode to quickly reproduce output for a series of runs.

The ANSYS CAE (Computer-Aided Engineering) software program was used in conjunction with 3D CAD (Computer-Aided Design) solid geometry to simulate the behavior of mechanical bodies under thermal/structural loading conditions. ANSYS automated FEA (Finite Element Analysis) technologies from ANSYS, Inc. to generate the results listed in this report.

Each scenario presented below represents one complete engineering simulation. The definition of a simulation includes known factors about a design such as material properties per body, contact behavior between bodies (in an assembly), and types and magnitudes of loading conditions. The results of a simulation provide insight into how the bodies may perform and how the design might be improved. Multiple scenarios allow comparison of results given different loading conditions, materials or geometric configurations.

Flexible and accurate quantitative post-processing of ANSYS CFX results is done very efficiently. ANSYS CFX post-processing enables the full power of the CFX Expression Language within the post-processor, and extends it with a range of post-processing specific functions such as exact mass flow, area, length and volume-based integrals and averages of any quantity. Expressions can also be used to define new variables for the presentation of user specified quantities.

The Turbo-Post mode simplifies post-processing for turbo machinery applications and includes a set of template reports based on machine type. The ANSYS CFX post-processor includes automated report generation. Report templates can be made to show charts, tables and figures; they can be re-used for each design to allow easy comparison of design alternatives. ANSYS CFX technology includes one of the most powerful CFD post-processors available.

2.5 MSc Nastran/Patran

According to Anonymous (N.D.) the import and export capabilities of Nastran and Patran also allow models to be saved and transferred in the format of most other industry standard FEA programs. For specific instances where customer requirements demand, this enables us to create new models or perform work on existing models in-house and to deliver them in the program-specific format required.

This Nastran/Patran software known as the multidiscipline simulation solutions software and also a comprehensive tool for the next generation design and development. MD Nastran is optimized across the multiple, integrated disciplines with the power to handle the large scale design problems and leverage high performance computing environment. Designed for manufacturers who need to perform interoperable, multidisciplinary analyses on ever-more complex models, MD Nastran offers the key capabilities that drive efficiency and streamline processes.

According to Anonymous (N.D.), MD Patran is the most comprehensive pre and post processing environment for MD Nastran and will help engineers to conceptualize, develop and test the product designs. Through the seamless integration of CAD geometry, pre and post processing capabilities and the ability to perform the sophisticated simulation on virtual parts, assemblies and structures, MD Patran is a key of the part design process for companies who rely on the fast time to market and extraordinary product quality to drive market share and profits.

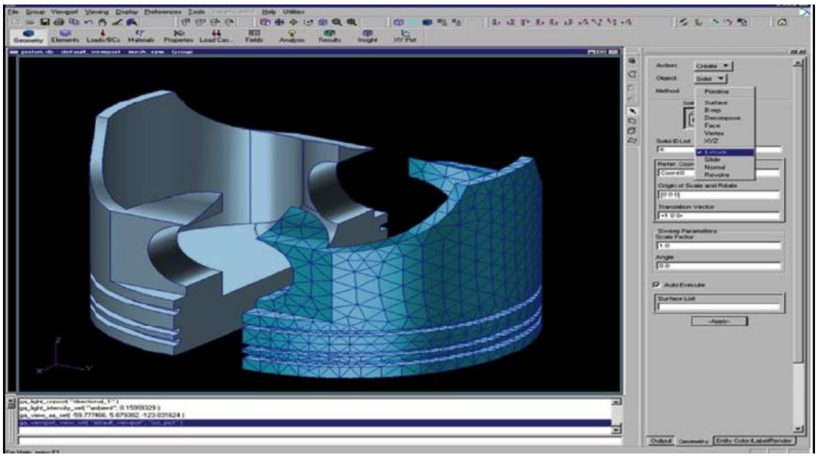


Figure 2.6: Example of the 3D simulation on MD Patran

2.6 Finite Element analysis (FEA)

David Roylance. (2001) explained that the Finite element analysis (FEA) has become commonplace in recent years, and is now the basis of a multibillion dollar per year industry. Numerical solutions to even very complicated stress problems can now be obtained routinely using FEA, and the method is so important that even introductory treatment of Mechanics of Materials.

The finite element method (FEM) also known as finite element analysis is a numerical technique for finding approximate solutions of partial differential equations (PDE) as well as of integral equations. The solution approach is based either on eliminating the differential equation completely (steady state problems), or rendering the PDE into an approximating system of ordinary differential equations, which are then solved using standard techniques such as Euler's method, Runge-Kutta and else.

In solving partial differential equations, the primary challenge is to create an equation that approximates the equation to be studied, but is numerically stable, meaning that errors in the input data and intermediate calculations do not accumulate and cause the resulting output to be meaningless. There are many ways of doing this, all with advantages and disadvantages.

The Finite Element Method is a good choice for solving partial differential equations over complex domains (like cars and oil pipelines), when the domain changes (as during a solid state reaction with a moving boundary), when the desired precision varies over the entire domain, or when the solution lacks smoothness. For instance, in a frontal crash simulation it is possible to increase prediction accuracy in important areas like the front of the car and reduce it in its rear (thus reducing cost of the simulation); Another example would be the simulation of the weather pattern on Earth, where it is more important to have accurate predictions over land than over the wide-open sea.

2.7 Product Design

Product design can be defined as the idea generation, concept development, testing and manufacturing or implementation of a product (physical object or service). Product Designers conceptualize and evaluate ideas, making them tangible through products in a more systematic approach. The role of a product designer encompasses many characteristics of the marketing manager, product manager, industrial designer and design engineer. The term is sometimes equated with industrial design.

The role of the product designer combines art, science and technology to create tangible three-dimensional goods. This evolving role has been facilitated by digital tools that allow designers to communicate, visualize and analyze ideas in a way that would have taken greater manpower in the past (Anonymous, N.D.).

2.7.1 Definition of Engineering Process

Yousef Haik (2003) states that the Clive L. Dym was defines the design as the systematic, intelligent generation and evaluation of specification for artifacts whose form and function achieve stated objectives and satisfy specified constraints. A formal definition of engineering design is found in the curriculum guidelines of the Accreditation Board of Engineering and Technology (ABET). It states the engineering design is the process of devising a system, component or process to meet desired needs.

The engineering design component of a curriculum must include most of the following features such as development of student creativity, use of open-ended problems, development and use of modern design theory and methodology, formulation of design problem statement and specifications, product processes, concurrent engineering and detailed system description. Furthermore, it is essential to include a variety of realistic constraints such as economic factors, safety, reliability, aesthetics, ethics and social impacts.

2.7.2 Design Process

Design is create a new product that turns into profits and benefits society in the same way. The ability to design requires both science and art. The science can be learned through the systematic process, experiences and problem solving technique. The art is gained by practices and total dedication to becoming proficient. The design system can be done in one of two ways such as evolutionary change and innovation.

a) **Evolutionary change**: A product is allowed to evolve over a period of time with only slight improvement. This is done when there is no competition. The creative capabilities of the designer are limited.
b) **Innovation**: Rapid scientific growth technological discoveries as well as competition among companies for their slice of the market have placed a great deal of emphasis on new products which draw heavily on innovation

the creative skill and analytical ability of the design engineer play n important role.

Proficient designers control the evolution and innovation so they occur simultaneously. Although the emphasis is on innovation, designers must test their ideas against prior design. Engineers can design for the future but must be based on the past.

Figure 2.5, Figure 2.6 and Figure 2.7 show the charts that described the design process which are offered by the 3 authors whose are Clive L.Dym, Johnson and the Pahl and Beitz.

Clive L. Dym is the Fletcher Jones Professor of Engineering Design and Director of the Center for Design Education at Harvey Mudd College. His interests include the design theory, knowledge-based (expert) system for engineering design, and structural and applied mechanics. He has previously served at the University of Massachusetts at Amherst (1977-1991), Bolt Beranek and Newman (1974-1977), Carnegie Mellon University (1970-1974), Institute for Defense Analyses (1969-1970) and the State University of New York at Buffalo (1966-1969). He completed his B.S.C.E at Cooper Union and M.S at Broolklyn Polytechnic Institute on 1964 and gets the Ph.D at Stanford University on 1967.

He has published more than 100 archival journal articles, proceedings papers and technical report. He also has served on the editorial boards of several journals and has edited six volumes and written ten of books and the last including of *Engineering Design: A Synthesis of views*, Cambridge University Press on 1994 and the *Engineering Design: A Project-Based Introduction* (co-authored by P.Little), John Wiley & Sons on 1999 and 2003. He also a member of the American Society of Engineering Education and has been elected a Fellow of the Acoustical Society of Civil Engineers. Apart of that, he also won *ASCE's Walter L. Huber Research Prize* on 1980, *ASSE's Western Electric Fund Award* on 1983 and the *Fred Merryfield Design Award* on 2002 and was the first runner-up for the 2001 *Boeing Outstanding Engineering Educator Award.*

Jerome B. Johnson is one of the author's Engineering Design book. He is explained about the design process map which includes the market survey, information search form the past work, mechanical design synthesis and the profit that get from the Production-distribution-consumption-recovery cycle.

Prof. G. Pahl and Prof. Wolfgang Beitz are one of the authors of the Engineering Design. The difference in these charts is in the sequence names. Careful examination of the charts leads to identification of the same stages and the some stages combined in the one process.

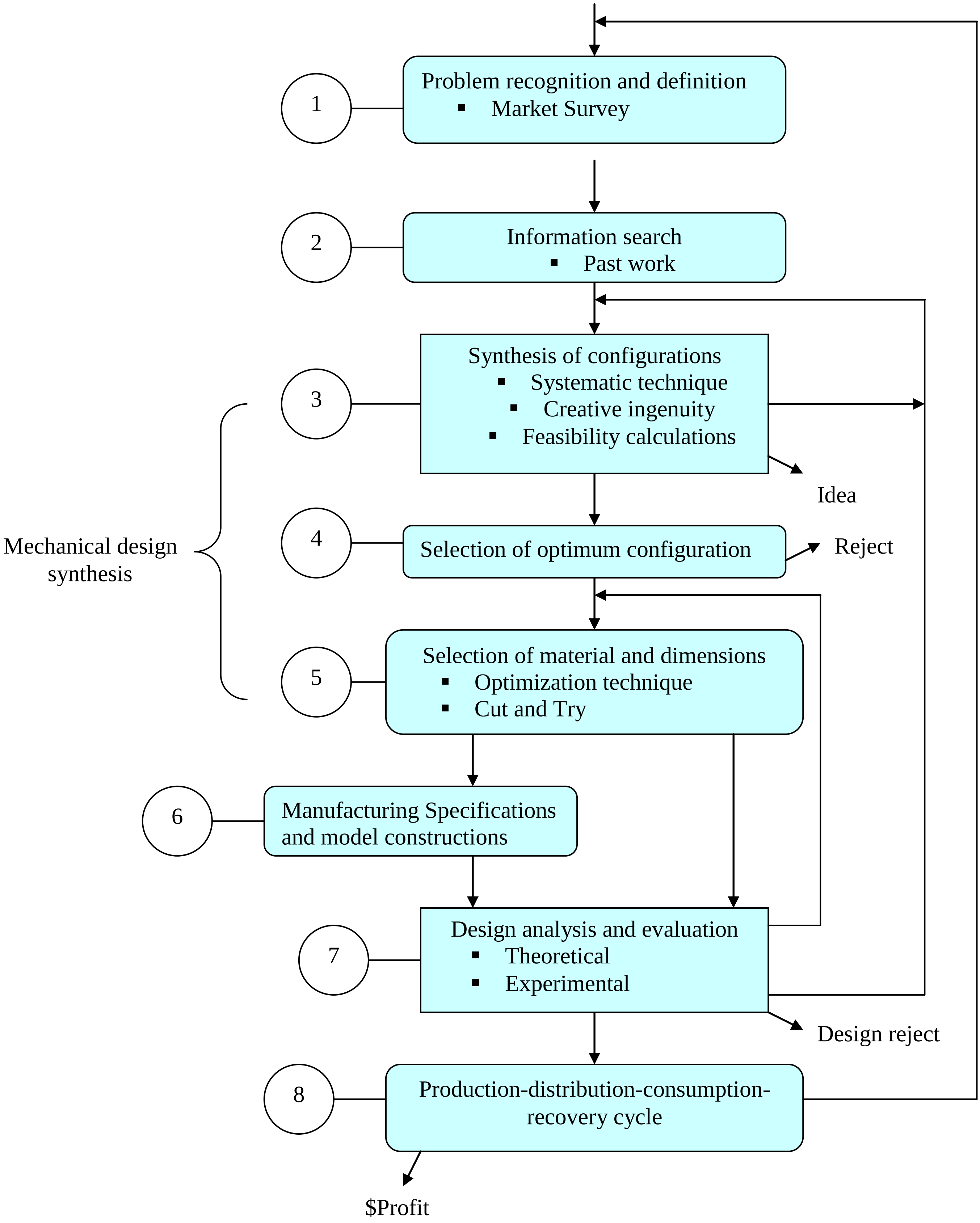


Figure 2.7: Design process map (From Johnson, 1978.)

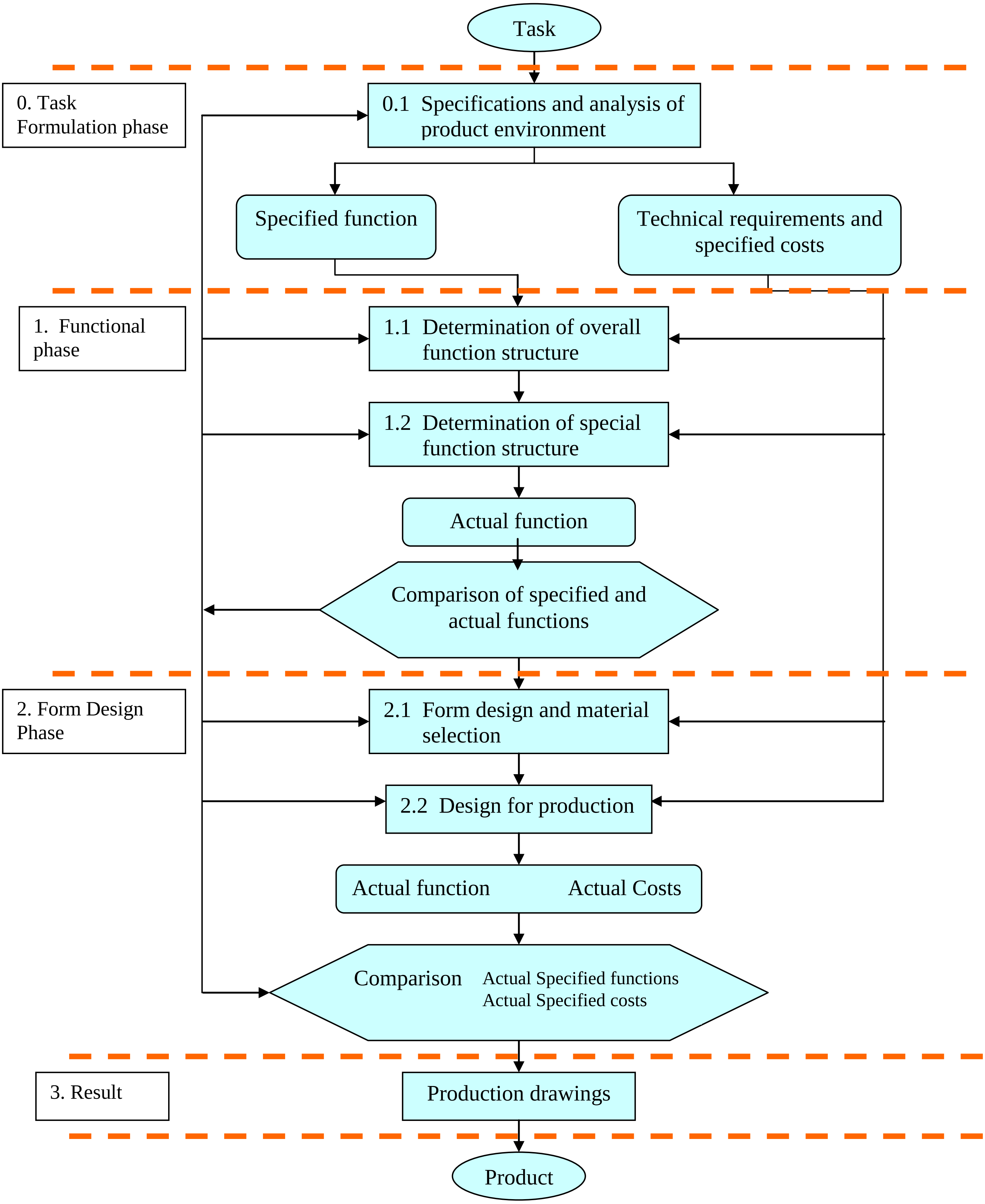


Figure 2.8: Design process map (From Dym, 1994.)

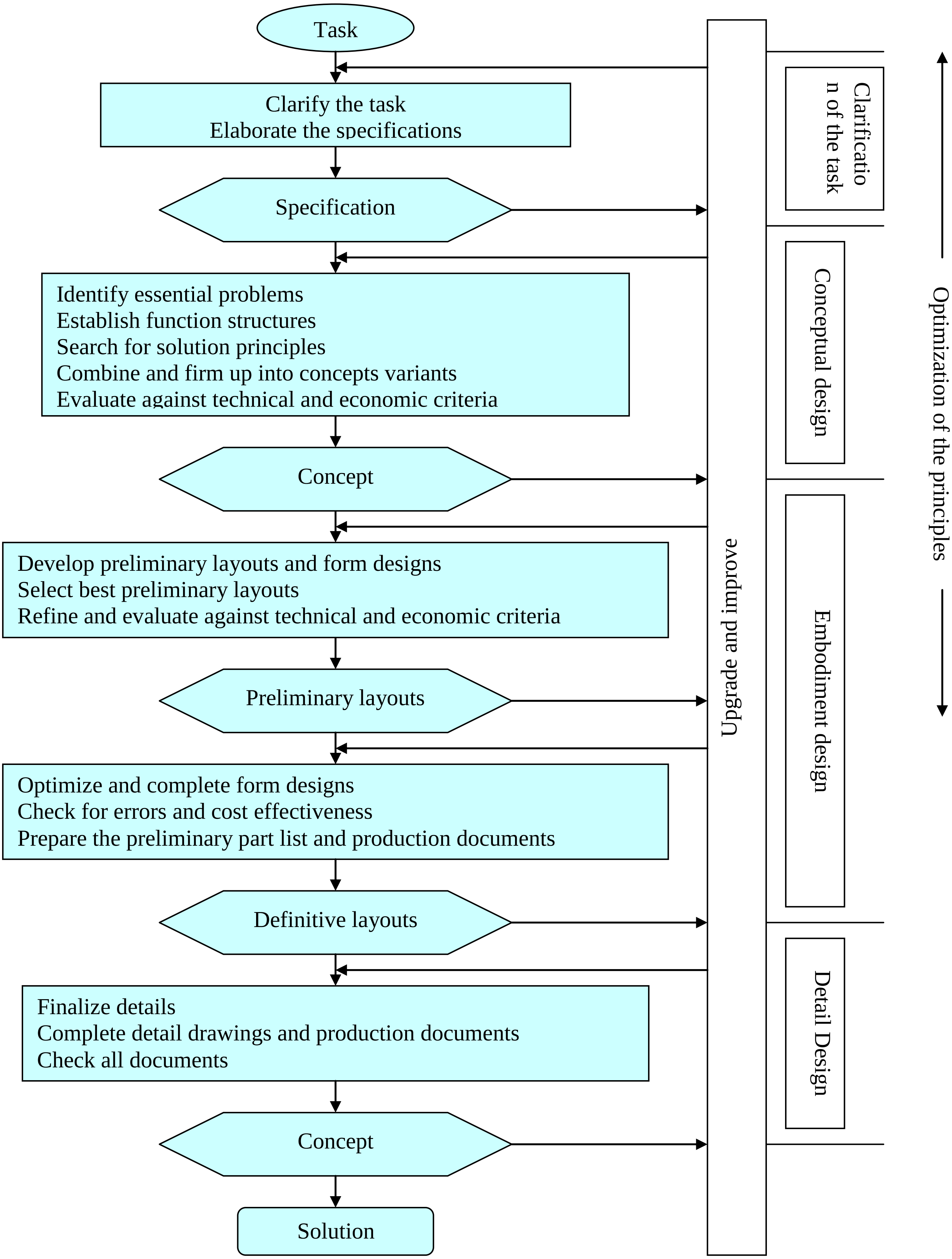


Figure 2.9: Design Process map (From Pahl and Beitz, 1996.)

2.7.3 A Generic Development Process

Karl T. Ulrich and Steven D. Eppinger (2003) explained that the process is a sequence of steps that transforms a set of inputs into a set of outputs. Most people are familiar with the idea of physical processes. A product development process is the sequence of the activities which an enterprise employs to conceive, design and commercialize a product.

The process begins with the planning phase, which is link to advanced research and technology development activities. The output of the planning phase is the project's mission statement which is the input required to begin the concept development phase and which serves as a guide to the development team. The conclusion of the product development process is the product launch at which time the product becomes available for purchase in the market place.

Development process is as the initial creation of a wide set of alternative product concepts and hen the subsequence narrowing of alternatives and increasing specification of the product can be reliably and repeatable produced by the production system.

Besides, development process is as an information processing system. The process is begins with the inputs such as the corporate objectives and the capabilities of available technologies product platforms and production systems. The process includes the information required to support production and sales has been created and communicated.

Furthermore, in the other word the development process is a risk management system. In the early phases of the product development, various risks are identified and prioritized. As the process progresses, risk are reduced as the key uncertainties are eliminated and the functions of the product are validated. When the process is completed, the team should have substantial confidence that the product will work correctly and be well received by the market.

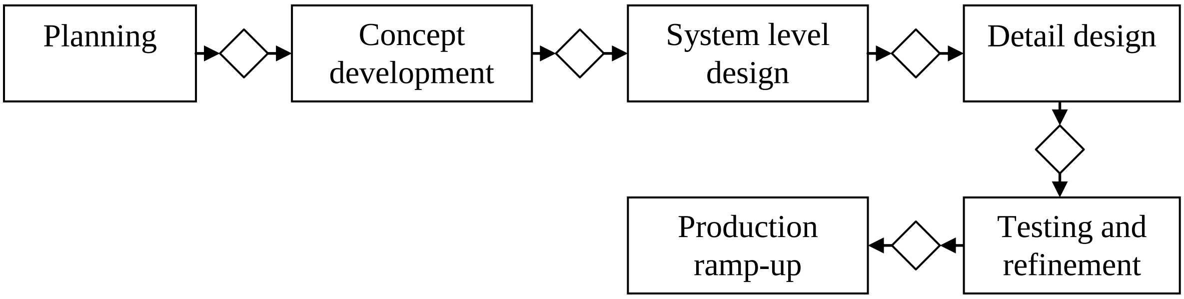


Figure 2.10: Generic Product development process

2.7.4 Concept development phase

Concept development also known as the Front-end process and this concept development phase includes the following activities.

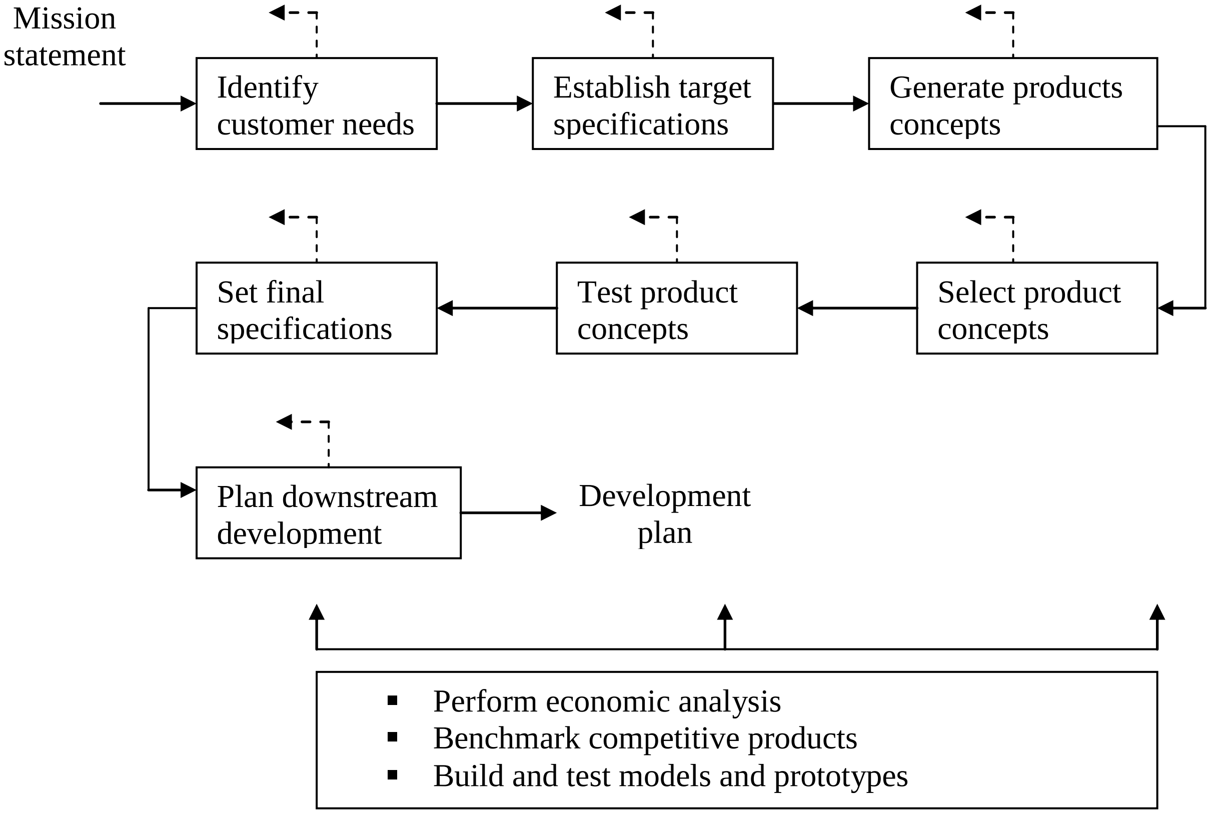


Figure 2.11: Many Front-End activities comprising the concepts development phase

2.8 Fixture System

Fixture is a production tool that locates, holds and supports the work securely so the required operation can be performed. It should be securely fastened to the table of the machine upon which the work is done. Fixtures vary in design from relatively simple tools to expensive and complicated devices. Fixtures also help to simplify metalworking operations performed on special equipment (Edward G. Hoffman, 2004).

2.8.1 Elements of the fixtures

P. H. Joshi (2003) said generally an element of the fixtures consists of:

a. **Locating elements** – To restrict the movement of a part and have the part positioned properly requires skill and planning.
b. **Clamping elements** – To hold the pump securely in the located position during operation.
c. **Holding element** – To position the pump in the placed securely during the operation.

2.8.2 Advantages of the fixtures

a. **Productivity**: Fixtures will eliminate the individual marking, positioning and frequent checking. This will be reduces the operation time and increase the productivity.

b. **Interchangeability**: Fixture facilitates the uniform quality in manufacture. Any part of the platform will fit properly in assembly and all similar components are interchangeable.

c. **Skill reduction**: Fixtures is simplified locating and clamping the pump. Tool guiding elements ensure the correct positioning of the tools with respect to the pump.

d. **Cost reduction**: The higher production, reduction in scrap, easy assembly and saving in labor costs results in substantial reduction in the cost of the platform produced with the jigs and fixtures.

2.8.3 Clamping Element

Edward G. Hoffman (2004) explained the clamping element is holding the product firmly engaged with the locating element during operation. The clamping system should be enough to withstand forces developed during operation. At the same time, the clamping force should not dent or damage the product. Speed of operation, operator fatigue and strategic positioning are other important considerations for contriving a clamping system.

2.8.3.1 Principle of clamping

a) Position

Clamping should be positioned to direct the clamping force on a strong and supported part of the product. The clamping system should not obstruct the path of loading and unloading of the product. Clamping the path of loading should be retractable.

b) Strength

The clamping system should be capable of holding the workpiece security against the forces developed during operation. The clamping forces should not dent or damaged the product with the excessive pressure. Clamps should be fitted with pads of softer, materials such as nylon or fiber to prevent damage and denting of the pump.

c) Productivity

By using hand knobs, Tommy bars, knurled screws, hand wheels and handles should minimize the clamping time. So that, the clamp can be tightened or loosened manually without using the spanner as a adds motions of the picking, aligning and laying it down.

d) Operator fatigue

Operator fatigue should be taken into an account. If a considerable number of clamps are to be tightened or loosened repeatedly. It is better to use pneumatic or hydraulic clamping which in addition to reducing the operator fatigue while save the clamping time.

e) Workpiece variation

The clamping points should be provided with the adequate radius to make the clamp operable even if there is variation in the pump. Misalignment between the clamp surface and the clamping nut due to tilting of the clamp can be countered by used of the spherical washers between the clamps and the nut.

The spherical seat transmits the clamping pressure from the nut to the clamp. Below show the clamp with the cylindrical washer (Figure 2.10).

In multiple clamping, a pivoted equalizer is used for clamping the two unequal pumps simultaneously. The equalizer clamp pivots around the pins to suit the pump (Figure 2.11).

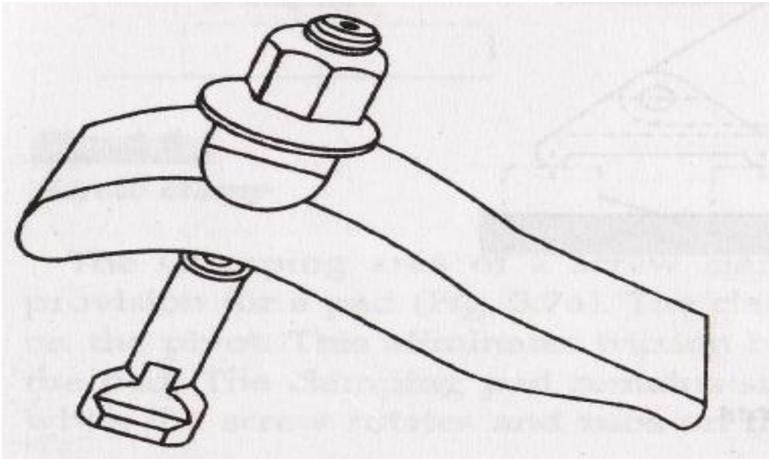


Figure 2.2: Universal clamp with cylindrical washer (Jigs and Fixture, P H Joshi, 2001)

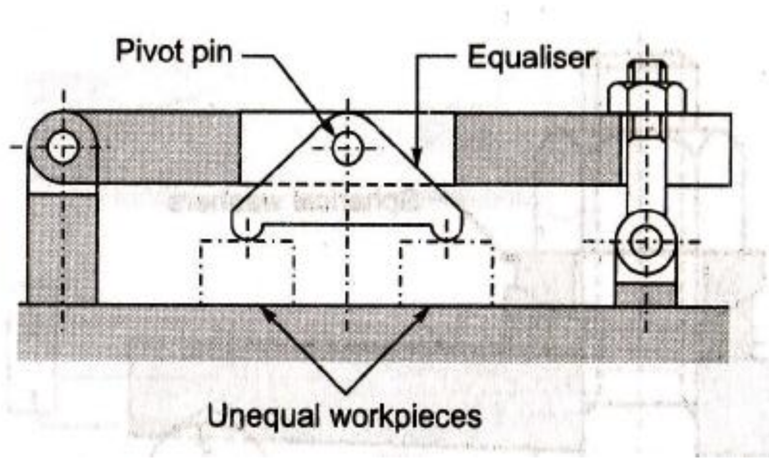


Figure 2.3: Equalizer for two workpieces (Jigs and Fixture, P H Joshi, 2001)

2.8.3.2 Work holder

Edward G. Hoffman (2004) states there are the following conditions of the clamp use:

1) The clamp must be strong enough to hold the part and to resist movement.
2) The clamp must not damage or deform the part.
3) The clamp should be fast acting and allow rapid loading and unloading of parts.

2.8.3.3 Basic rules of clamping

The function of a clamp is to hold the part against the locators during the operation cycle. To be effective and efficient, clamps must be planned into the tool design.

2.8.3.4 Positioning the clamping

Clamps should always contact the work at its most rigid point. This will prevent the clamping force from bending or damaging the part. The part must be supported if the work is clamped at a point where the force could bend the part. The ideal place to clamp the part is from its center hole. If it is held by the outer edge, the part must be supported. Below are the figure of the flange ring and the supported of the flange ring.

Clamps are also positioned so they do not interfere with the operation of the pump. It is important that the clamps be placed in order to ensure the operation work easily and safely without any problems (Edward G. Hoffman, 2004).

2.8.3.5 Clamping forces

Clamping forces is the forces required to hold a part against the locators. Clamping prevents the part from shifting or being pulled from the fixtures during the operation. . The tool forces working on the part usually determine the type and amount of clamping forces needed to hold a part and how the part is positioned in the tool (Figure 2.12).

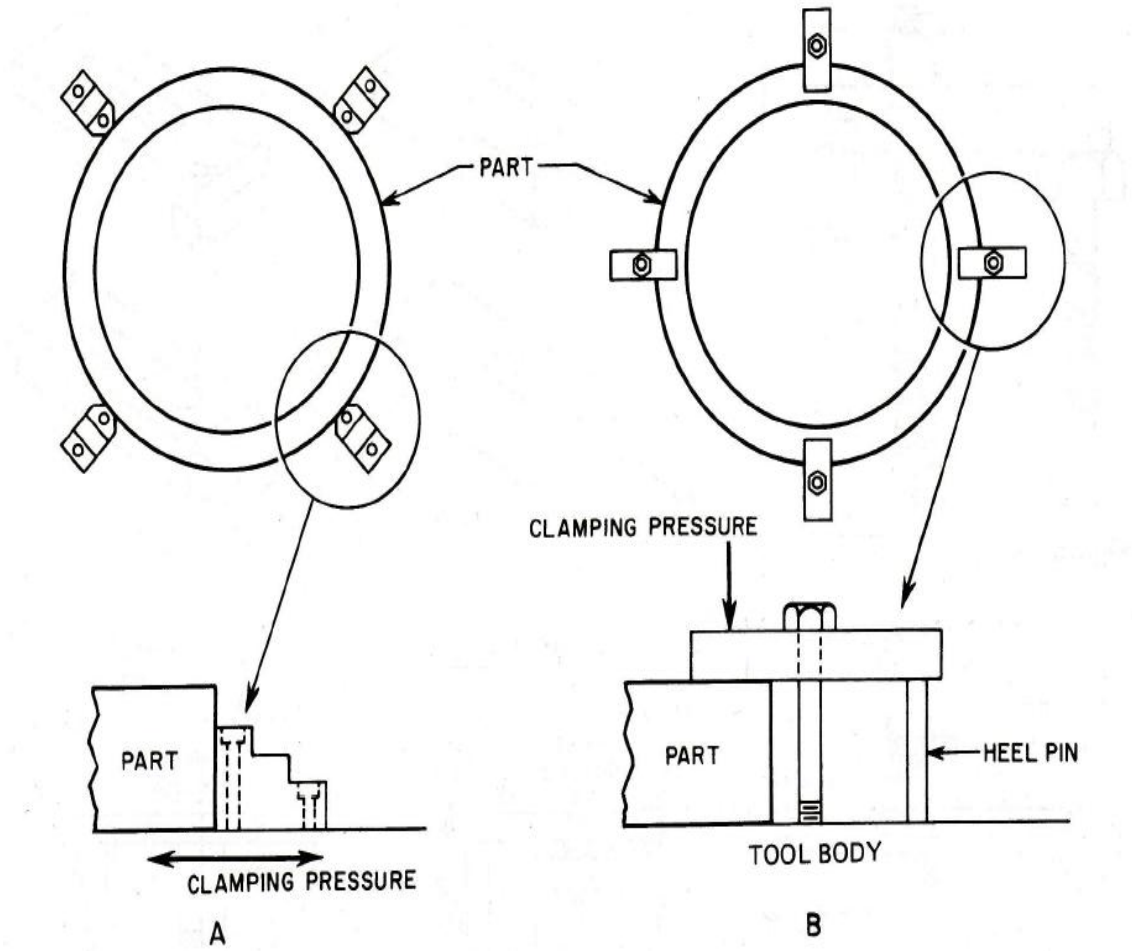


Figure 2.4: Clamping forces (Jig and Fixture design, Edward G. Hoffman, 2004)

Clamping pressure as a general rule should only be enough to hold the part against the locator.

2.8.4 Supporting and locating principle

Supporting and locating is to restrict the movement of a part and have the part positioned properly requires skill and planning.

2.8.4.1 Locating methods

Part is made in almost every possible shape and size. The tool designer must be able to accurately locate each part regardless of how it is made. A product can be located from:

a) Plane surface
b) Profile
c) Cylindrical surface

2.9 Fused Deposition Modeling (FDM)

Fused Deposition Modeling (FDM) is a free-form fabrication technology developed by Stratasys. Because it uses high strength ABS plastic, it is the favored technology for prototyping plastic parts requiring strength. FDM is a layered manufacturing method that extrudes a thin bead of plastic, one layer at a time. A thread of plastic is fed into an extrusion head, where it is heated into a semi-liquid state and extruded through a very small hole onto the previous layer of material. Support material is also laid down in a similar manner.

Fused deposition modeling, which is often referred to by its initials FDM, is a type of additive fabrication or (sometimes called rapid prototyping / rapid manufacturing (RP or RM)) technology commonly used within engineering design. The technology was developed by S. Scott Crump in the late 1980s and was commercialized in 1990. The FDM technology is marketed commercially by Stratasys, which also holds a trademark on the term.

Like most other additive fabrication processes (such as 3D printing and stereolithography) FDM works on an "additive" principle by laying down material in layers. A plastic filament or metal wire is unwound from a coil and supplies material to an extrusion nozzle which can turn on and off the flow. The nozzle is heated to melt the material and can be moved in both horizontal and vertical directions by a numerically controlled mechanism, directly controlled by a computer-aided manufacturing (CAM) software package. The model or part is produced by extruding small beads of thermoplastic material to form layers as the material hardens immediately after extrusion from the nozzle.

Several materials are available with different trade-offs between strength and temperature properties. As well as acrylonitrile butadiene styrene (ABS) polymer, the FDM technology can also be used with polycarbonates, polycaprolactone, polyphenylsulfones and waxes. A "water-soluble" material can be used for making temporary supports while manufacturing is in progress. Marketed under the name WaterWorks by Stratasys, this soluble support material is quickly dissolved with specialized mechanical agitation equipment utilizing a precisely heated sodium hydroxide solution.

The FDM fused deposition model process is additive which extrudes material in layers. A plastic filament is melted and extruded through a heated nozzle. The nozzle moves to produce a profile of the part then moves down and the next layer is built on top until the entire prototype model is fully built. The model is complete and requires no hardening. FDM is an excellent choice for any 3D Model that needs to closely represent the final product in strength and durability. CAD Models can be produced in about 24 hours depending on the size and complexity. Online price quotes are available for FDM parts Anonymous (N.D.).

Figure 2.14: Examples of the Product done using FDM Machine

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter consists of methodology, resources requirement and work planning. The project is followed the flow of the process planning for PSM I and PSM II.

This phase describes the best way that the Author used for fact-finding. It includes the proper method for the Author to get relevant information for the project. This includes Interviewing, Questionnaires, Observation, Internet Surveys, and so on.

It will describe the methodology and its phase that using the product design and development process flow. It also explained about the resources requirement, work planning and the method of FEA analysis which is ANSYS CFX and MSc Software Pastran & Nastran.

3.2 Methodology

The process flow of this chapter is detail explained in this section. Generally, this process flow is divided into 5 phase which are:

1. Planning
2. Concept development
3. Detail Design
4. Machining, analysis & refinement
5. Report Submission & final presentation

Figure 3.1 shows the process flow chart of this project which guided by the product development process flow.

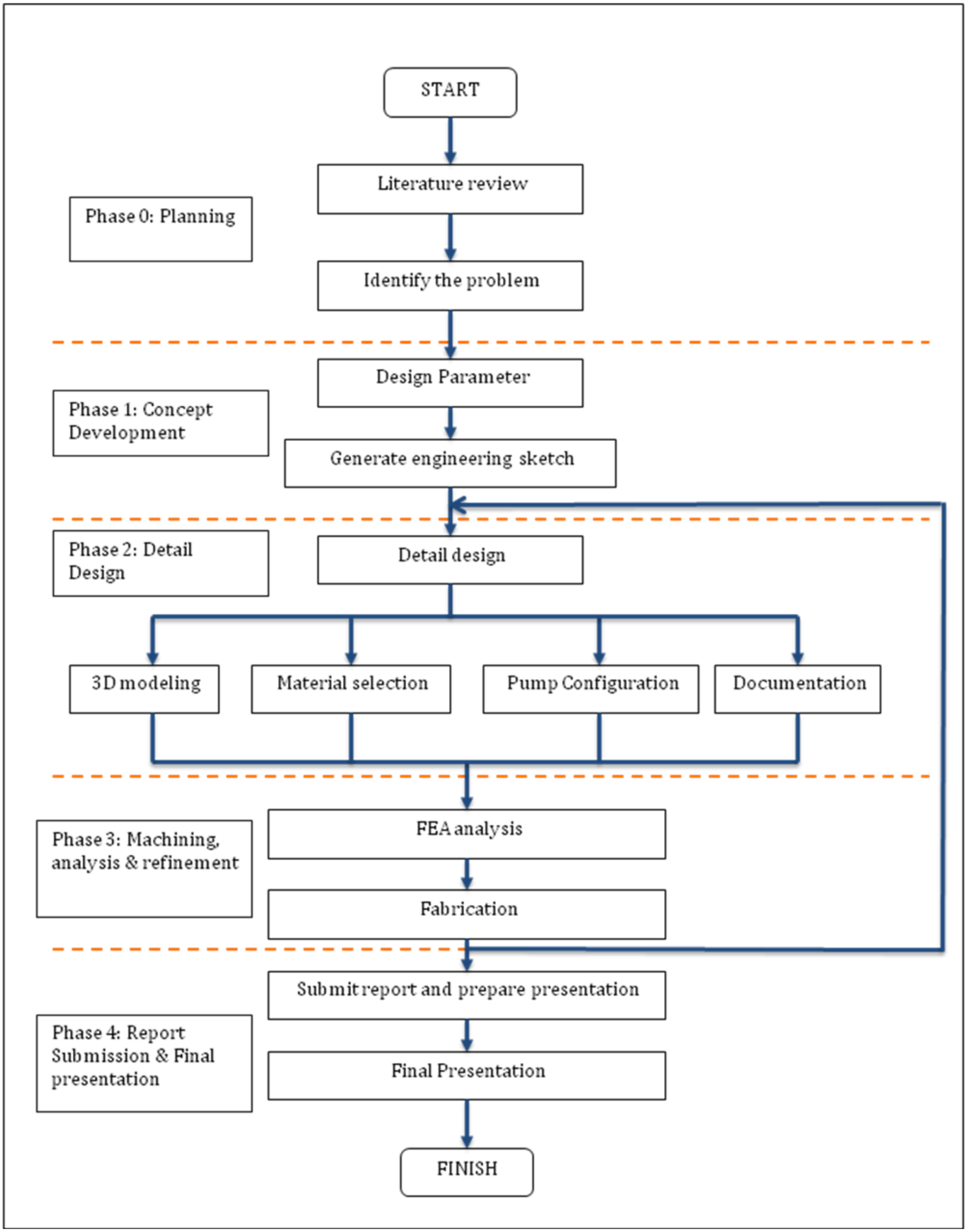


Figure 3.1: Product design Process flow

3.2.1 Phase 0: Planning

Planning is the essential to the creation and refinement of a plan, or integration of it with the other plans which is combines the forecasting of developments with the preparation of scenarios of how to react to them. It also identified the literature review which is explained about the process of developing the portable platform, the material used and the software that used to design the platform.

It also identified the problems on the application of holding, supporting and clamping securely during the pump operation. Besides, process planning is carried out to minimize the risks and the failure of the project.

3.2.2 Phase 1: Concept development

In the concept development phase, the design parameters are needed to identify, the alternative product concepts are generated and evaluated and one of the concepts is selected for the further development and testing. Design parameters is consists of the portable platform function and the mechanism of the material used.

Concept is a description of the form, functions and features of a product and is usually accompanied by a set of specifications. It also consists of generating the engineering sketch of the portable platform.

3.2.3 Phase 2: Detail Design

The detail design phase includes the complete specifications of the geometry, material selection, pump configuration, documentation and the tolerances of all the parts in this product.

The output of this phase is control documentation for the product which described the drawings or computer files in describing the geometry of each part and its production tooling, the specification of the purchase parts, the process plans for the fabrication and assembly of the product.

3.2.4 Phase 3: Machining, analysis & refinement

The machining, analysis and refinement phase will identified the consisting machining simulation in MSc Software Patran & Nastran and ANSYS CFX10 and followed by machining the design prototype using the rapid prototyping machine which is Fused Deposition modeling (FDM) machine.

Early prototype are tested to determined whether the portable platform will work as designed and whether the product satisfies the key customer needs. Later prototypes are usually built with part supplied by the intended production process. The goal for this prototype is usually to answer questions about performance and reliability in order to identify necessary engineering changes for the final product.

3.2.5 Phase 4: Report submission & Final presentation

This phase explained about the discussion on the design of portable platform, the improvement that achieved and the final report submission. The final presentation preparation also consists in this phase.

3.3 Material, hardware and software requirement

The material, software and hardware requirement are briefly explained in this section. Below is the table that shows all the requirement.

Table 3.1: Material, Hardware and software requirement

MATERIAL	HARDWARE	SOFTWARE
➢ **Plastic Resin (Acrylonitrile Butadiene Styrene** (ABS**))**	➢ **Rapid Prototype Machine – (Fused Deposition Modeling)**	➢ **MSc Software Nastran/Patran** ➢ **Solidwork 2005/2007** ➢ **ANSYS CFX**

3.4 Work planning

In this work planning, have the Work Breakdown Structure (WBS) of the project. All the task of the project have been identified and arranged in this structure. WBS will make it easier to make the estimation on the tasks and in addition. It also can ensure that are no task will be left out. Below is the table of the WBS.

Table 3.2: Work Breakdown Structure of Project

Phase 0: Planning
0.1. Define the Problem ▣ Define the problem statement ▣ Define the product of the project ▣ Define the objectives of the project ▣ Define the scope of the project 0.2. Literature Review ▣ Literature review on Floating pump

- Literature review on Quality Function Deployment (QFD)
- Literature review on Solidworks CAD
- Literature review on ANSYS CFX
- Literature review on MSc Software Nastran/Patran
- Literature review on Finite Element Analysis (FEA)
- Literature review on Product Design
- Literature review on Fixture System
- Literature review on Fused Deposition Modeling (FDM)

0.3. Define the material and methodology

- Project flow chart
- Methodology
- Hardware and software requirement
- Material requirement

0.4. Work planning

- Work Breakdown Structure
- Estimate resource and duration
- Develop Gantt chart

Phase 1: Concept Development

1.1. Design parameter of the platform

- Understand the problem and requirement
- Identified the function of the platform
- Identified the mechanism of the platform

1.2. Generate the engineering design

- Choose the best design among the 3 designs

Phase 2: Detail Design

2.1. 3D modeling (Simulation)

- Tool used
- Machining parameter

2.2. Material Selection

- Polymer and plastic resin

▣ Properties of the material 2.3. Pump Configuration 2.4. Documentation
Phase 3: Machining, analysis and refinement
3.1. FEA analysis ▣ Used the ANSYS CFX software ▣ Used the Msc Software Nastran/Patran 3.2. Fabrication ▣ Rapid prototyping machine (Fused Deposition Modeling)
Phase 4: Report Submission and Final Presentation
4.1. Submit report and preparation for presentation 4.2. Final Presentation

3.5 Concept selection

The concept chosen in this stage is concept scoring. Concept scoring is used when increased resolution will be better distinguish among competing concept. In this stage, the team weighs the relative significance of the selection criteria and focuses on more refined comparisons with respect to each criterion. These concepts are determined by the weighted sum of the rating. This concept must be following step by step.

Step 1: Prepare the Selection Matrix

The three design alternatives have been generated by sketching while the design reference is the existing fixture design. There are five selection criteria such as easy of clamping, easy of use, easy of manufacture, portability and lightweight and the weight as 25%, 30%, 15%, 10% and 20% respectfully.

Step 2: Rate the Concepts

Rating for is selection as on table 3.3 for three design alternative.

Step 3: Rank the Concepts

For the step 3, one time the ratings are entered for each concept, weighted scores are calculated by multiplying the raw score by the criteria weights. Example Design 1: easy of clamping (weight 25%), and rating (3), so the weighted score is 0.75.

Step 4: Combine and Improve the Concepts

For this design there is no combination and improvement because the different function and mechanism are used to rating this product.

Step 5: Select one or More Concepts

From the table 3.3, the high weighted score is design three with the value 4.50. This summary of this design suitable of easy of use weighted score.

Step 6: Result

So as a result and based on the concept scoring matrix, drawing three is selected to be fabricate.

Table 3.3: Concept Scoring Matric

CONCEPT SCORING MATRIC									
			A (Reference)		Drawing 1		Drawing 2		Drawing 3
No.	Selection Criteria	Weight	Rating	Weight Score	Rating	Weight Score	Rating	Weight Score	Rating	Weight Score
1	Easy of clamping	25%	3	0.75	3	0.75	3	0.75	5	1.25
2	Easy of use	30%	3	0.9	3	0.9	4	1.20	4	1.20
3	Easy of Manufacture	15%	2	0.3	4	0.6	3	0.45	5	0.75
4	Portability	10%	3	0.3	4	0.4	4	0.40	5	0.50
5	Lightweight	20%	3	0.6	4	0.8	4	0.80	4	0.80
		100%								
		Total score		2.85		3.45		3.60		4.50
		Rank				3		2		1
		Continue?				NO		NO		YES

3.6 Explanation about the Design

Design 1

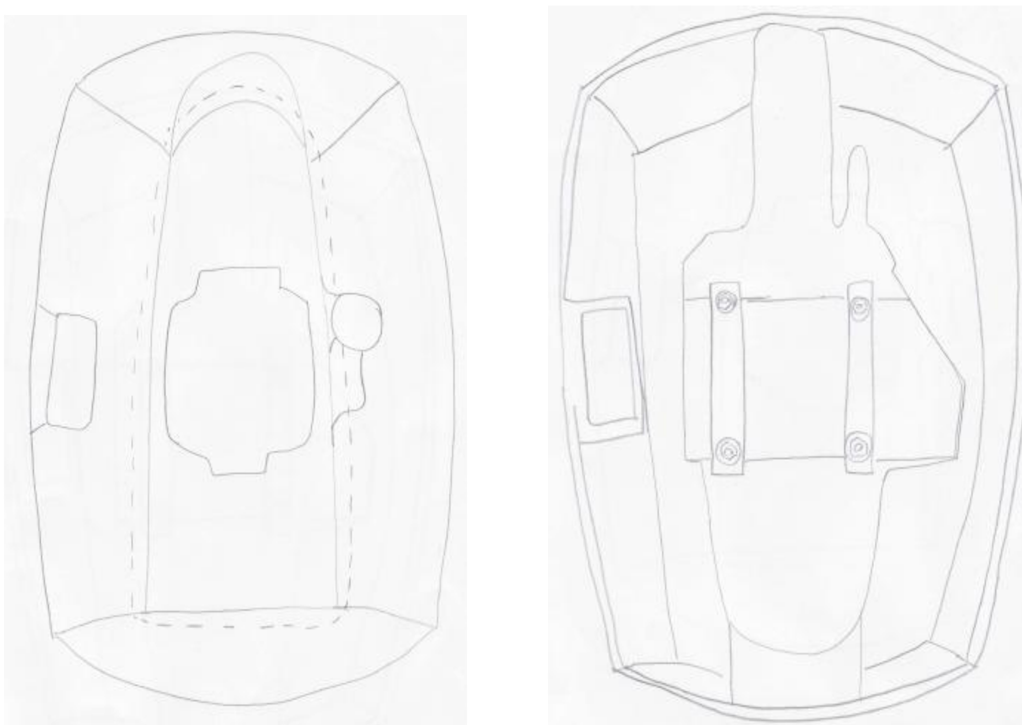


Figure 3.2: Design 1

Figure 3.2 shows the floating pump platform with the one handle and without the clamping devices. The pump will be hold and locate at the center without the clamping used to support it securely during the pump operation. This design has one handle to be it easy to bring it and portability because the material that used in fabricates it is plastic polymer.

Design 2

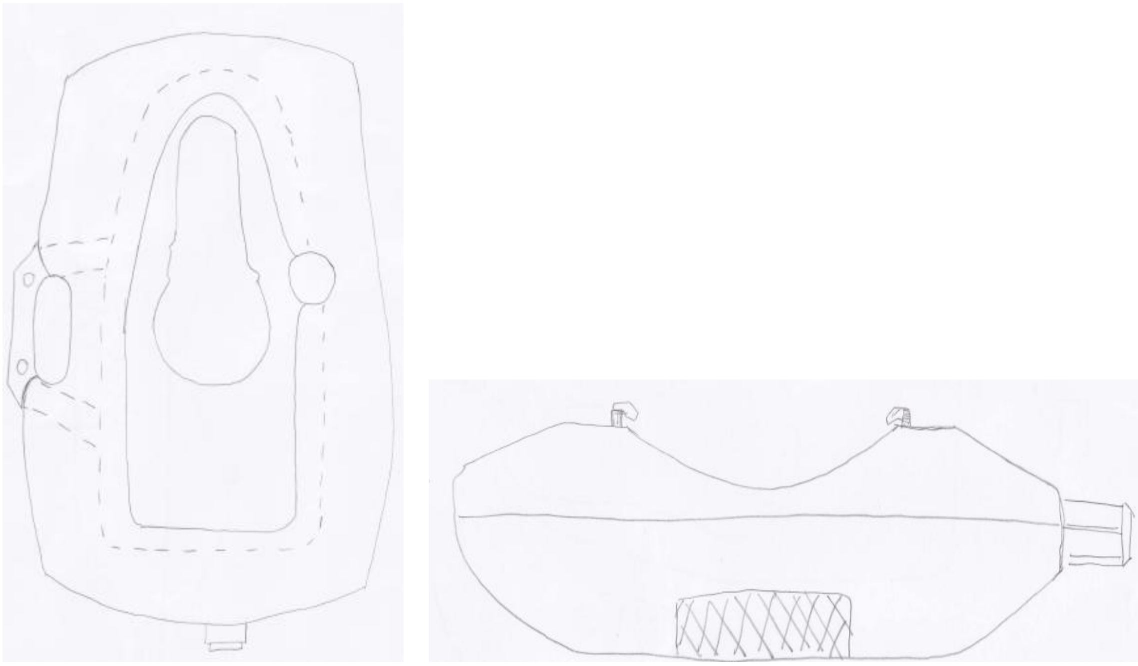


Figure 3.3: Design 2

Figure 3.3 shows the floating pump platform with one handle and only one clamping device to hold and support the pump securely during the pump operation. This platform has the highly rating in portability because the material to fabricate it is a plastic polymer. It also high rating in easy of use because the shape and the function compared to the design 1 because the shape is little bit simple than the design 1. While, the platform has the one clamping devices to hold the pump in its position.

Design 3

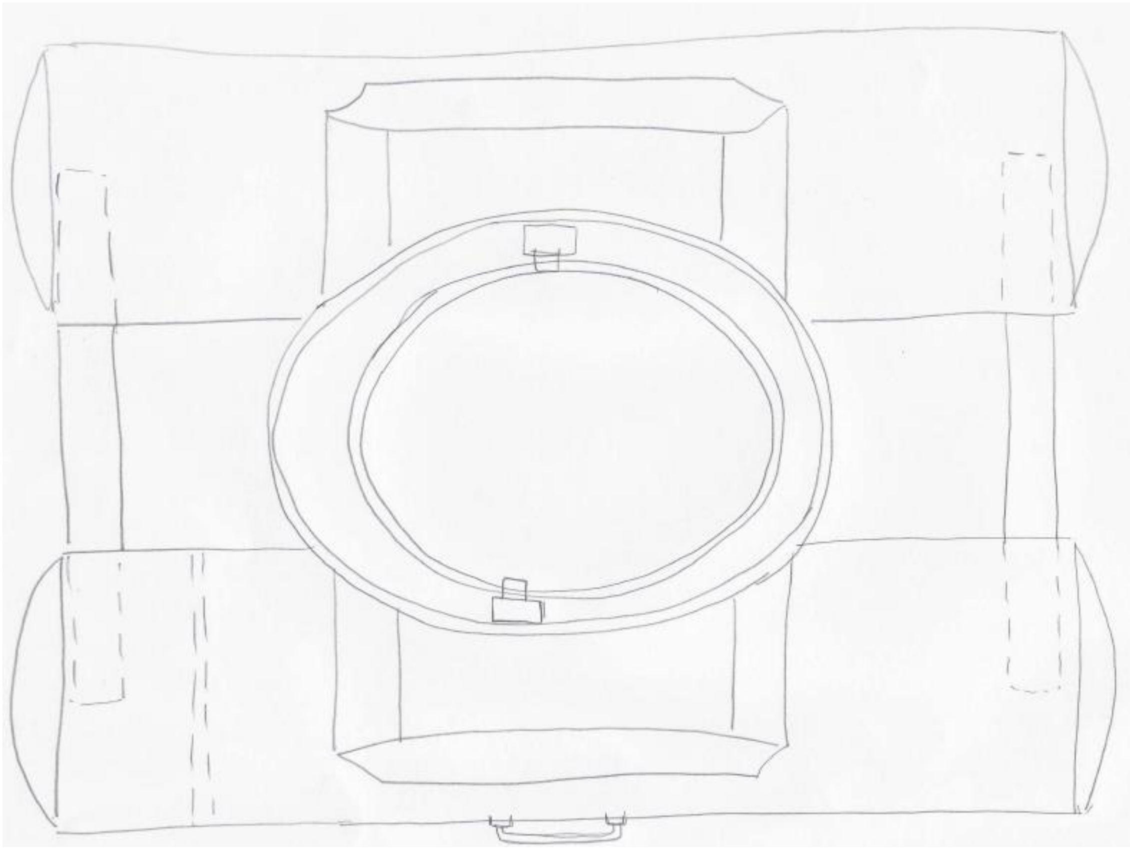


Figure 3.4: Design 3

Figure 3.4 explained that the floating pump platform is easier of clamping, easy of manufacture and portability compared to design 1 and design 2. This design 3 have more functionality than the rest because it have two clamping devices to hold, support and locate the pump securely during the pump operation. Besides, it is easy to carry with the one handle at the side of the platform.

3.7 Design Need

Design need must be identify before the next process of the design begin. There are 5 main categories of the customer need to design the portable platform. A simple needs matrix represent the relationship between the needs and the metrics. A mark in a cell of the matrix means the need and the metric associated with the cell is related. This matrix is a key element of the House of Quality, a graphical technique used in Quality Function Deployment (QFD).

	Material	**No. of part**	**Design Specification**
Easy to clamping			■
Easy to used	■		
Easy to manufacture	■		
Portability		■	
Lightweight	■	■	

Figure 3.5: The needs-metrics matrix

3.8 Rapid Prototyping Procedure

1. Design in the solidwork software is transfer to the STL.doc to be valid for the used in the FDM control center.

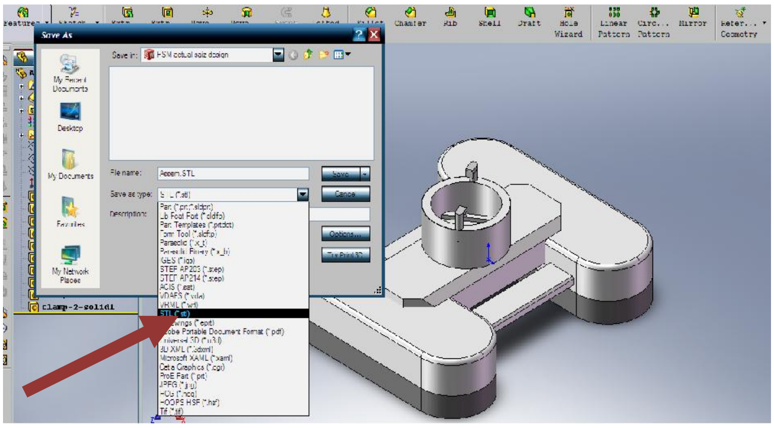


Figure 3.6: STL.doc

2. Open the FDM control center and choose the drawing which has been save in the STL format.

3. Then choose the part built parameter form the modeler setup.

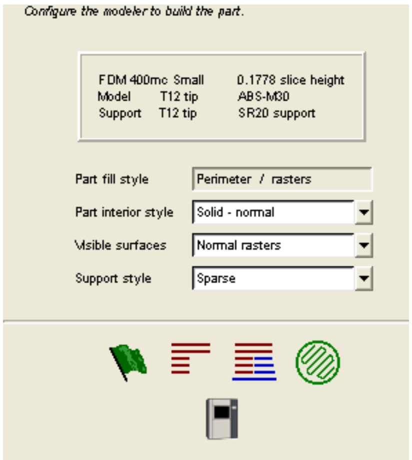


Figure 3.7: Modeler setup

4. After that, preparing the model to orienting the part in the build envelope.

5. Before it sends to the FDM machine, the file must be sliced into the layers that the FDM will extrude to construct the part.

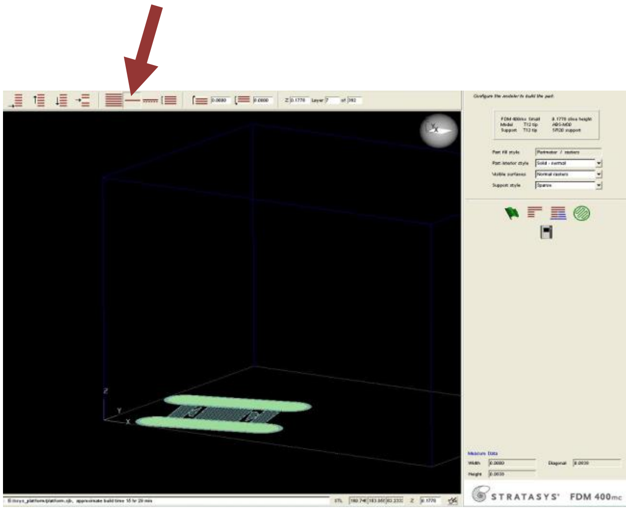


Figure 3.8: layers that the FDM will extrude to construct the part

6. Then, select the support button to create the supports. It's depending on the part sizes and the computer's processor speed.

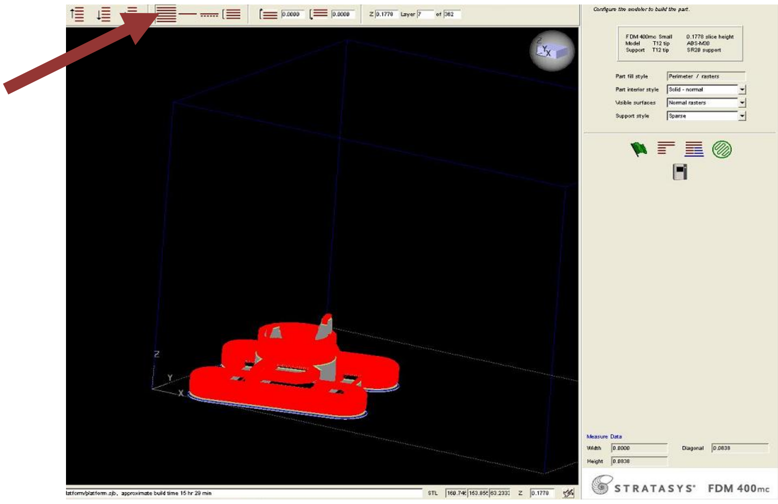


Figure 3.9: Support button to create the supports

7. Before sending the job file to the machine, the tool path for the part must be created.

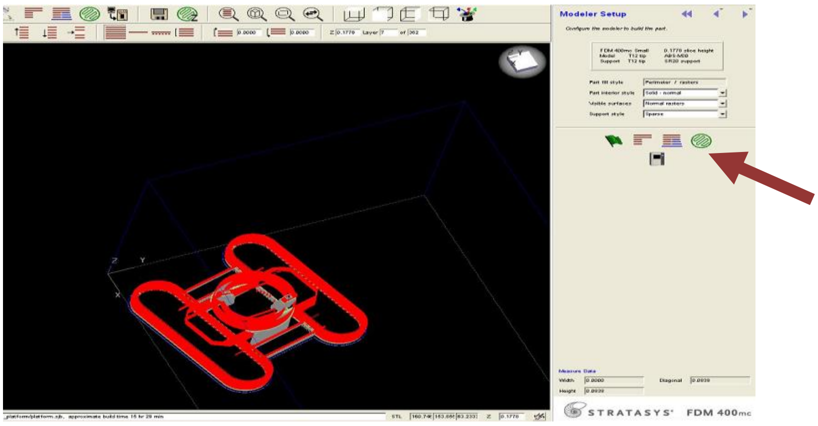


Figure 3.10: Creating Tool path

8. Then save as the tool path and the drawing is ready to be send to the modeler on the FDM machine.

CHAPTER 4

DATA AND RESULTS

4.1 Introduction

This result chapter consists of the technical detail drawing, analysis of mass properties data, tensile strength data, prototype data, simulation result and the safety factor for the product. The technical drawing includes of the detail drawing, projected view, assembly and bill of material of the product. The software used to produce this product includes Solidworks 2007, ANSYS CFX10 and MSc Nastan/Patran 2005.

The fixture system was analyzed in 3 situations which are holding, supporting, and clamping the floating pump securely during the operation. This analysis should be done to make sure the fixture is safe to be used. The fixture with the maximum load had been selected to get a better result during the analysis.

Three dimensional simulation results are carried out as the first step of analysis for the real product. This because on that stage the design which has been done using Solidworks software is imported to the finite element analysis software which is MSc Nastran/Patran while it also can save time and cost.

4.2 Technical drawing

Technical drawing consists of the detail drawing part by part, the projected view of the product, assembly view and the bill of material (BOM).

4.2.1 Detail drawing part by part (with dimension)

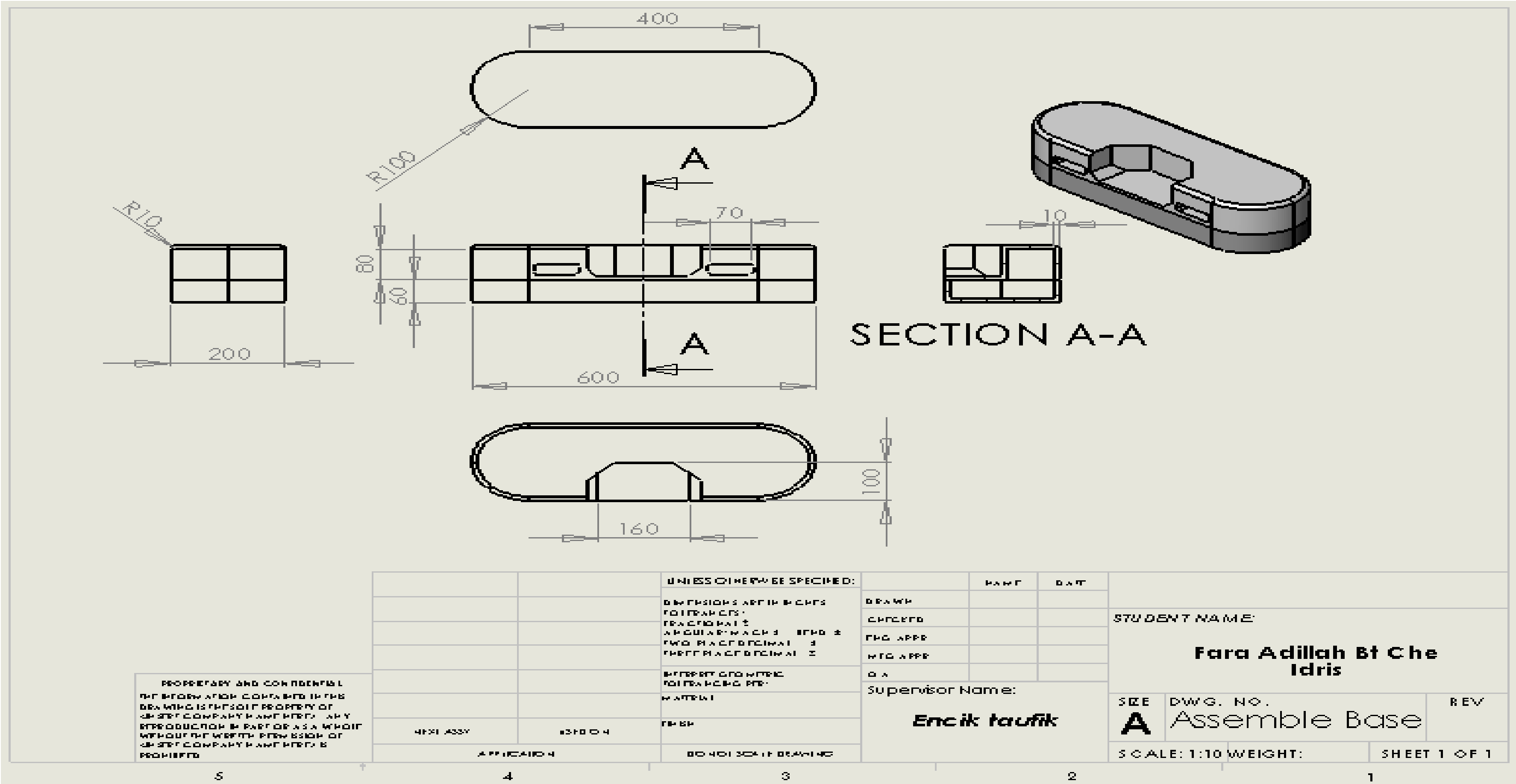


Figure 4.1: Base assembly detail drawing

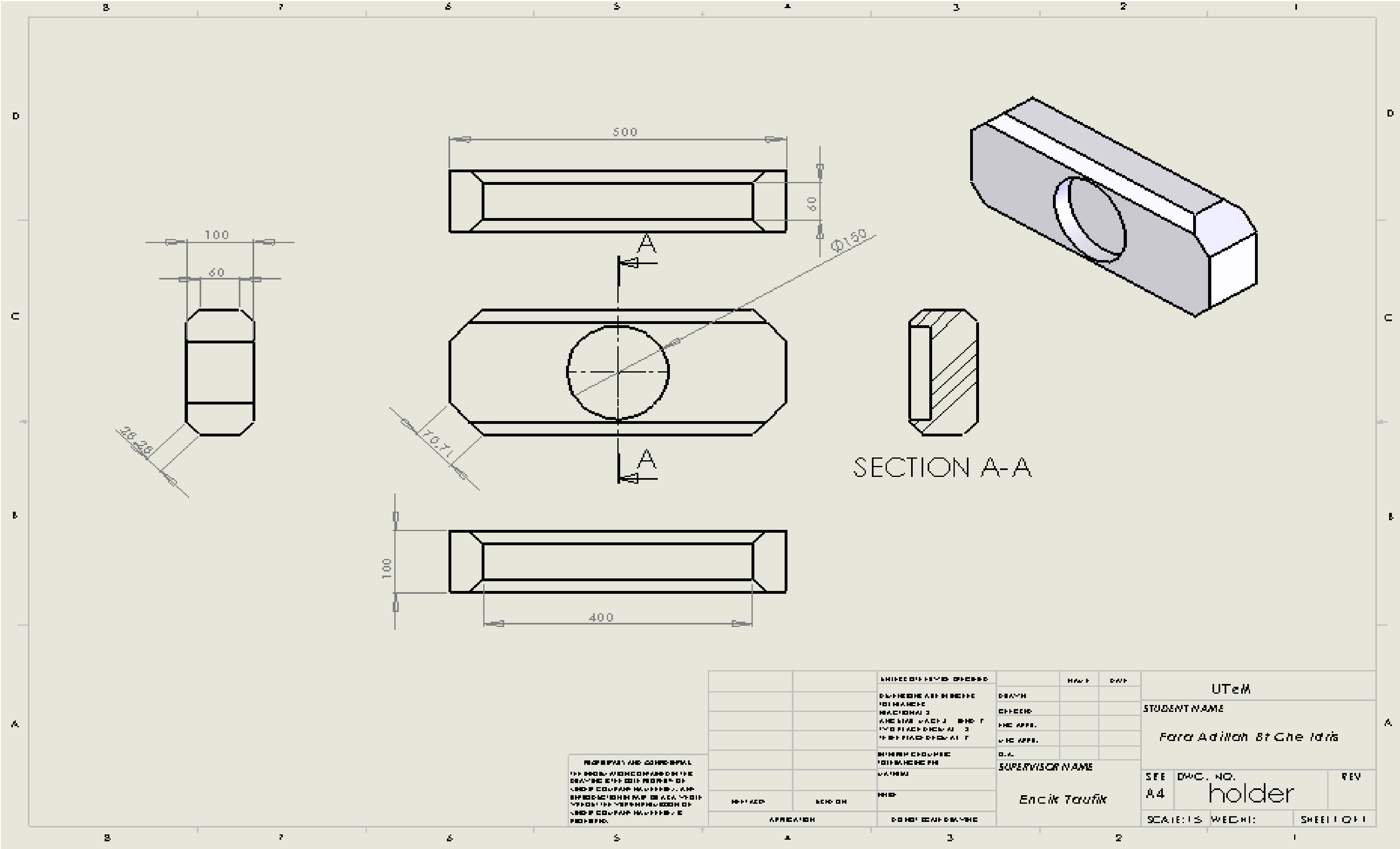


Figure 4.2: Holder Detail Drawing

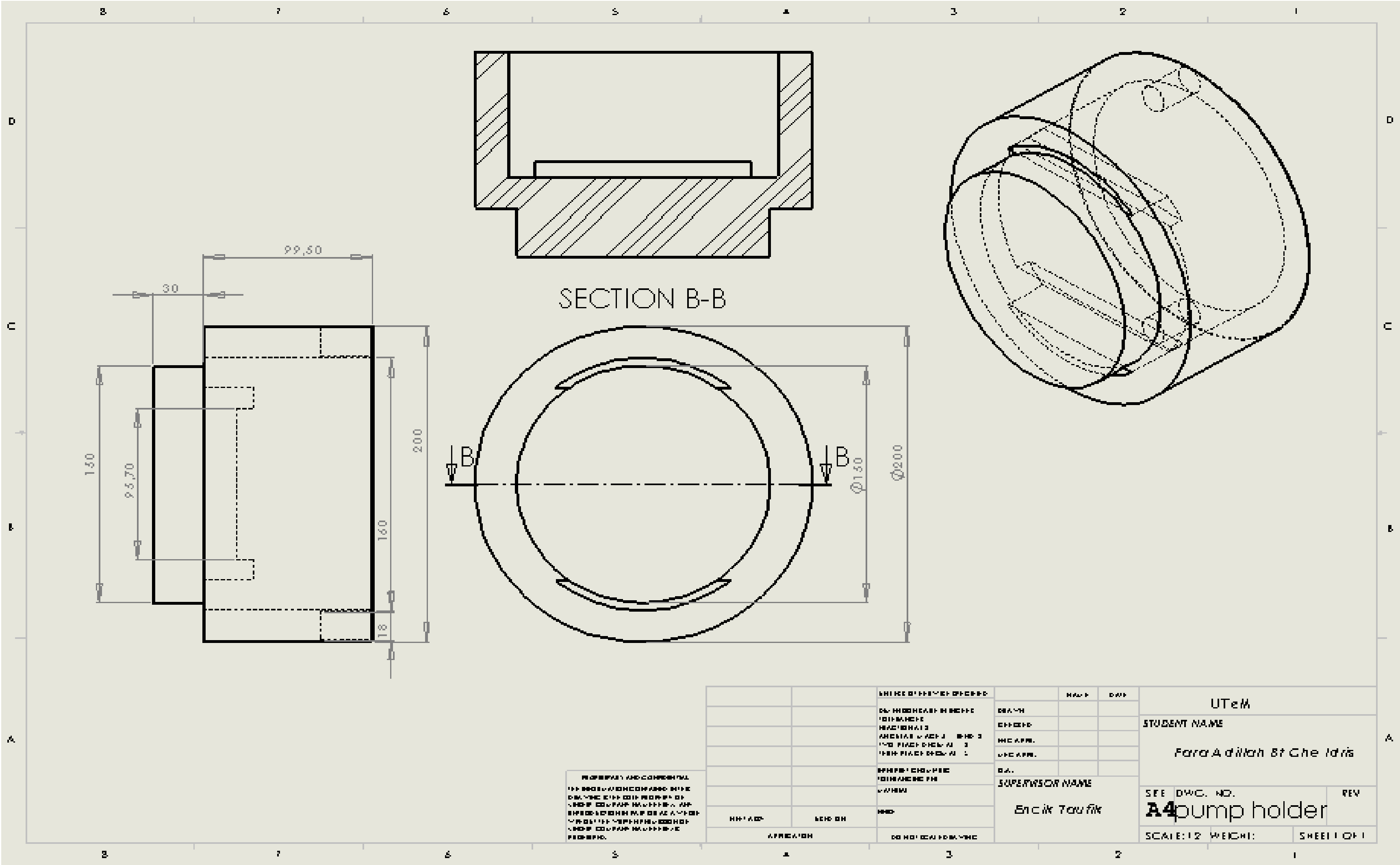


Figure 4.3: Pump Holder Detail Drawing

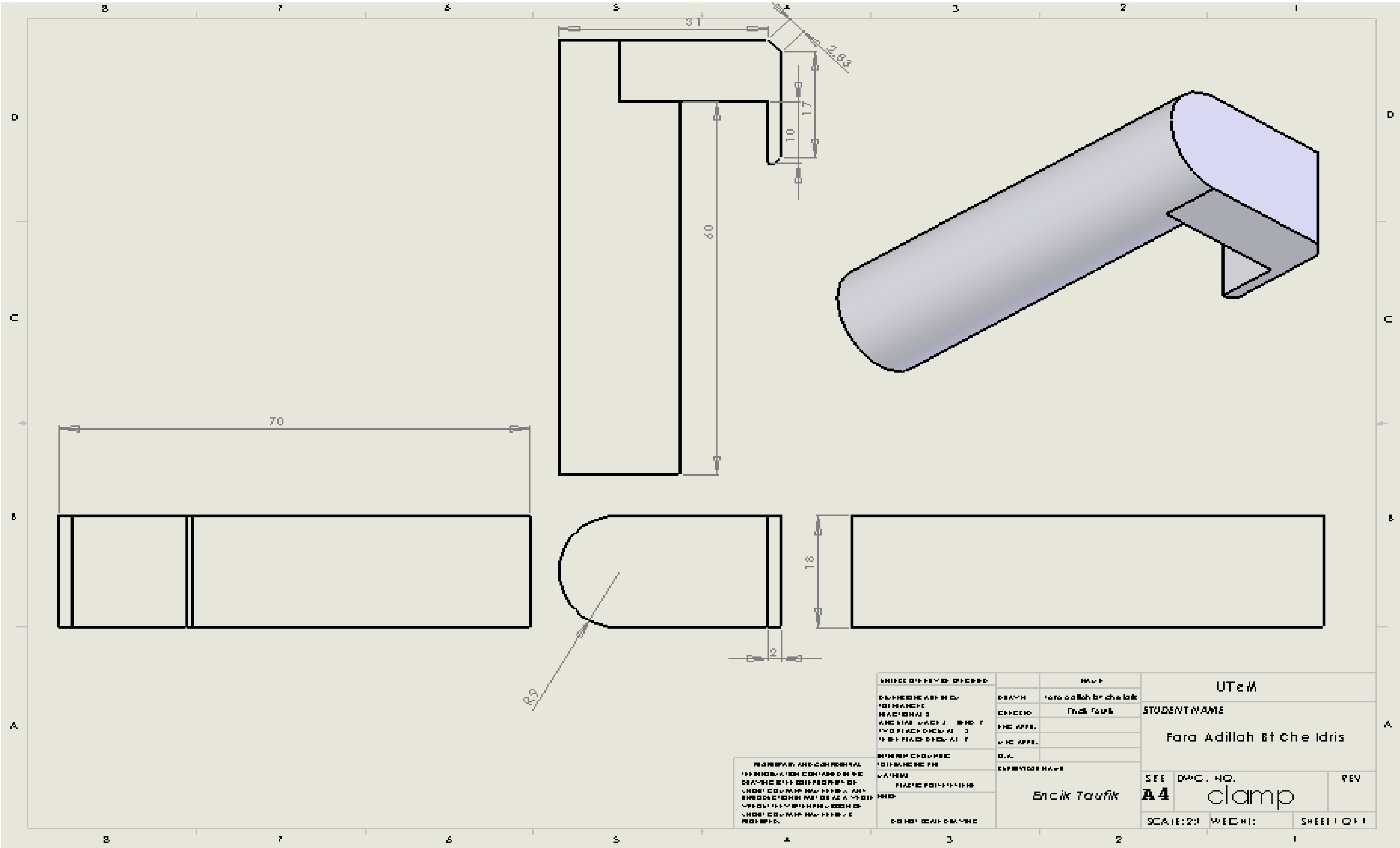


Figure 4.4: Clamp Detail Drawing

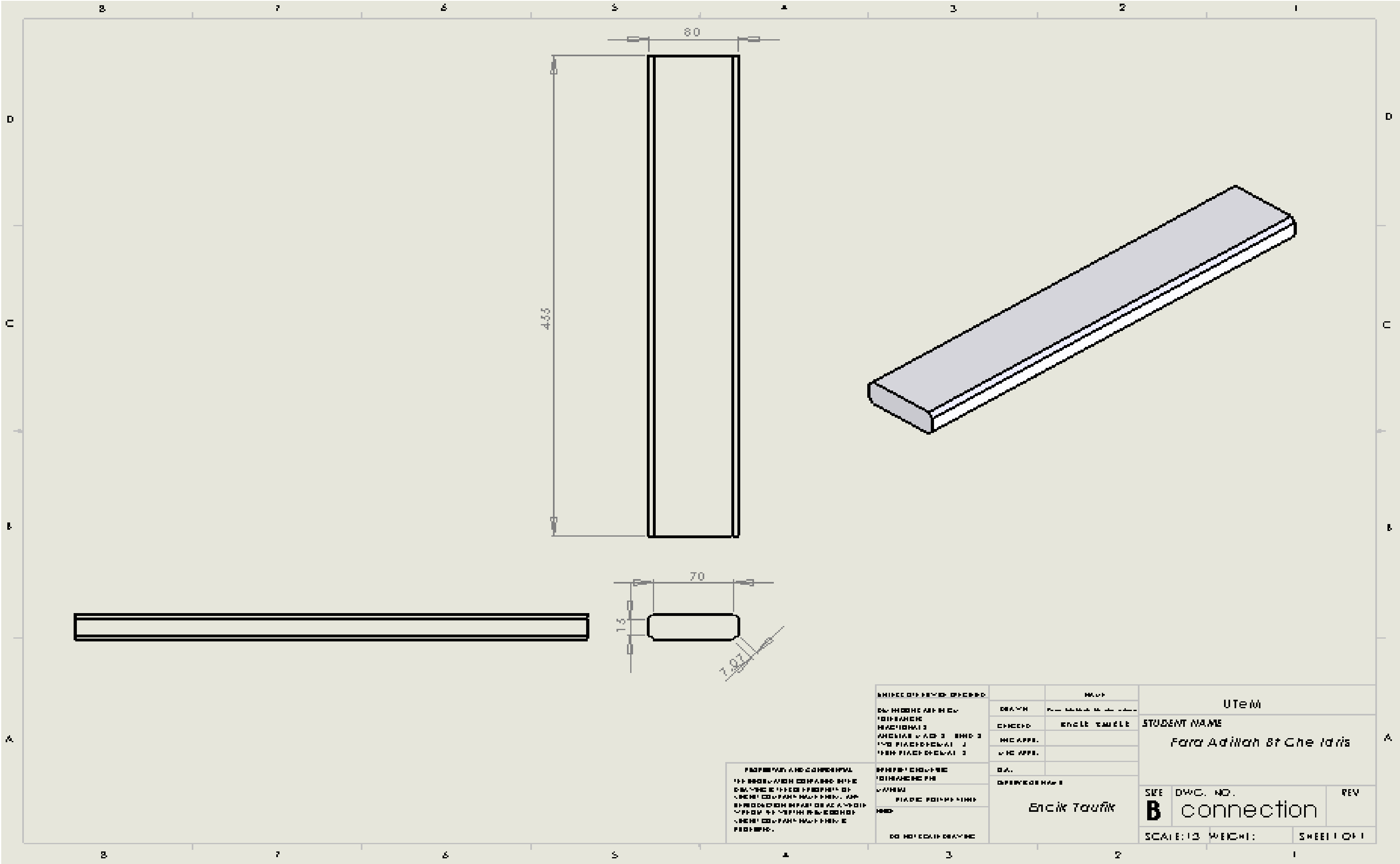


Figure 4.5: Connection Detail Drawing

4.2.2 Projected view (Full Assembly)

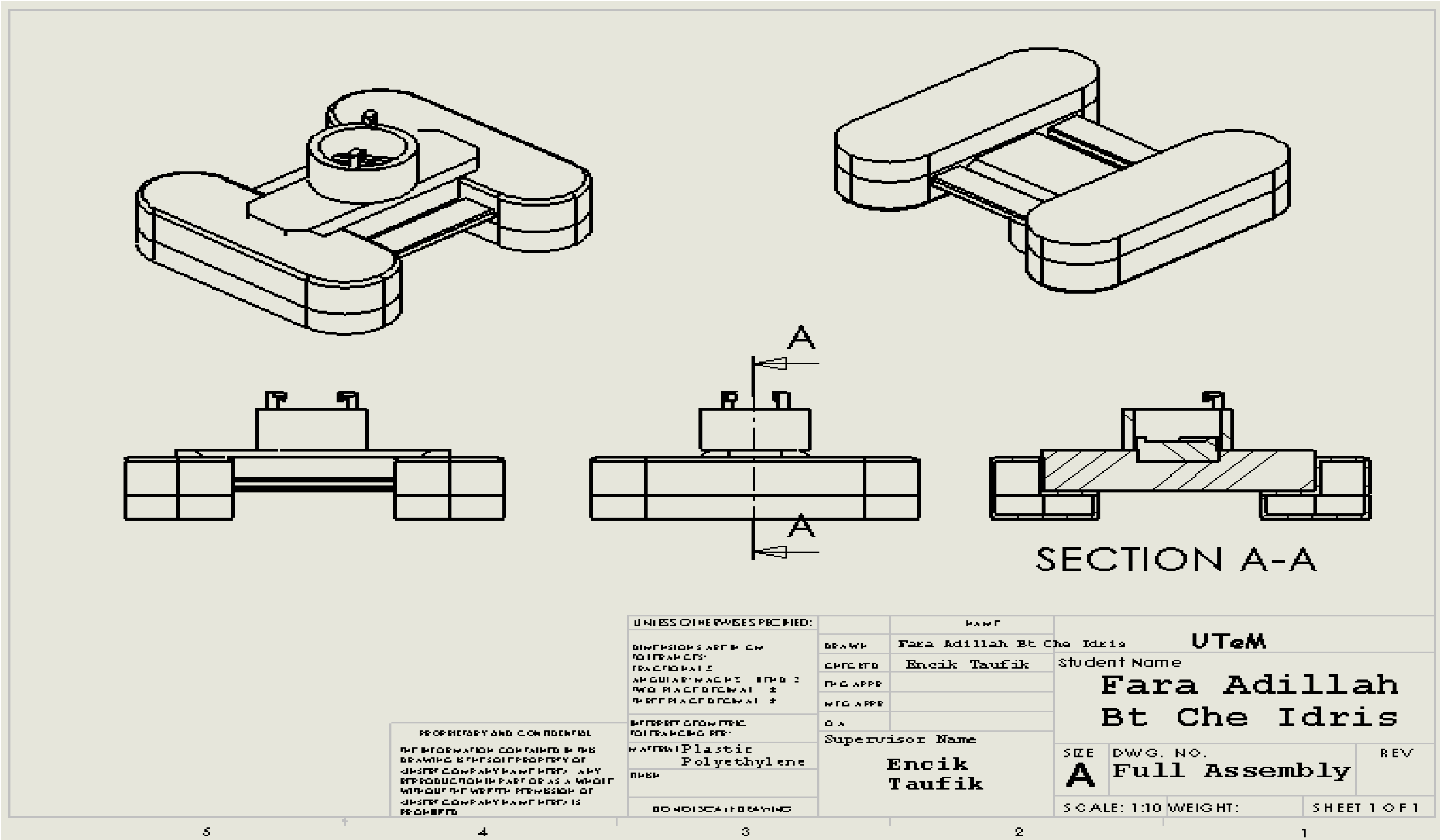


Figure 4.6: Projected View of Full Assembly

4.2.3 Bill of Material

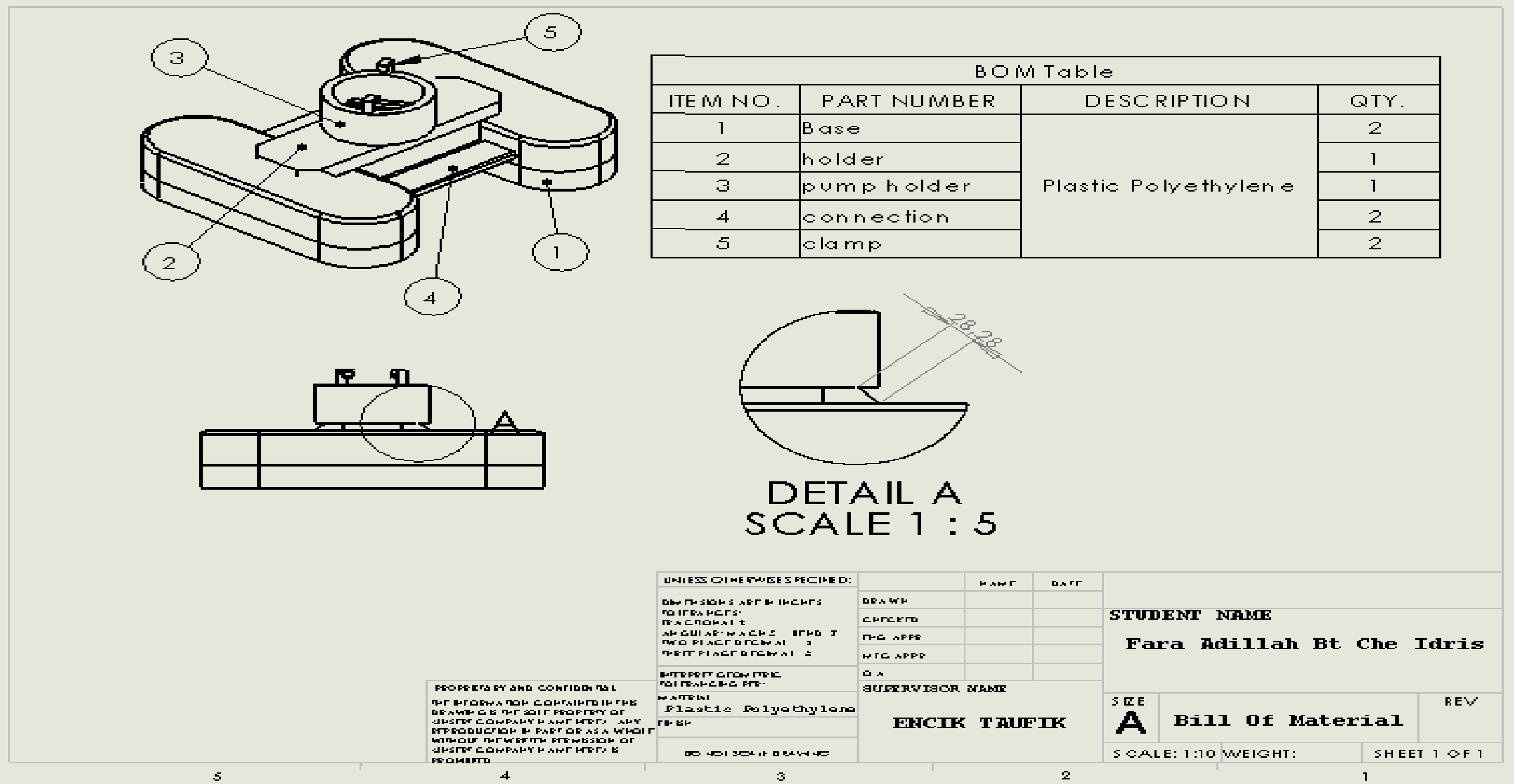


Figure 4.7: Bill of Material of the product

4.2.4 Material Selection

Polyethylene (PE) is chosen because it is a highly durable material that provides exceptional engineering characteristics in applications where ease of cleaning, stability, impact, wears, UV and weather resistance is desirable. It also has good stiffness and impact strength. Besides, They also have a lower melting temperature that will making them desirable for rotationally moulding. The mechanical properties for the PE are on the table below:

Table 4.1: Mechanical /Physical properties of PE

Table A2.1. *"Polyethylene"* Constant Properties	
Name	**Value**
Compressive Ultimate Strength	0.0 Pa
Compressive Yield Strength	0.0 Pa
Density	950.0 kg/m^3
Poisson's Ratio	0.42
Tensile Yield Strength	2.5×10^{7} Pa
Tensile Ultimate Strength	3.3×10^{7} Pa
Young's Modulus	1.1×10^{9} Pa
Thermal Expansion	2.3×10^{-4} 1/°C
Specific Heat	296.0 J/kg·°C
Thermal Conductivity	0.28 W/m·°C

4.3 Design Analysis

The design analysis is conducted before the part is done using the rapid prototyping machine. The parts that being analyze are:-

a) holding
b) supporting
c) clamping

This analysis consists of the material selection analysis, load analysis and the simulation result analysis. These analyses are done by the Pastran & Nastran and ANSYS CFX10. The analyses are briefly explained in the following subtopic which is 4.4-Simulation result.

4.4 Simulation Result

This section shows the result of the simulation which is done using the Pastran & Nastran 2005 software and the ANSYS CFX10. This simulation shows the stress tensor on the part, deformation of the part, displacement and the maximum forces that can handle by the part. The load force or the weight of the floating pump is about 220 N (22 KG). Using the floating pump weight as the total force, the analysis is carried out such as below.

4.4.1 Pastran / Nastran

4.4.1.1 Holder support

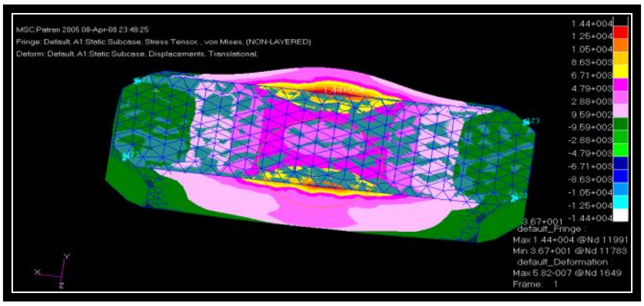


Figure 4.7: Stress Tensor for the holder support

Maximum *von misses stress* = 1.47 x 10^5 Pa

Maximum Deformation = 5.82 x 10^{-7} m

Safety Factor value,

$$\text{Safety Factor, } n = \frac{\text{Tensile Strength}}{\text{Maximum Stress}} = \frac{2.5 \times 10^{7}\ \text{Pa}}{1.47 \times 10^{5}\ \text{Pa}} = 170$$

4.4.1.2 Pump Holder

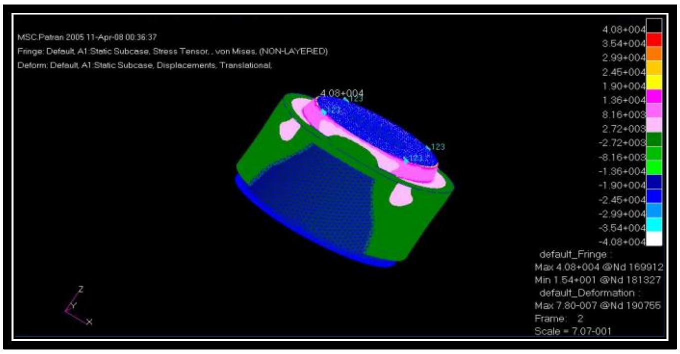


Figure 4.8: Stress Tensor for Pump Holder

Maximum *von misses stress* = 4.08x 10^5 Pa

Maximum Deformation = 7.80 x 10^{-7} m

Safety Factor value,

$$\text{Safety Factor, } n = \frac{\text{Tensile Strength}}{\text{Maximum Stress}} = \frac{2.5 \times 10^7 \text{ Pa}}{4.08 \times 10^5 \text{Pa}} = 61$$

4.4.1.3 Base

Base of the platform consists of the 2 part which is base 1 and base 2. The simulation analysis is done for the both part.

Base 1

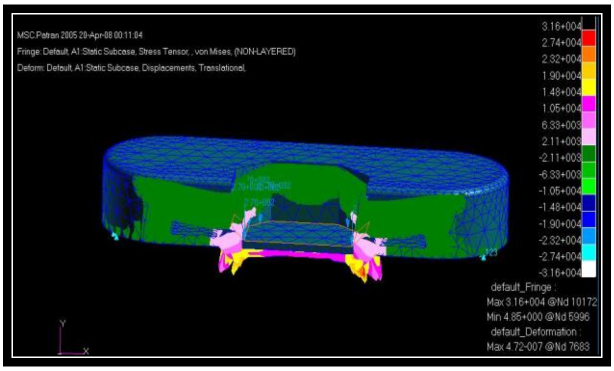


Figure 4.9: Stress Tensor for Base 1

Maximum *von misses stress* = 3.16 x 10^5 Pa

Maximum Deformation = 4.74 x 10^{-7} m

Safety Factor value,

$$\text{Safety Factor, } n = \frac{\text{Tensile Strength}}{\text{Maximum Stress}} = \frac{2.5 \times 10^{7}\ \text{Pa}}{3.16 \times 10^{5}\ \text{Pa}} = 79$$

Base 2

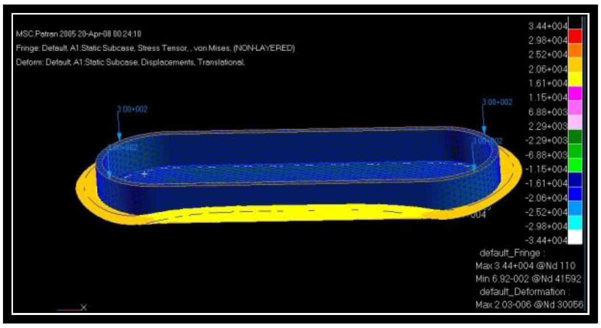


Figure 4.10: Stress Tensor for Base 2

Maximum *von misses stress* = 3.44 x 10^{5} Pa

Maximum Deformation = 2.03 x 10^{-6} m

Safety Factor value,

$$\text{Safety Factor, } n = \frac{\text{Tensile Strength}}{\text{Maximum Stress}} = \frac{2.5 \times 10^{7}\ \text{Pa}}{3.44 \times 10^{5}\ \text{Pa}} = 72$$

4.4.2 ANSYS CFX10

The parts that which analyze using ANSYS are holder support and the pump holder. Through this software, it can show the safety factor and shear factor table for the both part.

Table 4.2: Safety Factor

Name	**Scope**	**Type**	**Minimum**	**Alert Criteria**
"Stress Tool"	*"Model"*	Safety Factor	15.0	None
"Stress Tool"	*"Model"*	Safety Margin	14.0	None

Table 4.3: Shear Stress Safety Factor

Name	**Shear Limit**	**Shear Factor**
"Stress Tool 2"	Yield strength per material.	0.5

4.5 Rapid Prototyping Product

Material Used: Acrylonitrile butadiene styrene **(**ABS**)**

Time Machining: 15 hours 29 minutes (whole product)

Machine Used: Fused deposition modeling (FDM)

Document used: STL (transfer the Part. To STL doc from Solidwork software)

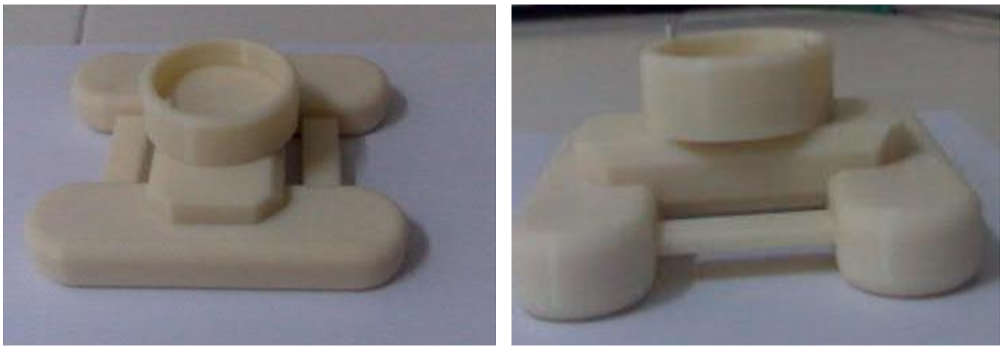


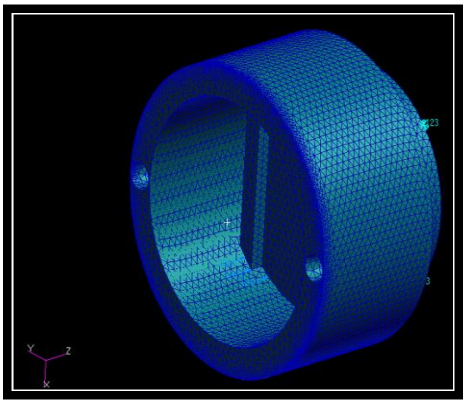
Figure 4.11: Prototype using FDM machine

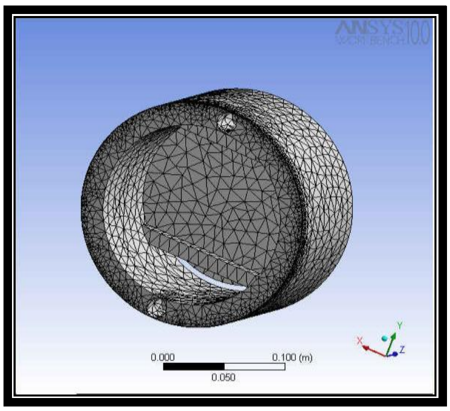
CHAPTER 5

ANALYSIS AND DISCUSSION

5.1 MESH ANALYSIS

Mesh analysis consists of the analysis from the MSc PATRAN/NASTAN and the ANSYS software. This analysis shows the element which performed in the part that has been analyzed is about 100778 point and 50889 elements.





(A) **(B)**

Figure 5.1: Mesh Element

(A) MSc PATRAN/NASTRAN

(B) ANSYS CFX 10

5.1.1 ANSYS CFX10

ANSYS mesh generation tools offer the capability to parametrically create grids from geometry in multi-block structured, unstructured hexahedral, tetrahedral, hybrid grids consisting of hexahedral, tetrahedral, pyramidal and prismatic cells and Cartesian grid formats combined with boundary conditions. Engineers can control mesh density using sliding controls and a built-in aspect ratio checker enables the software to generate fewer, better-shaped elements on the first pass to ensure accuracy and optimize speed.

5.1.2 MSc NASTRAN/PATRAN

MSc Patran finite element modeling system permits the user to direct access the model geometry and to quickly develop the finite element meshes. This analysis is the process which can be easily used to look at any problem where the model can be built parametrically.

5.2 ANALYSIS NASTRAN/PATRAN

5.2.1 Deformation analysis

The analysis of three-dimensional deformation is applied to the structures. The deformation is studied in order to understand the complex dynamic problems coded into the image sequences. In particular, methods have been developed to control the reconstruction and the spatial deformation of cerebral structures in different aspects of morphometry, isometry and densitometry. Finally, a simulation process of the deformation caused by a floating pump in real world cases has been performed.

The deformation which has been developed from the analysis for the whole part is in the average of 7.8×10^{-7} m. the value of the deformation analysis can be consider as the less value and it can tell us that the displacement which has deformed is still can safely hold the floating pump securely during the operation.

5.2.2 Stress Tensor

The stress tensor that applied to the part of the product is the von mises principal. This principal is theoretical measure of stress used to estimate fatigue failure with tensile and tensile-shear loading. In general, Von Mises is used for determining failure in ductile materials while Maximum principle stress (normal stress) is used for determining failure in Brittle materials. From the analysis which has been done, the von mises stress is about 1.47 till 1.68×10^6 Pascal for the part.

5.2.3 Safety Factor

$$\text{Safety Factor, } n = \frac{\text{Tensile Strength}}{\text{Maximum Stress}}$$

Figure 5.2: Safety Factor formula

Safety factor is the fraction of structural capability over that required or a multiplier applied to the maximum expected load (force, torque, bending moment or a combination) to which a component or assembly will be subjected. The two senses of the term are completely different in that the first is a measure of the reliability of a particular design, while the second is a requirement imposed by law, standard, specification, contract. Safety factor that are get from the calculation of the analysis is 15. This shows that the part is safely used because the safety factor is more than 1.

5.2.4 Shear stress factor

Table 5.1: Shear factor

Name	Shear Limit	Shear Factor
"Stress Tool 2"	Yield strength per material.	0.5

5.3 LIMITATION OF THE RAPID PROTOTYPING MACHINE

The machine which is used to produce the product is the Fused Deposition Modeling (FDM) machine. Material that used on this machine is Acrylonitrile Butadiene Styrene (ABS). A plastic filament is unwound from a coil and supplies material to an extrusion nozzle. The nozzle is heated to melt the plastic and has a mechanism which allows the flow of the melted plastic to be turned on and off. The nozzle is mounted to a mechanical stage which can be moved in both horizontal and vertical directions. Besides, this machine also have some limitation when produces the product. The machines only can produces the product with the size is about 10 inch length and 10 inch width. It also limited on the material of the product. The time to produce one part of the product also takes about 10 hours to be done. However, the PE has ability to float in the water due to density (950 kg/m^3) is less than density water 1000 kg/m^3.

5.4 SCENARIO 1

5.4.1 Model

This scenario shows the mass and the volume of the part which is get from the ANSYS CFX10 analysis. This analysis is form based on the fixed support analysis.

- The bounding box for the model measures 0.2 by 0.2 by 0.13 m along the global x, y and z axes, respectively.

- The model has a total mass of 1.92 kg.
- The model has a total volume of 2.02×10^{-3} m³.

Table 5.2: Bodies

Name	Material	Nonlinear Material Effects	Bounding Box(m)	Mass (kg)	Volume (m³)	Nodes	Elements
"pump holder"	*"Polyethylene"*	Yes	0.2, 0.2, 0.13	1.92	2.02×10^{-3}	22128	12387

5.4.2 Structural Support

This is the fixed support used to analyze the structural of the part. The reaction moment of the part when the force 220 N is applied on it is about 0.17 N.m. This shows that the part has a few displacements even though the fixed surface is applied.

Table 5.3: Structural Supports

Name	Type	Reaction Force	Reaction Force Vector	Reaction Moment	Reaction Moment Vector
"Fixed Support"	Fixed Surface	220.0 N	[0.0 N x, 0.0 N y, 220.0 N z]	0.17 N·m	[-8.43×10^{-3} N·m x, 0.17 N·m y, 0.0 N·m z]

5.5 Structural Load

Table 5.4: Structural result

Name	**Scope**	**Minimum**	**Maximum**	**Minimum Occurs On**	**Maximum Occurs On**	**Alert Criteria**
"Equivalent Stress"	*"Model"*	443.04 Pa	2.73×10^{7} Pa	pump holder	pump holder	None
"Maximum Shear Stress"	*"Model"*	255.78 Pa	1.57×10^{7} Pa	pump holder	pump holder	None
"Total Deformation"	*"Model"*	5,711.76 m	5,711.8 m	pump holder	pump holder	None

This is the result when the displacement is applied on the structural part. From the value given, it can show that the maximum stress that can be performed on the part is about 2.73×10^{7} Pa with the load is 220 N. If the load is more than that, the stress might be more that the actual stress and the part going to be failure.

5.6 SCENARIO 2

5.6.1 Model 2

This scenario shows the mass and the volume of the part which is get from the ANSYS CFX10 analysis. This analysis is form based on the displacement analysis.

- The bounding box for the model measures 0.5 by 0.2 by 0.1 m along the global x, y and z axes, respectively.
- The model has a total mass of 8.21 kg.
- The model has a total volume of 8.64×10^{-3} m³.

Table 5.5: Bodies

Name	Material	Nonlinear Material Effects	Bounding Box(m)	Mass (kg)	Volume (m³)	Nodes	Elements
"holder Support"	*"Polyethylene"*	Yes	0.5, 0.2, 0.1	8.21	8.64×10^{-3}	3305	1941

5.6.2 Structural Load

Table 5.6: Structural Loads

Name	Type	Magnitude	Vector	Reaction Force	Reaction Force Vector	Reaction Moment	Reaction Moment Vector

"Force"	Surface Force	240.0 N	[0.0 N x , 0.0 N y, - 240.0 N z]	N/A	N/A	N/A	N/A
"Displacement"	Surface Displacement	0.01 m	[0.01 m x, - y,- z]	4.66×10^{-3} N	[4.66×10^{-3} N x, 0.0 N y, 0.0 N z]	3.67×10^{-5} N·m	[0.0 N·m x, 0.0 N·m y, 3.67×10^{-5} N·m z]

This is the result when the displacement is applied on the structural part. From the value given, it can show that the displacement surface can be performed on the part is about 0.01 m with the load is 240 N. If the load is more than that, the displacement might be more that the actual displacement and the part can have more vibration from the floating pump.

CHAPTER 6

CONCLUSIONS

Major focus for this project is to improve the design for the floating pump platform which has the applications of holding, supporting and clamping the pump securely during the operation of the pump. The final year project report it consists of few important chapters that the Author has categorized it:

Introduction – Introduction is an overview of the floating pump platform system. It based on a broad introduction pertaining to the relevance, initiation of the project and some brief description of the project. It is basically, definition of how the current and manual system works, its performance, and its potential for future floating pump device markets. Apart from that, in this section also the Author describe the objectives and importance of the project.

Limitation – Limitation is a definition of the problems and weaknesses of the existing current and manual system and problems with existing online system that currently in operation.

New Idea – Here, the Author defined and discussed some solutions and new ideas based on the existing current technology and existing floating pump devices that in operation. The Author has provided some possible solutions that will give benefits and leads into system improvement.

Software/Hardware Development – In this section, the Author have discussed and justified some fact-finding methods used that include interviewing, observations, Internet surveys, and questionnaires. Then, system description and flow is shown in the form of diagrams and table that includes Entity Relationship Diagram, Data flow

Diagram, and so on. Apart from that, the Author has also mentioned about systems' requirements, how the implementation carried out and some testing conducted to verify and validate system performance. All these are done through information gathering, analysis, design, construction, and testing process.

Result/Discussion – This is based on the analysis of the product design using the ANSYS and the MSc Nastran/Patran software on how the platform can support the pump securely during the pump operation. This can be based on testing results, questionnaires that will show the system capability and performance. Based on this testing process, users' satisfaction and needs will be revealed.

Conclusion – Summaries of the developed project that include all the steps and activities that carried out through the system proposal to the end of the implementation and testing for acceptance process.

All these chapters describe how the Floating Pump System development is carried out. It shows direct explanation, description, and implementation that allow readers to understand and get some basic ideas on what Floating Pump System is all about. Even though, there are some shortcomings in the documentation and in the system, but what most important is, the main requirements and problems of the existing system has been meet and key area has been covered.

The recommendations for the future study are:

- ✓ Testing analysis at the actual platform in the real world.
- ✓ Analysis also can be done using the others software on Finite Element Method.
- ✓ Economic method to fabricate the platform.

Future Development

As for the future works, there will be a 1 click menu section for users to manipulate the functions for different way of handling fire. Here, the users can choose based on the level of the fire burning by triggering proper rate of fire handling. It will be the fast, efficient, scalable functions solution for them to get together. Apart from that, there will some expansion on the features utility for users, which tend to be user friendly. There will not be any major changes but there will better improvements in term of ease of use, floating pump capabilities and some extra features that will benefits all.

Then, as for the customers, there will some modification to provide and improve the current technology based on their requirements since we all know customers are always right. They know what they talking about since they used the system and they experienced it. The security aspect also will be improved to make sure it will not cause any errors. Here, what the Author intend to do is, there will be function called confirmation triggering will be added to avoid unauthorized users to access the system and also to verify they are aware the use of each function. Current security implemented is not efficient and stable enough.

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APPENDICES

A Questionnaire for Design the Scoring Matric

Questionnaire:

Which the criteria that are list below is the most important for a floating pump platform design?

a) Easy of Clamping
b) Easy of used
c) Easy of manufacture
d) Portability
e) Lightweight

Result of the questionnaire:

Selection criteria	No. of people tick the answer	Percentage
Easy of clamping	5	21.7 %
Easy of Use	4	17.4%
Easy of manufacture	5	21.7%
Portability	5	21.7%
Lightweight	4	17.4%
TOTAL	**23**	**100%**

Below shows the table weight of each selection material:

Selection criteria	Weight
Easy of clamping	5
Easy of Use	4
Easy of manufacture	5
Portability	5
Lightweight	4
TOTAL	**23**