



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DESIGN AND ANALYSIS OF STEP CLAMP USING SAND
CASTING AND RAPID PROTOTYPING**

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

by

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DECLARATION

I hereby, declared this report entitled “Design and Analysis of Step Clamp Using Sand Casting and Rapid Prototyping” is the result 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 fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design) (Hons.). The member of the supervisory committee is as follow:

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ABSTRAK

Tajuk projek ini adalah “Rekabentuk dan Analisis ‘Step Clamp’ Menggunakan Penuangan pasir dan Rapid Prototyping”. Projek ini dengan mengenal pasti masalah yang berkaitan dan menetapkan objektif projek iaitu untuk menyiasat parameter reka bentuk bagi proses tuangan pasir untuk produk ‘Step Clamp’, untuk mereka acuan tuangan pasir berasaskan tetapan yang terbaik menggunakan perisian CAD iaitu Solidwork, dan juga untuk menganalisa acuan tuangan pasir menggunakan perisian CAD seperti ANSYS. Produk yang dipilih iaitu ‘Step Clamp’ telah direka bentuk menggunakan Solidwork dan telah ditukar kepada format STL untuk menghasilkan ‘Pattern’ menggunakan proses Rapid Prototyping. Kemudian, sembilan konsep reka bentuk acuan tuangan pasir telah direka bentuk dan dianalisis menggunakan ANSYS berdasarkan tetapan yang telah ditetapkan. Berdasarkan analisis, perbandingan telah dibuat dan reka bentuk acuan terbaik telah dipilih dan sesuai untuk digunakan dalam proses tuangan pasir.

ABSTRACT

The title of this project is Design and Analysis of Step Clamp Using Sand Casting and Rapid Prototyping. The project was started by identifying the problem statement, and the objective which is to investigate the design parameter of sand casting for step clamp, to design a casting mold based on the optimum parameter using CAD tools such as Solidwork and to analyze the sand casting mold using CAD software such as ANSYS. The chosen manufacturing tool, Step Clamp was designed by using Solidwork and converted into STL file to transform the design into casting pattern by using Rapid-prototyping process. Then, nine design concepts of the casting mold were designed and were analyzed by using ANSYS according to the analysis parameter set. Based on the analysis, the comparison had been made and the best design concept has been selected which is suitable to use in the sand casting process.

DEDICATION

I dedicate this report to my beloved family especially to my parents, my lecturers,
and also to my friends.

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In the name of Allah S.W.T the most Merciful and the most Beneficent. Thanks to Him because give me strength and ability to complete this project

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TABLE OF CONTENT

Abstrak	i
Abstract	ii
Dedication	iii
Acknowledgement	iv
Table of Content	v
List of Tables	ix
List of Figures	xi
List of Abbreviations	xiii
CHAPTER 1:INTRODUCTION	1
1.1 Background of the Project	1
1.2 Problem Statement	2
1.3 Objectives	3
1.4 Scope and Limitation	4
CHAPTER 2:LITERATURE REVIEW	5
2.1 Introduction to Casting	5
2.2 Advantages and Disadvantages of Casting	6
2.3 Casting Terminology	7
2.4 Design Consideration in Casting	10
2.4.1 Design of Section Geometry	10
2.4.2 Design of Gating System	14
2.4.3 Design of Pouring Basin	16
2.4.4 Sprue Design	16
2.4.5 Design of Runners and Gates	17
2.4.6 Design of Parting Plane	17
2.4.7 Design of Riser	18
2.4.7.1 Riser Shape	19
2.4.7.2 Riser Size	19

2.4.7.3	Positioning of Risers	19
2.4.8	Draft Consideration in Design	20
2.4.9	Design of Core and Cored Hole	21
2.5	Types of Moulds	23
2.6	Types of Patterns	24
2.6.1	Solid Pattern	24
2.6.2	Split Pattern	24
2.6.3	Skeleton Pattern	24
2.6.4	Match-plate Pattern	24
2.7	Casting Defects	25
2.8	Sand Casting	28
2.9	Types of Materials Used In Casting	30
2. 10.2.1	Aluminium-base Alloy	30
2.10	Casting's Material Temperatures	31
2.11	Types of Sand Used In Casting	32
2.11.1	Green Sand	32
2.11.2	Dry Sand	32
2.11.3	Parting Sand	32
2.11.4	Facing Sand	33
2.11.5	Backing Sand	33
2.11.6	System Sand	33
2.12	Product Description	33
2.13	Function of the product	34
2.14	Product specification	34
CHAPTER 3: METHODOLOGY		35
3.1	Project Overview	37
3.2	Define the Problem Statement, Objective, Scope and Limitation	37
3.3	Literature Review	38
3.4	Product Design	38
3.4.1	Solidwork	38
3.4.2	Designing the product	40
3.4.3	Product Analysis	40

3.4.4	Mold Design	41
3.5	Machine and Specifications	41
3.5.1	Fused Deposition Modeling (FDM)	41
3.6	Design Concept Analysis	43
3.6.1	Analysis Software (ANSYS)	43
3.7	Design Selection	44
3.8	Sand Casting Process	45
3.8.1	Processs	45
CHAPTER 4: RESULT		50
4.1	Design Concept	50
4.2	Analysis Setup	52
4.3	Result of the Analysis	53
4.3.1	Design Concept 1 Mold A	53
4.3.1.1	Scaled Residuals	53
4.3.1.2	Static Pressure	54
4.3.1.3	Density	54
4.3.1.4	Total Temperature	55
4.3.1.5	Internal Energy	55
4.3.1.6	Turbulent Viscosity	56
4.3.1.7	Wall Shear Stress	57
4.3.1.8	Velocity Magnitude	57
4.3.1.9	Streamline	58
4.3.2	Design Concept 1 Mold B	59
4.3.3	Design Concept 1 Mold C	60
4.3.4	Design Concept 2 Mold A	61
4.3.5	Design Concept 2 Mold B	62
4.3.6	Design Concept 2 Mold C	63
4.3.7	Design Concept 3 Mold A	64
4.3.8	Design Concept 3 Mold B	65
4.3.9	Design Concept 3 Mold C	66

CHAPTER 5: DISCUSSION	67
5.1 Static Pressure	67
5.2 Density	68
5.3 Total Temperature	69
5.4 Internal Energy	70
5.5 Turbulent Viscosity	71
5.6 Wall shear Stress	72
5.7 Velocity Magnitude	73
5.8 Ranking for Mold Design	74

CHAPTER 6: CONCLUSION	75
6.1 Conclusion	75

REFERENCES	76
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APPENDICES

A	Gantt chart PSM 1
B	Gantt chart PSM 2
C	Technical Drawing of Design Concept 1 Mold A
D	Technical Drawing of Design Concept 1 Mold B
E	Technical Drawing of Design Concept 1 Mold C
F	Technical Drawing of Design Concept 2 Mold A
G	Technical Drawing of Design Concept 2 Mold B
H	Technical Drawing of Design Concept 2 Mold C
I	Technical Drawing of Design Concept 3 Mold A
J	Technical Drawing of Design Concept 3 Mold B
K	Technical Drawing of Design Concept 3 Mold C

LIST OF TABLES

2.1	List of Advantages and Disadvantages of Casting	6
2.2	The advantages and disadvantages of the Pattern	9
2.3	Properties of Mold	9
2.4	Minimum recommended section thickness	10
2.5	Shrinkage allowance for different materials	13
2.6	Types of mold	23
2.7	Defects in Casting Process	25
2.8	Castings Temperatures of Commonly Used Metals and Alloys	31
2.9	Step Clamp Dimension in Inch	34
3.1	Fused Deposition Modeling (FDM)	42
3.2	The material builds temperature	42
3.3	<i>Sand Casting Steps</i>	46
3.4	General Characteristic of Casting Process	49
4.1	Parameter of Design Concept	50
4.2	Properties of Aluminum Alloy	52
4.3	Setup value for mold	52
4.4	Summary of data for Design Concept 1 Mold A	58
4.5	Summary of data for Design Concept 1 Mold B	59
4.6	Summary Data of Design Concept1 Mold C	60
4.7	Summary Data of Design Concept 2 Mold A	61
4.8	Summary Data of Design Concept 2 Mold B	62
4.9	Summary data of the Design Concept 2 Mold C	63
4.10	Summary data of the Design Concept 3 Mold A	64
4.11	Summary data of the Design Concept 3 Mold B	65
4.12	Summary data of the Design Concept 3 Mold C	66

LIST OF FIGURES

1.1	Step Clamp	2
1.2	Operational cost between machining and casting process	3
2.1	Schematic illustration of sand mold	8
2.2	Use of fillet	12
2.3	Fillet produces different size of hot spot at the joint	13
2.4	Shrinkage eliminated by change in design	13
2.5	Recommended section changes	14
2.6	Comparison between initial and modified design	14
2.7	Use of straight parting line eliminates possible defects in castings	18
2.8	Draft facilitates smooth withdrawal of patterns	20
2.9	Use of core	21
2.10	Use of a chaplet	22
2.11	Schematic illustration of sand mould, showing various features	28
2.12	The Step Clamp dimension	34
3.1	Methodology Flow Chart	37
3.2	Example of solid model by using Solidwork	39
3.3	3D drawing of the step clamp	40
3.4	Data of the Step Clamp	40
3.5	Fused Deposition Modeling (FDM)	42
3.6	ANSYS Workbench	43
3.7	Table of Ranking	44
3.8	Outline of Production Step in a Typical Sand Casting Operation	45
4.1	Properties of Aluminum Alloy	52
4.2	Scaled Residuals for Design Concept 1 Mold A	53
4.3	Static Pressure of Design Concept 1 Mold A	54
4.4	Density of the Design 1 Mold A	54

4.5	Total Temperature of the Design Concept 1a Mold A	55
4.6	Internal Energy of the Design Concept 1 Mold A	56
4.7	Turbulent Viscosity of the Design Concept 1 Mold A	56
4.8	Wall Shear Stress of the Design Concept 1 Mold A	57
4.9	Velocity Vector of Design Concept 1 Mold A	57
4.10	Streamline of the Design Concept 1 Mold A	58
5.1	Graph of the Maximum Pressure	67
5.2	Graph of the Maximum Density	68
5.3	Graph of the Maximum Total temperature	69
5.4	Graph of the Maximum Internal Energy	70
5.5	Graph of the Minimum Turbulent Viscosity	71
5.6	Graph of the Maximum Wall Shear Stress	72
5.7	Graph of the Maximum Velocity	73

LIST OF ABBREVIATIONS

CAD	-	Computer Aided Design
CATIA	-	Computer Aided Three-dimensional Interactive Application
J	-	Joule
Kg	-	Kilogram
m	-	Meter
mm	-	Millimetre
s	-	second
STL	-	Stereolithography
UTeM	-	Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

Chapter 1 roughly explained about this project which is the background of the project title, "Design and Analysis Step Clamp by Using Sand Casting Mold and Rapid Prototyping". The problem statement, the objectives, the scope and limitation for this project were also had been stated in this chapter.

1.1 Background of the Project

Manufacturing process contains many type of shaping processes. Sand casting process is one of the shaping processes. The cavity of the sand casting is made according to the design or shape of the pattern. The pattern is usually made from the actual product or made from the wood or other material such as metal or plastic which is according to the design of the actual product. In this project, the sand casting process is collaborating with other process called Rapid prototyping. The function of using Rapid prototyping is to make the pattern. So, student needs to design the pattern using any CAD tool such as Solidwork or CATIA. Then, the design will transfer to the Rapid-prototyping machine so that the design will be transformed into the actual pattern. Then, the pattern will be uses to make the sand casting mold. Before that, the sand casting mold is also designed in CAD software either Solidwork or CATIA.

Design of the pattern is according to the production tool that had been chosen by student. For this project, the tool chosen was called Step Clamp which is the tool that

used to clamp the injection mold. The student needs to design the pattern according to the dimension or shape of the step clamp. Figure 1.1 shows the actual Step Clamp that had been selected as a product for this project.



Figure 1.1 Step clamp

1.2 Problem Statement

Reducing a cost is one of the elements used in this project to maintaining the productivity of the product. The existing Step clamps were made using a machining process which is costly compared to casting. This could be seen in figure 1.2 where the operation cost is higher in machining for equipment and material.

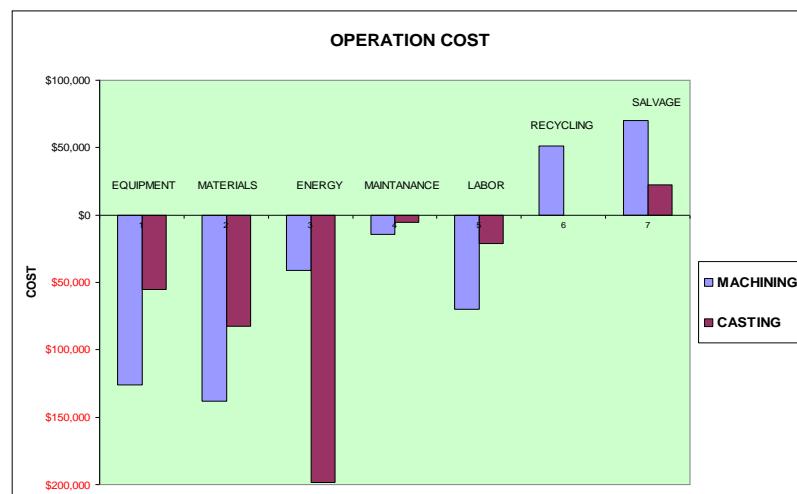


Figure 1.2: Operation Cost between Machining and Casting Process

In order to mass produce the product, casting process is chosen. The reason is the casting product is dependable on its design parameter. Therefore, the parameter analysis on the design is required to select the best design for the casting mold.

1.3 Objectives

The objectives that need to be achieved at the end of this project to fulfil the requirement needed for this project are stated as below:

- a) To investigate the design parameter of sand casting for step clamp.
- b) To design a casting mold base on the optimum parameter using CAD tools such as Solidwork.
- c) To analyze the sand casting mold using CAD software such as ANSYS.

1.4 Scope and Limitation

Selecting the best mold design of a Step Clamp is the main focus of this project. This project considered the optimum existing parameters when designing the casting mold using Solidwork and the designs were analyzed using suitable CAD software such as ANSYS.

The limitation of this project was dependent on the availability of material proposed either the mold or the product. Another limitation is furnace because the available furnace in the faculty is only capable of heating material for only 300°C and is not suitable to melt aluminum alloy. The actual choice of material for the product is also the limitation in this project.

CHAPTER 2

LIERATURE REVIEW

The literature review is also known as academic study is one of the earliest research processes to help in the process of the design development of a Step Clamp. Through this method early retrieval on a project weakness and advantage will be acquired through study method and comparison with present method and equipment. With this literature review also a product produced can fulfill current needs without fomenting.

2.1 Introduction to Casting

Casting is one of the shaping processes that used for converting molten material into finished products. The molten material is poured into a mold, which contains a cavity of the desired shape, and then allowed to solidify. The solidified part will be ejected or the mold will be broken out to complete the process. Casting materials are varied. The materials are usually metal or various cold setting materials that cure after mixing two or more components together such as epoxy, concrete, plaster and clay. Casting is most often used for producing a product that has a complex shape which is difficult or uneconomical to make by other methods of manufacturing processes.

In the principle of casting there are no limitation exist regarding the size or geometry of the parts. The limitations are usually depends on the material properties, the melting temperatures, the properties of the mold material which are mechanical, chemical, or thermal, and the material production characteristics whether it is used only once or many times.

In general, the differences among the casting processes are associated to the mechanical and thermal properties of the work and mold material, the suitable working temperature of the mold, the cooling method and cooling rate of the workpiece, the radiation of heat from the work and the mold material, the chemical reactions between the molten metal and the mold, the solubility of gas in the work material, and the functional requirements of the component (Wright, 1999).

2.2 Advantages and Disadvantages of Casting

Each manufacturing process has its own advantages and disadvantages. The selection of the suitable is depends on the requirement of the product that need to be produced. Therefore, an individual selecting manufacturing process for a particular job must weight not only the general but also the specific advantages and disadvantages of each possible processing technique. The table 2.1 shows the list of advantages and disadvantages of casting (Wright, 1999).

Table 2.1: List of Advantages and Disadvantages of Casting (Wright, 1999).

No.	Advantages	Disadvantages
1.	Products with complex forms and complicated internal and external shapes may be cast at relatively low cost.	Problems with internal porosity which traps air pockets.

2.	Materials such as certain alloys difficult to shape by using separating and forming techniques can be easily cast.	Dimensional variations due to shrinkage.
3.	Parts are often simplified. One-piece casting parts may require several pieces when using other techniques of manufacturing.	Trapped impurities, including solid and gaseous matter.
4.	Product design changes are often easily incorporated in casting.	Inability to produce high tolerance smooth surface especially in metals.
5.	Large or heavy metal parts may be cast. These parts may be economically or technically impossible to produce using other material processing techniques.	Inability to compete with stamping and deep drawing in production of thin or formed parts.
6.	High volume and low cost production is possible with casting.	Inability to produce metal parts with the toughness common to forged parts.

2.3 Casting Terminology

In the casting process, there are several terminologies that the designers need to know. A molding flask is a box that contains the molding aggregate. In a two piece mold, cope refer to the top half of the pattern, flask, mold or core and drag, the bottom half of any of these features. The seam between them is called parting line or parting surface. When more than two pieces are used the additional part is called cheek. Figure 2.1 shows of the example of the sand casting mold and also location of the casting of its features (Singh, 2008).

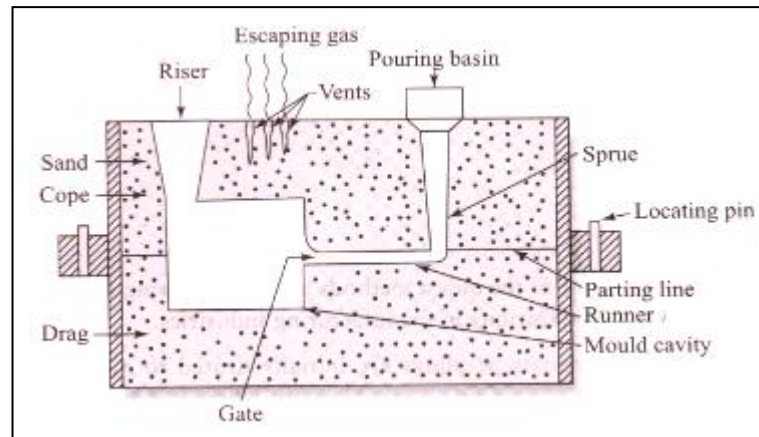


Figure 2.1: Schematic illustration of sand mold (Singh, 2008).

A pattern is the duplication of the part to be cast. The molding material that usually sand is packed around the pattern and then the pattern is removed to produce a mold cavity exactly of the size of the casting product that needs to be produced. A pattern may be made of wood, plastic or metal. There are several factors that influence the selection of a pattern material (Singh, 2008). The factors are listed below:

- 1) Size and shape of the casting.
- 2) Desired dimensional accuracy.
- 3) Number of castings to be produced.
- 4) Molding process to be used.

The strength and durability of the material selected for pattern is very important because the patterns are usually used repeatedly. Pattern is usually coated with a parting agent to ensure the patterns are easily to remove from the molds. Some patterns are removable or disposable type. For casting process that using removable pattern, sand is packed around the pattern and the pattern is removed so that the cavity is produced. Then, the cavity produced is filled with a molten metal (Singh, 2008).