



Faculty of Mechanical and Manufacturing Engineering
Technology

DESIGN AND DEVELOPMENT JIG AND FIXTURE FOR
WATERJET MACHINE

SHHRUL AFFIFUDIN BIN MOHD SAFEAI

B071610809

951020-10-6675

Bachelor of Manufacturing Engineering Technology (Process and Technology) with
honours
2019

DECLARATION

I hereby, declared this report entitled “Design and Development Jig and Fixture for Waterjet Machine” is the results of my own research except as cited in references.

Signature :

Author's Name : Shahrul Affifudin Bin Mohd Safeai

Date :

APPROVAL

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

.....

En. Abd Khahar Bin Nordin

ABSTRACT

AWJM or WJM are no longer foreign process in manufacturing industry. AWJM and WJM are non-traditional or non-conventional machining process. This process able to cut a wide range of materials using a high-pressure water jet or a combination of water and abrasive powder. Other than that, Jig and fixture is also one of the manufacturing tools that can minimize the loading and unloading time of the workpiece and thus improve the production efficiency performance. Previous design of the jig is simply by piling heavy objects to keep on top of the workpiece. This project is to develop a new suitable design that can improve the time loading and unloading time. Process or method that been used to fabricate this project are using laser cutting machine to cut the raw material of 3mm mild steel plate into a desire shape. Milling process to make a slot at the jig so it can be attached to the waterjet table by using a hook to make the jig sturdy when cutting process occur and welding process is to make joint of clamp bar with toggle clamp. At the end of this project is to see whether it achieve the objective of this project where it is to develop new design of jig and fixture and improving the time loading and unloading.

ABSTRAK

AWJM ATAU WJM tidak lagi proses yang asing dalam industri pembuatan yang kian membangun kini. AWJM dan WJM adalah salah satu proses pemesinan yang bukan tradisional proses yang dilakukan menggunakan mesin ini boleh memotong bermacam-macam jenis material dengan menggunakan tekanan air yang kuat dengan serbuk campuran bahan kasar. Selain itu, jig dan lekapan juga salah satu alat yang boleh meminimalkan masa untuk memasukkan dan mengeluarkan bahan kerja dan seterusnya meningkatkan produktiviti prestasi di dalam pengeluaran. Reka bentuk jig sebelum ini hanya meletakkan baranng-barang yang berat untuk memastikan bahan kerja itu tidak bergerak. Proses dan cara fabrikasi yang digunakan untuk membuat projek ini adalah dengan menggunakan mesin pemotongan laser dimana ia memotong plat "Mild steel" setebal 3mm ke bentuk yang diinginkan. Mesin "milling" digunakan untuk membuat slot supaya jig dan meja "waterjet" berada dalam keadaan yang kukuh apabila proses pemotongan berlaku dan proses percantuman pula untuk membuat penyambungan diantara plat pengapit dengan togol pengapit. Diakhir projek ini adalah untuk memastikan objektif projek ini tercapai dengan penukaran reka bentuk yang baru.

DEDICATION

To my father, Mr Mohd Safeai and to all my sibling I will never had a chance to say thank you for all your support for everything that I'm doing right now. I dedicate this report to my family which encourages me and support my passion toward my studies and joyful experience. Also thanks to my friends who helped me through all this year studies. Last but not least, my supervisor, Mr Abd Khahar Bin Nordin that teach me and guide me all this time throughout this final year project. I would like to say thank you for all your advices and also I'm would like to say sorry for not being able to be best student for you through this 1 whole year that you have been guided me. May Allah bless all of them.

ACKNOWLEDGEMENT

In the name of Allah, the most Gracious and most Compassionate.

Alhamdulillah, I praised to Allah S.W.T for giving opportunity strength to go through this Bachelor Degree Project. Firstly, I want to thanks my father Mr Mohd Safeai Bin Shaari for their support and unconditionally love to me. Thanks for all of the prayers and I really love you so much. Secondly, I want to give my highest gratitude to my Final Year Project Mr Abd Khahar Bin Nordin for supervising and supporting me to go through this project. I really appreciate every opinion, advice and knowledge that you gave to me, it really helps me to become a better person in the future. I'm very thankful for the time that he had been spent for the study and correcting my mistake even though he had busy working schedule. I also want to thanks all the technician and Universiti Teknikal Malaysia Melaka for allowing me to use the laboratory in order to complete my project. I would like to express thank to all my friends because helping me directly and indirectly during this project.

TABLE OF CONTENT

DECLARATION	i
APPROVAL	ii
ABSTRACT	iii
ABSTRAK.....	iv
DEDICATION	v
ACKNOWLEDGEMENT	vi
TABLE OF CONTENT	vii
LIST OF FIGURE	xi
LIST OF TABLE	xiv
LIST OF ABBREVIATION AND SYMBOL	xv
INTORDUCTION	1
1.1 Project background	1
1.2 Problem statement.....	1
1.3 Objective	2
1.4 Work scope	2
1.5 Gantt Chart.....	3
LITERATURE REVIEW	5
2 Introduction	5

2.1	Design and development.....	5
2.1.1	Design and Development Process	6
2.1.2	Product Design Analysis	7
2.1.3	Type of Software	10
2.2	Abrasive Waterjet Machining and Waterjet Machining	12
2.2.1	History	13
2.2.2	Type Water Jet cutting.....	14
2.2.3	Part of Abrasive Water Jet Machining	16
2.2.4	Abrasive Water Jet Machining Operational	21
2.2.5	Parameter Abrasive Water Jet Machining	23
2.3	Jig and fixture	25
2.3.1	Jig	25
2.3.2	Fixture.....	26
2.4	Classes of Jigs	28
2.5	Types of Jig.....	29
2.5.1	Template Jig	29
2.5.2	Plate Jig	30
2.5.3	Sandwich Jig.....	30
2.5.4	Box Jig.....	31
2.6	Type of Fixture	32
2.6.1	Vise-Jaw Fixture.....	32
2.6.2	Milling Fixture.....	33

2.6.3	Plate Fixture.....	34
2.6.4	Angle Plate Fixture.....	35
2.7	Elements of Jigs and Fixtures	36
2.7.1	Tool Body.....	36
2.7.2	Locating device.....	37
2.7.3	Tool Guide / Bushes	38
2.7.4	Clamping Device and Workholding Principle.....	39
METHODOLOGY		41
3	Introduction	41
3.1	Process Flow	41
3.2	Conceptual Sketch	43
3.3	3D CAD Design.....	44
3.4	Material Preparation	46
3.5	Machining Process	48
3.5.1	Laser Cutting Process	48
3.5.2	Milling process	49
3.5.3	Welding Process	49
3.6	Concept result	50
RESULT AND DISCUSSION		52
4.1	Introduction.....	52
4.2	Expected result.....	52
4.3	Detailed Drawing with fabrication process.....	53

4.3.1	Jig plate.....	53
4.3.2	Clamp plate.....	55
4.3.3	Full assembly.....	57
4.4	Test run with 2 different size of ceramic	60
4.4.1	Small ceramic tile (295mm x 295mm).....	60
4.4.2	Big ceramic tile (396mm x 396mm)	62
4.5	Factor that affect the result.	63
4.6	Project limitation.....	64
CONCLUSION AND RECOMMENDATION.....		66
5.1	Introduction.....	66
5.2	Conclusion	66
5.3	Recommendation for future work.....	67
REFERENCES		68
APPENDICES.....		71

LIST OF FIGURE

Figure 2.1: flowchart design and development process	7
Figure 2.2: Design fixture by using design software to accommodate with friction stir welding (Vijaya Ramnath et al., 2018).....	8
Figure 2.3: Stress and deformation diagram for C45 (Vijaya Ramnath et al., 2018).....	10
Figure 2.4: Stress and deformation diagram for D4	10
Figure 2.5: Stress and deformation for H20	10
Figure 2.6:Solid modelling using Autocad inventor.	11
Figure 2.7: Solid modelling using Solidworks software.	12
Figure 2. 8: Water jet machine	13
Figure 2. 9: Pure Water Jet cutting	14
Figure 2. 10: Abrasive Water Jet cutting	15
Figure 2. 11: Abrasive Water Jet Machine parts	16
Figure 2. 12: Nozzle Water Jet	17
Figure 2. 13: Orifice head.....	18
Figure 2. 14: Mixing chamber abrasive water jet	19
Figure 2. 15: Linear intensifier pump diagram.....	20
Figure 2. 16: Rotary direct drive pump diagram	20
Figure 2. 17: Abrasive water jet diagram	21
Figure 2. 18: Flow of abrasive waterjet.....	22

Figure 2.19: Process input and output parameter Abrasive waterjet machining. (Patel & Shaikh, 2015).....	24
Figure 2. 20: Typical jig design (Chikwendu Okpala, 2015).	26
Figure 2. 21: Typical fixture design (Chikwendu Okpala, 2015).....	27
Figure 2. 22: Boring jig is used to bore holes that are either too wide to drill or have to be made of an unusual size. (Hoffman, 2004).....	28
Figure 2. 23: Drill jig are used for drilling, reaming, chamfering, counterbore, reverse spot or reverse counterbore. (Hoffman, 2004)	29
Figure 2. 24: Template Jig	29
Figure 2. 25: Plate Jig	30
Figure 2. 26: Sandwich jig.....	31
Figure 2. 27: Box type Jig	31
Figure 2. 28: Vise-jaw Fixture diagram.....	33
Figure 2. 29: Underside milling base (Nagpal, 2012)	34
Figure 2. 30: Plate fixture diagram (Hoffman, 2004).....	35
Figure 2. 31: Modified angle plate fixture.....	35
Figure 2. 32: clamping forces	40
Figure 3.1: Concept sketch for clamping fixture at waterjet machine.....	43
Figure 3. 2: Amendment concept sketch jig and fixture for waterjet machine	44
Figure 3.3: Choice of selection in Solidwork software	45
Figure 3.4: selection of plane	45
Figure 3.5: 3mm mild steel plate	46
Figure 3.6: Toggle clamp	47
Figure 3.7: Nut.....	47

Figure 3.8: Hook.....	47
Figure 3. 9: laser cut machine that use to cut raw material of mild steel plate 3mm	48
Figure 3. 10: Milling machine use to make a drilling slot at the jig.....	49
Figure 3. 11: MIG welding machine	50
Figure 3.12: Assembly base clamping fixture with toggle clamp	50
Figure 3.13: Base plate fixture	51
Figure 3.14: Base Plate Fixture drawing	51
Figure 4. 1: Drawing part for jig that attached to waterjet table.	53
Figure 4. 2: single part of L-shape bar	54
Figure 4. 3: Mild steel plate 3mm thickness cut using laser jet machine	54
Figure 4. 4: Drawing part for clamping device	55
Figure 4. 5: Parameter of MIG welding machine which is 3.4 mm/min feed and 14.2 volt.	56
Figure 4. 6: Clamp bar welded with toggle clamp	56
Figure 4. 7: toggle clamp welded to base plate jig	57
Figure 4. 8: full assembly drawing for waterjet jig and fixture.....	58
Figure 4. 9: full fabrication of product	58
Figure 4. 10: product tested at waterjet machine.....	59
Figure 4. 11: previous design jig and fixture for waterjet machine.....	60
Figure 4. 12: Time taken for loading and unloading in second (small tile)	61
Figure 4. 13: Time taken for loading and unloading in second (big tile).....	63
Figure 4. 14: bar curve one slot away from the origin	64

LIST OF TABLE

Table 1.1	Gantt Chart PSM 1	3
Table 1.2	Gantt Chart PSM 2	4
Table 2.1	The properties and values were taken from the standard material values to be insert to analysis software where C45 (Cast iron), D4 (Die steel) and H20 (Tool steel and Hard alloy) (Vijaya Ramnath et al., 2018).	17
Table 4.1	Time taken for loading and unloading for small ceramic tile	61
Table 4.2	Time taken for loading and unloading for big ceramic tile	62

LIST OF ABBREVIATION AND SYMBOL

AWJM	–	Abrasive Water Jet Machine
WJM	–	Water Jet Machine
AWJ	–	Abrasive Water Jet
MVP	–	Minimum Viable Product
N/mm ²	–	Newton per metre square
mm	–	millimetre
C45	–	Cast iron
D4	–	Die steel
H20	–	Tool steel and Hard alloy
CAD	–	Computer Aided Design
MEP	–	Mechanical, Electrical and Plumbing Engineering
HAZ	–	Heat Affected Zone
Psi	–	Per square inch
SiO ₂	–	Silica Oxide or sand
m/s	–	metre per second

UHP	–	Ultra High Pump
NTM	–	Non Traditional Machining
MPa	–	Mega Pascal
MRR	–	Material Removal Rate
SMAW	–	Shielded Metal Arc Welding
TIG	–	Tungsten Inert Gas
MIG	–	Metal Inert Gas
Etc	–	Et cetera

CHAPTER 1

INTRODUCTION

1.1 Project background

Nowadays, Abrasive Water Jet Machining (AWJM) has been one of the convenience need in the industry world. AWJM and WJM are non-traditional or non-conventional machining process. Other than that, jig and fixture is also one of the need in manufacturing where the jig and fixture is one of the tool that can decrease loading and unloading time for workpiece thus, increase productivity output of the production. The importance of this project is to develop new design of fixture clamping for waterjet machine that can replace an older fixture that can hold the workpiece more securely.

1.2 Problem statement

Previous design jig and fixture for water jet machine are too big that consume a lot of space at the table. Other than that, the jig need an additional attachment to make it useable for small ceramic tile also when to clamp and unclamped the workpiece to the jig it need to loose the screw first so it takes a lot of time for loading and unloading the workpiece.

1.3 Objective

In order to finish the Final Year Project, there are some objectives that must be accomplished. The objective is:

- 1) To develop a new design jig and fixture for waterjet machine
- 2) Reducing time for loading and unloading.

1.4 Work scope

This Final Year Project, the experiment will be conducted at the FTK Manufacturing Process Laboratory by using Abrasive Water Jet Machine (AWJM). The model type is Mach2 1313b with 80 mesh of the abrasive size. The fixture will be design and fabricate by using SolidWork software and conventional machining process. Meanwhile, the fixture will be produce by using 3mm mild steel plate.

From this project, data will be collect and compare to the existing fixture whether the newer fixture achieved the objective that been set. Furthermore, this project primarily focused on design and development the existing fixture to new model of fixture. A good jig and fixture will increase machining accuracy and increase the productivity while decrease the manufacturing cost.

1.5 Gantt Chart

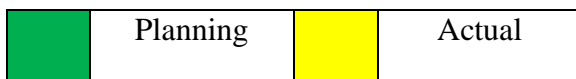
Table 1.1: Gantt Chart PSM 1

Project Activity	Weeks														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Choose and confirm the project title	Planning	Actual													
Collecting data and information		Planning	Actual												
Submit project proposal online		Planning	Actual												
Writing chapter 1					Planning	Actual									
Writing chapter 2							Planning	Actual							
Writing chapter 3									Planning	Actual					
Compile report											Planning	Actual			
Submit a report to the supervisor and panel													Planning	Actual	
Presentation														Planning	Actual

	Planning		Actual
--	----------	--	--------

Table 1.2: Gantt chart PSM 2

Project Activity	Weeks														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Concept sketch amendment	Planning	Actual													
Preparation of raw material		Planning	Actual												
Fabrication project		Planning	Actual	Planning	Actual	Actual	Actual	Actual							
Testing product and take data					Actual	Actual			Actual	Actual					
Writing chapter 4 & 5								Actual	Actual	Actual	Actual	Actual			
Compile report										Actual	Actual	Actual			
Submit full report to panel												Actual	Actual		
Presentation														Actual	Actual



CHAPTER 2

LITERATURE REVIEW

2 Introduction

From this chapter, it will have the overview background information about the project. Information have been gathered from the journal, book and also an article about project. Indirectly, this will help me to gain knowledge about the project that I want to produce which is “Design and development jig and fixture for waterjet machine. This chapter will provide explanation facts about design and development, abrasive waterjet machining thus jig and fixtures.

2.1 Design and development

According to (Blanchard, B. S., and W. J. Fabrycky, 2010) Design and development is the way toward characterizing the segments, modules, interfaces, and information for a system design to fulfil indicated necessities. Framework advancement is the way toward making or changing frameworks, alongside the procedures, practices, models, and philosophies used to create them. Other than that, product development regularly alludes to the majority of the stages engaged with bringing an item from an idea or thought, through

market discharge and past. At the end of the day, item improvement fuses an item's whole adventure, including:

- Identifying a market need
- Conceptualizing and designing the product
- Building the product roadmap
- Developing a minimum viable product (MVP)
- Releasing the MVP to users
- Iterating based on user feedback

2.1.1 Design and Development Process

Design approach begin with a planning. Designer need to engrave their sketching with a gather of small team in order to analyse any possible clarification. In the amid of design idea stage, present direction in sketch form, useful and scientific clarification. For expanding the design approach, designer need to review the prospect and level of ambition. The author found that the current arrangement process in product development are conceptual design, detailed design, process planning, prototype manufacturing and testing. By comparing the traditional sequential method, an existing engineering is an organize way to blend in to the concurrent engineering design and product related to the process. Existing engineering encourage product designer to acknowledge the life sequel of product in early phase of product development. In order to develop product quality, lower cost, shorten the product development cycle, and fulfil customers' requirements, concurrent engineering requires product designers to take all the factors involved in the life cycle of a product into consideration (Xu, Li, Li, & Tang, 2007).

On the other journal, the author stated that designer capable to design a good product by realizing the characteristic of the product itself. For an example, the design for a three years old toy can be more captivating, educational and intact if there is greater consideration of a child general logical (morris, 2016).

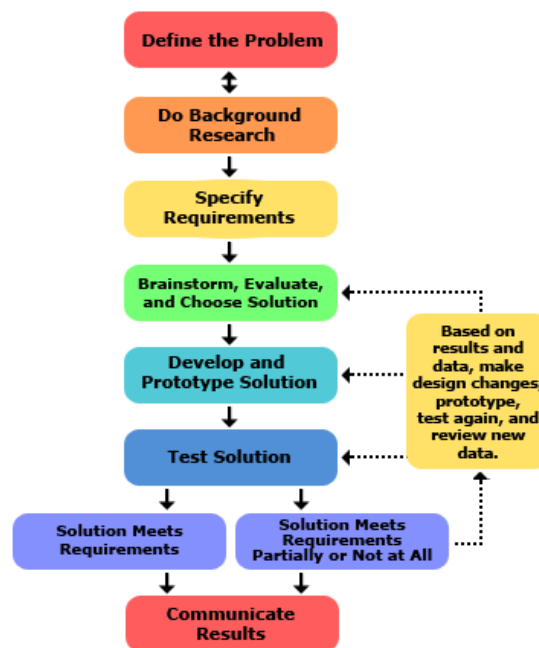


Figure 2.1: flowchart design and development process

Source: <https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-process-steps>

2.1.2 Product Design Analysis

In product development the most crucial part is in the early phase. The pioneer idea to develops a functional prototype are determined once all the feature of product requirement is being comply and a strategy is decided. At this point, design analysis plays as the key factor to assure the project starts and stay on track. Design analysis usually linked to part of design task where it can assist evaluate the efficiency of the