UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN FOR ASSEMBLY ANALYSIS FOR NEWLY DEVELOPED 3D ROUTER MACHINE

SHAHRUL AKMAL BIN ESMADEE

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A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Product Design) with Honours

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2023

DECLARATION

I declare that this Choose an item. entitled " Design For Assembly Analysis For Newly Developed 3d Router Machine " is the result of my research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : *Shahrul Akmal Bin Esmadee*

Date : 11 JANUARY 2023

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Product Design) with Honours.

Signature : .....

Supervisor Name : *Mrs. Umi Hayati Binit Ahmad*

Date : 11 JANUARY 2023

.....

DEDICATION

This work is wholeheartedly dedicated to all my valuable treasures:

For my beloved parent:
Mr. Esmadee Bin Nasrifan
Mrs. Kiswira Binti Tindek

For my supportive siblings:
Mrs. Nur Syahirah Binti Esmadee
Mr. Muhd Amirul Firdhaus Bin Esmadee
Mr Putra Eizlan Bin Esmadee

Thank you for always being there for me, morally, emotionally, and financially, and for giving me strength when I thought of giving up.

For my respective supervisor and co-supervisor:
Mrs Umi Hayati Binti Ahmad & TS. Dr. Hambali Bin Boejang

For all Utem lectures, Engineer Assistance, and my treasured friend:
Who shared their word of advice and encouragement to finish this study

ABSTRACT

CNC machines are widely used all over the world, and this CNC machine will undergo numerous improvements each year. As a result, there are numerous opportunities to learn, particularly for students studying Engineering Mechanical Technology. This thesis describes and applied the NPD process on creating a new product design idea by conducting research and studying the Engineering Design Phase. The ED process is critical, and being used to structure this newly developed CNC machine 3D router. This thesis are apply the ED phase, which consists of Formulation, Concept Design, Configuration Design, Parametric Design, and Detail Design. For Parametric Design, will not be covered because for this thesis only highligted DFA analysis which under the Configuration Design.Understanding the Problem Statement, which is this project's target market purpose on educational institutions such as technical high schools, vocational schools, and technology mechanical stream schools, before developing some new product. Beside to provide additional knowledge and exposure to students about CNC 3D routers, it will allow students to understand and be exposed to CNC machines more quickly. The primary goal of this research is to design and develop a new Y-axis sub assembly for a newly developed 3D router machine using CAD software and to compare DFA analysis using DFA 9.4 software on the Y-axis sub assembly between the current design (Original design) and the redesign (New design).

For this report methodology, it consisted of ED phase in which responsible in designing the Original design and DFA analysis was responsible on redesign the current design which make into the new design of Y-axis sub-assembly. There are many information are used to evaluate all the existing CNC milling machine that was applied in benchmarking method for this project. Some of the benchmarked existing CNC milling machine such as the Genmitsu PROVerXL 4030 CNC Router, the stepper motor type will be the benchmark because it can holding torque up to 4Nm and medium size and design that suit nicely and give aesthetic to the design. Then, the VFH Cam220 Classic router, the benchmark on the material used will be more focused because the aluminum material was light in weight and durability. With the right material, the stepper motor on the Y-axis will be more smoothed in power transmission. Lastly, the Carbide 3D Shapeko Pro 4 the benchmark on the transmit movement because ball screw gives precise movement for the axis due to low friction loss and high transmission efficiency. Therefore, generated the alternative concept for the feature such as the movement guide include linear rail block and bushing, transmit movement having lead screw, ball screw, and rodless cylinder, and lastly stepper motor type which consist of NEMA 17, NEMA 23, and NEMA 34. Then, total number combination for each alternative concept was 18 of the alternative concepts. Next, concept selection using the weight rating method resulting number 5 was selected from the 18 alternative concept generation where linear rail block, ball screw, and NEMA 23 where total rate are 3.75, 4.05 and 3.95 respectively. Furthermore, the final specification from the result for movement guide is linear rail block because it was more lighted than the bushing and more in aesthetic and durability. Meanwhile for transmit movement is ball screw due to low friction loss and high transmission efficiency with high precision. Last but not least stepper motor is NEMA 23 because holding torque up to 4Nm come with medium size and design that suit nicely and

give aesthetic to the design. Next, the Original 3D design was created by using Solidwork software

The DFA methodology able giving understanding the problems in the total assemble time for the Y-axis sub-assembly. This Y-axis subassembly has the same number of parts on the left and right sides. For the right side, it has additional part which is the number of bill of material (BOM) is 29 parts rather than left side only have 25 parts. The additional parts are limit switch board, limit switch mount, cap screw m5x25, and spring washer M5. Limit switch function to detect limit workspace that stop automatically when it touches and act as safety factor on newly develop CNC 3D Router machine for the user used. Then, following with DFA analysis result conclude in generate report suggestion fro redesign. For redesign new design of Y-axis sub-assembly, some redesign methods are part combination application and redesign part are applied. As result, it make a better production total assembly time. The total assembly time are generated automatically by DFA 9.4 software from DFA executive summary comparison which reduced from 848.23s to 559.46s. It shortens the assembly time about 317.67s or 34.04%. The reduction of assembly time contributed by the combination and redesign of certain part components based on DFA analysis result. This reduction of the part will improve the design efficiency.Therefore, the result for design efficiency was calculated and shown at the Table 3 below, where resulted the design comparison between Original design and New design show the huge gap of the total assembly time that effected with the total number of part decreases 9 part, and poorly increase on design efficiency around 0.46% but still acceptable

ABSTRAK

Mesin CNC digunakan secara meluas di seluruh dunia dan mesin CNC ini mengalami banyak penambahbaikan setiap tahun. Ini menghasilkan banyak peluang pembelajaran, terutamanya bagi pelajar kejuruteraan mekanikal. Tesis ini menerangkan dan menggunakan proses NPD untuk menjana idea reka bentuk produk baharu dengan menjalankan penyelidikan dan mengkaji fasa reka bentuk. Proses ED adalah asas dan digunakan untuk menstruktur penghala 3D mesin CNCyang baru dibangunkan ini. Kerja ini menggunakan fasa ED, yang terdiri daripada perumusan, reka bentuk konsep, reka bentuk konfigurasi, reka bentuk parametrik dan reka bentuk terperinci.Reka bentuk parametrik tidak akan diliputi kerana hanya analisis DFA yang terdapat dalam reka bentuk konfigurasi akan diserlahkan untuk kerja ini. Pemahaman terhadap masalah yang menjadi sasaran pasaran projek ini di institusi pendidikan seperti kolej teknikal, sekolah vokasional dan arus mekanikal-teknologi. sekolah sebelum membangunkan beberapa produk baharu. Selain menyediakan pelajar dengan pengetahuan tambahan dan cara menggunakan penghala CNC 3D, akan membolehkan pelajar memahami dan membiasakan diri dengan mesin CNC dengan lebih cepat. Objektif utama penyelidikan ini adalah untuk mereka bentuk dan membangunkan pemasangan sub-paksi Y baharu untuk mesin pengilangan 3D yang baru dibangunkan menggunakan perisian CAD dan membandingkan analisis DFA dengan perisian DFA 9.4 dalam subpemasangan paksi-Y antara reka bentuk semasa (reka bentuk asal) dan reka bentuk semula (reka bentuk baharu).

Untuk metodologi laporan ini, ia terdiri daripada fasa ED yang bertanggungjawab untuk mencipta reka bentuk asal dan analisis DFA yang bertanggungjawab untuk mereka bentuk semula reka bentuk semasa, menjadikan reka bentuk baharu sebagai subset kehendak Y - Axis. Terdapat banyak maklumat yang digunakan untuk menilai semua mesin pengilangan CNC sedia ada yang digunakan dalam metodologi penanda aras untuk projek ini. Bagi beberapa mesin pengisar CNC sedia ada yang telah dinilai, seperti penghala CNCGenmitsu PROVerXL 4030, jenis motor stepper akan menjadi penanda aras kerana ia boleh menyokong tork sehingga 4Nm dan saiz sederhana serta reka bentuk yang sesuai serta reka bentuk memberikan estetika. Kemudian penghala VFH Cam220 Classic, penanda aras dari segi material yang digunakan, akan lebih fokus kerana material aluminiumnya ringan dan tahan lasak. Dengan bahan yang betul, penghantaran kuasa motor stepper paksi Y akan menjadi lebih lancar.Akhir sekali, Carbide 3D Shapeko Pro 4 membandingkan pergerakan penghantaran kerana skru bebola menyediakan pergerakan tepat untuk paksi disebabkan kehilangan geseran yang rendah dan kecekapan penghantaran yang tinggi. Oleh itu, konsep alternatif telah dibangunkan untuk ciri seperti panduan gerakan termasuk blok rel linear dan sesendal, gerakan penghantaran menggunakan skru plumbum, skru bebola dan silinder tanpa rod, dan akhirnya jenis motor melangkah yang terdiri daripada NEMA 17, NEMA 23 dan NEMA34 . Jadi gabungan jumlah bagi setiap konsep alternatif ialah 18 daripada konsep alternatif. Pemilihan konsep kemudiannya disahkan menggunakan kaedah penarafan berat hasil #5 daripada 18 generasi konsep alternatif yang termasuk blok rel linear, skru bebola dan NEMA 23, dengan penilaian keseluruhan masing-masing 3.75 dan 4.05 dan 3.95. Selain itu, spesifikasi akhir hasil panduan gerakan ialah blok rel linear kerana ia lebih ringan daripada sesendal dan lebih estetik dan tahan lama. Manakala pergerakan penghantaran

adalah skru bebola kerana kehilangan geseran yang rendah dan kecekapan penghantaran yang tinggi dengan ketepatan yang tinggi. Akhir sekali, motor stepper ialah NEMA 23, memandangkan tork pegangan sehingga 4Nm disampaikan dalam saiz sederhana dan reka bentuk yang sesuai, memberikan reka bentuk estetik .

Metodologi DFA boleh memberikan pemahaman tentang isu yang berkaitan dengan masa pemasangan keseluruhan untuk subpemasangan paksi-Y. Subpemasangan paksi Y ini mempunyai bilangan bahagian yang sama di sebelah kiri dan kanan. Sebelah kanan mempunyai bahagian tambahan, nombor bil bahan (BOM) adalah 29 bahagian, berbanding sebelah kiri hanya mempunyai 25 bahagian. Bahagian tambahan ialah plat suis had, kurungan suis had, skru penutup M5x25 dan mesin basuh spring M5. Hadkan fungsi suis untuk mengesan had kawasan kerja, yang akan berhenti secara automatik apabila disentuh dan bertindak sebagai faktor keselamatan dalam mesin pengilangan CNC 3D yang baru dibangunkan untuk pengguna yang sedang digunakan.Kemudian, berdasarkan hasil analisis DFA, buat kesimpulan dengan menjana cadangan pelaporan reka bentuk semula. Untuk reka bentuk semula subpemasangan paksi Y, beberapa kaedah reka bentuk semula ialah penggunaan gabungan bahagian dan bahagian reka bentuk semula. Akibatnya, masa pengeluaran pemasangan keseluruhan bertambah baik. Jumlah masa pemasangan dijana secara automatik oleh perisian DFA 9.4 daripada perbandingan ringkasan DFAyang dikurangkan daripada 848.23s pada 559.46s. Mengurangkan masa pemasangan lebih kurang 317.67s atau 34.04%.Pengurangan masa pemasangan adalah disebabkan oleh gabungan dan reka bentuk semula komponen tertentu bahagian berdasarkan keputusan analisis DFA.

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LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
3D	-	3 Dimensional
CNC	-	Computer Numerical Control
DFMA	-	Design for Manufacturing and Assembly
DFA	-	Design for Assembly
DFM	-	Design for Manufacturing
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
PSM	-	Projek Sarjana Muda
UTeM	-	Universiti Teknikal Malaysia Melaka
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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter starts with an introduce to the background of this project and the problem statement followed by the research objective are state to recognise the main and clear objective that want to be achieve. Lastly, to help in achieve the research objective the scope of research are created for help to guide and avoide any unnasessary step.

1.2 Background

A Subtractive manufacturing (SM) is the process of developing three-dimentional (3D) objects by successively removing material from a solid block of material. Subtractive manufacturing can be performed manually, but it is most commonly done with a Computerized Numerical Control (CNC) machine. It is a computerised manufacturing process that controls the movement of production equipment using pre-programmed software and code. Advanced CNC machines use multiple tools and cut around at least three (x, y, and z) axes, reducing the need for operator to move the workpiece. It could be a block of metal, plastic, or wood, for example. Figure 1.1 are the example of 3D router machine in a market:

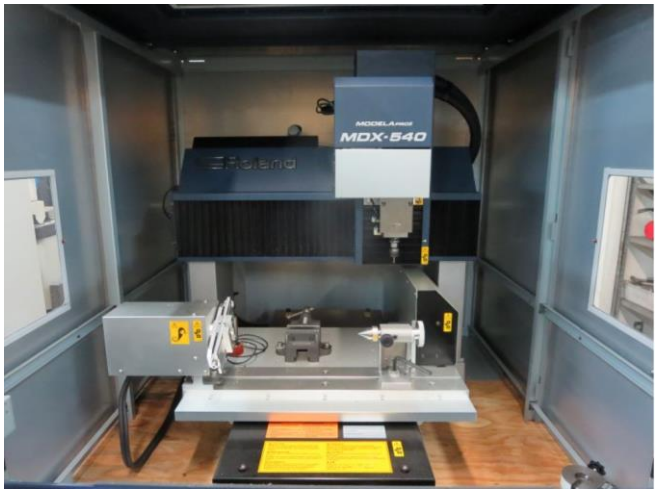

Figure 1.1: CNC 3D Router Machine available at Makmal Projek JTKP, FTKMP, UTEM.

Meanwhile, Talent Development Program (TDP): Developing Tomorrow's Engineering Expertise (TDP) is a program where these students are grouped under one organization or group and invent a large-scale project called CNC 3D router machines. The goal of this TDP program is to expose students to real-world situations when students enter the workforce. Fundamentally, this is the first program that was introduced by Dr Hambali bin Boejang on Disember 2021 with the Dean of Faculty of Mechanical and Manufacturing Engineering Technology (FTKMP) and other department heads'. This is due to the fact that this program can also provide students with real-world experience in learning something outside of their common skill and circumstances. This group's structure is similar to that of the professional world that includes investors, and it is led by project managers and other department heads. The logo of the TDP program selected for this time is shown in Figure 1.2.

Figure 1.2: Logo for Talent Development Program (Ibnur,2022)

1.3 Problem Statement

Nowadays, the cost of Computerized Numerical Control (CNC) 3 Dimentional (3D) router machines on the market is extremely high, creating a barrier for those who run a small business and do not have the financial capability to purchase 3D routers on the market. 3D router machine is a new product development project, so it offer a lot sapce for student to explore the potentional of the 3D router machine. Beside it is for education purposes to gain knowledge, it come with an affordable cost that can use by target institution example like polytechnics, vocational schools, skills schools, and secondary schools that take design and technology courses can buy this machine. Furthermore, there are many student in enggineering field that lack of knowledge and skill that need to be introduce to CNC 3D Router. Lastly, a typical CNC milling machine requires a large area, but this machine uses a tiny space. This machine is to help customers to cut customer costs from spending high money. Therefore, the research objective is produced based on the problem.