DESIGN AND FINITE ELEMENT ANALYSIS OF INTERFERENCE PRESS-FIT ALUMINUM NUT

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DECLARATION

I declare that this thesis entitle "Design and Finite Element Analysis of Interference Press-fit Aluminum Nut (INPREANUT)" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature: .....

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Date: 27/6/2014

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Manufacturing Engineering (Manufacturing System Engineering)

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DEDICATION

To my beloved parent, parent in-laws, wife, children, sisters and brothers for having the patience and supported me to reach this point. All of you provide me with a loving and supporting condition without giving up and also have encourage me in many ways. Without all of support, this journey would never have been accomplished.

ABSTRACT

Construction of mechanical platforms requires a suitable method for assembling two physical components. One of the assembly methods that are being used for discrete hardware component is called fasteners. In the world of Technical Vocational Education Training (TVET), some projects require students to design and produce a product that will involve the installation of mechanical components. Taking into account the difficulties faced to make such assembly, joining process involved cutting the parts accurately until the components could be mated together. Thus, the fastener innovation was rather innovated to provide a more effective alternative method. The Interference Press-fit Aluminum Nut (INPREANUT) has designed and manufactured to meet such purpose. Quality Function Deployment (QFD) is used to translate the user needs and requirements into technical requirements. Once this step is completed, Design for Manufacturing and Assembly (DFMA) is used to select the best approach in assembly to reduce the constraints such as assembly time, efficiency and most importantly, cost. During the design process of INPREANUT, the strength of the connection between INPREANUT with aluminum round tube was analyzed using Finite Element Analysis (FEA). The CATIA 3D software was employed to design INPREANUT being imported into ANSYS software to analyse the INPREANUT's shear strength. The strength of a mechanical connectivity is a key requirement to ensure that it has the expected friction force as well able to meet some of the other features. The features are easy to install, safe, light-weight, saves time and accurate. After completing the preliminary design and analysis, the INPREANUT is then fabricated and experiments performed to verify that the numerical methods used correlates with real measurement values. It is hoped that the INPREANUT fabrication will able to help students to make mechanical assembly components quickly, accurately and economically.

ABSTRAK

Pembinaan platfom mekanikal memerlukan kaedah yang sesuai bagi mencantumkan dua komponen diantaranya ialah komponen mekanikal diskrit iaitu fastener. Di dalam dunia pendidikan teknikal, beberapa projek memerlukan para pelajar untuk merekabentuk produk yang akan melibatkan proses pemasangan secara mekanikal. Dengan mengambilkira kesukaran yang dihadapi untuk membuat pemasangan pada penyambungan telah melibatkan proses pemotongan komponen sehinggalah kepada pemasangan, maka inovasi fastener telah dijanakan bagi menyediakan kaedah alternatif yang lebih efektif. Produk tersebut dinamakan Interference Press-fit Aluminum Nut (INPREANUT) telahpun direkabentuk dan dihasilkan bagi memenuhi tujuan tersebut. Teknik Quality Function Deployment (QFD) telah dipilih untuk menterjemahkan kehendak dan keperluan pengguna bagi mendapatkan mendapatkan maklumat teknikal. Seterusnya, Design for Manufacturing and Assembly (DFMA) telah digunakan bagi mendapatkan rekabentuk yang effisien dan mengurangkan kos. Semasa didalam proses rekabentuk, kekuatan penyambungan diantara INPREANUT dengan tiub bulat aluminum telah dianalisis dengan menggunakan Finite Element Analysis (FEA). Perisian 3D CATIA telah digunapakai untuk merekabentuk INPREANUT sebelum diimport kedalam perisian ANSYS bagi tujuan analisa kekuatan ricih. Kekuatan bagi penyambungan itu merupakan keperluan utama bagi menentukan bahawa ianya adalah boleh digunakan dan mempunyai ketahanan yang diharapkan disamping mampu memenuhi beberapa ciri-ciri yang lain. Ciri-ciri tersebut adalah mudah dipasang, selamat, ringan, menjimatkan masa dan tepat. INPREANUT kemudiannya difabrikasi dan dilakukan eksperimen bagi menentusahkan bahawa kaedah numerikal yang digunapakai memenuhi nilai sebenar pada penyambungan. Adalah diharapkan dengan menggalakkan penggunaan teknik fabrikasi dan pemasangan yang lebih selamat iaitu dengan menggunakan INPREANUT dengan tiub bulat aluminum akan dapat membantu para pelajar membuat pemasangan komponen mekanikal dengan cepat, tepat dan berpatutan.

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LIST OF ABBREVIATIONS

AEM	Assemblability Evaluation Method
DfMA	Design for Manufacture and Assembly
DfX	Design for X
DfA	Design for Assembly
DfM	Design for Manufacture
FEA	Finite Element Analysis
HOQ	House of Quality
INPREANUT	Interference Press-fit Aluminum Nut
QFD	Quality Function Deployment

CHAPTER 1

INTRODUCTION

1.1 Background

This chapter introduces the project as well as briefly describes the problem statements, objectives and its scope. This chapter will also provide an overview of the project's implementation.

Method that allow for easy to assemble and disassembly is the best method to be applied in student's design and build the project or mechanical construction model because of a few factors. The students are constrained with the time allocated and also need to work with the equipment and tools that will reduce the risk to harm them. Furthermore, the project need to be disassemble afterwards that due to storage constraint's and some parts is needs to be recycled by and for the next group of students. This situation reflect on the importance of disassembly that become as a premise in product recycling and also established important link of product remanufacturing (Tian et al., 2012). Furthermore, recycling, reuse and reduction (3R) of waste consider product disassembly pattern and modularity as a strategy to enhance 3R-abilities (Huang et al., 2012).

1.2 Problem Statement

The conventional method of permanent joint assembly such as rivet or welding the structure shows some difficulties and drawbacks. To overcome these issues, a new method for the joint assembly needs to be introduced. An innovative approach in improving mechanical fitting will be able to reduce the unnecessary process, increase safety aspect, allow students to modify the dimension of parts, relatively easy to assemble and disassemble, increase accuracy, reduce weight and reuse the parts. The key improvement in this approach is by mating the parts for locating round features within a round tolerance zone rather than the square traditional within a square tolerance zone. The mechanical fastener must meet the fits standard to signify the range of tightness or looseness that may result from the application of specific combination of allowances and tolerance in mating parts. Therefore, in this project the fastener is designed to meet the specified requirement.

However in the joining performance criterion are measured based on strength of the joint. To avoid unnecessary experimenting during the design process, a numerical model is the best option to be used. This is because the computer models can be used to make simulations and also prediction, uncertainty analyses or sensitivity studies (De Rocquigny et al., 2008). The finite element analysis (FEA) is one of the tools used to solve this type of problem. The developed numerical model, analyses the strength of mechanical assembly on which is then validated by experiment.

1.3 Objectives

The objectives of the project are as follows:

i. To design and validate INPREANUT based on the needs and the design efficiency.
ii. To performed Finite element analysis (FEA) of press-fit and pull-out INPREANUT
iii. To validate the FEA and hence the INPREANUT experimentally

1.4 Scope and limitation

The scopes of this project are as follows:

i. The Interference Press-fit Aluminum Nut (INPREANUT) is designed to joint aluminum hollow tubes with specified standard by using interference press-fit in manual assembly.
ii. The fastener will be modeled by using Mechanical CAD software (CATIA V5R18).
iii. The INPREANUT Finite element analysis (FEA) will be analyzed by using ANSYS software.
iv. The fastener fabrication will be done by the used of Didactic CNC Lathe machines and Conventional Lathe available in the workshop after machine capability is studied and understands.
v. The pull-out strength of assembly between INPREANUT and aluminum hollow tube will tested by using tensile test machine.
vi. The limitation of this project is that the INPREANUT will only be fabricated to match the hollow tube with inner diameter of, ∅10.9mm and ∅10.7mm.

1.5 Project Planning

The project milestone is shown in Table 1. The schedule is divided into two phases based on semester on which is for semester four and semester five. The project flow begins with a review of papers, Interference Press-Fit Aluminum Nut (INPREANUT) design, interference press-fit. The pull-out of INPREANUT shears strength will be analyses by using the Finite element analysis (FEA), INPREANUT fabrication, parts assembly and testing.

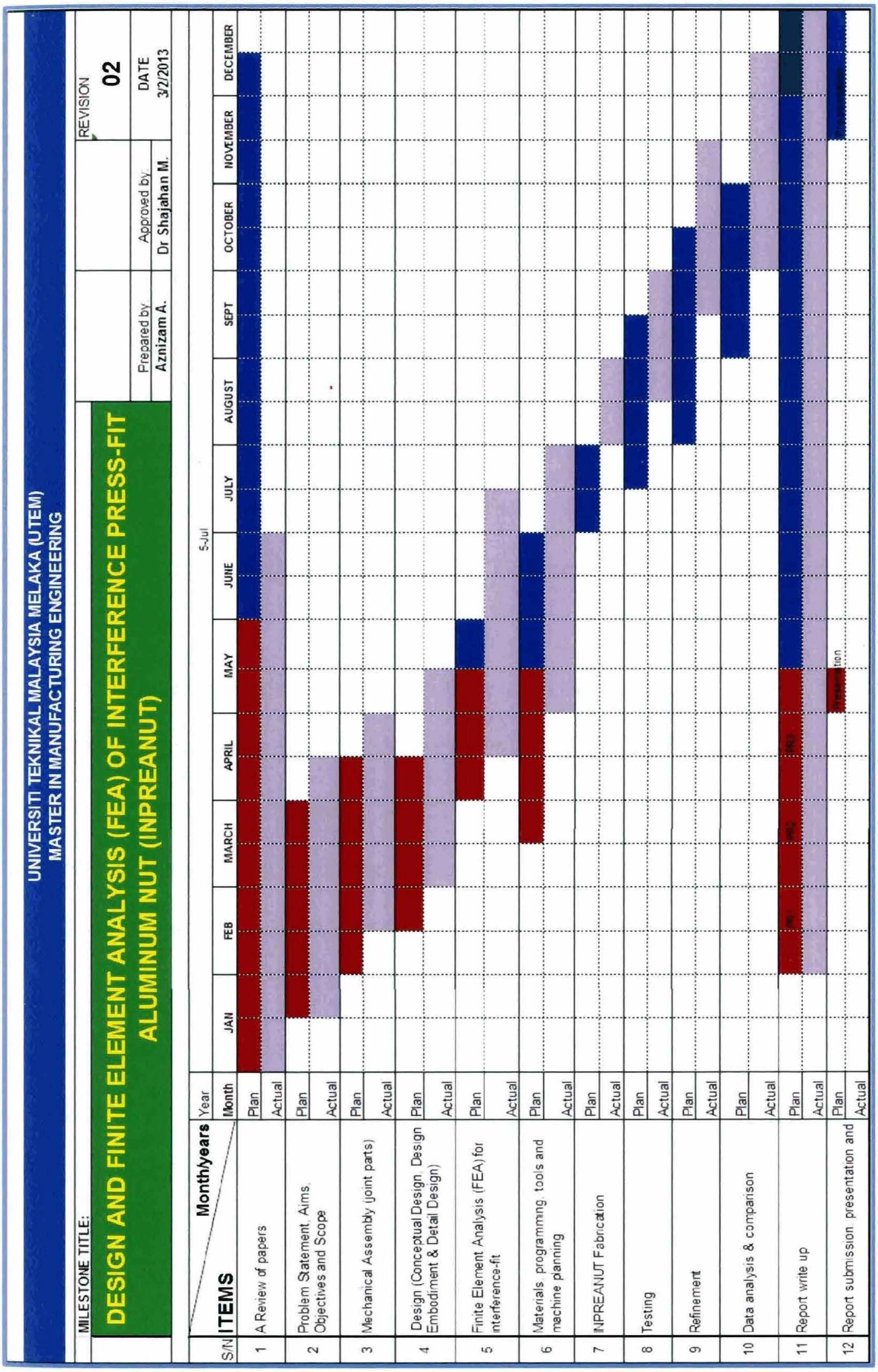

Table 1: Master Project Milestone Chart

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is divided into three major sections:

i. Mechanical fastening and integral mechanical attachment

ii. The concept of Design for Manufacturing/Assembly

iii. Finite element analysis (FEA) of Fasteners and Mechanical Joining

2.2 Mechanical fastening and integral mechanical attachment

Mechanical joining of parts or structural elements into assemblies or structures requires some means for developing interference forces or interlocking between those parts or elements at their mating or faying surfaces to prevent unwanted movement (at least in some directions) or unintentional disassembly (Messler, 2004).

Messler (2006) divides mechanical joints into two subgroups (i) mechanical fastening and (ii) integral mechanical attachment. The joining is achieved completely through mechanical force with at some scale interlocking arises resulting in physical interference among parts. At a macroscopic level, interlocking and interference arise from Designed-in or processed-in (or, in nature from naturally occurring) geometric features. In mechanical fasteners, the features are the result of the parts being joined and a supplemental of part or devices known as "fastener" whereas in integral mechanical