UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY OF EPOXY RESIN BONDING PROCESS OF ALUMINUM ALLOY : CHEMICAL PICKLING PROCESS (HYDROCHLORIC ACID)

This report submitted in accordance with the requirements of the University Technical Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Process) with Honours.

by

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Faculty of Manufacturing Engineering

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DECLARATION

I hereby declare that this report entitled **"STUDY OF EPOXY RESIN BONDING PROCESS OF ALUMINUM ALLOY: CHEMICAL PICKLING PROCESS (HYDROCHLORIC ACID)"** is the result of my own research except as cited in the references.

Signature	:	
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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 Process). The members of the supervisory committee are as follow:

Mr. MOHD FAIRUZ BIN DIMIN
(Main Supervisor)

ABSTRACT

This paper work describes about the analysis performance of metal to metal bonding (cold cured). The analysis focus on the surface combined using bonding technique. Normally, there have variety of graft or joining technique such as welding, riveting, or etc. The initial purpose for this project is to investigate the strength of the graft when using bonding process with chemical pickling (hydrochloric acid). This project also uses to make comparison and identify the strength of metal bonding using universal testing machine with different chemical pickling. The difference of the selective acid had been marked as to compare the effect of the bonding. This experiment applied an aluminum alloy typed '2018'as a work material with a dogbone shape. Work material will be cleansed from silicon base, oil, contaminant, dust or etc using ultrasonic bath. After that, it has to go for a process. Moreover, the process needs to continue with pickling process with the rate of concentration is about 5%-25 % and 2nd will be used immersion time about 1-5 minutes. When everything settled, the bonding will takes place using the cold cure technique. To put it in a nutshell, the specimen will be tested using Universal testing machine. As a result, the rough surfaces can strength the bonding area. The overall of the experiment need to be studied and some attentions time by time especially during the testing using Universal Testing Machine. A few factors were identified can give some effects to the bonding process and its need to be taken as a serious aspect to make sure the experiment will give an excellent result.

ABSTRAK

Kertas kerja ini menggambarkan tentang prestasi analisis ikatan logam ”cold cure” Tumpuan analisis adalah dengan menggunakan teknik ikatan secara sejuk (ibarat seperti gam). Biasanya, teknik ikatan yang digunakan adalah seperti teknik kimpalan, ikatan skru, dan sebagainya. Tujuan permulaan untuk projek ini adalah bagi mengkaji kekuatan ikatan yang dihasilkan menerusi kaedah rendaman acid (asid hidroklorik) di tempat yang hendak disatukan. Projek ini juga adalah untuk membuat perbandingan serta mengenalpasti tahap kekuatan ikatan logam menggunakan mesin ”Universal Tensile Machine”. Dua asid telah dipilih untuk membuat perbandingan terhadap kesan rendaman. Kerja pertama adalah membersihkan bahan kerja bagi mengelakkan daripada asas silikon, minyak, pencemaran debu dan sebagainya menggunakan kaedah mandian ultrasonik. Selepas itu, ia diteruskan dengan proses rendaman dan kadar kepekatan rendaman adalah 5% hingga 25% asid yang bercampur air manakala kajian kedua adalah mengkaji tempoh masa rendaman iaitu dari 1 minit hingga 5 minit meggunakan kepekatan rendaman yang sama. Apabila semuanya selesai, ikatan yang telah dicantumkan akan dibiarkan kering mengikut suhu bilik di dalam kebuk wasap. Untuk menilai kekuatan ikatan tadi, ia akan diuji menggunakan mesin khas iaitu mesin "Universal Tensile Machine. Hasil daripada ujian ini akan diulas dan direkodkan. Semua perjalanan proses ini harus diteliti bagi mendapatkan hasil yang baik.

DEDICATION

Special thanks for my supervisor.

For my beloved dad, mom, and my brother and my sister.

Especially for my special one.

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Bismillahhirrahmanirrahim.

Assalamualaikum

First of all, thank to ALLAH S.W.T for giving me the strength to complete this Project Sarjana Muda. Thank to my family for their support in every aspect.

Special thank to my supervisor, En. Mohd Fairuz B. Dimin, and UTeM's lecturer that helped and guided me throughout this project.

Last but not least, I would like to convey my appreciation to all the staff of Manufacturing Engineering Faculty, my friends and colleagues for their support and help in the project. Thank you.

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LIST OF ABBREVIATION

BSE	-	Back scattered electrons
HCl	-	Hydrochloric acid
H_2O	-	Moisture / water
PVC	-	Polyvinyl chloride
SEI	-	Secondary electron imaging
SEM	-	Scanning electron microscope
UTM	-	Universal Testing Machine
UTeM	-	Universiti Teknikal Melaysia Melaka
VARTM	-	Vacuum Assisted Resin Transfer Molding

CHAPTER 1
INTRODUCTION

1.1 Background

Adhesive bonding makes it possible to join non-weldable materials without using rivets or screws. It is used to join metals to non-metals such as plastic, wood, rubber, glass and porcelain. This bonding is also used and in the cases where welding the materials to be joined would cause adverse changes to their mechanical properties. Thin work pieces in particular which can only be riveted or welded at great expense or not at all, may be joined together by adhesive bonding. Moreover, adhesive bonding of metals can offer engineering and economic advantages in mass production.

In many industrial products and equipments, layered plates bonding is often found as a means of assembly. Especially in the semi-conductor and electronics industry, example in the fabrication of multi-layered microelectronic package or sputtering target assembly, quality bonding techniques are of utmost importance to avoid failures such as cracks due to residual stress or delaminating due to the shear stress at the interface. In this study, metal of a dough bone shape with the thickness is than 2mm are considered to be bonded, which consists of four sequential steps as: (1) ultrasonic bath, (2) applying chemical pickling, and (3) putting them together (bonding), and (4) cooling the assembly down to the room temperature for bonding(curing).

1.2 Objectives

The objective of this project is to determine and study the tensile strength using Universal Testing Machine (UTM) of Aluminum Alloy 2018 sheet joining together by bonding process and pre-treated chemical pickling used of Hydrochloric acid. Have to analyze different concentration level of acid being used during the pickling process. It is also the aim of this project to focus on the full process or technique of bonding process.

1.3 Problem Statement

It is known that pickling is an important part of metal bonding in enhancing the process. The study will determine the most suitable type of pickling chemical and it's concentration for the bonding process through analyzing the tensile strength result of the test sample.

1.4 Scope of Project

This project is done to analyze the different concentration level of pickling chemical to determine the best Aluminum Alloy bonding technique which is test in Chemistry Laboratory of UTeM. All of the samples will be analyzed using Universal Testing Machine. The discussion will be done based on the result obtained. The duration of study is almost one year which started on July 2008 until April 2009. The result may be not applicable for other organisation which is different production process.

CHAPTER 2

LITERATURE REVIEW

2.1 Epoxy

2.1.1 Introduction

In chemistry, epoxy or polyepoxide is a thermosetting epoxide polymer that cures (polymerizes and crosslinks) when mixed with a catalyzing agent or "hardener". Most common epoxy resins are produced from a reaction between epichlorohydrin and bisphenol-A. The first commercial attempts to prepare resins from epichlorohydrin were in the United States. Credit for the first synthesis of bisphenol-A-based epoxy resins is shared by Dr. Pierre Castan of Switzerland and Dr. S.O. Greenlee of the United States. Dr. Castan's work was licensed by Ciba, Ltd. of Switzerland, which went on to become one of the three major epoxy resin producers worldwide. Ciba's epoxy business was spun off and later sold in the late 1990s and is now the advanced materials business unit of Huntsman Corporation of the United States. Dr. Greenlee's work was for the firm of Devoe-Reynolds of the United States. Devoe-Reynolds, which was active in the early days of the epoxy resin industry, was sold to Shell Chemical (now Hexion, formerly Resolution Polymers and others).

2.1.2 Applications of epoxy

2.1.2.1 Adhesives

Epoxy adhesives are a major part of the class of adhesives called "structural adhesives" or "engineering adhesives" (which also includes polyurethane, acrylic, cyanoacrylate, and other chemistries.) These high-performance adhesives are used in the construction of aircraft, automobiles, bicycles, boats, golf clubs, skis, snow boards, and other applications where high strength bonds are required. Epoxy adhesives can be developed to suit almost any application. They are exceptional adhesives for wood, metal, glass, stone, and some plastics. They can be made flexible or rigid, transparent or opaque/colored, fast setting or extremely slow setting. Epoxy adhesives are almost unmatched in heat and chemical resistance among common adhesives. In general, epoxy adhesives cured with heat will be more heat- and chemical-resistant than those cured at room temperature. Some epoxies are cured by exposure to ultraviolet light. Such epoxies are commonly used in optics, fiber optics, optoelectronics and dentistry.

2.1.2.2 Industrial Tooling and Composites

Epoxy systems are used in industrial tooling applications to produce molds, master models, laminates, castings, fixtures, and other industrial production aids. This "plastic tooling" replaces metal, wood and other traditional materials, and generally improves the efficiency and either lowers the overall cost or shortens the lead-time for many industrial processes. Epoxies are also used in producing fiber-reinforced or composite parts. They are more expensive than polyester resins and vinyl ester resins, but usually produce stronger and more temperature-resistant composite parts.

2.1.2.3 Electrical Systems and Electronics

Epoxy resin formulations are important in the electronics industry, and are employed in motors, generators, transformers, switchgear, bushings, and insulators. Epoxy resins are excellent electrical insulators and protect electrical components from short circuiting, dust and moisture. In the electronics industry epoxy resins are the primary resin used in over molding integrated circuits, transistors and hybrid circuits, and making printed circuit boards.

2.1.2.4 Consumer and Marine Applications

Epoxies are sold in hardware stores, typically as a pack containing separate resin and hardener, which must be mixed immediately before use. They are also sold in boat shops as repair resins for marine applications. Epoxies typically are not used in the outer layer of a boat because they deteriorate by exposure to UV light. They are often used during boat repair and assembly, and then over-coated with conventional or two-part polyurethane paint or marine-varnishes that provide UV protection. There are two main areas of marine use. Because of the better mechanical properties relative to the more common polyester resins, epoxies are used for commercial manufacture of components where a high strength/weight ratio is required. The second area is that their strength, gap filling properties and excellent adhesion too many materials including timber have created a boom in amateur building projects including aircraft and boats.

2.1.2.5 Aerospace Applications

In the aerospace industry, epoxy is used as a structural matrix material which is then reinforced by fiber. Typical fiber reinforcements include glass, carbon, Kevlar, and boron. Epoxies are also used as structural glue. Materials like wood and others that are

'low-tech' are glued with epoxy resin. This design is based on a classic wooden lattice structured fuselage and a classic wooden spar, internally stiffened with foam and completely covered with plywood. Except for the plywood covering the wings, everything is glued with epoxy resin.

2.1.2.6 Wind Energy Applications

Epoxy resin is used in manufacturing rotor blades of wind turbine. The resin is infused in the core material like balsa, foam & reinforcing media glass fabric. The process is called VARTM i.e. vacuum assisted resin transfer molding. Due to excellent properties & good finish, epoxy is most favored resin for composites.

2.1.2.7 Chemistry

When epoxies are mixed with the appropriate catalyst, the resulting reaction is exothermic, and the oxygen on the epoxy monomers is "flipped." This occurs throughout the epoxy, and a matrix with a high stress tolerance is formed, and "glues" the materials together.

2.2 Bonding Process

2.2.1 Introduction of Bonding Process

Adhesive bonding is used mainly for attaching stringers to fuselage and wing skins to stiffen the structures against buckling. It is also used to manufacture stiff lightweight structures of metal honeycomb cores inside metal skins for the flight control component

structures (elevators, ailerons, spoilers, etc). The adhesive materials used for these purposes fall into three distinct groups. These are:

I. Metal/metal - Hot cure (The hot cure adhesive materials used by the aircraft industry are mainly based on either phenolic or epoxy resin systems).
II. Metal/metal honeycomb - Hot cure (Only epoxy systems are used for these applications. Epoxy adhesives form very mobile liquids as they reach the cure temperature and would run out of joints in metal to metal bonding situations if they do not contain flow modifying additives or scrim).
III. Metal to metal - cold cure (There are numerous two-part curing epoxy systems available. The Araldite series being particularly well known).

Adhesive bonding makes it possible to join non-weldable materials without using rivets or screws. It is used to join metals to non-metals such as plastic, wood, rubber, glass and porcelain. This bonding is also used and in the cases where welding the materials to be joined would cause adverse changes to their mechanical properties. Thin work pieces in particular which can only be riveted or welded at great expense or not at all, may be joined together by adhesive bonding. Moreover, adhesive bonding of metals can offer engineering and economic advantages in mass production.

According to Lazar.A (2003) Aluminum and magnesium-based light metals are particularly well-suited to adhesive bonding, non-ferrous heavy metals less so. Shear strength, i.e. the ratio of the breaking load to the bonding surface of a single-shear bonded joint, decreases as the yield point or elongation limit of the metal grows and the thickness of the adhesive film increases. The strength of the adhesive is a function of its structure and the conditions under which it is used. **Figure 2.1** shows the chemical reaction of bonding process.

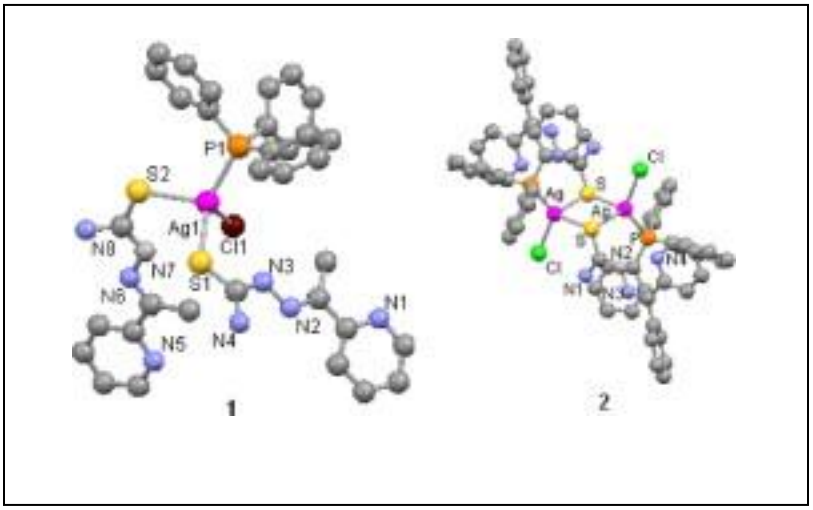

Figure 2.1: chemical reaction of bonding process

2.2.2 Principle of Adhesive Bonding

Numerous parts and components can be joined and assembled by adhesives rather than by one or more of the joining methods described thus far, Adhesive Bonding has been a common method of joining and assembly in such applications as labeling, packaging, book binding, home furnishings, and footware. Develop in 1905; plywood is a typical example of adhesive bonding with several layers of wood bonding with wood glue. Adhesive bonding has gained increased acceptance in manufacturing ever since its first use on a large scale: the assembly of load-bearing components in aircraft during World War II (1939-1945). Adhesive are available in various form; liquid, paste, solution, emulsion, powder, tape and film Kalpakjian.S (1991).

To meet the requirements of a particular application, an adhesive may require one or more properties such as strength: shear and peel, toughness, resistance to various fluids and chemicals, resistance to environmental degradation, including heat and moisture, capability to wet the surfaces to be bonded.

2.2.3 Type of Adhesive

Several type of adhesive are available, and more continue to be developed that provide adequate joint strength-including fatigue strength. The three basic type of adhesives are the following:

I. Natural adhesives - such as starch, dextrin (a gummy substance obtained from starch), soya flour, and animal product.

II. Inorganic adhesives - such as sodium silicate and magnesium oxychloride.

III. Synthetic organic adhesive - which may thermoplastic (used for non-structural and some structural bonding) or thermosetting polymers (used primarily for structural bonding).

2.2.4 Surface Preparation

Surface preparation is very important in bonding process. Joint strength depends greatly on the absence of the dirt, dust, oil and various other contaminants. This dependent can be observed when one is attempting to apply an adhesive tape over a dusty or oily surface. Contaminants also affect the wetting ability on the adhesive and prevent even spreading of the adhesive over the interface. Thick, weak or loose oxide film on a workpiece surfaces are detrimental to adhesive bonding. On the other hand, a porous or a thin and strong oxide film may be desirable, particularly one with some surface roughness to improve adhesion or to introduce the mechanical locking. However the roughness must not be too high, because air may be trapped and the joint strength is reduced. Various compounds and primers are available which modify surfaces to improve adhesive-bond strength. Liquid adhesives may be applied by brushes, sprayers, and rollers Kalpakjian.S (2006).