TYPES OF DAMAGE IN PIN-LOADED ALUMINUM PLATE AND OTHER MATERIAL

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A report submitted in partial fulfilment of the
requirements for the award of the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2009

UNIVERSITI MALAYSIA PAHANG
FACULTY OF MECHANICAL ENGINEERING

We certify that the project entitled *Types of Damage in Pin-Loaded Aluminum Plate and Other Material* is written by *Mohammad Afifi B. Mohammad*. We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering.

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SUPERVISOR’S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurently submitted for award of other degree.

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To my Beloved Father and Mother

ACKNOWLEDGEMENTS

First of all, I am very gratefully to Allah swt for giving me strength and ability to complete this thesis. I would like to acknowledge and extend my heartfelt gratitude to the Mr. Lee Giok Chui who has made the completion of this thesis. This thesis could not have been written without Mr. Lee Giok Chui who not only served as my supervisor but also encouraged and challenged me throughout my academic program. He guided me through the dissertation process, never accepting less than my best efforts.

For this research, experiments were essential. I did a lot of experiments at mechanics lab and I would like to thank Mr Jamiludin as mechanics lab instructor for his valuable knowledge and guidance that he gave to me to handle the universal testing machine.

I also wish to express sincere appreciate to the lecturers, technical staff of Faculty Mechanical Engineering, University Malaysia Pahang for their teaching and help during the period of the project. My fellow postgraduate students and friends should also be recognized for their support.

Last, but not least, I thank to my family especially my parents, Mr. Mohammad Abdul Rahim and Mdm. Noor Zariyoum Mohammad have been an inspiration throughout my life. They have always supported my dreams and aspirations. They did a fine job raising me. I'd like to thank them for all they, and all they have done for me. My elder sisters, Noor Zariza, Noor Zariyani, Noor Zariyati and younger sister Noor Afifah for sharing their experience of the dissertation writing endeavor with me, for listening to my complaints and frustrations, and for believing in me.

ABSTRACT

The investigation is about the types of damage in pin loaded aluminum plate and mild steel plate. The experiment had done using various dimensions of the specimens by varying the edge distance to hole diameter ratio (E/D) and width size to hole diameter ratio (W/D). There are three types of mechanical joint failure that has been studied in this research which known as normal or net-tension failure, shear-out failure, and bearing failure. The specimens were tested using universal testing machine. The movement for upper crosshead of the testing machine will be stopped when the failure mode under investigation was seen on the specimen. For each specimen, the failure load was taken and determined from the load vs. displacement graph which is obtained from the computer that connects with the universal testing machine. The differences dimensions of the specimens give different value of failure load and some changing on the failure mode occurred on the specimens. Bearing failure which is preferred in this investigation due to less hazard and damage compared with normal and shear-out failure only occurred when W/D=4 for aluminum plate and W/D equal to 3 and 4 for mild steel plate. Finally, the graph of failure load vs. E/D ratio can be used to determine the optimum value of W/D ratio in designing field to avoid failure that will cause any disaster.

ABSTRAK

Kajian adalah mengenai jenis-jenis kerosakan pada kepingan aluminium dan besi lembut dengan pin berbeban. Eksperimen ini dijalankan menggunakan model kepingan berlainan saiz dengan mengubah nisbah jarak tepi dengan diameter lubang (E/D) dan nisbah kelebaran dengan saiz diameter lubang (W/D). Terdapat tiga jenis kegagalan sambungan mekanikal yang dikaji dalam penyelidikan ini yang mana dikenali sebagai kegagalan normal atau net-ketegangan, kegagalan ricih keluar dan kegagalan sudut.Spesimen diuji denan menggunakan mesin uji universal. Gerakan untuk kepala pemegang bahagian atas mesin uji akan diberhentikan apabila kegagalan yang dikaji dapat dilihat pada spesimen. Untuk setiap specimen, nilai beban yang menyebabkan kegagalan diambil dan ditentukan daripada graf beban melawan sesaran yang diperolehi dari computer yang disambung pada mesin uji universal. Perbezaan saiz pada setiap spesimen memberikan nilai yang berbeza untuk beban kegagalan dan beberapa perubahan pada jenis kegagalan yang berlaku pada spesimen. Kegagalan sudut yang mana lebih dipilih dalam penyelidikan ini kerana kurang bahaya dan keroskan jika dibandingkan dengan kegagalan normal dan ricih keluar hanya berlaku apabila W/D=4 untuk plat aluminium dan W/D adalah 3 dan 4 untuk plat besi lembut. Akhirnya, graf beban kegagalan melawan nisbah E/D boleh digunakan untuk menentukan nilai optimum nisbah W/D dalam bidang reka bentuk untuk mengelakkan kegagalan yang akan menimbulkan bencana.

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LIST OF SYMBOLS

L : Length of the plate

P : Load by Universal Testing Machine

E : Distance between centre of hole and edge of the plate

W : Width of the plate

D : Diameter of the plate

t : Thickness of the plate

LIST OF ABBREVIATIONS

FML : Fiber Metal Laminates

FEA : Finite Element Analysis

Al : Aluminum

Ms : Mild Steel

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Mechanical joining using pin or a rivet is one method for joining parts. The pin-joint structure is one of the important members of aerospace vehicles. There are many reasons to be careful in dealing with these structure members, because of the possibility of serious failures such as crack due to stress concentration induced by contact phenomenon. Many researchers have dealt with pin-joint structures. In most cases, the contact condition is the issue of these joint structures, while many other design parameters such as friction, interference-fit, and clearance-fit also affect the structural safety. The interference-fit pin-joint is a member whose diameter of the pin is larger than that of the hole, and the clearance fit is the opposite case. To solve the contact problem of pin-joint structures, various analytic solutions and numerical methods such as the finite element method can be used. The difficulty with this method is that the presence of a hole in a plate subjected to external loading introduces a disturbance in the stress field. Stress concentrations are generated in the nearest area of the hole making the joint a weak one.

The example of material that usually used in pin joined situation on aerospace is composite material. Composite materials are becoming more popular and are used in almost all fields due to their high strength to weight ratio, good fatigue resistance, corrosion resistance etc. compared to metals. They are used for aircraft structures to golf clubs, electronic packaging to medical equipment, and space vehicles to home buildings due to their good mechanical properties. In the practical use of composite structures certain discontinuities like holes and cutouts arise while joining by rivets or pins.

However, because of composite material that have expensive price and it is hard to make, the aluminum and mild steel plate will be used in this research. Aluminum is a common sheet metal that usually has in composite plate combined with other type of fiber. The common failure modes in mechanical joint will be examined. Failure in mechanical joint can be classified into three types that are bearing, shear out and net-tension or normal. So, types of damage in pin-loaded aluminum plate and mild steel plate will be examined whether it is bearing, shear out, net tension or combination of these.

1.2 PROBLEM STATEMENT

In mechanical joint, we need to find the correct point where the hole of joint such as rivet or pin that is suitable for the part. It is important to avoid from any incident that cause of the joint such as in aerospace technology. The location where the part join need to be at best point where if the failure happened, it will not cause any disaster such as bearing failure. So the ratio E/D and W/D [refer to **Figure 3.2**] is important and needed to find the correct location where the part can be jointed and analyze the failure that occur at the point.

1.3 OBJECTIVES

To investigate the type of mechanical joint failure (net-tension, bearing and shear out) in pin loaded aluminum plate and mild steel plate.

Investigate failure load in an aluminum plate, with a circular hole, which is subjected to a traction force by a pin.

1.4 SCOPES

Vary the edge distance to hole diameter (E/D) and width to diameter (W/D) ratios [refer to **Figure 3.2**].

Using aluminum plate and mild steel plate with same thickness that is 2mm.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In many fields such as Airbus A380 design and manufacturing, there exist codes and standard that are put in place by various agencies that must followed by all designers and manufactures. Regardless of the extreme care taken in design, manufacturing, and material selection for machines and components, failure are unavoidable, resulting in loss of property and unfortunately, sometimes, life. Every engineer should be completely familiar with the concept of failure of materials and able to extract information from a failed component as to the causes of failure. Responsible operating practice, good maintenance and through periodic inspection of the fracture – critical components are the best ways to avoid failures.

Materials engineers are frequently involved in choosing inspection intervals and techniques. (The Science and Design of Engineering Materials, 2nd edition). In most cases scientists and engineers carefully analyze the failed component to determine the cause of failure. The information gained is used to advance safe performance and minimize the possibility of failure through improvements in design, manufacturing process, and materials synthesis and selection.

2.2 FAILURE

Failure may be defined as inability of a material or a component to :

- perform the intended function
- meet performance criteria although it may still be operational
- perform safely and reliably even after deterioration.

Yielding, wear, buckling (elastic instability), corrosion and fracture are examples of situations in which component has failed. Engineers are deeply aware of the possibility of fracture in load-bearing component and its potentially detrimental effort on productivity, safety, and other economical issues. As a result of all design, manufacturing, and materials engineers use safety factors in their initial analysis to reduce the possibility of fracture by essentially overdesigning the component or machine. [1]

2.2.1 Ultimate Failure

In mechanical engineering, ultimate failure describes the breaking of a material. In general there are two types or failure: fracture and buckling. Fracture of a material occurs when either an internal or external crack elongates the width or length of the material. In ultimate failure this will result in one or more breaks in the material. Buckling occurs when compressive loads are applied to the material and instead of cracking the material bows. This is undesirable because most tools that are designed to be straight will be inadequate if curved. If the buckling continues the material will create tension on the inner side of the material and compression on the outer part, thus fracturing the material.

In engineering there are multiple types of failure based upon the application of the material. In many machine applications any change in the part due to yielding will result in the machine piece needing to be replaced. Although this deformation or weakening of the material is not the technical definition of ultimate failure, the piece has failed. In most technical applications pieces are rarely allowed to reach their ultimate failure or breakage point, instead for safety factors they are removed at the first signs of significant wear.

There are two different types of fracture brittle and ductile. Each of these types of failure occurs based on the material's ductility. Brittle failure occurs with little to no plastic deformation before fracture. An example of this would be stretching a clay pot or rod, when it is stretched it will not neck or elongate merely break into two ore more pieces. While applying a tensile stress to a ductile material, instead of immediately breaking the material will instead elongate. The material will begin by elongating uniformly until it reaches the yield (engineering) point, then the material will begin to neck. When necking occurs the material will begin to stretch more in the middle and the radius will decrease. Once this begins the material has entered a stage called plastic deformation. Once the material has reached its ultimate tensile strength it will elongate more easily until it reaches ultimate failure and breaks.

There are numerous methods to improve the strength of a material and therefore increase its ultimate failure point. Cold working a material is done by plastically deforming a material below its recrystallization temperature. This is most commonly seen by manufacturers hammering a material at room temperature. Hot working is any plastic deformation that is done above the recrystallization temperature. Cold working remains less effective because it is done below the recrystallization factor, but also remains more accurate. Because of thermal expansion and contraction of a material when heated hot working adds additional strength but also adds a rougher surface due to oxidization.

Heat treatment of a material is when the material is heated to extreme temperatures and quenching the material in water to cool it quickly. By heating the material to these very high temperatures the materials atomic structure is capable of being altered into a stronger material. This will also hopefully remove any cracks or deformations that will weaken a material. These cracks will weaken a material because they focus the stress or strain of a material to a particular point.

2.2.2 Mechanical Joint Failures Modes

Net-Tension Failure

Net-tension failure or normal failure involves a fracture across the width of the joint, as illustrated in **Figure 2.1**, and normally occurs when the W/D ratio is small.

Figure 2.1: Net-Tension Failure

Shear-Out Failure

Shear-out failure occurs when a plug of material separates from the laminate ahead of the pin, as shown in figure 1 and normally occurs when the E/D ratio is small (or in conventional composites, if an excessive amount of 0° plies are used). Shear- out failure can therefore occur after some bearing damage has initiated.

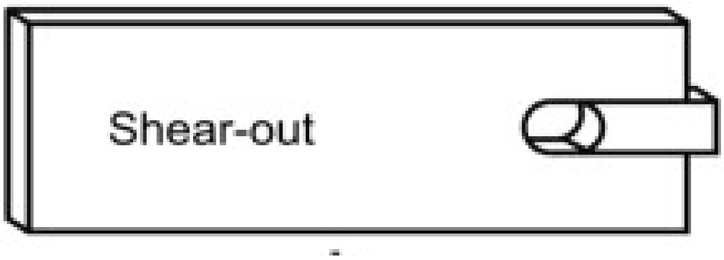

Figure 2.2: Shear-Out Failure