INVESTIGATE THE INFLUENCE OF NOTCHES ON STRESSES FOR MILD STEEL AND ALUMINUM

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Thesis submitted in fulfillment of the requirements

for the award of the degree of

Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2009

STUDENT'S DECLARATION

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 concurrently submitted for award of other degree.

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Date:

Dedicated to my beloved family and friends

ACKNOWLEDGEMENT

Thank god that finally I had completed the thesis that is the final step of my long journey in obtaining my Bachelor Degree in Mechanical Engineering. I have been accompanied and supported by many people along my way to finish the project. It is a pleasant way for me to give an opportunity to express my appreciation for all of them.

First of all, I would like to give a million thanks to my supervisor, Mr. Lee Giok Chui for his great kindness, patience and efforts to guide and show me clearly about my project. With his support, I am able to finish up my project and also thesis writing with lots of ideas that been given to me. Without his guidance and encouragement, I might not be able to finish my project.

I would also like to thank all lecturers and lab instructors who had shared their experiences with me and help me directly or indirectly. Thankful to my family and fellow friends that always be together with me, give support and also ideas for me to complete my task. They were always be by my side whenever I went through the most difficult moment. It was completely meaningful experience that I had gained during the collaboration with all of you rather than finish this thesis alone.

ABSTRACT

The diameter and type of notches has the influence to stresses any of design that has the notches. So, there is lot of research been done about the relationship of notches and stress. Many failures in engineering applications or machine components have been caused by notches at which stress was concentrated. Hence, the main objective of this study is to investigate the influence of notches on stresses for mild steel and aluminum. The investigation was based on the types and radius of notches. Both experiment and simulation were done in order to validate the result. The experiment was carried out by using tensile test to obtain maximum stress to the specimen while the simulation was analyzed by using ALGOR V22 software to obtain the stress of the specimen. The material that used in the experiment is mild steel and aluminum and for ALGOR V22 is steel ASTM-A36 and aluminum alloy 1100-H14. The experimental results and the finite element analysis results show that the maximum stress will decrease when the ratio r/d is increase. Thus, the influence of notches on the stresses has been evaluated.

ABSTRAK

Diameter dan jenis takik mempengaruhi tekanan bagi reka bentuk yang memiliki takik. Jadi, ada banyak kajian telah dilakukan mengenai hubungan antara takik dan tekanan. Banyak kegagalan dalam teknik aplikasi atau komponen mesin telah disebabkan oleh tekanan pada takik di mana ia tertumpu. Oleh kerana itu, tujuan utama dari kajian ini adalah untuk menyiasat pengaruh takik dengan tekanan untuk mild steel dan aluminium. Penyelidikan ini berdasarkan pada jenis dan radius takik. Baik eksperimen dan analisis elemen dilakukan dalam rangka untuk memvalidasi keputusan. Percubaan ini dilakukan dengan menggunakan mesin uji tarik untuk mengetahui tekanan maksimum pada spesimen sementara simulasi pula dianalisis dengan menggunakan perisian ALGOR V22 untuk mendapatkan tekanan daripada spesimen. Bahan yang digunakan dalam eksperimen ialah mild steel dan aluminium manakala bahan yang digunakan dalam perisian ALGOR V22 adalah steel ASTM-A36 dan aluminium alloy 1100-H14. Keputusan percubaan dan keputusan simulasi menunjukkan bahawa stres maksimum akan menurun ketika nisbah r / d adalah meningkat. Dengan demikian, pengaruh takik pada tekanan telah dibuktikan.

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LIST OF ABBREVIATIONS

AISI	American Iron and Steel Institute
ASTM	American Society for Testing Materials
FE	Finite Element
FEA	Finite Element Analysis
FEM	Finite Element Model

LIST OF SYMBOLS

A	Cross Sectional Area
mm	Millimetre
s	Second
t	Thickness
l	Length
w	Width
d	Characteristic length
N	Newton
P	Load
K_t	Stress concentration factor
E	Modulus of Elasticity
σ	Stress

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The fracture of a material is dependent upon the forces applied and stress which the material have. The fracture can be analyzed by various type of testing but the industry more familiar with tensile test. From tensile test many data can be collected such as yield strength, ultimate tensile strength, toughness and many more. The important to know the maximum stress is crucial since involving the safety and life time of structure which mean the quality of the design. It is the engineer responsibilities to make sure the material could be use longer. This study is about searching the influence of the notches diameter on stresses.

1.2 PROBLEM STATEMENT

The diameter and type of notch is effect the value of the maximum stress. The designer needs to know the maximum stress of the specimen. Upon the ratios of the geometric parameter involved like the ratio r/d in the case of a hole and fillet, the designer can know the value of maximum stress. The designer is more interested in the maximum value of the stress in a given section, than in the actual distribution of stresses in that section, since his main concern is to determine whether the allowable stress will be exceed under a given loading and not where this value will be exceeded.

1.2 OBJECTIVE

The objectives of this study are:

i. To investigate the influence of notches on stresses for mild steel and aluminum.
ii. To plot the graph of maximum stress versus r/d.
iii. To simulate the testing by using Finite Element Analysis (FEA).

1.4 PROJECT SCOPE

For the experiment, the specimen will be testing by using the universal tensile machine. The material that will be used is mild steel and aluminum. The dimension of specimen is varying the ratio r/d in the case of hole and fillet. The value of maximum stress that obtain is recorded and the graph of maximum stress versus r/d is plotted.

For the simulation, the modeling and analysis of the test is using Finite Element Method (FEM). The model is validated by review the results from FEM with the results obtained from the tensile test. The dimension of specimen is varying the ratio r/d in the case of hole and fillet. The value of maximum stress that obtain is recorded and the graph of maximum stress versus r/d is plotted.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The analysis of literature review was the important part in the project. It gives more details information of the project. The material that used for literature review was from the book, internet and the journal. The objective is to find out the relevance of the study or project.

2.2 NOTCH SENSITIVITY

The definition of the notch sensitivity is the extent to which the sensitivity of material to fracture is increased by the presence of a surface in homogeneity such as a notch, a sudden change in section, a crack, or a scratch. Some materials are not fully sensitive to the presence of notches. Low notch sensitivity is usually associated with ductile materials, and high notch sensitivity with brittle materials. The theoretical stress concentration factors apply mainly to ideal elastic materials and depend on the geometry of the body and loading. Based on Walter D. Pilkey and Deborah F. pilkey 2008, when the applied loads reach a certain level, plastic deformation may be involved.

2.3 STRESS CONCENTRATION

According to Walter D. Pilkey and Deborah F. pilkey 2008, the stress concentration factor K can defined as the ratio of peak stress in the body or stress in the perturbed region to some other stress. The stresses near the points of application of concentrated loads can reach values much larger than the average value of the stress in the member. When a structural member contains a discontinuity, such as a hole or a sudden change in cross section, high localized stresses can also occur near the discontinuity. Figure 2.1 below show the stress distribution in the narrowest part of the connection where the highest stresses occur.

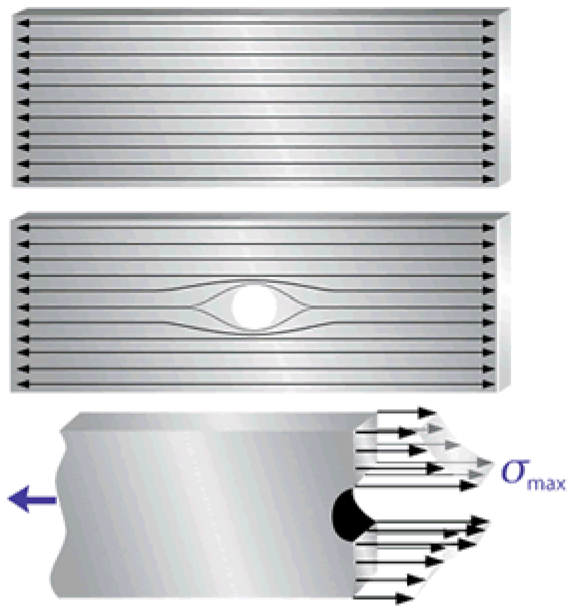

Figure 2.1: Stress distribution near circular hole

Source: Ferdinand P. B. E. Russell J. Jr. John T. D, Mechanics of materials fourth edition in SI units, Mc Graw Hill, 2006.

The result that obtained in this project is maximum stresses that influence by the notches for the specimen. The values of radius was change from the 5.5mm, 6.0mm, 6.5mm,7.0mm, 7.5mm, 8.0mm, 8.5mm, 9.0mm, 9.5mm and 10mm for flat bar with holes. The specimen of flat bar with holes is shown in Figure 2.2 below.

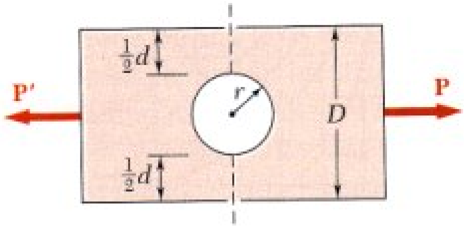

Figure 2.2: Flat bar with hole

Source: Ferdinand P. B. E. Russell J. Jr. John T. D, Mechanics of materials fourth edition in SI units, Mc Graw Hill, 2006.

For the flat bar with fillet, the arrangements of radius will change from 1mm, 2mm, 3mm, 4mm, and 5mm. The fillet is placed at the top and bottom of the specimen as shown in Figure 2.3 below.

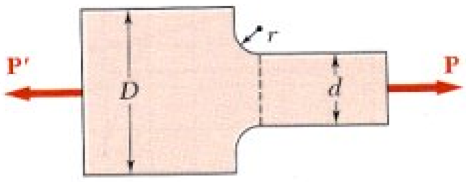

Figure 2.3: Flat bar with fillet

Source: Ferdinand P. B. E. Russell J. Jr. John T. D, Mechanics of materials fourth edition in SI units, Mc Graw Hill, 2006.

2.4 PREVIOUS STUDIES

From other research, the paper of investigated the influence of notch geometry and interface on stress concentration and distribution in micro-tensile bond strength specimens was proposed. The objective is to describe stress distribution and compare stress concentration factor for homogeneous micro-specimens with different notch geometries and stick-shaped homogeneous and biomaterial specimens by means of finite element (FE) analysis. The specimen was prepared as in the Figure 2.4.

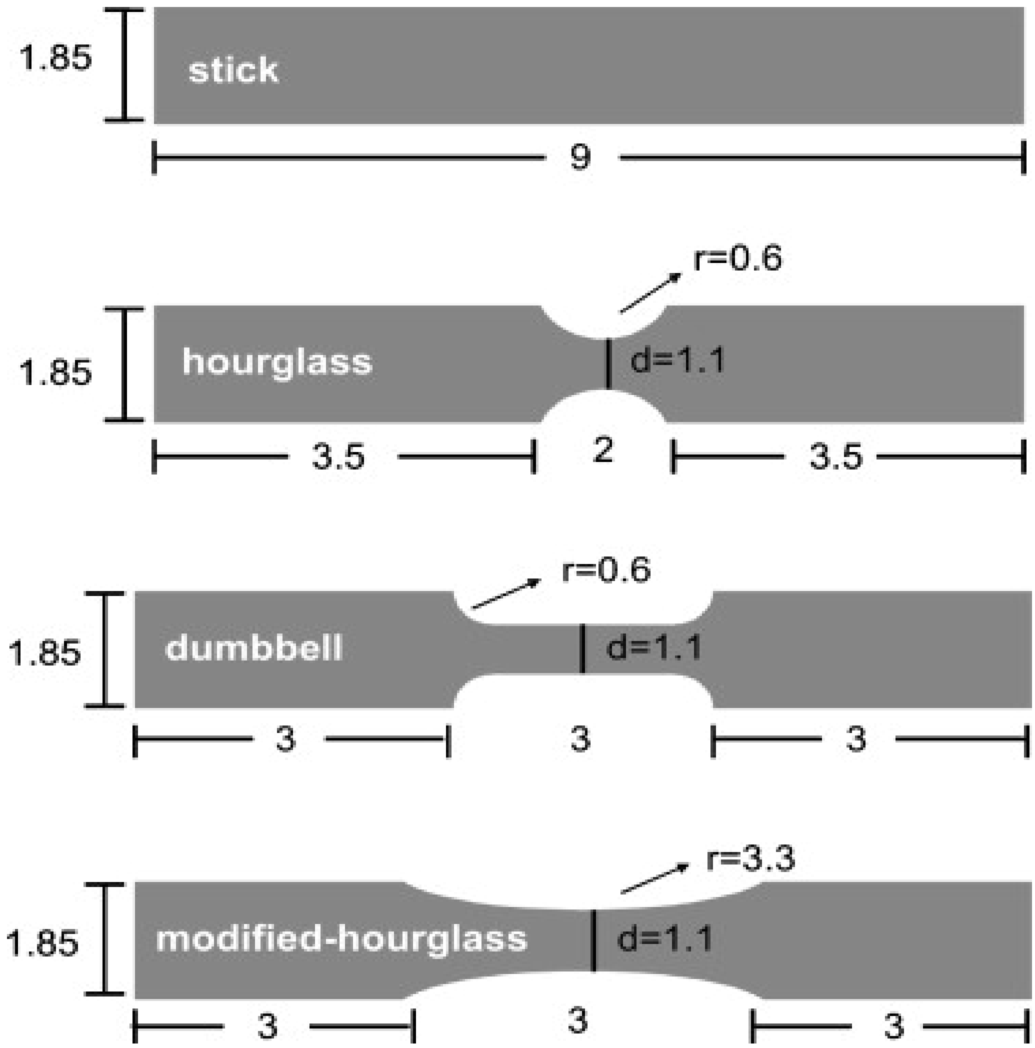

Figure 2.4: Dimensions and notch geometries of homogeneous test specimens studied.

Source: Aline de A. N, Aduardo C, Marcio V. C, Siegfried J, Paul La, Jos V. S, Hans V. O, Bart V. M. 2008. Influence of notch geometry and interface on stress Concentration and distribution in micro-tensile bond strength specimen.

The result that obtained in this research was show in Table 2.1.

Table2.1: Comparison of K_t obtained with FE analysis for the different notch geometries of µTBS specimens with values described in the literature for similar geometries

Model	Net section stress (MPa)	σ_{max} (MPa)	K_t (obtained)	K_t (Peterson 1974)
	15[a]	15[a]	1[a]	Not applicable[a]
Hourglass	42.4	56	1.32	1.37
Dumbbell	42.4	42.7	1	Not available
Modified-hourglass	42.4	47.3	1.11	1.07

[a] Stick.

Source: Aline de A. N, Aduardo C, Marcio V. C, Siegfried J, Paul La, Jos V. S, Hans V. O, Bart V. M. 2008. Influence of notch geometry and interface on stress Concentration and distribution in micro-tensile bond strength specimen.

Stress concentration factors obtained in this study were very similar to the theoretical values and always higher for the hourglass (Kt = 1.32) and modified-hourglass specimen (Kt = 1.115). As expected, the stick-shaped specimen presented no stress concentration factor (Kt = 1) as no notch is present. The dumbbell specimen also showed a stress concentration factor equal to 1. Table 2.2 shows, however, the effect of notch geometry on the area subjected to the high stress concentrations.

It is possible to note that the dumbbell specimen, although having practically no stress concentration at the cross-section (Table 2.1), has shown the largest surface area with stress concentration (stresses numerically higher than the net section stress value).

Model	Area (mm^2)
Stick	0
Hourglass	0.031
Dumbbell	0.372
Modified-hourglass	0.025

Table 2.2: The effect of notch geometry on the area subjected to stress concentration for the homogeneous model.

Source: Aline de A. N, Aduardo C, Marcio V. C, Siegfried J, Paul La, Jos V. S, Hans V. O, Bart V. M. 2008. Influence of notch geometry and interface on stress Concentration and distribution in micro-tensile bond strength specimen.

2.5 MECHANICAL PROPERTIES

Material analysis in engineering is important to measure and know the properties for any material. Technology in material science allows the determination of materials properties even before it has manufactured (Gedney Richard T, 2007). Mechanical properties that is always use like yield strength, stress, strain, modulus of elasticity, ultimate tensile strength and so many.

2.5.1 Stress

Stress is the internal resistance to oppose the breaking of materials (Meyers, Marc A., and Chawla, Krishan Kumar, 1999). When the material is given an external load in tensile test, the force that applied will break the internal bond. There are three types of stress which is tensile stress, compressive stress and tensile stress. Tensile stress will happen the material is pull by the force. For the compressive stress, the stress will happen when the material is compress by a force and shear stress will happen when the material failed along the parallel to the force applied. Basically a uniaxial stress is defined as the force (F in Newton) acting on area (A in m^2) or simply denoted by a symbol σ (Benham, P.P., Crawford, R.J., and Armstrong, C.G., 1996).

2.5.2 Ultimate Tensile Strength

Every material has it own ultimate tensile strength. The definition of the ultimate tensile strength is the maximum stress for material can withstand when the load is applied on it without breaking. It corresponding to the maximum stress divides by the area. When the tensile strength is exceeding, the material will break.

2.6 MATERIALS

2.6.1 Mild Steel

Mild steel is the most familiar material with the low of the price but promise the material properties that are satisfactory for many applications. The percent of carbon in mild steel is 0.16–0.29% carbon which makes the mild steel neither brittle nor ductile. The tensile strength of mild steel is pretty low but it is malleable and cheap. The surface hardness of mild steel can be increased during carburizing. In the construction field, mild steel is frequently use in large of amount when the steel needed. Medium-carbon steels (AISI 1029-1053, 1137-1151, and 1541-1552) can be heat treated to have a excellent balance of ductility and strength. These steel usually use in large part, machine component and forging. For the automotive industry, AISI 1040 and its modifications is use in producing bolts, rods, crankshafts and tubings. Axles, gears, and components that need higher hardness and wear resistance are frequently made of AISI 1050. Mild steel have the density about 7,861.093 kg/m^3 (0.284 lb/in^3), the tensile strength is a maximum of 500 MPa (73,000 psi) and the Young's modulus is 210,000 MPa (30,000,000 psi).

2.6.2 Aluminum

Aluminum has the benefit which is light weight (one-third of steel). High purity of aluminum (99 per cent and above) has excellent durability and low density, electrical conductivity and high thermal but low strength. For more purpose of uses, alloying element are introduced to create metals that preserve these general characteristics but with higher strength. The aluminum and aluminum alloys has the excellent durability and corrosion resistance due to the formation of a really hard oxide coating on the metal surface when exposed to air. If the surface is pitted by any of the air-borne pollutants generally found in industrial or marine atmospheres, the resulting chemical reaction produces a larger volume of powdered corrosion product than the volume of the original pit, thereby sealing off the surface and inhibiting more corrosive action. In specific, any great degree under strong acid and alkaline conditions can cause the corrosion to the aluminum.

2.7 MECHANICAL TESTING

There are many mechanical testing to determine the mechanical properties and behavior of the material. The mechanical testing that usually use in engineering mechanical is tensile test, compression, impact, torsion, fatigue, hardness, creep, bending and few other specific material tests. Each test have own particular properties to determine.

2.8 FINITE ELEMENT METHOD

The finite element method FEM and also referred to finite element analysis is the numerical method for finding the solution. This solution includes the partial differential equations as well as of integral equation. The FEA is a computerized method for predicting how the real object can react for the forces acting on it in term of failure. Finite element analysis is a computerized method for predicting how a real world object will react to forces, heat, vibration, etc., in terms of whether it will break, wear out, or work the way it was designed. It is called analysis, but in the product design cycle it is used to predict what is going to happen when the product is used. (Algor Help File, Algor Corp)

2.8.1 Basic Steps in Finite Element Analysis

The basic step of finite element analysis can be divide in three major step which is set the model, analyzed the model and result estimation. For the first step which is set the model, define the unit and create the model and done with the meshing. The analysis parameter and element of the model must be set and after that is the load boundary