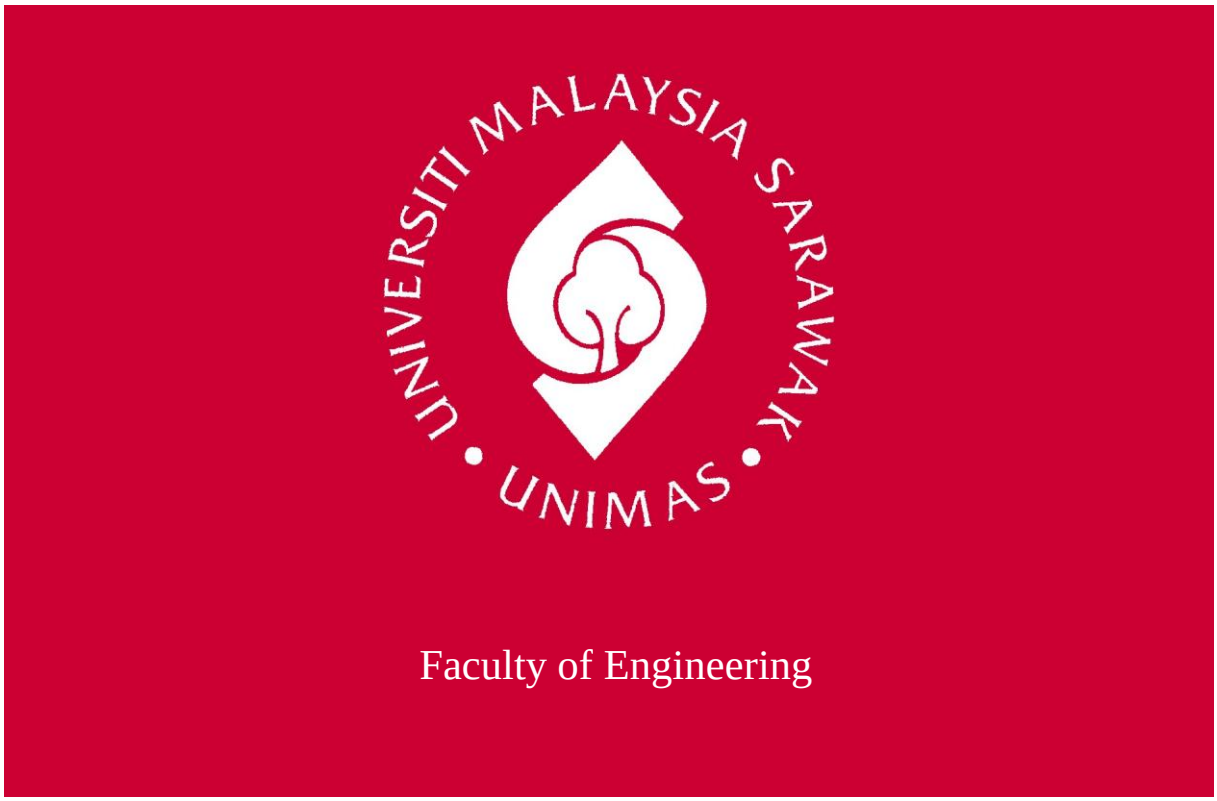

FINITE ELEMENT ANALYSIS IN T-JOINT PIPE FOR BRASS AND PVC

DAYANG DIYANA BT ABANG BOHARI

Bachelor of Engineering with Honours

(Mechanical and Manufacturing Engineering)

2009

UNIVERSITI MALAYSIA SARAWAK

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Ir. Dr. Mohd. Shahril bin Osman Date

Project Supervisor

FINITE ELEMENT ANALYSIS IN T-JOINT PIPE FOR BRASS AND PVC

DAYANG DIYANA BT ABANG BOHARI

This project is submitted as partial fulfillment of the requirement for the degree of
Bachelor of Engineering with Honours
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Faculty of Engineering

UNIVERSITY MALAYSIA SARAWAK

2009

Dedicated to my beloved family, friends and all who has supported me.

ACKNOWLEDGEMENT

All praises and thanks are to Him, the Almighty and the Lord of the universe, for allowing me to complete my Final Year Project II (KNJ 4214) without much complication. I would like to express my sincere gratitude and appreciations to my supervisor Ir. Dr. Mohd Shahril B. Osman for his continue support, generous guidance, help, patience and encouragement in the duration of the thesis preparation until its completion.

Next, I would like to extend my special thanks and express my sincerest appreciation to lab technician Pn. Hasmiza, for helping me in conducting all the laboratory works in Non-Destructive Testing (NDT) laboratory.

Special thanks to my father (Abang Bohari B. Abang Hj Pauzi), mother (Rosita B. Mohd Yahya), and family for their encouragement, moral supports, love, and endless praying.

Finally, to all peoples who involved directly or indirectly upon completing this project, I am really grateful for it. All of your contribution and efforts are well appreciated and well remembered. May Allah bless all of you. Thank you.

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LIST OF SYMBOLS

σ_1, σ_2	=	principal of stress
$\varepsilon_x, \varepsilon_y$	=	principal of strain
n	=	index of refraction
c	=	velocity of light in vacuum, $3x10^8$ m/s
v	=	velocity of light in the medium
N	=	fringe order
K	=	strain-optical coefficient
λ	=	wavelength, 575nm
f_s	=	fringe value
V_s	=	Poisson's constant of structure material
E_s	=	Young's modulus of structure material
R_0	=	zero reading of digital compensator
R_1	=	final reading of digital compensator
f_c	=	calibration value of coating material
t_c	=	plastic thickness, inches

ABSTRACT

Material measurement test is important to be assessed as it determined stress distributions within the specimen that subjected to the well define loads. Photoelastics stress analysis and finite element analyses are the method that carried out in this project to test and analyze the strength of the specimen. Photoelastics technique is involved with optical principle method that is applied to the investigation of the physical properties of the material by using polariscope. Finite element analysis method is known as numerical method used for analyzing structures which are usually too complicated to be solved through standard analytical techniques. In this project, both of these methods are employed to analyze the distribution of stress of t-joint pipe for brass and PVC (Polyvinyl chloride). Then, the analyzing data is collected and graph is plotted. Further discussion of the result analysis is engaged followed by comparison of the mechanical properties of the chosen materials.

ABSTRAK

Ujian pengukuran bahan adalah penting untuk diadakan bagi mengkaji taburan tekanan pada subjek kajian apabila beban dikenakan ke atasnya. Analisis fotoelastik dan analisis unsur terhingga adalah di antara kaedah yang digunakan menguji dan menganalisis kekuatan spesimen. Teknik fotoelastik adalah kaedah optik yang di jalankan bagi menyiasat ciri fizik sesuatu bahan dengan menggunakan polariskop. Analisis unsur terhingga juga dikenali sebagai kaedah numerikal dijalankan untuk menganalisis struktur yang biasanya sukar di selesaikan melalui teknik analitikal yang standard. Dalam projek ini, kedua-dua kaedah tersebut di gunakan untuk menganalisis taburan tekanan pada paip-T bagi loyang dan PVC (Polyvinyl chloride). Kemudian, data yang diperolehi daripada analisis yang di jalankan di kumpul dan graf di plot. Perbincangan selanjutnya bagi keputusan analisis dilakukan. Ini di ikuti dengan perbandingan bagi sifat bahan-bahan yang telah di pilih untuk projek ini.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Material measurement test is important to be assessed as it determined stress distributions within members that are subjected to the well define loads. Experimental testing and finite element analysis should be done to measure the mechanical properties of the material.

In this work, the non-destructive test called photoelastics is employed to measure the mechanical properties of the material. *Photo* refers to optical, while for *elasticity* refers to principles to overcome the engineering problems. The use of optical principle method is employed to overcome the engineering problems.

Photoelasticity technique is one of the common techniques of the non-destructive test. Photoelasticity technique is commonly used to measure the stress

distribution in material. These techniques are applied to the investigation of the physical properties of the material the influence of not only mechanical but also electrostatic, magnetic and electromagnetic fields (Holister, 1985).

The specimen of material is elastically deformed or subjected under a well define load, the optical properties of a photoelastics specimen become anisotropic. Using a special optical system and polarized light, the stress distribution within the specimen may be deduced from interference fringes that are produced (William D. Callister, 2004).

The stress distribution can also be analyzed by using finite element analysis (FEA). Finite element analysis normally used to analyze the strength of the specimen. FEA is a numerical method to find the appropriate solution of partial differential equation (PDE) in addition to the integral equations. FEA allows comprehensive visualization at the point of which the structures being bend, twist, or when the force or pressure is applied to specimen. FEA also point out the stress distribution and its displacement.

In this field of study, there are several objectives that need to be achieved. The main objective of this experiment is to measure the mechanical properties of the T-joint pipe as the specimen by using the photoelastics stress analysis technique and to learn more about the photoelastics principle and techniques. The second objective is to use the finite element analysis to point out the stress distribution and its displacement of the t-joint pipe when the load is applied to it and to determine the stress characteristics of

Brass pipe and PVC pipe. The third objective is to coat the t-joint pipe with photostress plastics coating for experiment purposes and to conduct photoleastics experiment to the specimen subjected under the well define load. The fourth objective is to reveal the stress of the sample for engineering application and finally, to distinguish the material characteristic between brass T-joint pipe and PVC (Polyvinyl chloride) T-joint pipe.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss more on the appropriate principles and technique that related to this project. This includes the discussion of the theory of photoelasticity, classification of polarization, photoelastics stress analysis, review on the existing experiment on photoelastics stress analysis and finite element analysis basic principles and techniques.

This chapter is important to guide concerning on photoelastics principle and techniques. These reviews will help in better understanding in conducting the photoselastics analysis to reveal the stress pattern of the specimen

2.2 Theory of Photoelasticity

In recent years, the photoelastics techniques have become an indispensable tool for the measurement of the stress and strain analysis of a material. Photoelasticity are one of the techniques of non-destructive test. These techniques are commonly used to measure the stress distribution in material and the stress pattern will show the fringe pattern of stress when subjected with the loads. Figure 2.1 below shows the fringe pattern of incrementally test part.

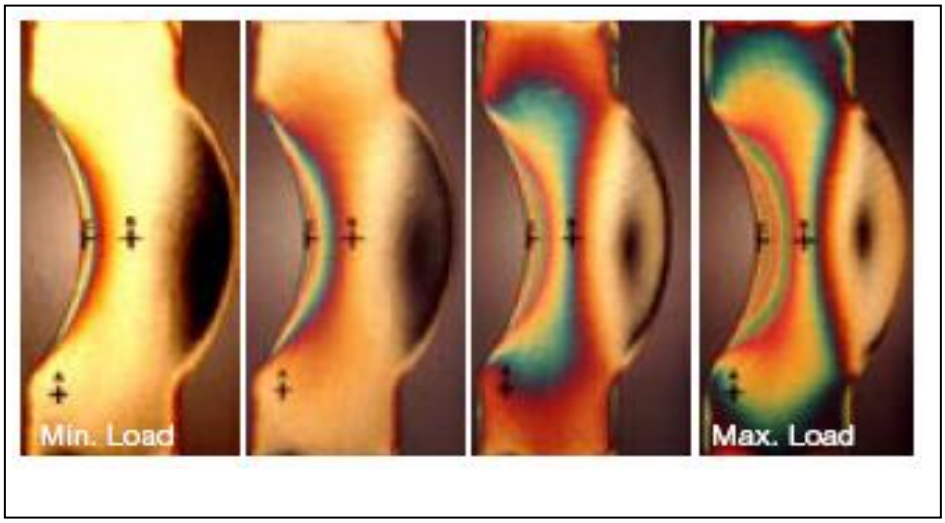

Figure 2.1: Incrementally loaded test part (Vishay Micro Measurement Group, 2005).

Photoelasticity is a classic interferometric technique stated by Cloud (1998) for practical and instructional reasons. In refractive index, the differences of path length are being measured due to the local direction –dependent variations. These variations are frequently induced by stress. The Photoelastics models surface act as a beam splitter that split and divides the incident light into orthogonally polarized components. The

path length is different due to the different of refractive index although the polarized component travels into the same thickness of materials. The polarized components show the difference in the relative phase when it exits the specimen or the photoelastics model surface. Amplitude information is gain from the transformations of the phase difference into analyzer. This is form due to the combination of two components at the downstream polarizer (Cloud, 1998).

Photoelasticity is an amplitude-division class of technique due to the beam splitting split into a single wave train of waves. It is also known as the interferometer since the two orthogonally polarized waves follow the identical geometric paths through the whole instrument. The coherence requirements are not rigid and the common light source are appropriate since the fact that the path length is differ by merely 20 or so wave length. Beside that there is no affect on the vibration makes the interferometer are suitable for the usage in the noisy environments (Cloud, 1998).

2.3 Refraction

Electromagnetic radiation in the simple form can be shown in harmonic plane wave which described by the equation below

— (2.1)

The propagation along the z-axis is depends on the material properties contained in the wave equation

— (2.2)

The speed of light in a vacuum use as the reference velocity to express the speed of light in other materials. Therefore "absolute index of refraction" of materials defined as

— (2.3)

Where = speed of light in the materials

c = speed of light in a vacuum

The desirable to relate the speed of light in an object to the speed of light in the medium surrounding the object are often

— — (2.4)

The relationships between index of refraction and wavelength are complicated. The index is depending on the wavelength and the relationships can be defined using simple models of the interaction of radiation and material (Cloud, 1998).

2.4 Classification of Polarization

In form of plane wave, light are define to be linearly polarized (Hyperphysics). In term of definition, light is a transverse electromagnetic wave. However natural lights are generally unpolarized. When light is composed of two planes wave of equal amplitude by differences in phase of 90°, the light are circularly polarized. Therefore if two plane wave of different amplitude are related in phase by 90°, with the relative phase other than 90° then the light consider to be an elliptically polarized (Hyperphysics)

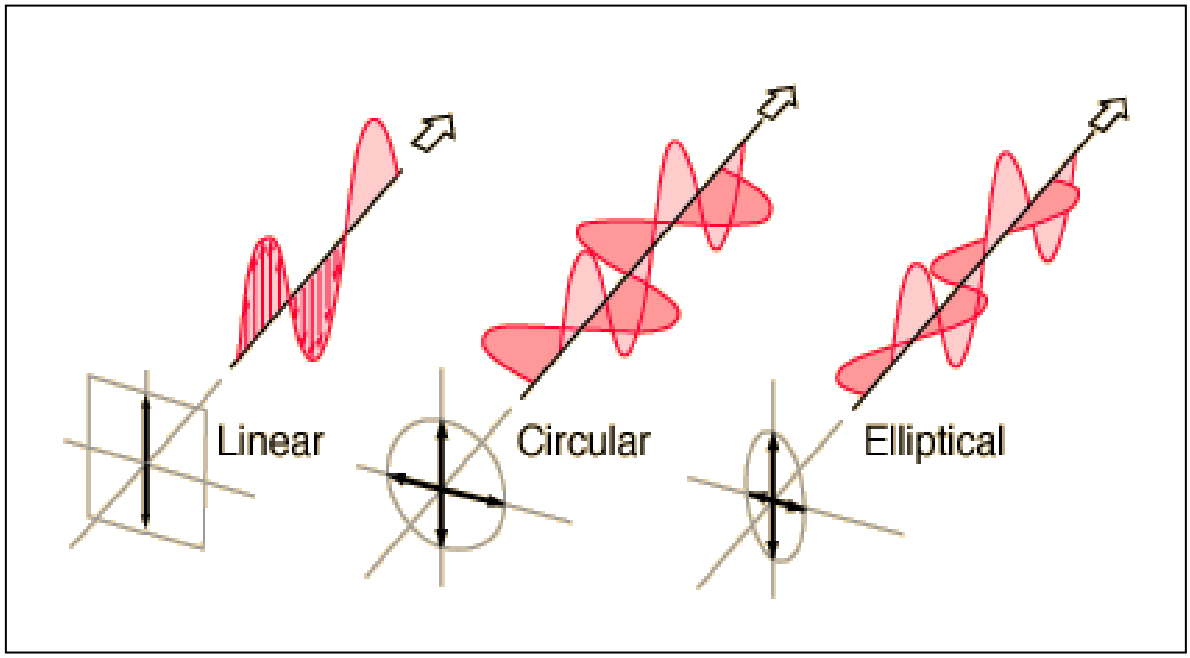

Figure 2.2: Classification of Polarization (Hyperphysics)