FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

INVESTIGATION OF THE BUCKLING BEHAVIOUR OF CONE-CYLINDER TRANSITION WITH DIMPLE IMPERFECTION

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INVESTIGATION OF THE BUCKLING BEHAVIOUR OF CONE-CYLINDER TRANSITION WITH DIMPLE IMPERFECTION

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Mechanical Maintenance) with Honours. The member of the supervisory is as follow:

Signature: …..…………………………...

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ABSTRAK

Kajian ini menumpukan kepada penyiasatan kelakuan lekuk pada kon-silinder keluli lembut yang dipotong di bawah beban paksi. Kajian ini dijalankan secara eskperimen menggunakan SHIMADZU 50kn Universal Testing Machine. Terdapat sejumlah 12 sampel dengan pelbagai kedalaman lekuk dan bilangan lekuk. Kesan kedalaman lekuk serta variasi bilangan lekuk pada kapasiti penyimpanan beban kon-silinder diselidiki. Akhirnya, perbandingan antara beban keruntuhan cangkerang kon-silinder sempurna dan tidak sempurna dilakukan. Perbandingan menunjukkan jumlah 1 lekuk pada cengkerang kon-silinder mempunyai kapasiti penyimpanan beban yang tinggi daripada jumlah lekuk yang banyak pada cengkerang kon-silinder. Adalah diperhatikan bahawa cangkerang kon-silinder yang mempunyai 1 lekuk mempunyai kesan yang minima pada kadar kapasiti penyimpanan beban pada tahap kedalam berbeza.

ABSTRACT

The study focuses on investigating the buckling behavior of mild steel cone-cylinder structure under the effect of axial compression. The study is conducted experimentally using SHIMADZU 50kN Universal Testing Machine. There are a total of 12 samples with various number of dimple imperfection and dimple amplitude on the middle part of cone surface. The effect of dimple imperfection on load carrying capacity of cone-cylinder structure are investigated. Finally, a comparison between the collapse load of single dimple imperfection and multiple dimple imperfection are conducted. The comparison shows that single dimple imperfection have higher buckling load than multiple dimple imperfection on cone-cylinder structure. It is observed that single dimple imperfection have minimal effect on the bucking behavior at certain amplitude.

DEDICATION

This report is dedicated to my supervisor who has always been a constant support and encouragement during the challenges and tough times. Also not to forget to both of my parents who have always support and been there during my entire university life.

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LIST OF SYMBOLS

β	**-**	Cone semi-vertex angle
r	**-**	Top radius of cone
R	**-**	Bottom radius of cone
h	**-**	Height of cone
L	**-**	Slant length of cone
y	**-**	Height of cylinder
x	**-**	Length of cylinder

LIST OF ABBREVIATION

UTeM	Universiti Teknikal Malaysia Melaka
DXF	Drawing Interchange Format
CAD	Computer Aided Drawing
MIG	Metal Inert Gas

CHAPTER 1

INTRODUCTION

1.1 Background

Cone-cylinder structure often utilized as pressure vessels, silos, pressure tanks and in piping systems. Cone-cylinder structured is considered as complex structure where two shapes joined directly together along the boundaries using various method such as, welding, riveting and molding. Aeronautical engineering apply cone-cylinder structure for the fuselage that usually constrained by elastic buckling. Other than that, the cone-cylinder structure also often utilize as end closures, reducers of a piping system as well as roofs. The large compression along the circumference of the structure often lead to failure by buckling. This is cause by radial inward ring load at the intersection between cone and cylinder. A few cases that utilize thin wall cone-cylinder structure are submarines, missile, automobile bodies and oil tanks.

The structure are often subjected to various types of loading conditions, axial compression is one of it. The limit for which the structure can be loaded or deform is affected by many factors such as buckling and instability (Shakouri & Kauchakzaded, 2013; Jabareen & Sheiman, 2009). The structure subjected to various type of loading parameter, for example axial compression, external pressure, internal pressure or combine loading (Wullschleger & Meyer-Piening, 2002). Buckling is a well-known phenomenon that exist in structural engineering and solid mechanics for thin and thick shells subjected to various loading conditions. The impact of buckling in lost of structure's stability, is a major catastrophe, in various fields such as mechanical, chemical, marine, military etc. (Boorboor et al. 2012). Imperfection in shells structure also influence in buckling strength. Amazigo & Budiansky (1972) and Stein (1968) did research on buckling imperfection stability of shell structures consisting of geometric imperfections. However, Cooper & Dexter (1974) state that imperfections occur locally rather than axisymmetric of buckling modes.

1.2 Statement of Purpose

The purpose of this study are:

1) To design and fabricate cone-cylinder with and without dimple imperfection at the middle of the cone axial length using mild steel.
2) To study the effect of different dimple amplitude on the buckling behavior of axially compressed cone-cylinder structure.

1.3 Problem Statement

Buckling behavior has been studied over the years by numerous researchers. Buckling phenomenon occurs in structures, which are stiff in loaded and slender direction. The phenomenon of imperfect structure is the most challenging issues in industry. Buckling load of certain structures depends on the initial geometric imperfections. Buckling behavior on cone-cylinder often affected by intersection. Welded section of cone and cylinder structure is called intersections. Zhao (2005) state there are two types of buckling mode identified on cone-cylinder structure: shell buckling mode and ring buckling mode.

However, there is little informations on study of the buckling behaviour of cone-cylinder structure having dimple imperfections. There are several studies of dimple imperfections carried out by Ifayefunmi & Blachut (2013) on cones, Schillo et al. (2015) and Khakimova et al. (2016) on cylinder and Evkin & Lykhachova, (2017) on spheres but there is no information and study on dimple imperfections on complex geometry. This study approach on the effect of dimple imperfections on cone-cylinder structure towards buckling behavior on axial compression for further investigations due to lack of data on the said effect.

1.4 Scope

This research is conducted based on experimental approach to study the effect of dimple imperfections on the buckling behavior of cone-cylinder structure subjected axial compression. The material used in designing and fabricating cone-cylinder structure was mild steel with thickness of 0.5 mm.

In this experiment, dimple imperfections will be introduced on cone structure surface only. The number, position and depth of dimples are varies between each specimens. In order to achieve accurate data, two samples of each dimple imperfections were made making a total of 12 samples altogether to be tested. The specimens with no dimple imperfections was done to establish as baseline. LaserJet cutting machine was used to cut the cone-cylinder structure. The fabricating process of the sample continue with rolling and welding.

All specimens will undergo axial compression test by using INSTRON Universal Testing Machine. The results obtained from the compression test will be recorded and analysed.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

2.1.1 Application of Cone-cylinder Structure in Industries

Cone-cylinder structure has been used widely across engineering industries. The application varies from nuclear industries (Ismail et al., 2018) to energy industries (Skopinsky, 2001), aviation industries and automobile (Petraszkiewics & Konopinska, 2015) etc. Commonly, cone structure is combined to cylinder structure using weld joint, known as intersections (Teng, 1995). Over the years, cone-cylinder stability design proposed by Zhao & Teng (2003) have gains lots of interest amongst engineers, designers and researchers to enhance the structure even more. By doing so, the structure performance in load carrying capacity can be increased.

The cone-cylinder structure are being utilized as pressure vessel and piping (Zhao, 2005; Khalili & Showkati, 2012), as well reducers, liquid storage tanks and silos (Teng, 1995). Sofiyev (2011) mentioned that cone-cylinder structured are also used in spacecraft, jet nozzels, missiles and other civil, marine and aerospace engineering structures. Application in hydrotechnical constructions, petrochemical and pipe branch also utilized cone-cylinder structure (Skopinsky, 2001). Typical configuration of cone-cylinder structure is shown in Figure 2.1.

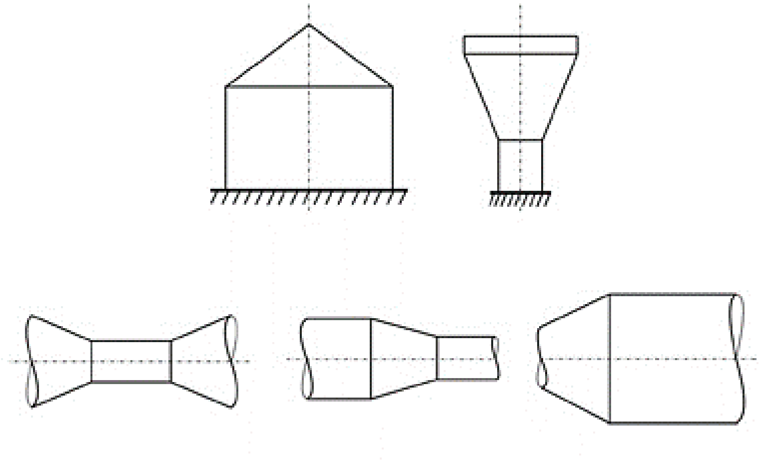

Figure 2.1: Typical Configurations of cone-cylinder compound structures (Petraszkiewics & Konopinska, 2015)

2.2 Buckling Behaviour of Shells

2.2.1 Buckling Behaviour of Cone structure

Buckling and instability are two most common failure modes for shell structure (Jabareen & Sherman, 2008). Long list of research have been done over half of centuries ago on buckling behavior of cone structure such as Seide (1956), Krenzkie (1959) and Singer (1966). Krenzkie (1959) performed six buckling test of 45° unstiffed cone. The experiment was to test the effect of stiffeners on load carrying capacity. Chryssanthopoulos et.al (1998) studied buckling of shell structure by using finite element modelling. However, the modelling result is complicated for computer software however,