UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EXAMINATION OF BUCKLING BEHAVIOUR OF AXIALLY COMPRESSED CYLINDER WITH UNEVEN LENGTH HAVING SQUARE WAVES

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Automotive) with Honours.

by

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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 (Automotive) with Honours. The member of the supervisory is as follow:

Signature: …….

Supervisor : DR OLAWALE IFAYEFUNMI

ABSTRACT

This research intends to examine the effect of the buckling behavior of cylindrical shell with uneven length having square waves. Eighteen mild steel cylinders were manufactured with a constant imperfect wavelength, which is 2A = 0.56mm. All of the samples were manufactured from 1mm mild steel plate. The cylindrical samples were all tested under axial compression. The collapse loads of all samples were validated by comparing the experimental results with numerical results. Results show a small percentage different between experiment and numerical result, where the percentage is less than 10 percent. In addition, comparison of load versus deflection curve and deformed shapes are in good agreement. From the results, it can be concluded that imperfection in the form of square waves results in reduction of the buckling load of the cylinder subjected to axial compression.

ABSTRAK

Kajian ini berhasrat untuk mengkaji kesan kelakuan gelang shell silinder dengan panjang yang tidak rata yang mempunyai gelombang persegi. Lapan belas silinder keluli ringan dihasilkan dengan panjang gelombang tidak sempurna yang tetap, iaitu 2A = 0.56mm. Semua sampel dihasilkan dari plat besi 1mm. Sampel silinder semuanya telah diuji di bawah mampatan paksi. Beban keruntuhan semua sampel telah disahkan dengan membandingkan hasil eksperimen dengan keputusan berangka. Hasil menunjukkan peratusan kecil yang berbeza antara eksperimen dan hasil berangka, di mana peratusan kurang daripada 10 peratus. Di samping itu, perbandingan beban berbanding lengkung ubah bentuk dan bentuk cacat adalah dalam persetujuan yang baik. Dari hasilnya, dapat disimpulkan bahwa ketidaksempurnaan dalam bentuk gelombang persegi mengakibatkan pengurangan beban tangki silinder yang tertakluk kepada pemampatan aksial.

DEDICATION

This report is dedicated to my beloved parents, my siblings and my friends, who always support me during this final year project work. Last but not least, my final year report group mates who were always with me to complete my final year project research.

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DXF	-	Drawing Exchange Format
MIG	-	Metal Inert Gas

CHAPTER 1

INTRODUCTION

1.1 Background

Buckling is one of the major failure phenomenon of cylindrical shells when in use; it may be influenced by the type of applied load, material properties of the shell and imperfections in construction. Investigation of buckling behavior towards cylindrical shells proved that rolling and construction-induced imperfections give the direct effect to the cylindrical structures.

Thin shells are efficient structures that can withstand very high buckling loads. However, unlike columns and plates, shells usually have a very unstable postbuckling behavior, which strongly affects their buckling characteristics. Therefore, their buckling and postbuckling behavior has presented scientific and engineering challenges for decades (Singer et al, 2004).

The interaction buckling curves of perfect composite shells subject to different combination of axial compression, bending, torsion and lateral pressure are obtained. The postbuckling analysis of composite cylinders with geometric imperfections of eigen-mode shape is carried out to investigate the effect of imperfection amplitude on the critical buckling (Tafreshi and Bailey, 2007).

From the literature study, it is found that in buckling behaviour of cylinder shells the geometric imperfection plays a dominant. However, there are still other factors which are not explored yet. Hence, this experimental project work intend to examine the effect

of uneven length with square waves on the buckling behaviour of axially compressed cylinder with.

1.2 Problem Statement

Cylindrical shells have been relatively less used since they require more rigorous modelling and because of the high sensitivity to imperfection. The postbuckling response of cylindrical shells is difficult to predict due to the random nature of the imperfection profile. Current effort have considered modelling imperfection in statistical manner to obtain a better estimate of postbuckling response (Hu and Burgueño, 2015).

Unstiffened thin walled shell structures under axial compression are prone to buckle. Within the first half of the last century, a significant deviation between buckling loads determined theoretically and buckling loads determined experimentally was identified. The reason for this discrepancy is explained by the presence of imperfections, i.e. any deviations of the real structure from the perfect shell structure. The presence of geometrical imperfections is found to have a high degrading effect even though the deviations from the perfect shell structure are within the limits of manufacturing tolerances (Friedrich et al, 2015).

Vertical cylindrical welded steel tanks are widely used for fluid and bulk storage in industrial and agricultural plants. Some of it, develop in oil industry (oil storage tanks) that are put into service in recent decades, especially large tanks (Figure 1.1). As typical thin-walled structures, tanks are very susceptible to buckling under wind load especially when they are empty or partially filled. Over the past few decades, buckling failures of cylindrical steel tanks and silos during windstorm have occurred in many countries and regions. Because of serious economic losses and environmental problems due to the

destruction of storage tanks, studies about buckling of tanks under wind load have been conducted extensively over the past few decades. However, the changing of pattern can leads to the low structural strength possibility that has not been considered in details (Zhao and Lin, 2014).

Figure 1.1 Steel Tanks in Practical Engineering (Zhao and Lin, 2014)

From this several facts, an investigation must be carried out to identify the buckling strength between perfect cylinder and cylinder with uneven length having square wave.

1.3 Project Objective

Based on the problem statement discussed, the objectives of this study are:

1. To design and fabricate mild steel cylindrical shells with uneven length having square wave.

2. To examine the effects of uneven length on the buckling behavior of axially compressed mild steel cylinder.

3. To validate the experimental results by using numerical analysis.

1.4 Project Scope

This project intends to study the effect of buckling behaviour of axially compressed cylinder with uneven length. 1 mm mild steel plate was used in designing and fabricating the cylindrical shell. There are 6 different samples of cylindrical shell were designed in 2D and 3D drawing. The first one was perfect shell, and the other 5 samples were designed to have 4, 6, 8, 10 and 12 square waves.

Once the drawing was completed, the fabricating part was the next step of this research. The cylindrical shells were cut by using the laser machine. The drawing should be ensured to meet the format used in the laser machine which is DXF format to prevent any wrong cutting of shell. After that, the rolling and welding step should be done to continue the experiment.

Last part of the project was the testing for the effect of buckling behaviour of axially compressed cylindrical shell. All of the cylindrical shells were tested and the results were recorded. Numerical analysis was conducted to compare to the experimental results for the validation of data collected. Both results were compared in form of data, graphs and also deformed shape.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Thin Shell Structure

Thin-shell structure is common parts in the design fields because of it helps to ensure the component durability and stability structure. Paschero and Hyer, 2009, stated that thin-walled shells are particularly susceptible to loss of stability. In order to produce suitable design for practical purpose, loss of stability behaviour of shells is indispensable.

The thin shell structure has been improved progressively in engineering application because of this materials is often used in order to reduce cost. Cylindrical shells are the most commonly used thin-shell structure geometry. This due to its simple geometry and relative ease of manufacture (Ifayefunmi, 2016).

Thin shells are competent structures that can resist critical buckling loads. However, different of plates and columns, shells commonly have a very unstable postbuckling behaviour, which really affects their buckling characteristics. Because of this, many researcher are still interested in studying this field.

2.2 Material of Cylinder

There are several type of material that have been used by researchers in studying the behaviour of cylindrical shell such as aluminium, mild steel, carbon fibre and combined alloy. Blachut, (2014) carried out the study of buckling of cylinders by using aluminium as the type of material. Figure 2.1 shows the aluminium cylinder used in the experiment.