UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY OF THE BUCKLING BEHAVIOUR OF AXIALLY COMPRESSED CYLINDER WITH SINUSOIDAL UNEVEN LENGTH

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 propose to investigate the study of the buckling behavior of axially compresses cylinder with having sinusoidal uneven length. Ten mild steel cylinders were manufactured with a constant imperfect wavelength, 2A = 0.56 mm of the height of cylinders. All of the samples were manufactured with 1mm mild steel plate and the radius is 50 mm. The cylindrical samples were all tested under axial compression by using the Instron Machine. The collapse loads of all samples were validated by comparing the experimental results and the numerical results. In this project, all of the results show Young's Modulus, Lower Yield Stress, Upper Yield Stress and Ultimate Tensile strength. These results can be validated by compared to the graphs and deformed shapes. From the results, it can be concluded that the collapsed load decrease as the number of waves increases.

ABSTRAK

Kajian ini mencadangkan untuk menyiasat kajian tingkah laku gelangsar silinder paksi secara paksi dengan mempunyai panjang sinusoidal yang tidak rata. Sebanyak sepuluh silinder keluli ringan dihasilkan dengan panjang gelombang yang tidak sempurna, iaitu 2A = 0.56 mm. Semua sampel dibuat dengan plat keluli ringan dengan ketebalan sebanyak 1 mm dan radius keluli tersebut ialah 50 mm. Sampel silinder semuanya diuji di bawah mampatan paksi dengan menggunakan Mesin Instron. Beban runtuh untuk semua sampel telah disahkan dengan membandingkan hasil percubaan dan hasil berangka analisis komputer. Dalam projek ini, semua keputusan menunjukkan Modulus Young, Tekanan Senyawa Rendah, Tegasan Permintaan Atas dan Kekuatan Tegangan Tepat. Keputusan ini dapat disahkan dengan membandingkan graf melalui hasil percubaan daripada Mesin Instron dan analisis komputer. Dari hasilnya, dapat disimpulkan bahwa beban runtuh menurun seiring dengan peningkatan jumlah gelombang.

DEDICATION

This report is dedicated to my beloved parents, my family members and my friends who always give me fully support and encourages completing my final year project. In addition, my final year group mates who giving me guidance and assists during the project.

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L	- Length
t	- Thickness
R	- Radius
E	- Young Modulus
υ	- Poisson's Ratio
2A	- Amplitude of Waves

LIST OF ABBREVIATIONS

SDI	Single Dimple Imperfection
SPLI	Single perturbation Load Imperfection
SPL	Single Perturbation Load
Fcyl	Elastic Critical Buckling Load Approach
SPLA	Single Perturbation Load Approach
DXF	Drawing Exchange File
MIG	Metal Inert Gas
F	Local coordinate direction when available
H	Global direction for vector-value output
U	Translation and rotation
CF	Concentrated force and moment
FG	Functionally Graded
U2	Spatial displacement
RF2	Reaction force
RF	Reaction force and moment

CHAPTER 1

INTRODUCTION

1.1 Background

Cylindrical shells are widely used in many divisions of engineering for example, pipelines, cooling towers, nuclear containment vessels, metal silos and tanks for storage of bulk solids and liquids, and pressure vessels. Axial compression such as global bending, external or internal pressure and wind loading are some of the utmost common loading forms in applied design structures. The loading conditions for these shells are pretty varied dependent on the specific purpose of the shell.

The circular cylinder is overall in column design, such as in shape tubing, piping and in offshore platforms Thin-walled cylinders of various constructions. Stiffened and unstiffened metallic and coated composite thin (large diameter to thickness ratios) shells are used commonly in underwater, surface, air, and space vehicles as well as in the construction of pressure vessels, storage bins, and liquid storage tanks (Simitses, 1986). However, according Rotter 2003, the cylindrical shells under axial compression has been known to be generally sensitive to imperfection in the shell.

In addition, according to Blachut, 2015, whenever the cylindrical segments are connected together and to arrange as prime load bearing structure in axial compression, the interaction between the two neighbouring cylindrical segments becomes critical.

A cylindrical shell in the meridional direction under compression can fail by overall buckling (global/Euler), local buckling or the material strength being reached. Various failure mechanisms of composite cylindrical shells, as affected by initial geometric imperfections, boundary conditions, lamina stacking sequence, anisotropic coupling effects and load eccentricity, were identified by in terms of laminate configurations and shell proportions (Priyadarsini et al., 20110).

According to Ifayefunmi and Fadzullah 2017, the buckling behaviour of cylinders under axial compression depends on its geometry parameter such as the radius-to-thickness ratio (thinness ratio) but for thin cylinders with high radius-to-thickness ratio, their failure is usually noticed by elastic buckling. The failure by the plastic collapse was influenced by a lower radius-to-thickness ratio for thicker cylinders. The imperfection such as a non-uniform length, a noon-uniform loading, inaccurate modelled boundary conditions, the influence of pre-buckling deformation and material discontinuity or crack are sample of the imperfection that linked to the actual buckling load of axially compressed cylinder.

Furthermore, according to Karyadi, 1991, pure bending will influence of the length variation in the linear buckling behaviour of isotropic cylindrical shells subjected to pure bending and the results of this study show that the maximum critical bending stress is essentially equal to the critical uniform axial compressive stress. Narayana et al., 2015, conclude that a better explanation for the nonlinear phenomenon as this approach can effectively capture the influence of imperfections on post-buckling behaviour of imperfect cylindrical shells.

According to Blachut, 2010, once the axial compression is applied, the shape in axial and circumferential dimensions of the gap will change. The diminishing dimension of the gaps results in a variable contact length between two cylinders or uneven loading or localized plastic deformation. Moreover, data on a buckling test of axially compressed cylinder is abundant and it is the absence of information.

The shells are very sensitive to the buckling where the shell reaction changes in boundary condition. Difference between theory and experiment is expected in the case of cylindrical shells unless the boundary and loading situations are accurately modelled and the initial geometric imperfections are precisely taken into account in any theoretical model (Ullah and Ahmad, 2007).

According to Narayana et al., 2015, many researchers across the world and the complete understanding of the mechanical behaviour of these cylindrical shells exposed to different combinations of these fundamental loads is still an active area of current research examined the complex behaviour of these imperfect composite cylindrical shells subjected to axial compressive bending and torsion loads.