



SCHOOL OF MECHANICAL,
INDUSTRIAL & AERONAUTICAL
ENGINEERING

Supersonic flow Separation Over the Shoulder of Cone-cylinder and Hemisphere-cylinder at Incidence

MECN7018 - Research Project

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University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for
the degree of Bachelor of Science in Engineering.

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INDIVIDUAL DECLARATION WITH TASK SUBMITTED FOR ASSESSMENT

I, the undersigned, am registered for the course **MECN7018 - Research Project** in the year 2020. I herewith submit the following task "**Supersonic flow Separation Over the Shoulder of Cone-cylinder and Hemisphere-cylinder at Incidence**" in partial fulfilment of the requirements of the above course.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and / or without acknowledging the original source) is wrong;
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- This task has not been submitted before, either individually or jointly, for any course requirement, examination or degree at this or any other tertiary educational institution;
- I have followed the required conventions in referencing the thoughts and ideas of others;
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Signed this 18th day of October 2020

A handwritten signature in black ink, appearing to read 'T.K. Chan', written in a cursive style.

T.K. Chan

Abstract

The study of supersonic flow and flow separation over slender bodies have been studied extensively in the past where research towards fuselage and projectile body applications were common. However, the research of supersonic flow separation requires emphasis in the 3D domain using computational analytical tools to contribute towards the extensive research of such topic. The purpose of this research is to analyse, in detail, three-dimensional (3D) supersonic flow separation while utilizing computational tools to assist with flow visualization. The supersonic flow separation characteristics and properties over the shoulder of a cone-cylinder and hemisphere-cylinder are investigated at various angles of incidence and Mach numbers.

The hemisphere-cylinder and cone-cylinder have a diameter of 16mm and the cone-cylinder has a cone deflection angle of 25° . The selected flow conditions were M2.8 and M3.2, corresponding to high Reynolds numbers where turbulent flow separation conditions are present. Computational fluid dynamics (CFD) results are validated qualitatively with experimental data obtained from wind tunnel testing. Optics and surface oil flow visualization techniques were used to gather experimental results. Flow separation characteristics and properties are presented as surface flow streamlines, cross sectional contours, flow field streamlines, planar vectors, and 3D surfaces.

The hemisphere-cylinder encountered more complex flow separation characteristics over the shoulder compared to the cone-cylinder at high angles of incidence. The angle of incidence of the slender bodies affected the initiation of flow separation over the shoulder hence generating complex vortical flow structures downstream of the shoulder. The variation of freestream Mach number flow conditions did not indicate significant differences in the flow separation characteristics.