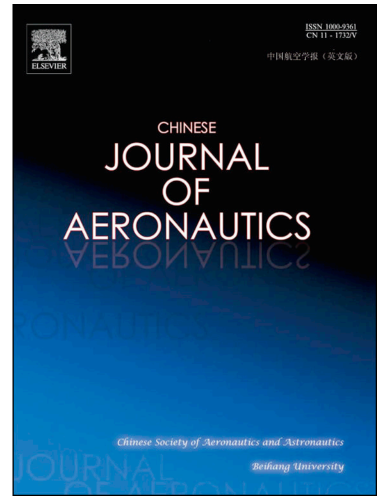
Accepted Manuscript



Full Length Article

Effect of multiple rings on side force over an ogive-cylinder body at subsonic speed

Priyank Kumar, J.K. Prasad

PII: S1000-9361(18)30131-6
DOI: https://doi.org/10.1016/j.cja.2018.04.007
Reference: CJA 1037

To appear in: *Chinese Journal of Aeronautics*

Received Date: 6 July 2017
Revised Date: 9 October 2017
Accepted Date: 19 October 2017

Effect of multiple rings on side force over an ogive-cylinder body at subsonic speed

Priyank KUMAR* **, J.K. PRASAD**

Department of Space Engg. & Rocketry, Birla Institute of Technology, Mesra, Ranchi 835215, India

Received 6 July 2017; revised 9 October 2017; accepted 19 October 2017

Abstract

Experiments and computations were performed over an ogive-cylinder body having an lift-to-drag ratio of 16 at a diameter Reynolds number of 29000. The side force on the slender body augments with increasing angles of attack for the case without a ring. This increase was mainly due to the increase in the asymmetry of the existing vortex pair in the wake of the body. Attempts were made to completely reduce the existing side force at the angle of attack ranging from 35° to 45°. Three rectangular cross-sectioned circumferential rings having a height of 3% of the local diameter were placed at axial distances of 2.5, 3.5 and 4.5 times the base diameter from the tip of the body so as to reduce the side force. The results obtained indicate that inclusion of three rings completely alleviated the side force on the slender body at the angle of attack ranging from 0° to 45°. The presence of rings was found to alter the growth of the vortices that helped in the reduction of the side force. Computations performed were in reasonable agreement with the experiments.

Keywords: slender body; ogive; asymmetric vortex; side force; high angle of attack; vortex lift

**Corresponding author. E-mail address: priyankkumar@bitmesra.ac.in*

1. Introduction

With the advancement in the aerospace technologies, the aerospace vehicles such as missiles and aircraft are often subjected to flying at large angles of attack either for a long or short duration in different flow regimes. The oncoming flow separates and curls up into a couple of vortices that further lift in the downstream owing to the adverse pressure gradients. The flow becomes highly complex in the case of vehicles having pointed forebody as the flow which leads to the establishment of multiple vortex systems arranged alternately. These vortex systems appear to be asymmetric in different cross planes (Fig. 1). It is a well-known fact that pointed nose vehicles flying at lower angles of attack experience a symmetric vortex pattern due to which the pressure distribution at any circumferential location remains symmetric and hence no side load is generated. With the increasing angles of attack, one of the vortices lifts while the other remains closer to the body. This leads to the non - symmetric static pressure distribution circumferentially and hence at high angles of attack the body experiences a side force. These side forces were firstly reported by Allen and Perkins in 1951 [1]. Since then investigations have been made to interpret the underlying flow physics for the onset of side force and several control methods have been employed to lessen the side force at different α. The side force highly depends upon factors like Reynolds number, the geometry of forebody, slenderness ratio, nose fineness, roll angles, etc. Lamont et al. [2, 3] did extensive experimental investigations on the ogive-cylinder body and reported the dependence of side force on the angles of attack α, Reynolds number *Re*, and roll angles. Zilliac et al. [4] and Dexter and Hunt [5] conducted the experiments with a very good surface finished model, damping system, and low turbulence wind tunnel; however, the dependency of the side force on the roll angles could not be omitted. Hence, they were forced to conclude that the changes in the side force are more or