Effect of Body Flap on the Aerodynamics of RLV-TD at Subsonic Mach Number

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Extended Abstract

Introduction

The development of Space Transportation Vehicle (STV) is essential in order to have low cost to access space. A thorough knowledge in Technology Demonstrator Vehicle (TDV) will give confidence in the design & execution of STV. Hence aerodynamic characterization of a TDV is necessary. Reusable Launch Vehicle–Technology Demonstrator (RLV-TD) is a wing-body configuration designed by ISRO for the demonstration of key technologies such as hypersonic aerothermodynamics, controlled re-entry, autonomous landing etc, in the Hypersonic Experiments (HEX) mission.

RLV-TD is boosted by modified HS9 booster. It is intended to fly in flight regimes ranging from hypersonic speeds to low subsonic speeds during its return path. After separation from the booster, the TDV (Technology Demonstrator Vehicle) re-enters the atmosphere at hypersonic Mach number. ISRO successfully demonstrated first RLV-TD on 23rd March 2016.

In general winged body configurations use elevator for pitch control and rudder for roll control. In RLV-TD, the body flap was provided to trim the vehicle. In the present paper, effect of body flap on the aerodynamics of RLV-TD at subsonic Mach number have been studied in detail.

The tests were conducted in National Wind Tunnel Facility (NWTF), IIT-Kanpur. It is a state of the art 3m X 2.25m low speed closed-circuit, continuous, atmospheric wind tunnel.

Test Conditions

The test was conducted at subsonic Mach number of 0.2 with angle of attack range (α) of -6° to 36° @ 2° interval. Range of angle of sideslip (β) tested was 0°, 10° and 20°. The Reynold's Number of the model is 8.08 million based on MAC of wing. The body flap deflected conditions are 10° and 20° downwards. Figure 1 shows the photograph of 1:6.25 model in NWTF with and without body flap.

Results and discussions

Effect of presence of body flap

The effect of body flap has been studied with different sideslip (β) angles such as 0°, 10° and 20°. Figure 2 shows the variation of force and moment coefficients at $\beta = 0°$. It is observed that

1. For $\beta = 0°$ and angle of attack up to 20°, variation of C_L, C_D and C_m are negligible. After 20° angles of attack, C_{PM} reduces (less negative) for without body flap case indicates the vehicle is slightly unstable. C_D also slightly decreases for angles of attack higher than 20°. The L/D is more or less same for entire range of angles of attack.
2. The effect of body flap on side force, rolling moment and yawing moment coefficient is minor for all side slip angles.

Effect of body flap deflection

Figure 3 shows the effect of body flap deflection on aero coefficients. It is observed that,

1. The lift and drag coefficient increase with body flap deflection. The downward deflection of body-flap produces nose down pitching moment.
2. The effect of body flap deflection on side force, rolling moment and yawing moment coefficient is small.

More details will be provided in full length paper.

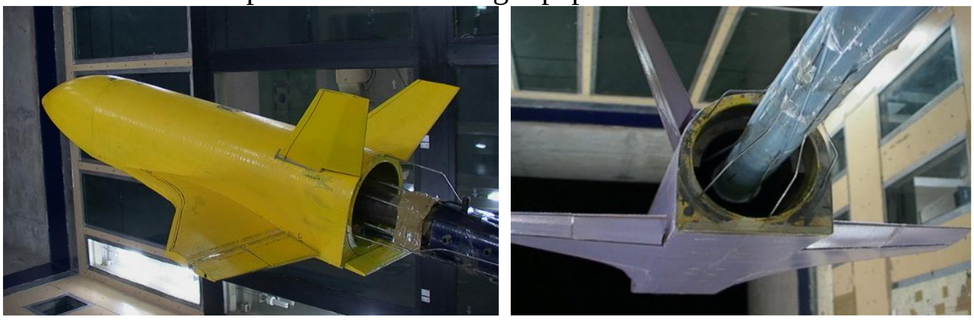

Figure 1: Photograph of 1:6.25 model in NWTF with and without body flap

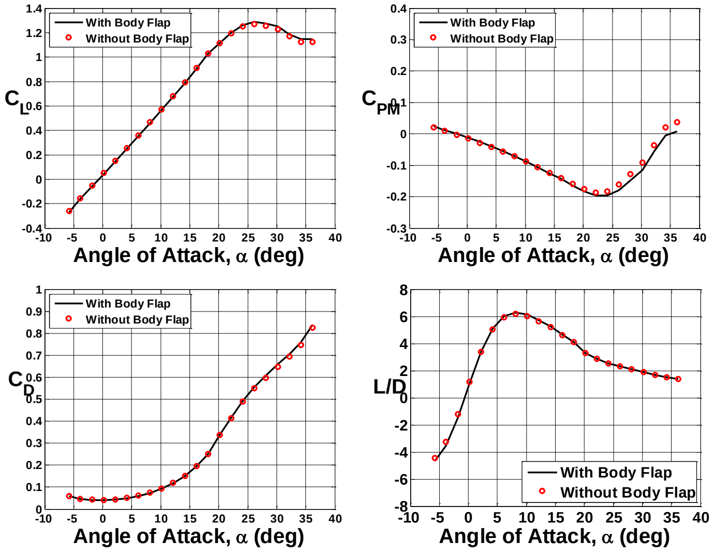

Figure 2: Effect of Body flap on aero coefficients at β=0°

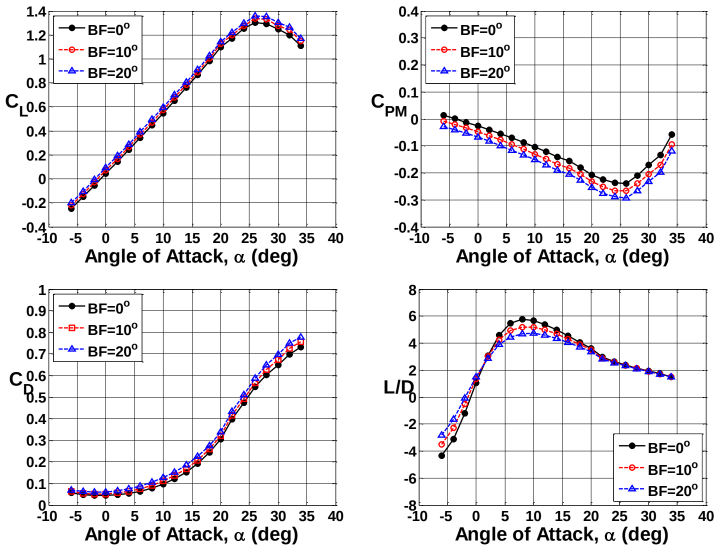

Figure 3: Effect of Body flap deflection on aero coefficients