Drag coefficient as a function of Mach number for PrawieR5 rocket

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Abstract

This paper presents the results of flow simulations conducted in Solidworks for the PrawieR5 rocket model. The ensuing drag coefficient graphs, as a function of Mach number, are analyzed and compared with existing literature data. Additionally, the document discusses the utilized meshes and presents futher information about few choosen simulations.

Nomenclature

ρ	Density of Air
A	Area of cross-section of rocket
C_d	Drag coefficient
k	Specific heat ratio
M	Mach number
p_0	Total pressure
p_d	Dynamic pressure
p_s	Static pressure
v	Relative velocity

1 Problem of drag coefficient

This basic study does not take into account the complex nature of aerodynamic drag and simplifies drag effect to a one minimal equation for geometric and friction forces. The aim is to establish a singular drag coefficient, treated as a function of Mach number. This study seeks to produce plot resembling those found in Modern Exterior Ballistics for projectiles.

1.1 Basic physics used in study

This study will focus on one drag coefficient, which in this case will be determined with usage of the equation for isentropic compressible flow.

$$p_d = p_s \cdot (1 + \frac{k-1}{2} M^2)^{\frac{k}{k-1}} - p_s \tag{1}$$

This p_d in now used in equation for aerodynamic drag:

$$F_d = C_d \cdot A \cdot p_d \tag{2}$$

1.2 CFD model

As mentioned previously, simulations were conducted using Solidworks Flow Simulations. Initial conditions of simulation:

Mach number change was dependant only on changes in velocity. Depending on the simulation, different meshes were applied for parametric studies at low and high Mach numbers. For high Mach parametric studies (Mach number greater than or equal to 3), the high Mach flow option in Solidworks settings was utilized.

2 Initial studies

3 Parametric study for low mach

4 Parametric study for high mach

5 Resoults

References

[1] Robert L. McCoy (1999) Modern Exterior Ballistics: The Launch and Flight Dynamics of Symmetric Projectiles, Schiffer Military History