1   Introduction

1.1   The problem of aerodynamic drag

Dlaczego badamy oraz wzór na opór aerodynamiczny. Że bazujemy na modern exterior balistics i jakieś inne z literatury bo to łądnie brzmi.

1.2   Methodology of the present work

For simulations, two programs were chosen to compare the results. The first program, Solidworks Flow Simulation, was used for both CFDs and model preparation. The second program utilized was Ansys Fluent.

Initially, the models were prepared in Solidworks and subsequently exported to .step (214) file format for importation into Ansys. Within Ansys, Fluent with Meshing was used to prepare the mesh, followed by the execution of simulations. Solidworks Flow Simulation was also employed for mesh preparation and simulation execution, enabling subsequent comparison with results obtained from Ansys Fluent.

Parametric studies/sets were conducted for all models, encompassing nine different velocities ranging from 0.1 to 1.0. Subsequently, resulting graphs depicting the drag coefficient versus Mach number were analyzed and compared.

1.3   Tested models

R6-Endcone, R6-No-Endcone, PrawieR5

For each set of simulations, computational domain mesh setting and graph of velocity and pressure for 0.6 mach will be shown.

2   Initial study

ChatGPT
    The work was initiated with the remodeled R5 model, which had been prepared in Solidworks and featured an endcone, a modification in comparison to the original R5 model. Subsequent testing of the model was conducted using Solidworks Flow Simulation. However, this model was solely utilized for comparing the results of the older model with the new one. The results can be observed here
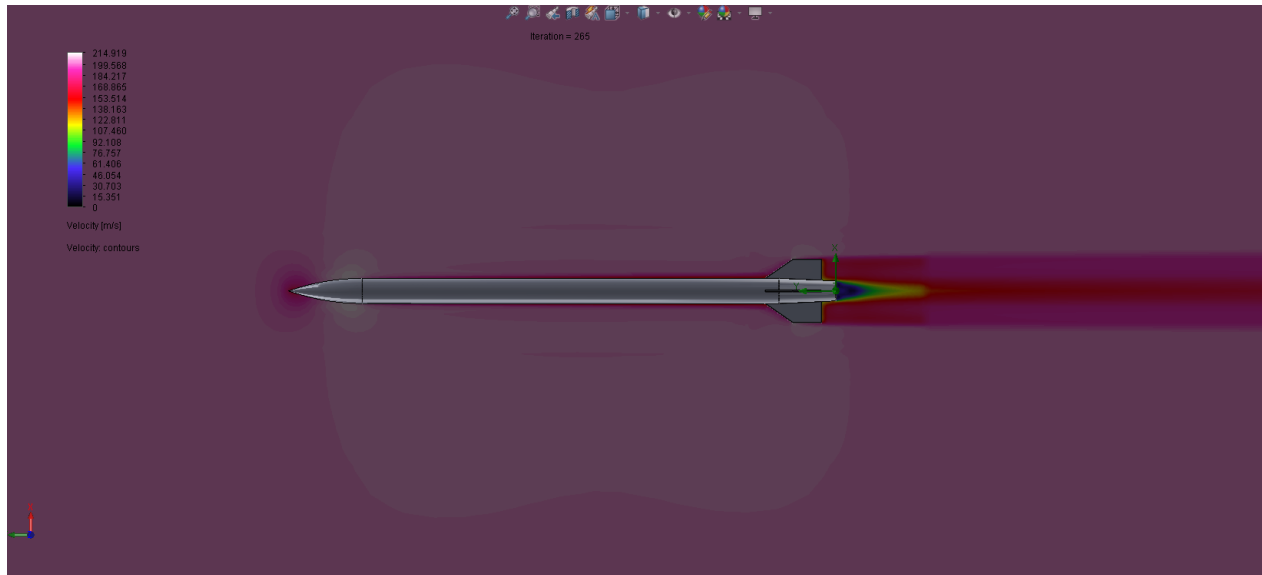
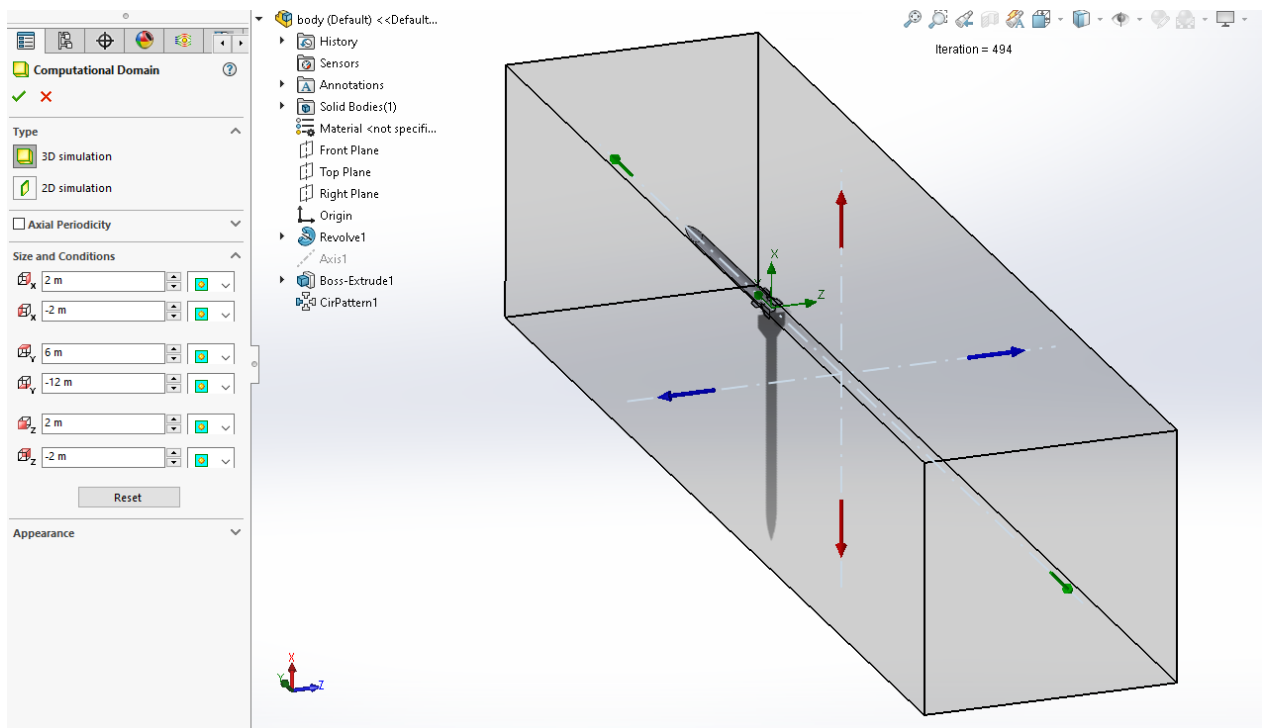Figure 1: Velocity graph for PrawieR5 model at Mach 0.6

Figure 2: CD graph for PrawieR5 model at Mach 0.6

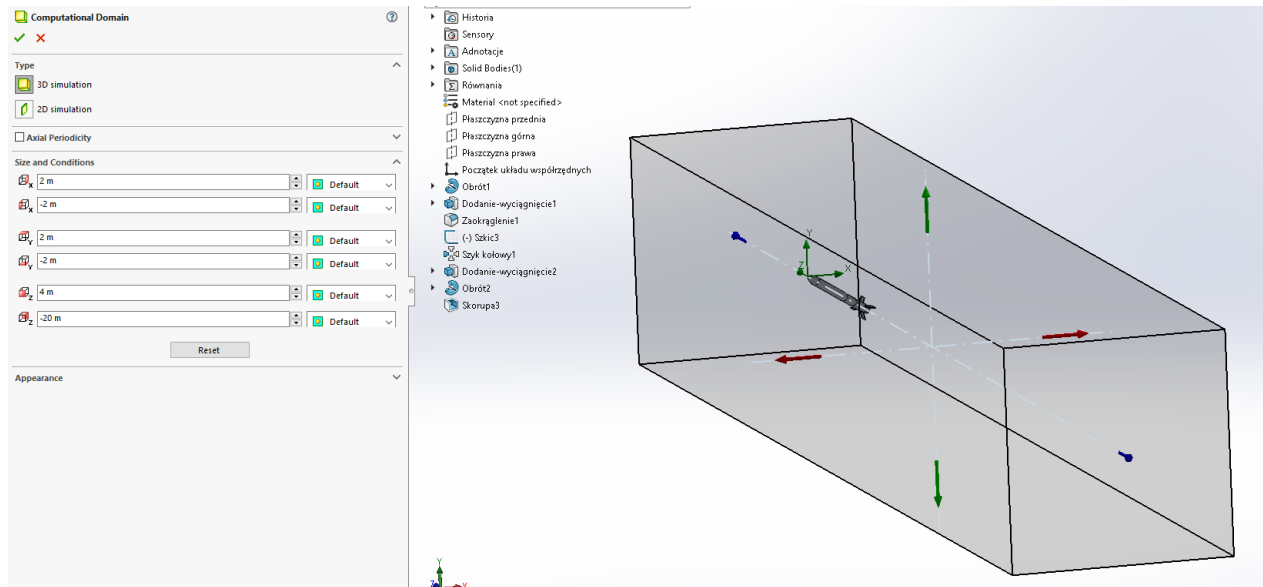# 3 Preliminary research of endcone effect in Solidworks

3.1 R6 Endcone

Figure 3: Computational domain for R6-Endcone model

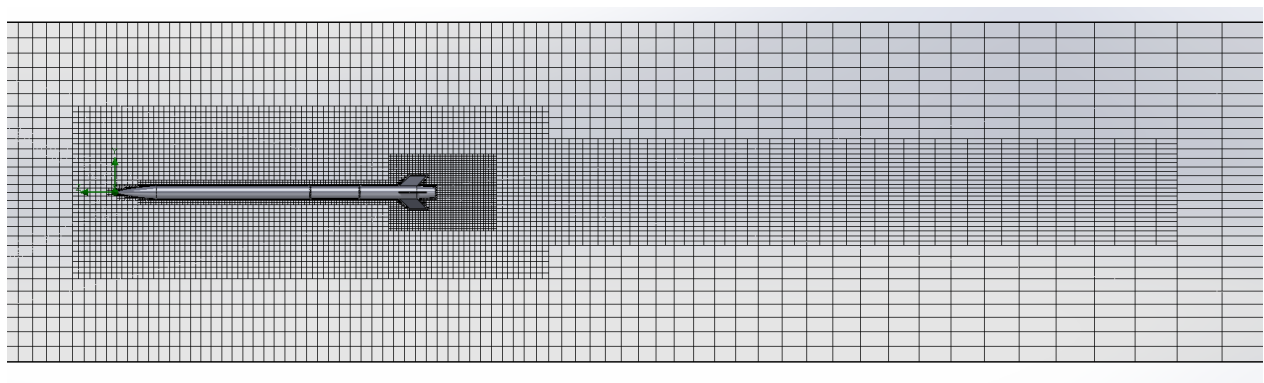|	
Total cells	351,913
Fluid cells	351,913
Fluid cells contacting solids	51,217

Figure 4: Cell number for R6-Endcone model

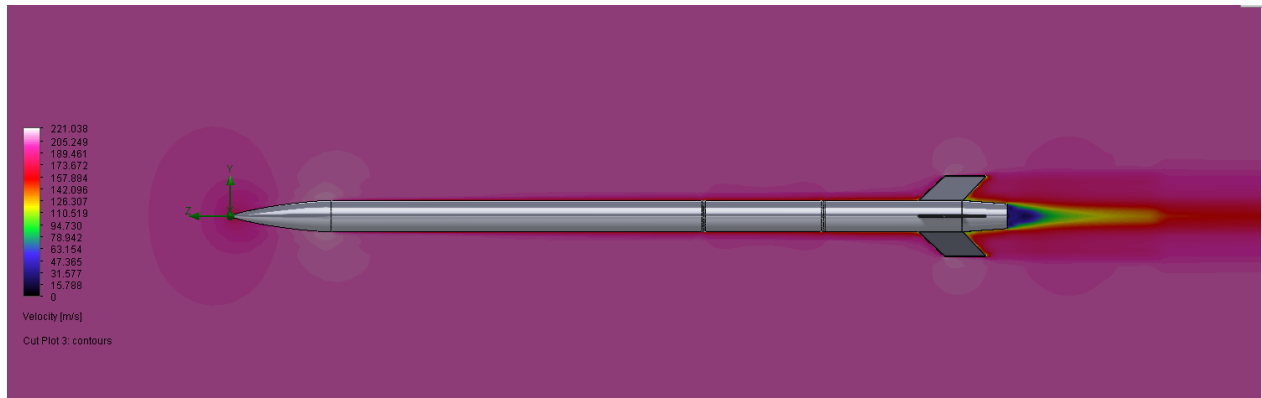Figure 5: Mesh for R6-Endcone model
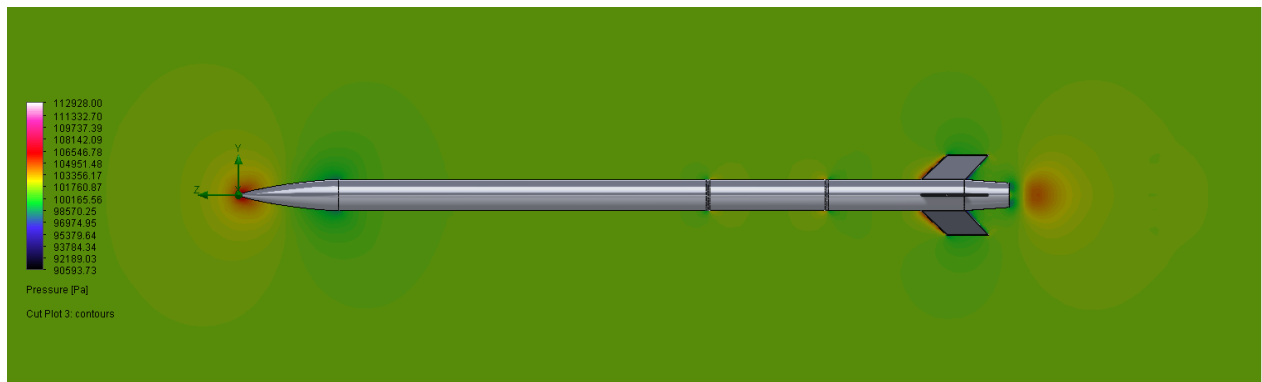
Figure 6: Velocity graph at 0.6 Mach for R6-Endcone model

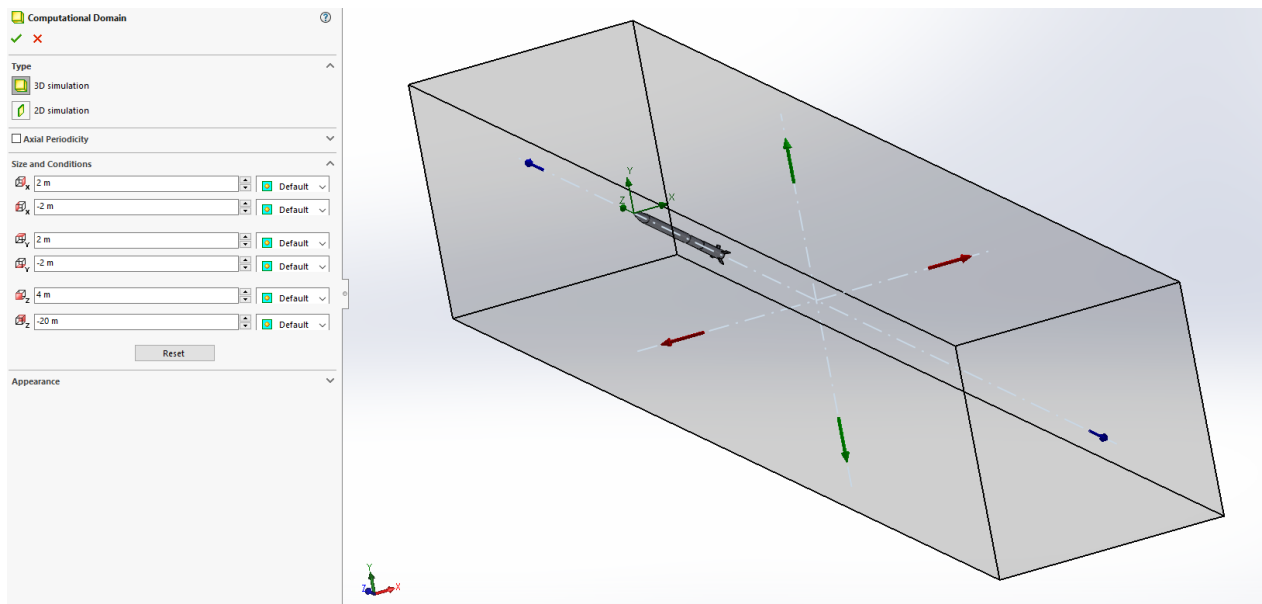Figure 7: Pressure graph at 0.6 Mach for R6-Endcone model

3.2   R6 No Endcone

Figure 8: Computational domain for R6-NoEndcone model

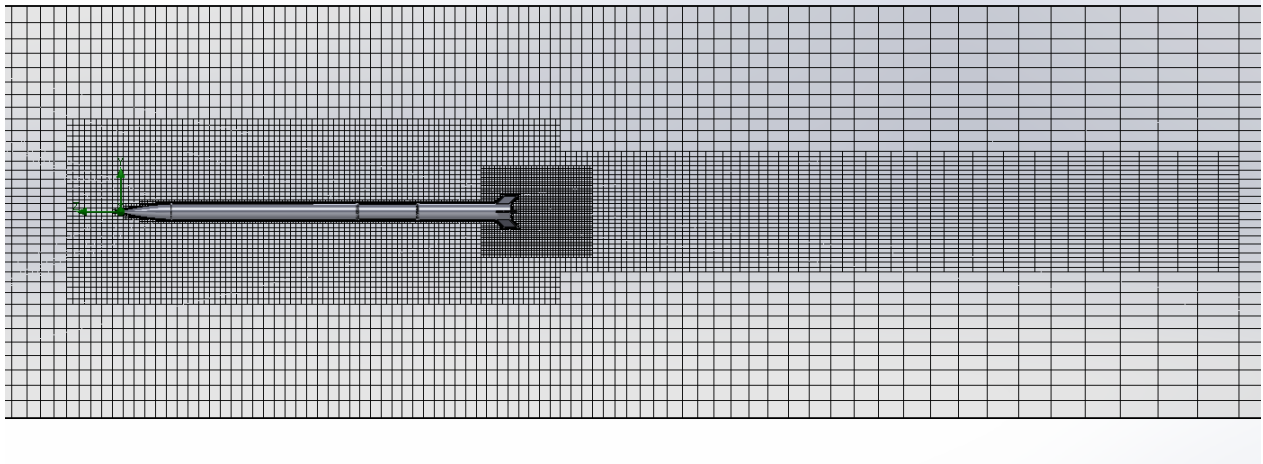|	
Total cells	475,197
Fluid cells	475,197
Fluid cells contacting solids	74,456

Figure 9: Cell number for R6-NoEndcone model

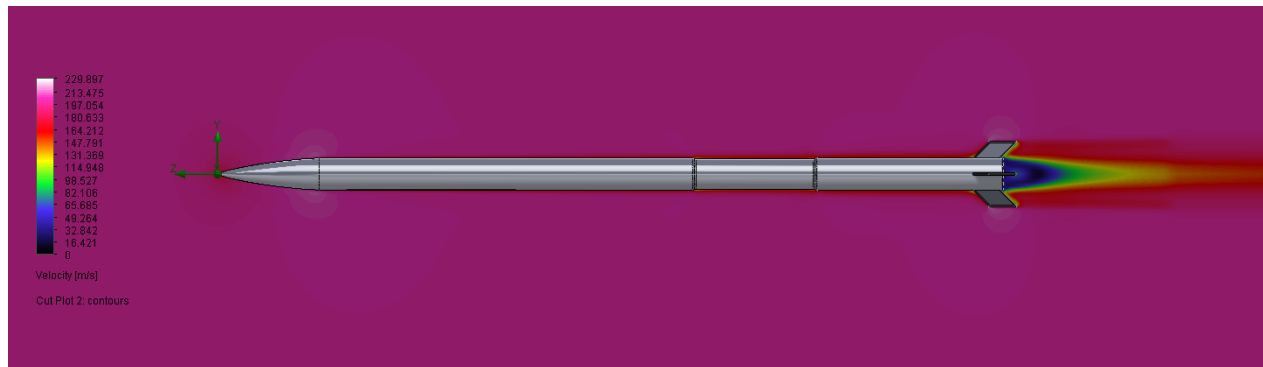Figure 10: Mesh for R6-NoEndcone model

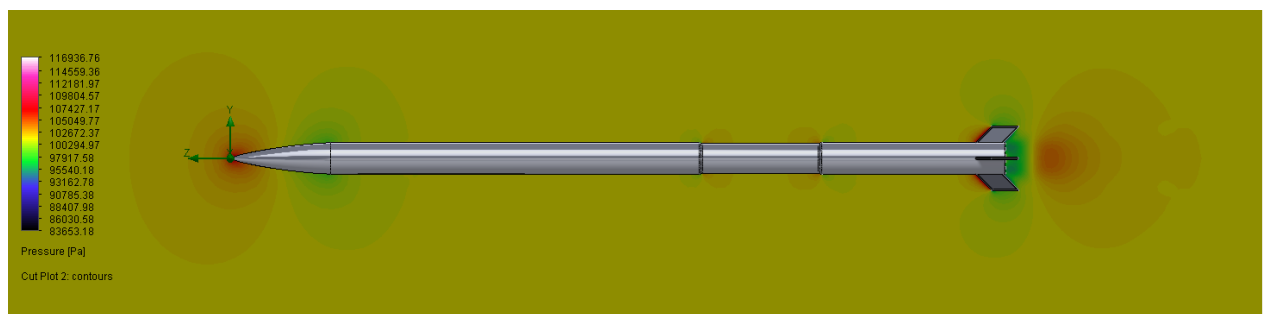Figure 11: Velocity graph at 0.6 Mach for R6-NoEndcone model

Figure 12: Pressure graph at 0.6 Mach for R6-NoEndcone model
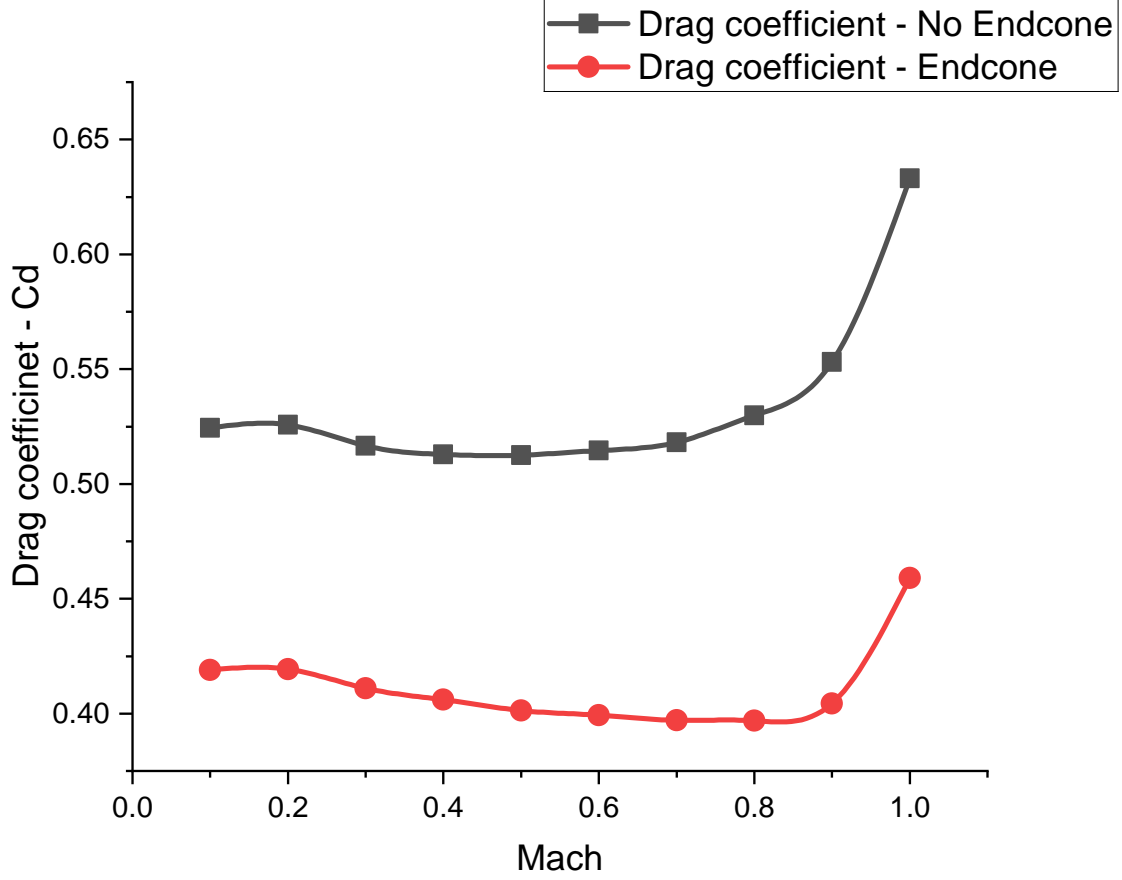
3.3 Results of the preliminary research

Figure 13: CD graph of R6-Endcone and R6-NoEndcone models

Preliminary research indicates that the endcone model exhibits significantly lower drag coefficient for 8 degrees endcone angle, while keeping trends of change on the chart. Even more, for endcone model the trans sonic spike starts later compared to no endcone model. This would be very beneficial for the range of 0.6-0.9 Mach.

Table 1: Average values and differences

	R6 Endcone	R6 No Endcone	Difference	% Difference
0.1 - 1.0 Mach	0.411	0.534	0.123	29.8%
0.1 - 0.6 Mach	0.409	0.518	0.108	26.5%

For a range of 0.1 to 0.6 Mach, the endcone model exhibited a 26% lower drag coefficient in comparison to the no endcone model. This is a significant difference, indicating that the endcone model is much more aerodynamically efficient.

4 Results and discussion

- Wykresy CD solida

- Wykres CD fluenta

- porównanie CD dla wyników solida i ansysa jakąś tam statystyką z użyciem pythona(ja to zrobie)

- Podsumowanie że wyszedł lepszy dla endcone(co się zgadza z literaturą i przewidywaniami) oraz jakieś tam gadu gadu o Solidzie że gorszy.