Fundamental Numerical Study for Performance of an Expansion-Deflection Nozzle according to the Base Nozzle Length

Kihwan Lee(leeh1021@naver.com)[1], Hansol Kim[1], Hwanil Huh[2]

[1]Department of Aerospace Engineering, Graduate School of Chungnam National University, Daejeon, Republic of Korea, [2]Department of Aerospace Engineering, Chungnam National University, Daejeon, Republic of Korea

Abstract

Altitude compensation nozzle can reduce performance losses due to altitude increases using specific shapes or devices, Unlike conventional bell nozzle. Among the various altitude compensation nozzles, the Expansion-Deflection nozzle has a pintle inside the nozzle and obtains a performance gain according to the effective area ratio change. The Expansion-Deflection nozzle was a concept proposed in the 1960s, but technology at the time had difficulty in researching. However, as the numerical analysis developed in the 21st century, many researches have been carried out. Especially in Europe, there is a case where the Expansion-Deflection nozzle is applied to the upper engine of the Ariane-5 ESC-B launch vehicle to obtain the weight gain for the nozzle length reduction.

In this study, fundamental numerical analysis is performed to confirm the effect of nozzle length reduction on performance in Expansion-Deflection nozzle. The Expansion-Deflection nozzle is designed using the Expansion-Deflection nozzle design method of University of Bristol and using the specifications of the Korean Space Launch Vehicle first-stage nozzle. Main design variables such as nozzle throat angle and pintle inflection angle are fixed, and the Expansion-Deflection nozzle is designed by reducing constantly the base nozzle length.

The inlet conditions of the interpretation is derived from the Korean launch vehicle first-stage nozzle published in the literature by putting it into the NASA CEA code, and sea level condition is used for the atmospheric condition. then 200,000 grids are selected through grid convergence analysis.

As a result, When the E-D nozzle design method is applied to the specifications of Korean Space Launch Vehicle first-stage nozzle, there is an over-expansion that resulted in the loss of performance of the nozzle. This tendency is also observed in the Expansion-Deflection nozzle with reduced nozzle length. Therefore, it is necessary to perform numerical analysis of altitude in order to confirm that the altitude at which the internal flow is fully expanded to the nozzle tip is reduced when the length of the Expansion-Deflection nozzle is reduced.

Keywords: *Expansion-Defelction Nozzle, Base Nozzle Length, Over-Expansion*

References

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Biography

Kihwan Lee is M.S. candidate in Aerospace Engineering at Graduate of Chungnam National University. His research interests include performance of launch vehicle related to altitude compensation nozzle. Currently, he is conducting research focusing on Expansion-Deflection nozzle using experiments and numerical analysis.