리세스가 있는 케로신/산소 동축 분사기의 난류 연소 유동 해석

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Numerical Analysis of Turbulent Combustion of a Kerosene/Oxygen Coaxial Injector with a Recess

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ABSTRACT

A multi-step quasi-global mechanism is developed for the kerosene/oxygen combustion analysis including dissociation products. Reaction constants of the global reaction are determined to have agreement with experimental data. The mechanism is used for the numerical analysis of the combustion flow field of the kerosene/oxygen shear coaxial injector. The results from high-resolution numerical analysis confirmed qualitatively that the recess enhance the fuel/air mixing and combustion efficiency by the increased flow instabilities.

초 록

케로신/산소의 연소 해석을 위하여 연소 해리 성분을 고려한 다단 준총괄 반응을 개발하였다. 총괄 반응 상수는 실험 데이터에 잘 부합하도록 결정하였다. 개발된 다단 총괄 반응을 이용하여 케로신/산소 축대칭 전단 동축 분사기의 연소 유동에 대한 수치 해석을 수행하였다. 고해상도 기법을 이용한 해석을 통하여 리세스가 유동 불안정성의 증가시켜 연료 공기 혼합 및 연소 효율을 증대에 기여하는 정성적 특징을 확인하였다.

Key Words: Kerosene combustion(케로신 연소), Multi-step Quasi-gloabl Reaction(다단 총괄 반응), Coaxial Injector(동축 분사기), Recess(리세스)

A multi-step quasi global combustion mechanism is suggested based on the modification from the quasi-global mechanism of ethylene combustion [1]. Thermodynamic data for gaseous component are taken from NASA polynomial, while the kerosene data is taken from Franzelli et al.[2] Reaction order of the global mechanism was selected by intuition from the comparison with the existing quasi-global models while maintained

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as integer values differently from the existing multi-step kerosene mechanism of Wang [3]. The integer values of the reaction order is crucial for the stability of reacting flow CFD code where the implicit scheme is used for the time integration of the multi-species multi-step reactions. Fig. 1 is the ignition delayed time compared with experimental data in Dagaut and Cathonnet.[4] The pre-exponential factor and activation energy of the global reaction were tuned to get better agreement with the experimental data.

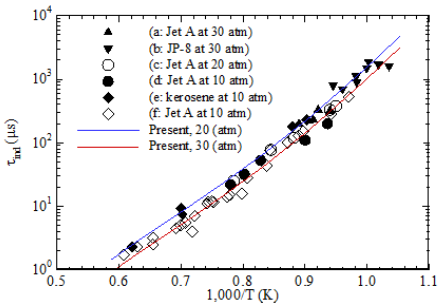

Fig. 1 Ignition delay compared with experimental data

A comparison of combustion temperature has been compared with chemical equilibrium solution by NASA CEA code. While most of the global mechanism fails in prediction of combustion temperature that is quite crucial in high temperature system such as liquid rocket engine, the multi-step quasi-global reaction including minor species gives better prediction of combustion temperature.

The suggested mechanism was implemented to a existing CFD code with DES turbulence model[5,6], and applied for the kerosene-oxygen liquid rocket model with single shear coaxial injector. Fig. 2 is the instantaneous contour plots from DES analysis of the kerosene-oxygen liquid rocket combustion. The overall flow field results and pressure variation confirmed qualitatively that the recess enhance the fuel/air mixing and combustion efficiency by the increased flow instabilities.

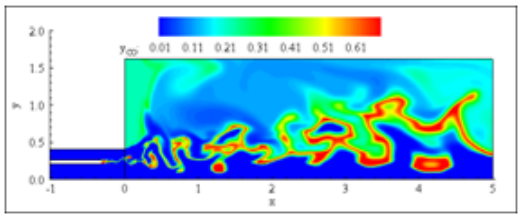

Fig. 2 DES simulation results for kerosene-oxygen coaxial injector with recess, LRecess=3.2mm.

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