FUNDAMENTALS OF COMBUSTION

Final Report

Hydrogen - air pre-mixed combustion in a rough micro combustor

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OBJECTIVES:

The objective of this submission is to present final verification work performed in Ansys. We intend to perform the final tests based on a smooth micro combustor.

PROBLEM FORMULATION:

In order to obtain proper dimensions of the micro combustor, species and their reactions and boundary conditions for combustion of a premixed H_2/Air mixture, we have referred to the paper Comparative analysis of hydrogen/air combustion CFD-modelling for 3D and 2D computational domain of micro-cylindrical combustor. This paper is available in the INTERNATIONAL JOURNAL OF HYDROGEN ENERGY. This paper has been authored by Dmitry Pashchenko.
We have used a 2-dimensional axisymmetric model in this paper.

Micro- Combustor:

- ## Diagrams and Dimensions:

Dimensions: 6	
H12	18 mm
H14	20 mm
H15	2 mm
V11	2 mm
V13	3 mm
V16	1 mm

MESH:

We had initially generated a coarse mesh which has been refined by reducing the size of each mesh element. Details are attached below:

Defaults	
Physics Preference	CFD
Solver Preference	Fluent
Element Order	Linear
Element Size	4.e-002 mm
Export Format	Standard
Export Preview Surface Mesh	No

Statistics	
Nodes	36826
Elements	36250

MESH DETAILS

BOUNDARY CONDITIONS:

Table 2 – Boundary conditions.

No.	Parameter	Inlet	Outlet
1	Excess air ratio	1.0	–
2	Mass flow rate H_2+air	1.8551×10^{-5} kg/s	–
3	H_2 mass flow rate	5.25×10^{-7} kg/s	–
4	Mass fraction: $H_2/O_2/N_2$	0.028301/0.22641/0.745289	–
5	Turbulent intensity	5%	5%
6	Hydraulic diameter	2×10^{-3} m	3×10^{-3} m
7	Gauge pressure	0.0 Pa	0.0 Pa

- **The inlet temperature is 1000K**

Chemistry Of Combustion:

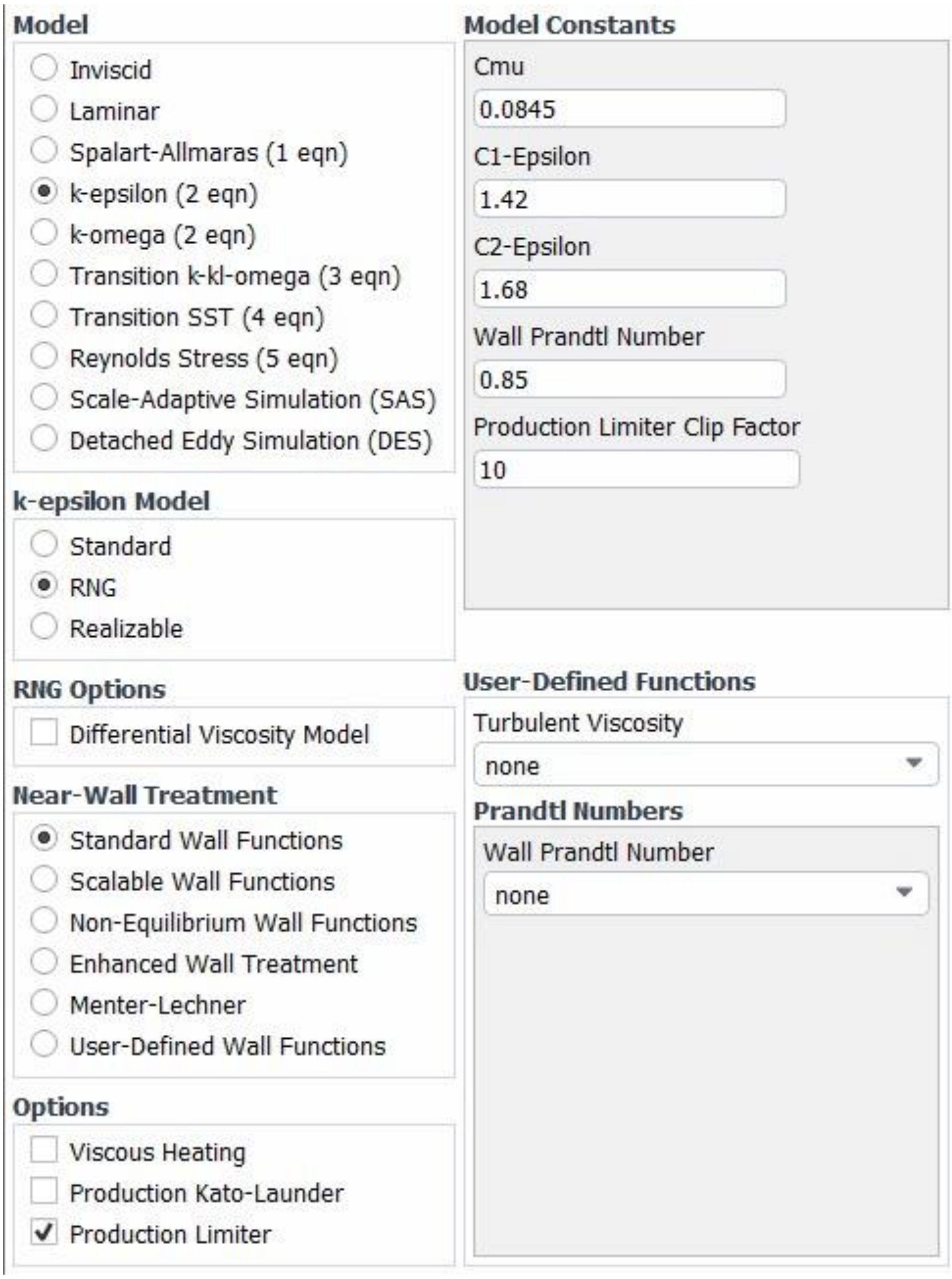
We have used a 9 species, 19 reaction mechanism imported from Chemkin database.

Table 2 H_2/air chemical reaction mechanism

Reaction	A (m^3/kmol s)	β	E (J/kmol)
$H + O_2 = O + OH$	5.1×10^{13}	-0.82	6.91×10^{7}
$H_2 + O = H + OH$	1.8×10^{7}	1.0	3.7×10^{7}
$H_2 + OH = H_2O + H$	1.2×10^{7}	1.3	1.52×10^{7}
$OH + OH = H_2O + O$	6.0×10^{6}	1.3	0.0
$H + OH + M = H_2O + M^a$	7.5×10^{17}	-2.6	0.0
$O_2 + M = O + O + M$	1.9×10^{8}	0.5	4.001×10^{8}
$H_2 + M = H + H + M^b$	2.2×10^{9}	0.5	3.877×10^{8}
$H_2 + O_2 = OH + OH$	1.7×10^{8}	0.0	2.0×10^{8}
$H + O_2 + M = HO_2 + M^c$	2.1×10^{12}	-1.0	0.0
$H + O_2 + O_2 = HO_2 + O_2$	6.7×10^{13}	-1.42	0.0
$H + O_2 + N_2 = HO_2 + N_2$	6.7×10^{13}	-1.42	0.0
$HO_2 + H = H_2 + O_2$	2.5×10^{10}	0.0	2.9×10^{6}
$HO_2 + H = OH + OH$	2.5×10^{11}	0.0	7.9×10^{6}
$HO_2 + O = OH + O_2$	4.8×10^{10}	0.0	4.2×10^{6}
$HO2 + OH = H2O + O_2$	5.0×10^{10}	0.0	4.2×10^{6}
$HO_2 + HO_2 = H_2O_2 + O_2$	2.0×10^{10}	0.0	0.0
$H_2O_2 + M = OH + OH + M$	1.3×10^{14}	0.0	1.905×10^{8}
$H_2O_2 + H = HO_2 + H_2$	1.7×10^{9}	0.0	1.57×10^{7}
$H_2O_2 + OH = H_2O + HO_2$	1.0×10^{10}	0.0	7.5×10^{6}

[a] Enhancement factors: H_2O/20/.
[b] Enhancement factors: H_2O/6/, H/2/, H_2/3/.
[c] Enhancement factors: H_2O/21/, H_2/3.3/, O_2/0/, N_2/0/.

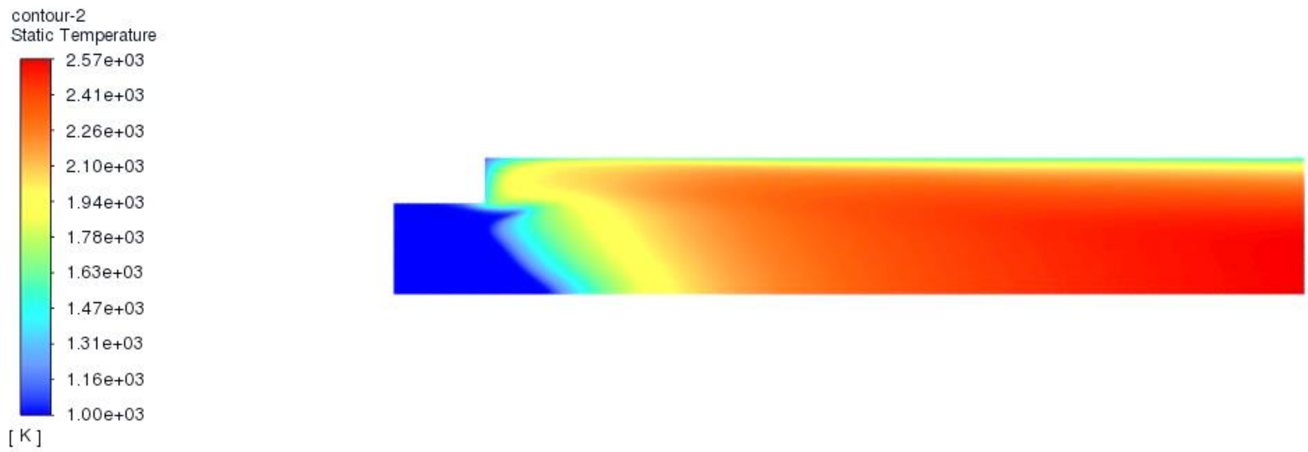
VISCOUS MODEL:



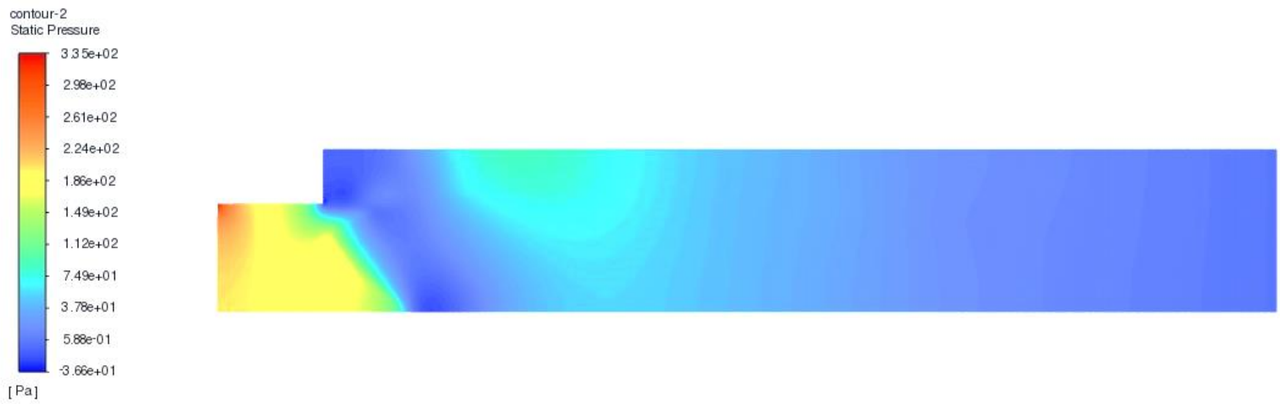
Radiation Model:

In this study, P-1 radiation model is used for developed numerical model. The chosen P-1 radiation model is the simplest case of the more general P-N model, which considers the influence of geometry on the radiative heat transfer.

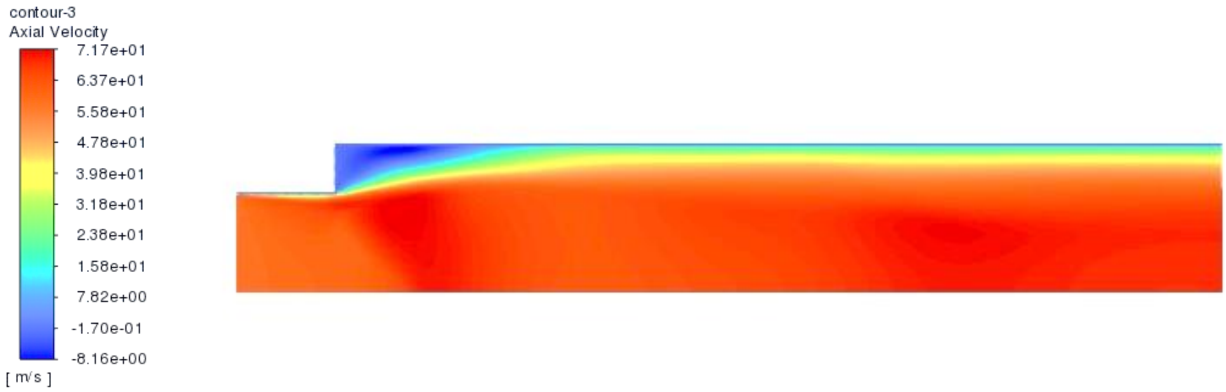
Result Obtained from Our Simulation:



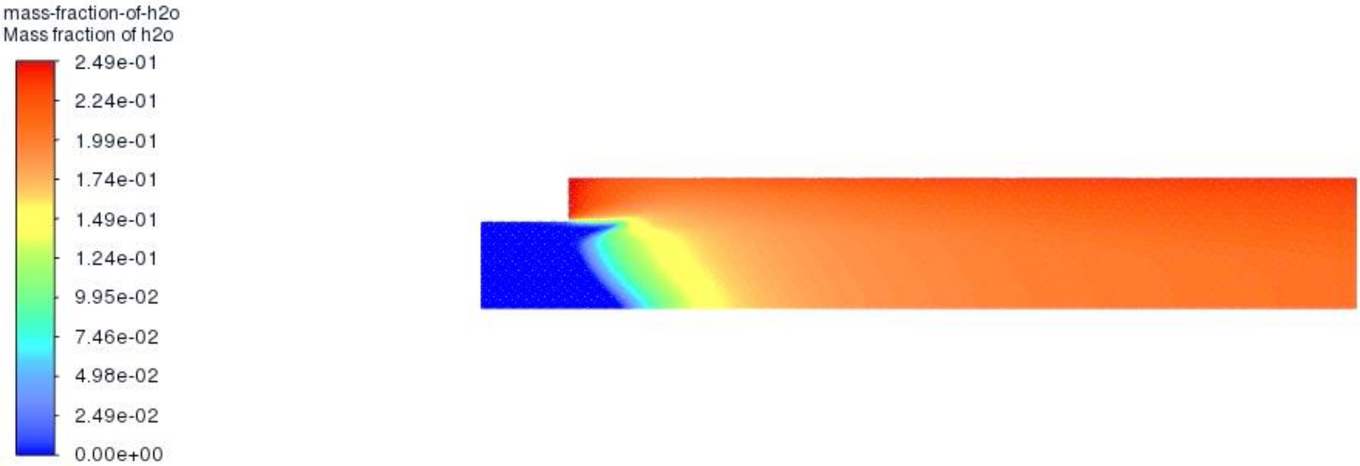
STATIC TEMPERATURE DISRTIBUTION



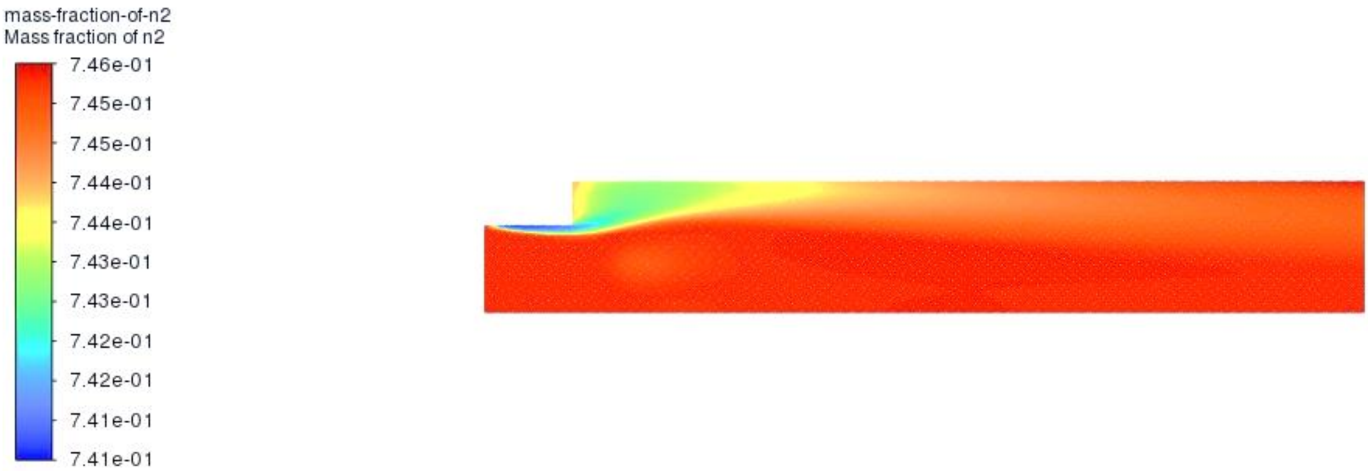
STATIC PRESSURE DISTRIBUTION



AXIAL VELOCITY DISTRIBUTION



MASS FRACTION OF H_2O



MASS FRACTION OF N_2