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Experimental and numerical analysis of syngas Mild combustion

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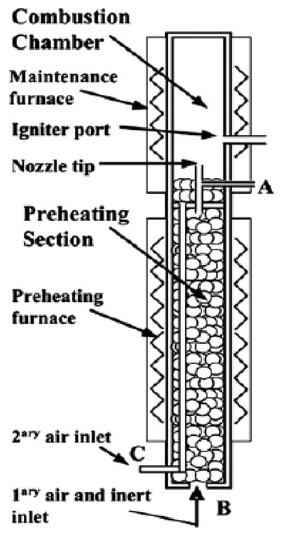
OBJECTIVE

Aim of this work is to develop a CFD model for prediction of NOx emissions, temperatures and species mole fractions in a Mild combustion experimental burner which was fed with H2 and H2 /CO2/H2O mixtures.

Experimental apparatus



Fuel: H2 /CO2/H2O mixtures

Experimental and modelling runs investigated

Run number	H2 (Nml/min)	Air1 (Nml/min) (preheated)	N2 (Nml/min) (preheated)	CO2 (Nml/min)	H2O (Nml/min)	Preheater temperature (K)
1	407.6	999.5	1293.1	0	0	1173
2	596.6	1463.1	2705.6	149	745	1373
3	596.6	1463.1	543.3	149	745	1373

The models Used in this work

- Turbulence models: Standard K-ε, k-ω-Transition, RSM-Transition.
- Combustion models: Eddy dissipation/Finite Rate (ED/FR), Eddy Dissipation Concept (EDC), modified EDC [5,6].
- Kinetic mechanisms: Dryer-Westbrook mechanism (WD), POLIMI-H2CO1101 [7].

Effect of turbulence models on prediction of middle temperature and outlet CO emission (used models: modified EDC with POLIMI-H2CO1101)

CO (ppm, dry basis)		EXP	SKE	k-ω-Transition	RSM-Transition
Run 1	CO (ppm)	0.5	0	0	0
	Temperature (K)	1060	1090	1090	1080
Run 2	CO (ppm)	130	2	42	129
	Temperature (K)	1284	1335	1330	1290
Run 3	CO (ppm)	18	0.7	6	23.2
	Temperature (K)	1285	1300	1294	1280

- The RSM- transition gives a better prediction for temperature and CO.

Effect of combustion models and kinetic mechanisms on temperature and CO distribusion. (Run 2)

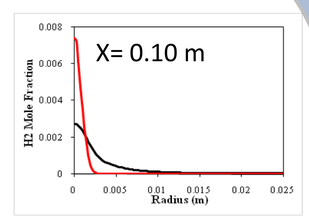
(a) ED/FR with (WD) mechanism, (b) modified EDC with (WD) mechanism, (c) modified EDC with POLIMI 1101, (d) EDC with POLIMI 1101.

- Temperature distributions are almost similar for all the combustion models and mechanisms, but the CO distributions are quite different. when the (WD) mechanism is used, the value of CO mole fraction is higher than that of the POLIMI syngas mechanism.

Effect of diffusion on temperature and H2 mole fraction

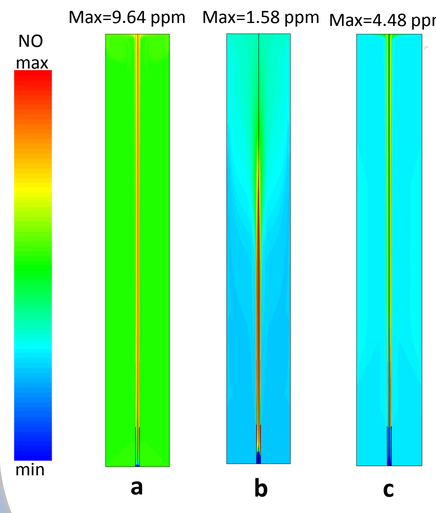
modified EDC with POLIMI 1101 (Runs 2).

X= 0.05 m X= 0.10 m X= 0.05 m

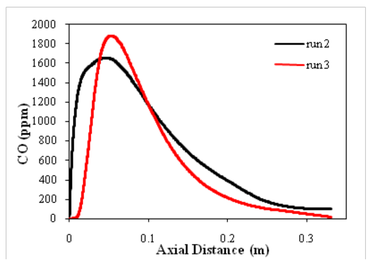


- when laminar diffusion terms are included in the calculations, the temperature profile varies slightly, but the H2 profile varies significantly.

Prediction of CO and NO emissions



a=run1, b=run2 and c=run3.



- The maximum value of NO belongs to run 1.
- a high concentration region of NO can be observed near the central axis of burner in all three runs.
- when the flow rate of N_2 in inlet mixture is increased, the peak value of CO profile at the beginning of chamber decreases.

CONCLUSIONS

The results of this work showed that the KPP and CFD results are in good agreement with experimental observations only when the RSM-transition turbulence model together with modified EDC and POLIMI 1101 syngas mechanism are employed in the model. The results also revealed that as the nitrogen flow rate in the gas mixture increased (runs 2 and 3), the CO mole fraction at the burner outlet increased.

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[7] Frassoldati, A., Faravelli, T., Ranzi, E., Ignition, Combustion and Flame Structure of carbon Monoxide/Hydrogen Mixtures. Note1: Detailed kinetic Modeling of Syngas Combustion also in Presence of Nitrogen Compounds, Int. J. Hydrogen Energy 32: 3471-3485 (2007), Available at: http://www.chem.polimi.it/CRECKModeling).