The Solar Conversion of CO_2 to CO and O_2 for the Production of H_2

Ralph Price, Thomas Fletcher
Brigham Young University

Scott Hill
Combustion Resources

Reed Jensen
Renewable Energy Corporation

Introduction

- At high temperatures CO_2 is known to dissociate into CO and O.
- A prototype unit using only solar energy has achieved a 4-6 mole percent CO conversion from CO_2.
- The prototype device was modeled using two different modeling programs (PCGC-3 and Fluent).

Objectives

- Used Fluent and PCGC-3 to predict the following:
  - Flow profiles
  - Temperature profiles
  - Reaction kinetics and photolysis reactions
  - Thermodynamic equilibrium
  - Radiation
- Researched H_2 production processes.
- Modified prototype to improve performance.

Prototype Apparatus

Converter in sun

Reflecting Mirrors

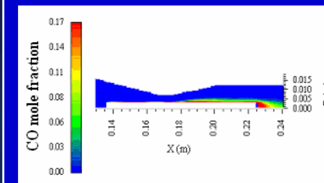
Solar Collector

Zirconia Rod

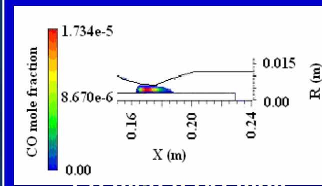
Prototype Description

- Mirrors focus sunlight into converter.
- Zirconia rod in converter is heated by sunlight to approximately 2350°C.
- CO_2 stream passed over hot rod causing CO_2 to dissociate into CO and O_2.
- Product stream (4-6 mole percent CO) is cooled quickly.
- CO is separated and used in water-gas shift reaction.

PCGC-3 Profiles

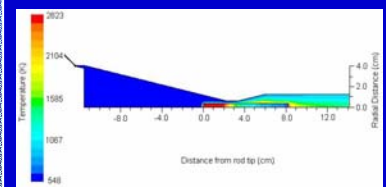


Predicted CO mole fraction profile

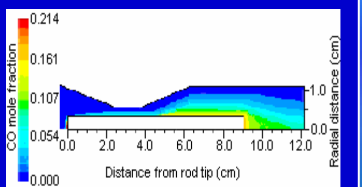


Predicted CO mole fraction from photolysis

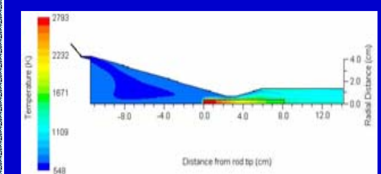
Fluent Profiles



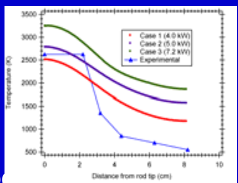
Predicted temperature profile with reactions using a known rod temperature



Predicted CO mole fraction profile using a known rod temperature



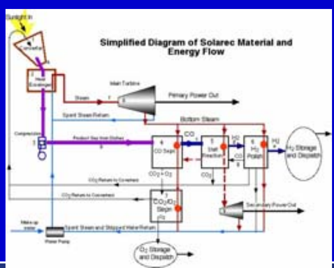
Predicted temperature profile using solar irradiation



Rod temperature profile using irradiation versus the known temperature

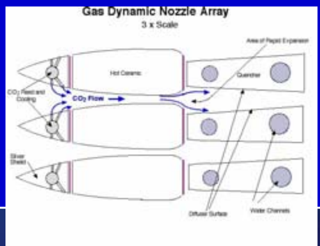
Production of H_2

- Separation of CO from CO_2 / CO / O_2 product stream.
- Reaction of CO with H_2O to produce H_2 (Water-gas shift reaction).
- Separation of H_2 and recovery of CO_2.



Prototype Improvements

- Designed to:
  - Increase the thermal boundary layer by adding roughness to zirconia.
  - Increase the high-temperature region.
  - Improve cooling.



Conclusions

- Fluent model accurately predicted experimental CO conversion.
- PCGC-3 model was accurate in modeling formation of CO, but not cooling.
- Residence time in the throat were too low to permit significant photolysis.
- The formation of CO occurs only in the throat area and not upstream of the rod.
- Solar conversion of CO_2 to CO has the potential to provide a useable fuel from a CO_2 stream.
- Radiation model accurately predicts rod temperature with an irradiation of 4-5 kW

Acknowledgements

This work was sponsored by Renewable Energy Corporation Los Alamos, NM

ACERC

BYU BRIGHAM YOUNG UNIVERSITY