Design of a Domestic Hydrogen Combustion Burner

Introduction

Reducing Greenhouse Gases using mix H_2/CH_4 as combustion burner fuel

Context

Climate Change Act (UK)
- Reduce GHGe by **80%** between 1990 and 2050.

Natural gas used in over **80% of households** in the UK.

GHGe = GreenHouse Gases Emissions

Residential emissions
- **14%** of the total GHGe In the UK

CO_2 + NO_x emissions:
- **2.5tonnes/year/household** in UK, 2016

Concept

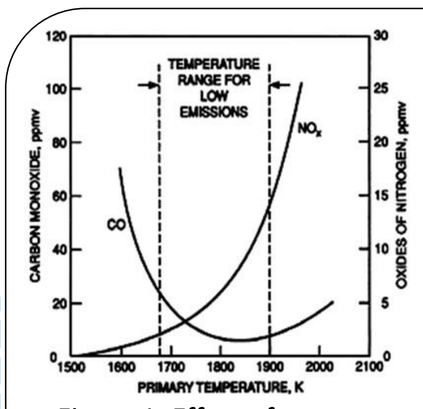


Figure 1: Effect of temperature on NOx and CO emissions [1]

- **Hydrogen Enriched Combustion** type :
  - **Mixture H_2/CH_4** use as fuel burner in domestic boilers
- **Energy demand** higher in january
  - Power needed → 24 kW
- H_2/CH_4 emissions limited by **NO_x/CO/CO_2 constraints**

Methodology

Combustion simulation changing %H_2 inlet and analysing emissions outlet

1. Inlet parameters
   - Boiler Worcester = most common
2. CFD (Fluent) simulations
   - From 50%-50% (CH_4-H_2)
   - Increase %H_2
3. Is the design meeting our energy demand ?
   - NO → back to 1
   - YES → 4
4. Extract datas from Fluent to input in Aspen
   - (Temperature, pressure, flowrate)
5. CO, CO_2, NO_x emissions respect the constraints ?
   - NO → back to 1
   - YES → Results

Aspen System

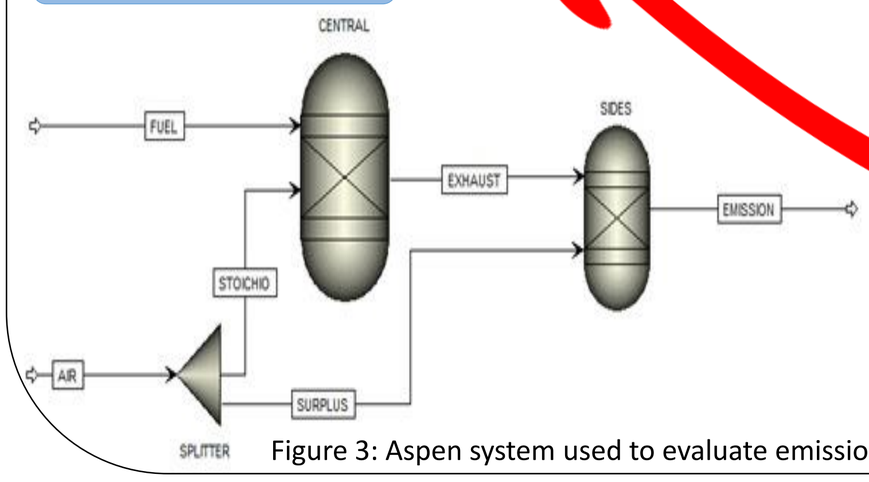
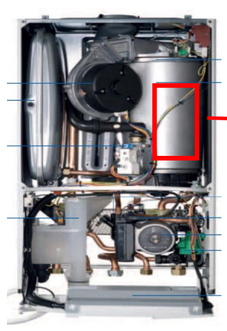


Figure 3: Aspen system used to evaluate emissions

CFD Model



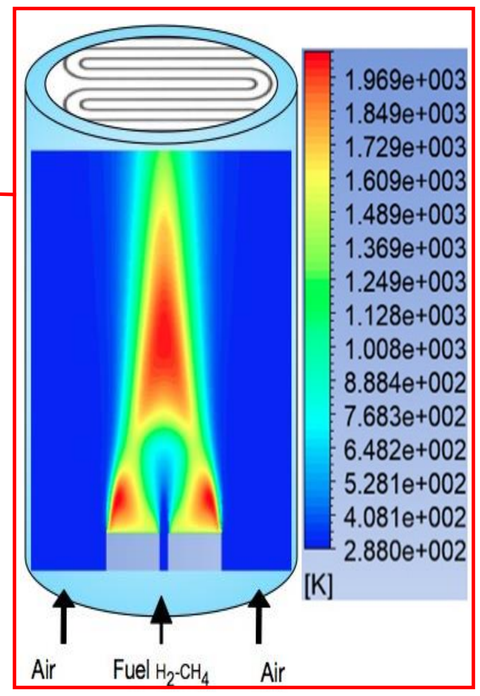


Figure 2: Location and scheme of CFD Fluent model used for simulations [2]

Results

FINDINGS

- **%H_2 optimal = 95 %**
- Meet NO_x/CO/CO_2 emissions constraints
- **Class A** energy efficiency
- Single flame, non-premixed, bluff body burner
- Tiered, overhead primary heat exchanger

IMPROVEMENT

- Increasing Bluff body:
  - Decreasing maximum T on the heat exchanger
  - Better heat distribution
  - Reducing cost material

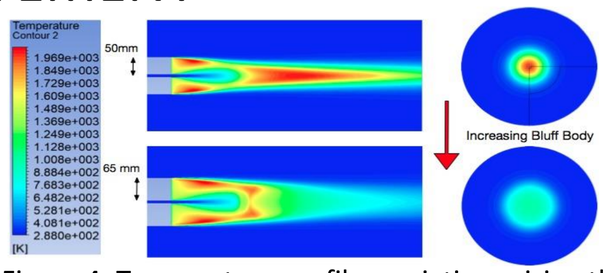


Figure 4: Temperature profiles variation raising the bluff body

[1] A. H. Lefebvre, *Gas Turbine Combustion*. 1999; [2] G. Gatti, "Computational Modelling of Heat Transfer in a Combustion Chamber," Cranfield University, 2017.

BROWNE Rebecca | D'URZO Riccardo | MANZANARES PANADERO Carlos | MELARA Stefano | AHMAD Salman | VAUBOURG Inès

p.t.clough@cranfield.ac.uk

www.cranfield.ac.uk

Supervisors:
- Dr. Peter CLOUGH
- Dr. Dawid HANAK
- Dr. Ali Seyed NABAVI