Modelling of Turbulent Spray Combustion in Gas Turbine Combustors

Bram de Jager, Jim Kok, Theo van der Meer

b.dejager@ctw.utwente.nl

University of Twente
The Netherlands
Laboratory of Thermal Engineering
Faculty of Engineering Technology

Introduction

Combustion is an essential step in generating power using a gas turbine. The apparatus facilitating this combustion is the combustor. Depending on local resources, different fuels can be used for firing a combustor. Natural gas is often used as a source of fuel. However, in many situations oil is the primary fuel available. Oil is very easy to handle and store and also widely available. Very promising is the use of bio-oil, extracted from biomass.

Objective

In this project the aim is to develop modelling tools for liquid fuel combustion with steam injection. Driven by the need for very low emissions of polluting substances, optimal insight is needed for design of combustors and gas turbines. The use of advanced modelling tools is one of the keys in this.

Figure 1: A methanol spray flame

Problems

Several aspects related to liquid fuel combustion need research:

First, the injection of liquid fuel into a combustor using an atomiser, creating a spray of oil droplets, not easily characterised.

Before the spray of oil droplets is combusted it evaporates and mixes with combustion air.

Combined with evaporation comes combustion. Due to the composition of the evaporated fuel, combustion chemistry depends on several different hydrocarbon molecules.

Related to this liquid fuel combustion or turbulent spray combustion is the concept of lean-premixed-prevaporised combustion (LPP) with steam injection, applied in modern gas turbines. Modelling tools for this concept need to be improved.

Method

The approach in our modelling work is focused on the description of turbulent spray combustion with an Eulerian-Eulerian model.

Interaction between the two phases will be modelled using source terms describing vaporisation, combustion and turbulence. The focus will be on phase-transport from oil droplet to gaseous phase, mixing of air and evaporated oil and detailed modelling of chemistry.

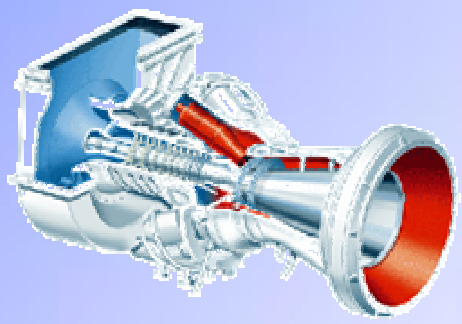

Figure 2: The ALSTOM Power Tempest dual fuel gas turbine

Chemistry will be modelled using the FIRST-combustion code, based on projecting the reaction mechanism on three reaction progress variables. For these RPV's a database is needed which can be derived from detailed reaction mechanisms for liquid fuels using CSP techniques.

Future work

The main job is to build an advanced model, combining and developing submodels based on the given method.

After that the complete model described above needs to be implemented and validated against experimental data for turbulent spray combustion.

References

"Efficient numerical calculation of evaporating sprays in combustion chamber flows." R.Schmehl, G.Klose, G.Maier and S.Wittig, paper presented at RTO AVT, RTO-MP-14, 1998

"LES of spray combustion in compressible high Reynolds number swirling flows", V.Sankaran and S.Menon, Journal of Turbulence, Feb. 2002

"Modelling drop size distributions", E.Babinsky and P.E.Sojka, Progress in Energy and Combustion Science 28, 2002

"On turbulent combustion of coal gas", J.J.J.Louis, PhD Thesis, University of Twente, 1997

Address:
Faculty of Engineering Technology
Laboratory of Thermal Engineering
P.O. Box 217
7500 AE Enschede
The Netherlands

Phone: (++31) 53 489 1091
Fax: (++31) 53 489 3663
Email: b.dejager@ctw.utwente.nl