Particulate and Vapour Deposition in Gas Turbines Fired on Coal Derived Gases

OBJECTIVES

Fuel gas derived from coal can contain various impurities such as dust and alkali salts, which can deposit on the blades of gas turbines used in cleaner coal systems and lead to increased turbine degradation. It is important to be able to estimate these deposition rates in order to assess different systems.
This project is aimed at:

- providing more accurate models for particulate deposition in gas turbines running on coal derived gases to provide greater accuracy and easier and more rapid use
- extending an existing vapour deposition model to include additional species to better predict corrosion in such gas turbines
- applying the models to example cases of turbines with some representative contaminant levels for both integrated gasification combined cycle (IGCC) and air blown gasification cycle (ABGC) systems

SUMMARY

Many cleaner coal technologies, including the various IGCC and ABGC systems derive their inherently high efficiency by coupling a gasification process with a gas turbine combined cycle unit. The coal is converted into a fuel gas that is then used to fire the combined cycle unit. Gas turbines are designed to operate on clean gaseous fuels such as natural gas, whereas the fuel gas derived from coal will contain various impurities such as dust (ash) and also alkali salts. These can cause deposit build-up, erosion and/or corrosion of the gas turbine blades, leading in turn to increased operating costs, both in terms of replacement blades and the associated down times, and reduced efficiency. Conventional IGCC's can clean the fuel gas to very pure levels using low temperature processes. The ABGC, and second generation IGCC's will use hot gas clean up where the degree of alkali removal and dust capture may not be as efficient. This will improve the efficiency of the plant and lower capital costs, but may have deleterious effects on the gas turbine.

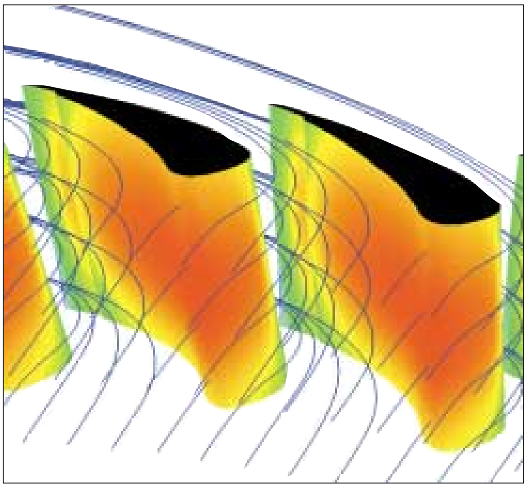
To predict the degree of deposition, erosion and corrosion in the gas turbine, it is first necessary to be able to model (i) the behaviour of small particles within the turbine passages, including their impact on the blades and (ii) the deposition rate of alkali salts on the turbine blades. Current models for deposition are difficult to apply and not always physically accurate. Improved models are needed to provide better estimates of the degradation and determine the degree of cleanliness required in coal-derived fuel gases fed to gas turbines.

A computer program will be developed to calculate the behaviour and deposition of small particles in the three dimensional flow fields typical of gas turbines. This program will incorporate the models for both inertial and turbulent effects, which current models can only consider separately.

A rig which can study particle deposition in a pipe flow, using fluorescent dye as a particle tracer will be used to study deposition of different particle sizes in a cascade of turbine blades. Initially a stationary cascade will be used, progressing later to using a rig with a rotating blade row. Model predictions will be tested against the experimental results to aid model validation.

An existing model for alkali vapour deposition assumes that the alkali metals (sodium and potassium) are present in the gas phase as chloride salts (NaCl, KCl) which is valid for UK coals. For operation with world coals, the chloride levels are expected to be very much lower and the principal alkali salt species in the gas is likely to be the hydroxides (NaOH KOH) or oxides (Na_2O, K_2O). The model will therefore be reconfigured to account for these different species.

To demonstrate the capabilities of the developed models, they will be applied to turbines with some representative contaminant levels for both IGCC and ABGC systems to obtain estimates of deposition levels for both particles and alkali.



Calculated particle trajectories through turbine blade row

COST

The total cost of the project is £240 000 with a contribution of £90 000 from the DTI

DURATION

36 months commencing April 2001

CONTRACTOR

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In collaboration with Rolls Royce plc and Cambridge University

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