dti

PROJECT SUMMARY NO PS217

Development of a Gasket Seal for Metal-Supported Solid Oxide Fuel Cells

OBJECTIVES

The objective of this project was to develop a viable compressive gasket sealing solution for 3rd Generation Metal Supported Solid Oxide Fuel Cells (3G-SOFCs) that operate at temperatures of 500-600°C. More specifically the aims were to:

- Define, test and characterise a refined gasket material suitable for 3G-SOFCs operating between 500°C and 600°C

- Develop computer based design tools to predict and improve gasket seal performance using gathered data

- Compare expected seal performance with results from fuel cell seal tests

- Evaluate a mass manufacturing route for the refined gasket form and design

SUMMARY

- All project milestones and targets were met or exceeded.

- Modifications were made to the gasket material that significantly simplified stack construction and improved seal capability.

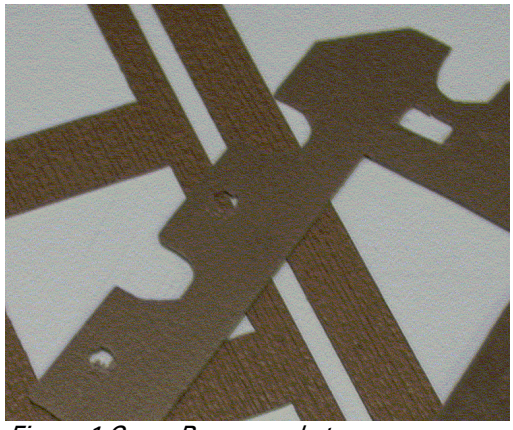

Figure 1 Ceres Power gaskets

- An extensive material characterisation study was concluded, suggesting that the refined gasket material is suitable for Ceres Power's planar 3G-SOFC technology.

- A stack computer model was successfully developed and validated at ambient temperature and extended to predict behaviour at temperatures up to 600°C.

- A gasket leak rate significantly lower than the project target of 1% of fuel flow was predicted by the computer model, and demonstrated in practice.

- A 100We stack was tested for 1000hrs showing an improvement in the stack seal

- 23 thermal cycles were demonstrated on a 100We stack,

whilst maintaining stable stack open circuit voltage and seal integrity.

- Stack sealing integrity was improved from the start to the end of the project by more than 45%.

- A method suitable to mass manufacturing stack gaskets has been evaluated and costed.

CONTRACTOR

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COST

The total cost of this project was £275,929, with the Department of Trade and Industry (DTI) contributing £142,460 and Ceres Power Ltd. , BHR Group Ltd., and Flexitallic Ltd. contributing the balance

DURATION

12 months – April 2004 to March 2005

BACKGROUND

Drawing on financial support from the DTI, Ceres Power has partnered with two UK companies, Flexitallic Ltd. and BHR Group Ltd., to develop, characterise and model a promising gasket material for SOFC stack operation that is technically and operationally effective, durable and mass producible. Such a seal is to our knowledge pioneering in the fuel cell world, removing one of the critical areas of concern for extended SOFC stack life operation for sub 50kWe global application markets. Furthermore, development of a predictive gasket design capability plays a key role in achieving reliable stack designs. It allows for rapid investigation of stack design parameters, cost optimised selection of stack materials such as bolts and endplates and reduces overall development time.

THE WORK PROGRAMME

Gasket material

Improvements have been made to Flexitallic's proprietary high temperature sealing material, which have simplified stack construction and improved sealing characteristics at low compressive loads. Characterisation of this new material showed suitably low leak rates and good geometric stability under operating conditions.

Model development

A computer model of a Ceres Power stack, in particular its gasket layers, was successfully developed using advanced finite element codes. As a first step, a gasket sealing design with a lower compressive load requirement was conceived to replace the original design. Multiple stack layers, full operational cycles and sensitivity of the model to parameters such as model mesh densities, bolt load, gasket creep and multiple operational cycles were analysed at temperatures up to 600°C. A routine was devised to turn computed stress and strain results into predictions of stack leak rates.

Stack development and model validation

Several tests were conducted to validate the developed computer model and the degree of effectiveness with which the gasket material has been applied in the Ceres stack design. Measurement of the actual stack gasket stress distribution was used to validate computer model predictions at ambient temperature. Stack gasket leak tests at 23°C and 585°C demonstrated leak rates well below <1% of fuel flow, in agreement with the leak rates predicted by the finite element model using material leak test data. Furthermore, pressure decay tests on a 100We stack showed that the stack gas leak integrity improved over a 1000hr period. A separate 100We stack was successfully subjected to 23 thermal cycles, showing a similar improvement in stack seal over the first two cycles and remaining constant thereafter.

Gasket commercialisation

A method suitable to mass manufacture of the gasket material has been evaluated and costed. Improvements were made to the supplied material form to maximise utilisation, ease fabrication of stack gaskets and adjust clearances between stack layers.

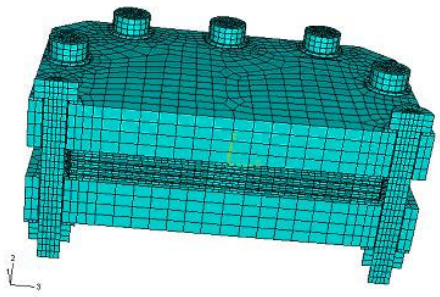

Figure 2. Computer model of Ceres Power stack

CONCLUSIONS

The 12 month development project has been successfully concluded, with all project milestones and targets met or exceeded:

- Gasket material developments were achieved that significantly simplified

stack construction and improved seal capability by up to 30%.

- An extensive material characterisation study was concluded, suggesting that the refined gasket material is suitable for Ceres Power's planar 3G-SOFC technology.

- The stack gasket design was modified, reducing required assembly loads by 25%.

- A stack computer model was successfully developed and validated at ambient temperature and extended to predict behaviour at temperatures up to 600°C. Selected assembly parameters were confirmed to be suitable and gasket stresses seen to homogenise as the number of stack layers was increased.

- A gasket leak rate significantly lower than the project target of 1% of fuel flow was predicted by the computer model, and demonstrated in practice.

- A 100We stack was tested for 1000hrs showing an improvement in the stack seal.

- 23 thermal cycles were demonstrated on a 100We stack, whilst maintaining stable stack open circuit voltage and seal integrity.

- Stack gas integrity was improved from the start to the end of the project by more than 45%.

- A method suitable to mass manufacturing stack gaskets has been evaluated and costed.

The presented results demonstrate a major advance in the development of seals for planar SOFC stacks. The financial contribution made by the DTI towards this work and the efforts of the partner companies is kindly acknowledged.

POTENTIAL FOR FUTURE DEVELOPMENT

The outcomes of this project have fed directly into the Ceres Power stack development programme, enabling the informed development of larger output stacks. In spite of the significant achievements a number of development activities remain that could further enhance stack performance:

- Study the effect of gasket parameters on stack performance in further detail.

- Parameter optimisation within the computer model to reduce the overall analysis cost and development time.

- Automation of the stack leak prediction routine to allow parameter changes to be assessed more readily by their impact on stack leak rate.

- Use the optimised modelling approach to model larger stacks.

- Investigate how more complex heating and cooling profiles may affect stack and gasket performance via computer modelling.

- Examine actual seal conditions on larger stacks and compare these to model predictions.

- Prolong test periods and extend number of thermal cycles to confirm seal performance.