UK/US Collaboration in Energy R&D: Clean Coal Technology

Advanced Materials Program

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Outline

- Background
- Why Collaborate?
- Collaboration Framework
- Phase 1 Tasks - Outputs and Benefits
- Plans for Phase 2
Background 1

• MOU Renewal
  - Under discussion 1999 - 2000
  - Signed 6th November 2000
  - Materials identified as a priority topic for collaboration

• DOE/DTI Workshop
  - Held in Knoxville, Tennessee in June 2001
  - Workshop identified many topics of common interest where collaboration would be possible
  - Text for Implementing Arrangement revised
  - Materials, Virtual Plant Demonstration, Near-zero Emission Power Plants, CO₂ Capture & Sequestration, Distributed Generation listed as ‘tasks’ to be developed

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Implementing Arrangement for Fossil Energy RTD
- Signed 10th March 2003
- Sets a framework for collaborative ‘tasks’ with named UK and US leaders
- Followed up with workshop at NETL, Pittsburgh in June 2003
- Agreed to proceed with collaborative tasks on Materials and Virtual Plant Simulation
- Draft tasks prepared at the workshop

Framework for Materials Collaborative Task
- Contributions from nationally-funded public domain research
- Task proposals define equitable research collaboration
- Detailed work program aligning UK and US activities to maximise exchanges and benefits
- Exchange and sharing methodology based on EU COST Program

Collaboration starts April 2004

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Why Collaborate?

Improved vision of industrial needs and national strategies

Critical review of methods & results

Access to unique facilities

Improved confidence in outputs

Increased specialist knowledge pool

Highly cost effective - small extra cost

Reduced risk of wasted effort

Improved quantity & quality of data

Less time to develop design & modelling capability
EU COST Program

Map of Europe showing participating countries in the EU COST Program.
UK/US Collaboration on Advanced Materials
Phase 1 Tasks

All tasks aimed at increased plant efficiency and reduced emissions

• Steam Oxidation
• Boiler Corrosion & Monitoring
• Gas Turbines Fired on Syngas and Other Fuel Gases
• Oxide Dispersion-Strengthened (ODS) Alloys
• Standards & Databases

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Steam Oxidation

Why?

• Advanced steam cycles = increased efficiency = increased temperature
• New alloys needed to achieve these goals
• Need basis for confident service life prediction

Challenges

• Higher temperatures = reduced lifetime
• No reliable design data
• Potential failure modes unknown

Strength Limitations of Conventional HT Alloys

After Shingledecker, 2006

Major strength criterion
Outputs & Benefits

• New testing capabilities
• >1m hours of specimen exposures
• Tools for data qualification & extrapolation
• New degradation models

Proposed Work Plan (Phase 2)

• Standardized testing approach
• Correlate lab. data to plant experience
• Lifetime model development
Boiler Corrosion & Monitoring

Why?
- Alternative fuels, emission controls, advanced cycles increase operating risks
- Understand impact on materials performance
- On-line condition monitoring to improve plant operation

Challenges
- Quantify specific fuel effects on materials behavior
- Develop reliable monitoring techniques
- Correlate lab. data to plant experience
Outputs & Benefits

• Ranked alloys in simulated operating environments
• Established limitations of current probe designs
• Identified approaches for monitoring probe design improvements

Proposed Work Plan (Phase 2)

• Advanced lab. testing procedures
• Further development of corrosion monitoring probes (electrochemical)
• Emphasis on oxy-firing, co-firing, advanced cycles
Gas Turbines Fired on Syngas and other Fuel Gases

Why?

• Enable the use of SOA GTs with fuels derived from gasification of coal and/or biomass
• Understand impact on critical hot gas path components
• Ensure reliable operation and reduce risk

Challenges

• Understand and predict threat from these combustion environments
• Provide a versatile simulation testing facility
• Quantify impact on alloy and coating performance
• Identify cost-effective alloy and coating combinations to reduce operational risks
Gas Turbines Fired on Syngas and other Fuel Gases

Outputs & Benefits

• Demonstrated ability to correctly simulate plant environments
• >650,000h of specimen exposures
• Validated predictions of damage modes
• Predicted component lives for plant systems

Proposed Work Plan (Phase 2)

• Expansion of life predictions to new systems
• Generation of input for GT life prediction models
• Integration with advanced NDE techniques
Why?

- Class of materials with exceptional characteristics, but challenges to practical application
- Opportunity for step change in performance of existing and new plant components

Challenges

- Need for better joining techniques
- Processing for improving strength of tubes
- Improved oxidation resistance
Outputs & Benefits

- Identified viable joining techniques
- Commercial processing routes for strength improvement
- Identified coating for improved high-temperature service life
- Proposed Work Plan (Phase 2)
  - Qualify *new commercial ODS alloy*
  - Alternative processing routes for strength improvement
  - Fabricate demonstration components
  - Explore novel process for making components from ODS alloys
Why?

• Need test results from different partners to be directly comparable
• Need ability to share and compare data and testing methods among different laboratories

Challenges

• System for data collection, analysis, and exchange
• Ensure full and consistent record keeping
• Enable full, future replication of testing
Outputs & Benefits

- Identified sources of differences in data among tests by partners
- Standardized approaches
- Developed a full-featured database
- Provided secure, central access to all partners

Proposed Work Plan (Phase 2)

- Task completed, separate future activities not required

USDOE FE Materials Conference – 12-14 May 2009

UK-US Collaboration on Fossil Energy R&D - Advanced Materials
Summary of Phase 1 Experience

- Accelerated progress in complex areas
- Extensive and faster data development
- Effective working relationships to face new challenges
- Shared experience improves outputs and reduces risks
- Awareness of current testing limitations
- Formulation of new approaches
- Effective benchmarking and data qualification
- Improved awareness of industrial needs and national priorities
Approved
Phase 2 Tasks

- Steam Oxidation
- Materials for Advanced Boilers and Oxy-Combustion Systems
- Gas Turbine Materials Life Assessment and Non-Destructive Evaluation
- Oxide Dispersion-Strengthened Alloys
Thank you for your attention

http://us-uk.fossil.energy.gov/