The Challenge for ODS Materials: An Industrial Gas Turbine Perspective.

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Drivers & Requirements for Industrial Gas Turbines

Business drivers/
Customer requirements

Cost
- First cost
- Life cycle cost
- Operation cost

Performance
- Plant power
- Plant efficiency

Capabilities
- Emissions
- Operational flexibility
- Regulatory compliance
- Upgradeability
- Reliability, availability
- Time-to-market
The Potential of ODS Materials
The Message (from the Materials Engineer)

ODS alloys exhibit excellent oxidation and corrosion resistance, along with outstanding creep resistance at temperatures of up to 1300 °C.
The Interpretation (by the Design Engineer)

- ODS alloys are expensive
- ODS alloys have poor properties (except oxidation, corrosion & creep resistance).
- ODS alloys are difficult to manufacture
- ODS alloys can not be repaired

“The first thing you hear about a new material is always the best”
Wherever possible, a Designer will use an existing validated alloy in preference to new material.

- Minimize risk: experience, current design philosophy
- Minimize lead time: existing materials properties database
- Lowest cost: existing materials properties database

Will consider a new material only once the other alternatives have been explored and exhausted.

- Coatings
- Cooling scheme (geometry, film cooling, etc.)
- Other conventional alloys
- Additional cooling, etc.

Don’t under estimate the “The Comfort Factor”
What Drives the Introduction of a New Material?

The Chicken and the Egg

What drives the successful introduction of a new material into the gas turbine?

- The availability of a new material (the egg), or
- The component design (the chicken)

“Technology Push” versus “Technology Pull”
Integrated Approach

Advanced Materials & Coatings Systems
Advanced Manufacturing Technologies
Advanced Designs

Innovative Manufacturing Technology: Bridging the Gap
Manufacturing & Supply Considerations

- Material cost
- Material availability: Ability to source locally on globally basis
- Sole Source Concerns:
  - Lack of competition (price)
  - Stability – labor disputes, political issues, etc.
  - Acts of God – fire, severe weather, earthquakes, etc.
- Manufacturing base: experienced vendors (e.g. machining, joining)
- Inspection:
  - Non Destructive Inspection
  - Acceptance criteria – composition, mechanical, microstructure
- Vendor qualification and surveillance
- Compatibility with other materials – CTE; joining; wear
- Re-work and non-conformance – scrap rates
The Future for ODS Alloys
Critical Questions for ODS Implementation

What can you do?
- Develop components or sub-components that take advantage of the attributes of ODS alloys.

By when?
- Good question – commercial availability of ODS alloys?

What difference will it make?
- Greatly improved materials system performance: 5x increase in TBC spallation life compared with SOA gamma prime strengthen superalloys

What makes you think that you can do it?
- Modular component design
- Additive manufacturing technologies
Modular Component Design: Potential Advantages

- Addresses manufacturing limitations
- "Expensive" manufacturing processes maybe cost effective for smaller sub-components
- The individual sub-components / segments can be offered with different properties to match specific component section needs (leading edge, airfoil tip etc.)
- Advanced but costly materials could be selectively used where they are needed, or where specific disadvantages do not limit their use.
- Rapid prototyping: an individual section of the part can be redesigned or upgraded to fulfill a specific need.
- Reduced fall-out rates after service: Repair of blades / vanes by sub-component replacement may be possible.
Challenges of Modular Components

- Joining of dissimilar materials
- Differences in thermal expansion
- Cooling air leakage
- Wear at interfaces
- Fit-up of individual parts – machining tolerance
- Additional manufacturing operations
- Development and qualification of vendor base
Key Success Factors

Concurrent Engineering Approach

Materials Engineering
- Adequate materials data for preliminary design
- Validated properties for final design
- Materials system benefits

Design Engineering
- Tangible benefit: balance risk with reward
- Appropriate design and lifing rules

Manufacturing
- Guaranteed supply base
- Robust processes: Quality; on-time delivery

Service
- Qualified repair processes
Thank you
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