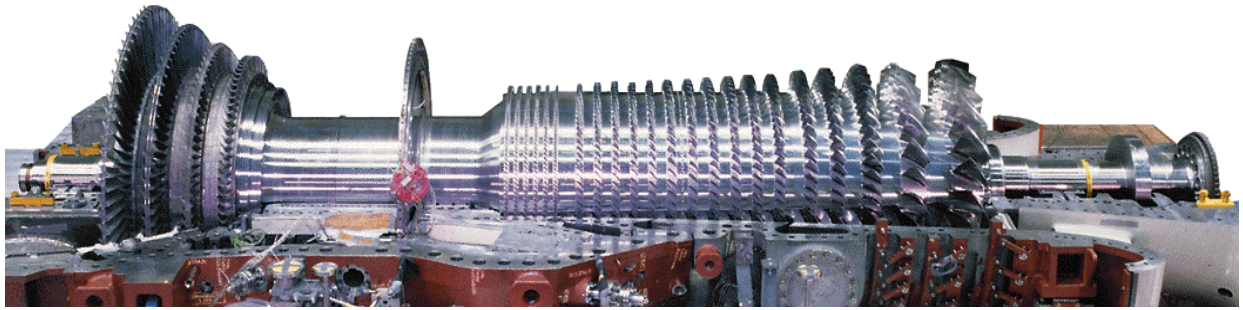
Energy Materials

UK Energy Materials.
Materials Developments For Energy Generating Gas Turbines.

Neil Glover.

Head of Materials Capability Acquisition, Rolls-Royce plc,
P.O.Box 31, Derby, DE24 8BJ.



Alstom GT26

9/10 October 2008.
Loughborough University

Outline.

- Gas turbine power generation.
- Technology status and challenges.
- Current R&D.
- Future Research Needs.
- UK Capabilities and opportunities.
- Conclusions.

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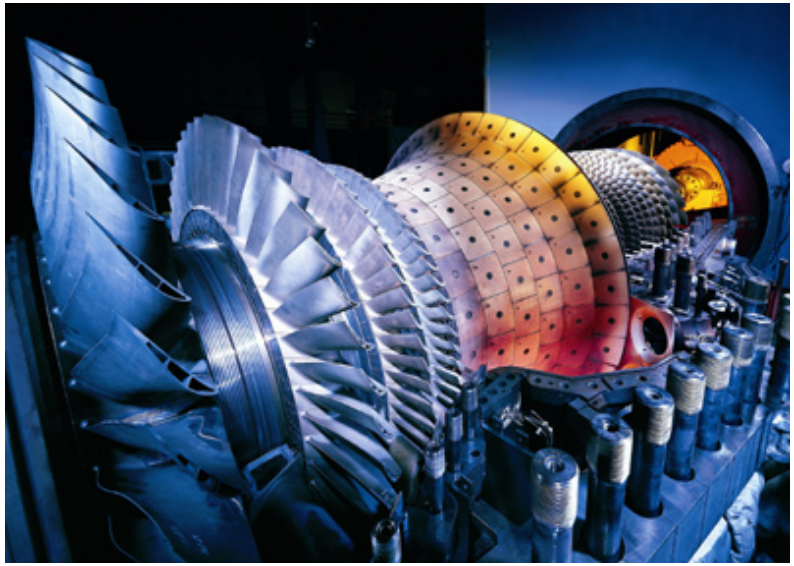

Siemens SGT5-4000F
Siemens Press Picture

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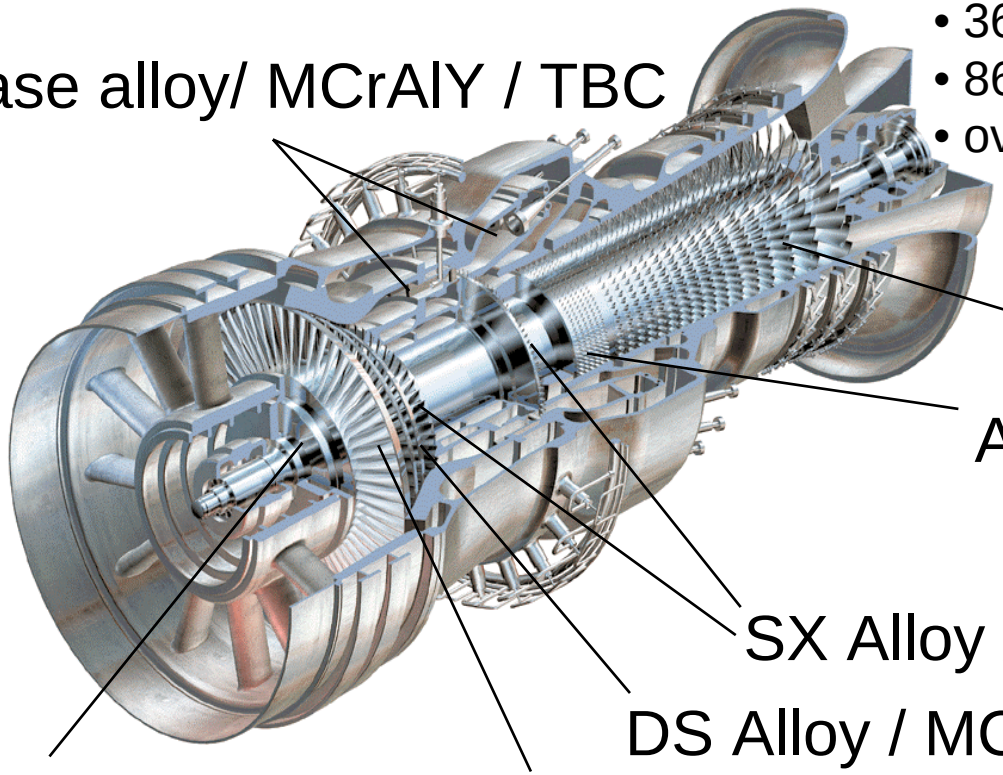

- 360 single crystal components
- 86 DS components
- over 1000 precision cast parts

Ni-base alloy/ MCrAlY / TBC

Ferritic Steel

Austenitic Steel

SX Alloy / MCrAlY / TBC

DS Alloy / MCrAlY

Rotor ferritic steel

Ni-base Alloy / Chromizing

Siemens SGT5-8000H.

Siemens Press Picture

Samarinda, Indonesia.

60MW combined cycle installation
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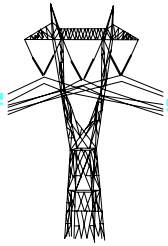
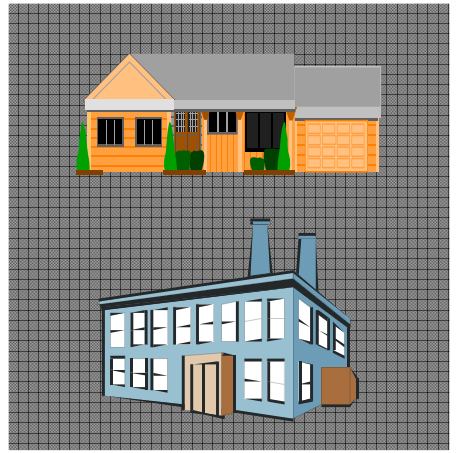
Gas Turbine Use in the Energy Industry.

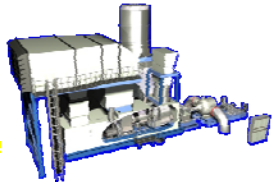
Power Station.





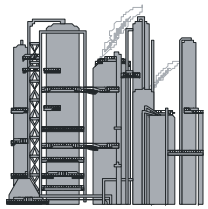
House and Factory.

Gas.

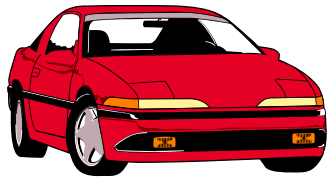


Pipeline

Oil.



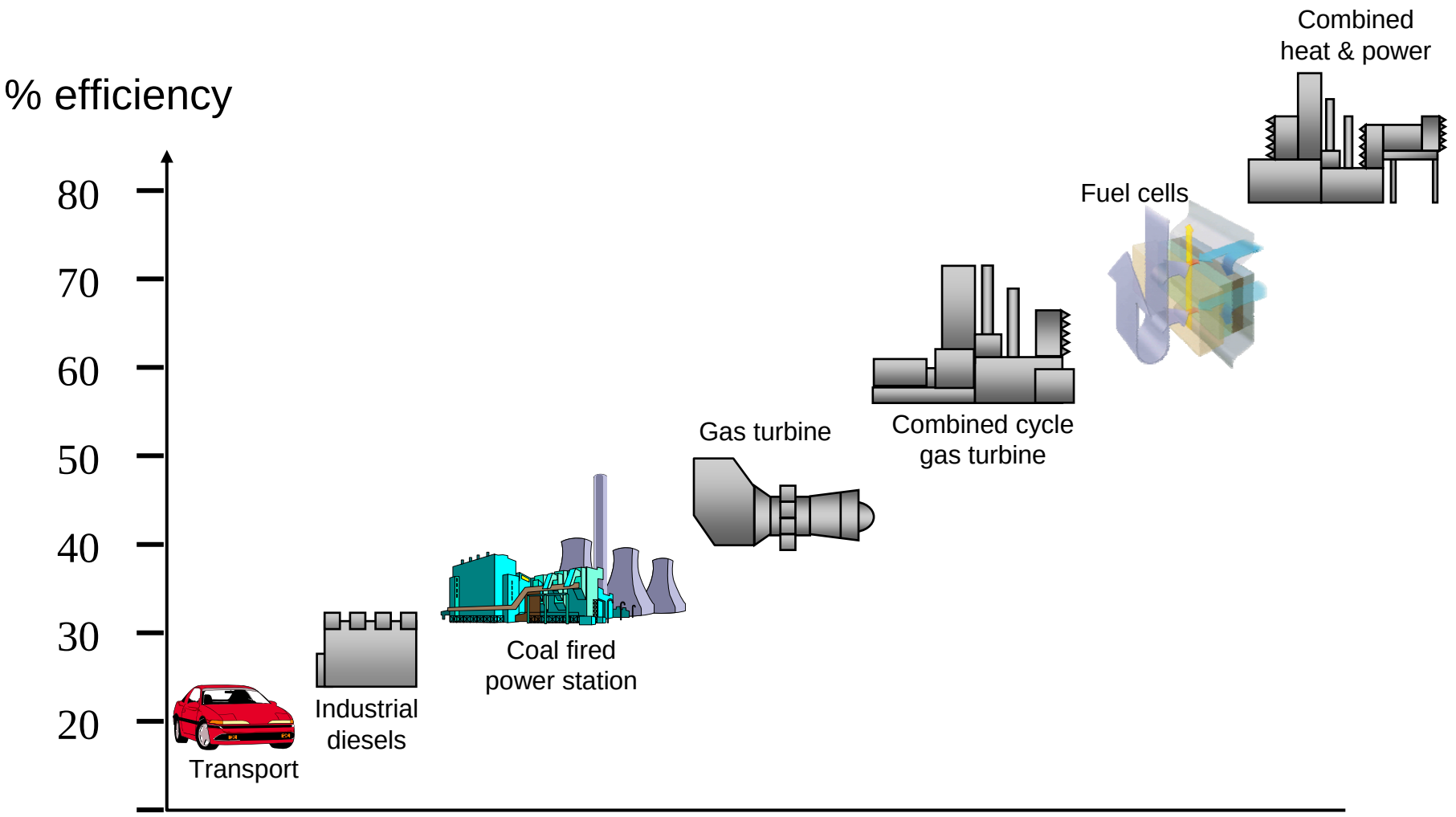
Oil Refinery.



Transport.

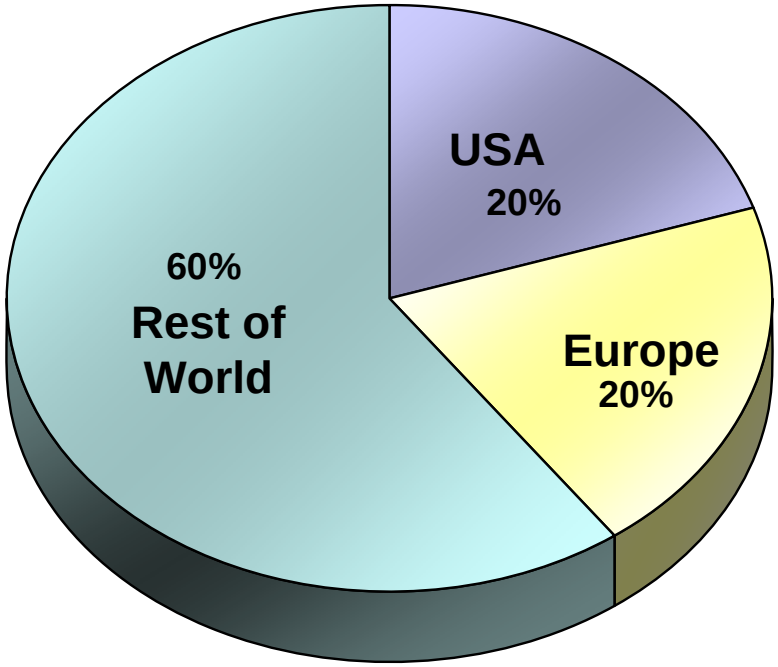
Compressor Stations.

Energy Conversion.



World Demand – 10 Years From 2007.

- Estimated to be $137bn.
- Demand traditionally driven by US and Europe.
- Rest of the World increasingly important. driven by China, India, Russia and Latin America.



Source: Forecast International 2007

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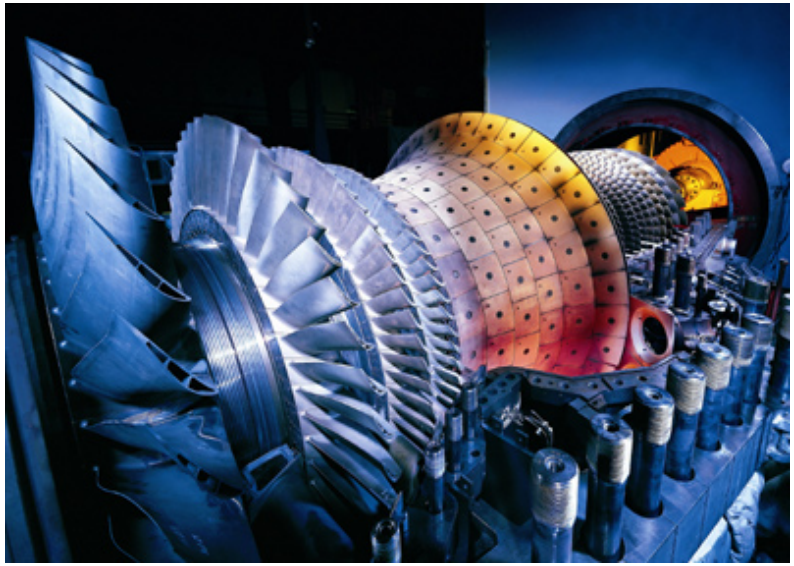
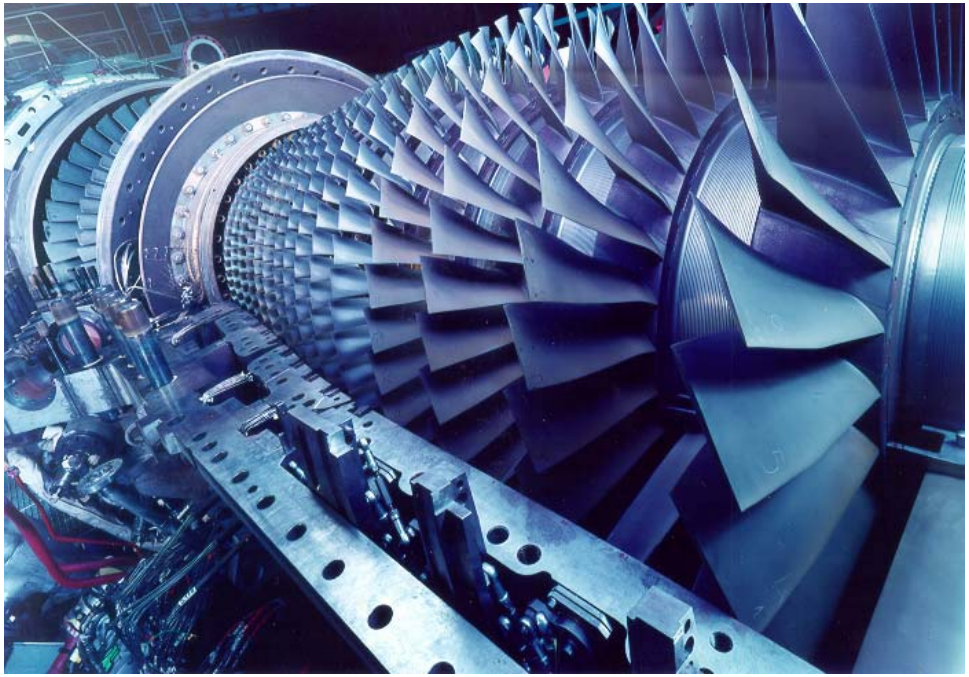


Siemens SGT5-4000F
Siemens Press Picture

Key Areas.

- Compressors.
  - Fe and Ti based alloys.
- Combustors.
  - Wrought Ni sheet.
- Turbines.
  - Blades.
    - Cast or wrought Ni-alloys.
  - Discs.
    - Wrought Ni-alloys.
- Steel rotors.
- Sealing.
- Coatings.
- Repair.



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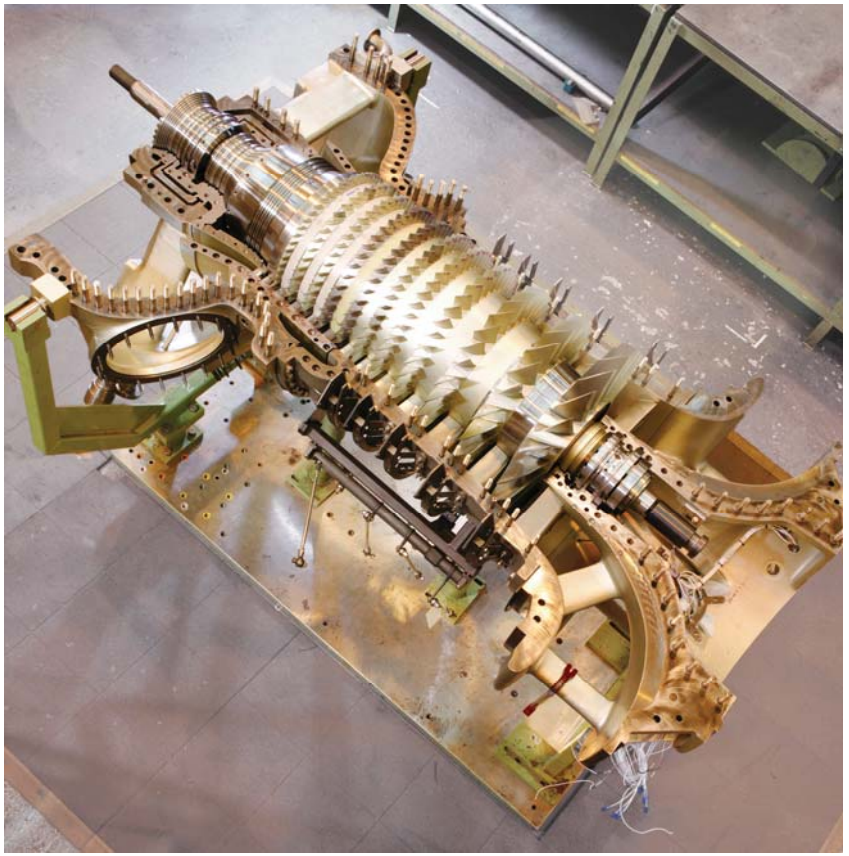
Issues and Limitations 1.

- **Increased Temperature.**

  - Driven by need for efficiency and low emissions.
  - In all areas current materials are operating at or beyond their limits.
  - Coatings increasingly used as a short/medium term solution.
  - Urgent need to increase temperature capability at extended lives and at an affordable cost.
  - Material distress, damage, unscheduled repair and replacement.



Siemens SGT- 400
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Issues and Limitations 2.

- **Oxidation/Corrosion.**
  - **Becoming a bigger issue. Corrosion appearing more widely throughout the engine and in areas it is not expected in – not understood.**
  - **Oxidation limiting high temperature performance in hot areas – unable to predict lives reliably.**
  - **Early failures and unplanned repair /maintenance.**

Industrial Trent Gas Turbine
© Rolls-Royce plc

Issues and Limitations 3.

- **Whole life costs.**
  - **Biggest challenge for existing and new materials.**
  - **Raw materials costs increasing rapidly (e.g CMSX4 – Re $9,500/kg).**
  - **Cost effective manufacturing (net net shape).**
  - **Repair and re-use.**
  - **Disposal.**

GT13 Gas Turbine
© Alstom

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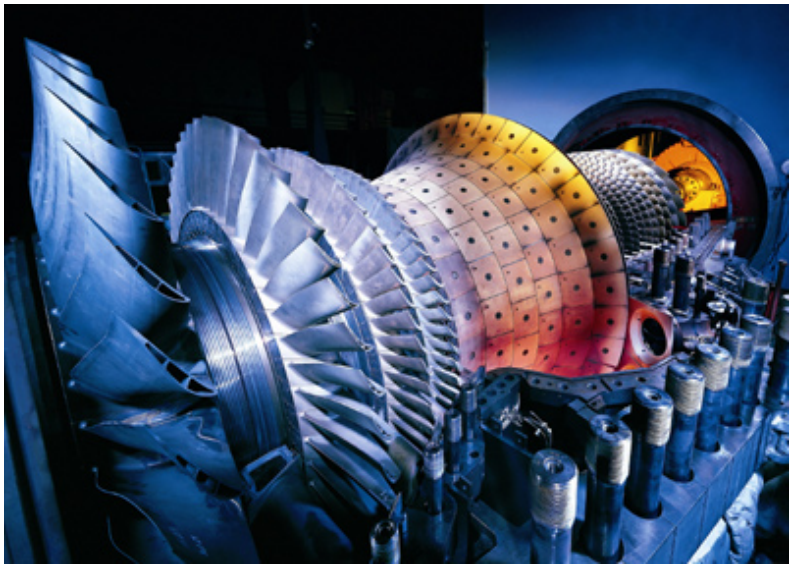

Siemens SGT5-4000F
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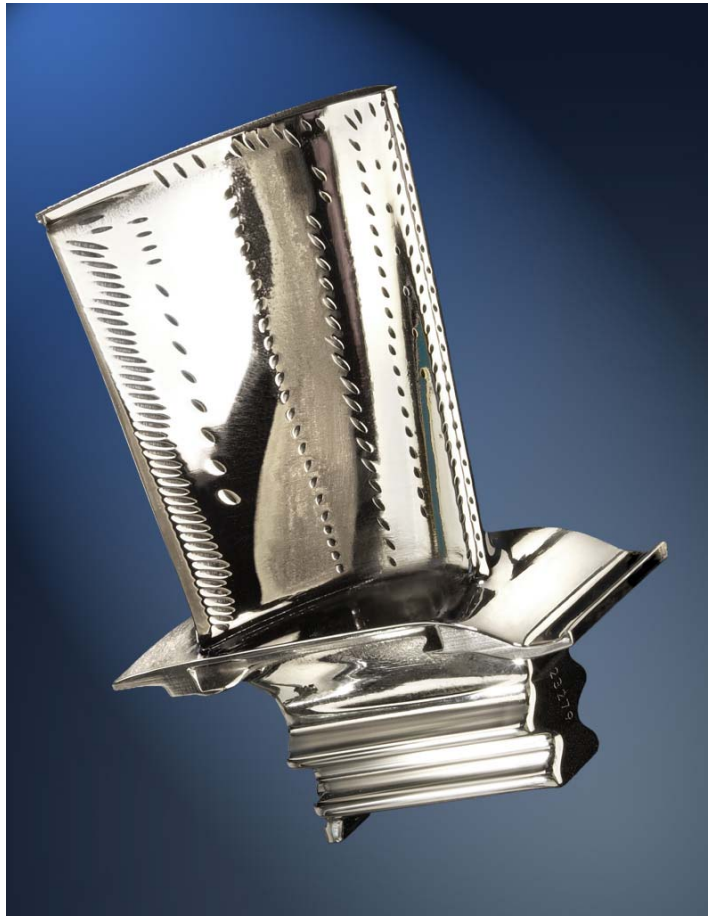
Current R&D Trends.

- Concentrating on incremental development of existing materials and coatings.
- Very dependant on aero derived technology in many areas leading to issues of affordability and suitability.
- Tends to be based on OEMs and specific to individual companies – little collaboration.



HP Turbine blade
© Rolls-Royce plc

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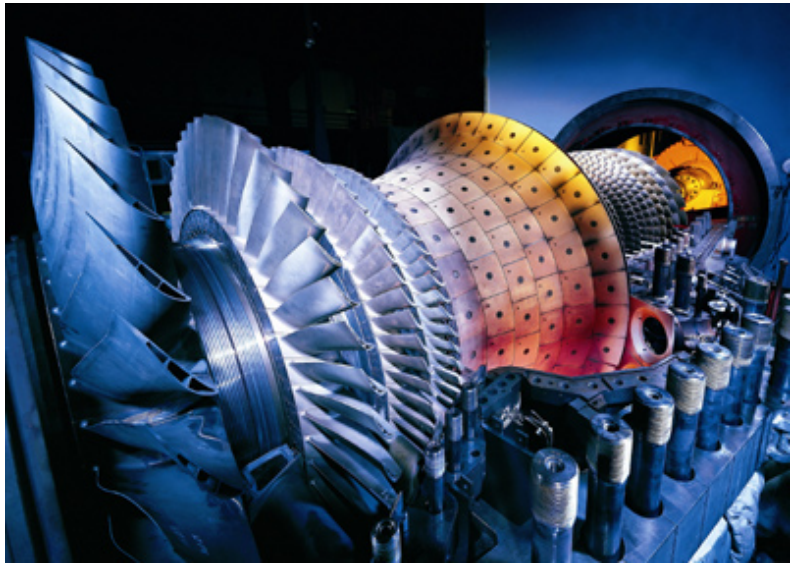


Siemens SGT5-4000F
Siemens Press Picture

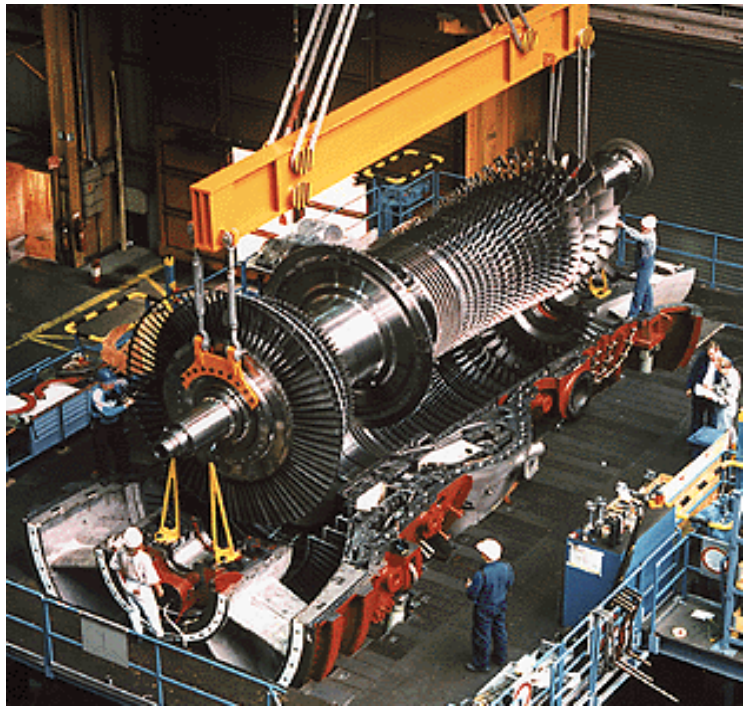
Future Needs - General.

- Urgent need to validate existing new alloys at real scale – over dependence on unvalidated models and lab/small scale experiments.
- Integration of all aspects needed to deliver a systems solution (materials, coating, NDE, lifing, joining and repair).
- Increasing focus on extending existing power plant lives (e.g. Supergen 2).

Compressor blades

5 Years.

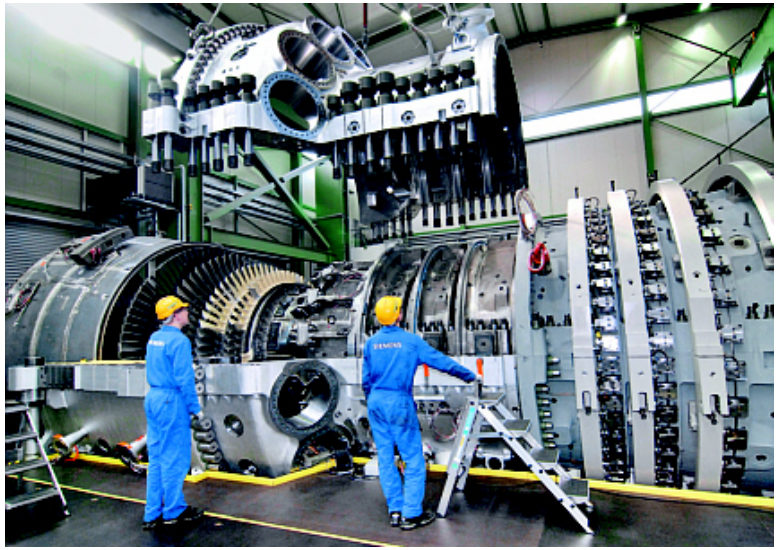
- Integrated development of existing classes of materials
  - Materials for increased life/temperature capability at appropriate scale.
  - Coating technology that can be applied to above to address oxidation/corrosion and erosion issues and increase temperature capability.
- Development of effective repair and refurbishment for existing plant and materials.
- Advanced joining technology (including bolts).
- Robust sealing technology.
- Increased collaboration (OEM, end users, academia supply chain) – especially on low TRL issues.



GT26 Gas Turbine
© Alstom

10 Years.

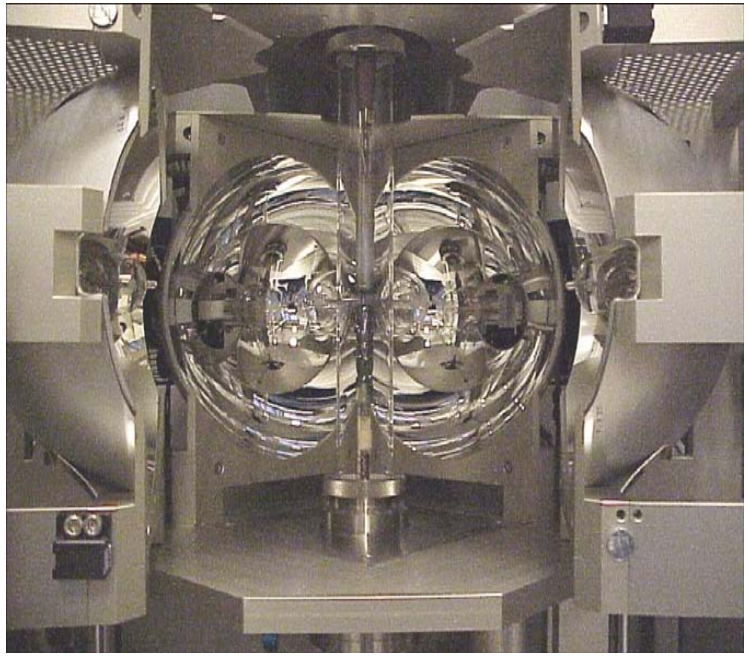
- Development of new material systems solutions based on existing knowledge including behaviour in realistic environments.
- Development and application of process modelling to new materials to speed up introduction and help define new system solutions.
- Adopting a total system approach to critical part design and life prediction with multi-material components with joints and coatings.



Siemens SGT5-8000H
Siemens Press Picture

20 Years.

- Development of novel , step change, material systems that will enable high overall efficiencies that will significantly reduce emissions.
  - Not based on existing technology.
  - Will require radical thinking about manufacturing and processing.
  - Opportunity to avoid traditional high cost strategic materials.
- Needs to be launched now to deliver in time.



Mirror furnace
© DTU Risoe

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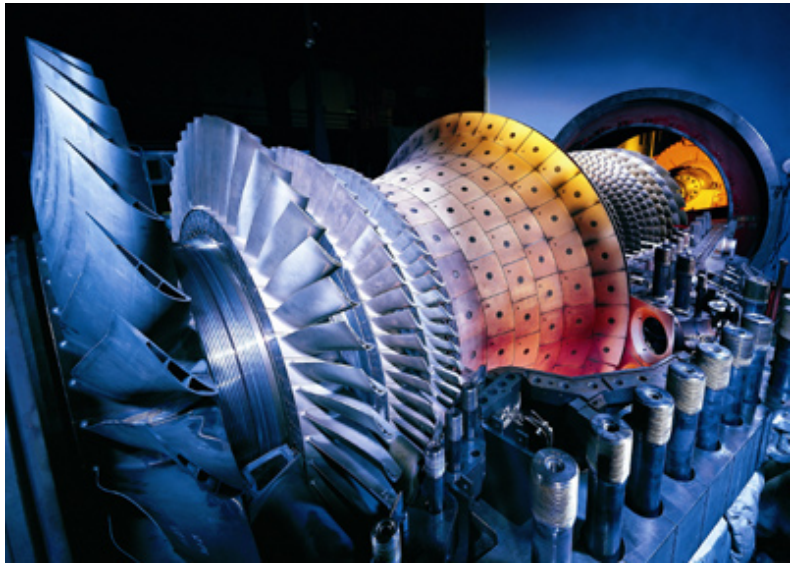

Siemens SGT5-4000F
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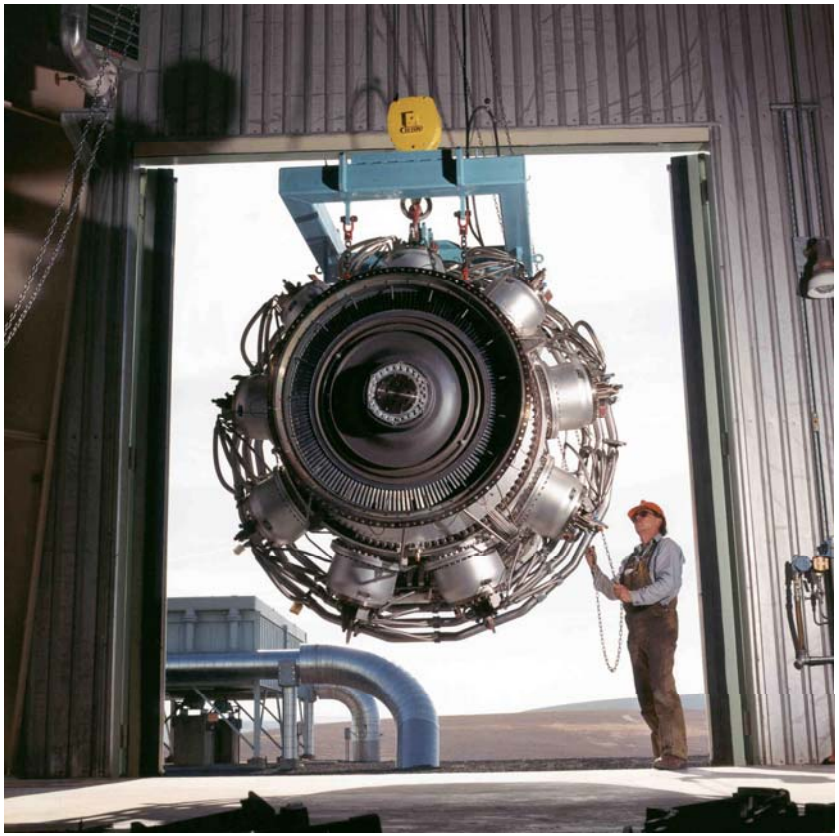
UK Capabilities and Opportunities.

- **Strengths.**
  - **Strong academic network for materials development and understanding in all areas.**
  - **Large OEMs active in R&D and who are capable of driving research agenda.**
  - **Support from funding agencies to help make it happen.**
- **Weakness**
  - **Supply chain is largely offshore.**
  - **Lack of long term funding strategy.**
  - **Unfashionable materials.**
  - **Lack of consistent policy.**



RB211-DLE Industrial Gas Turbine
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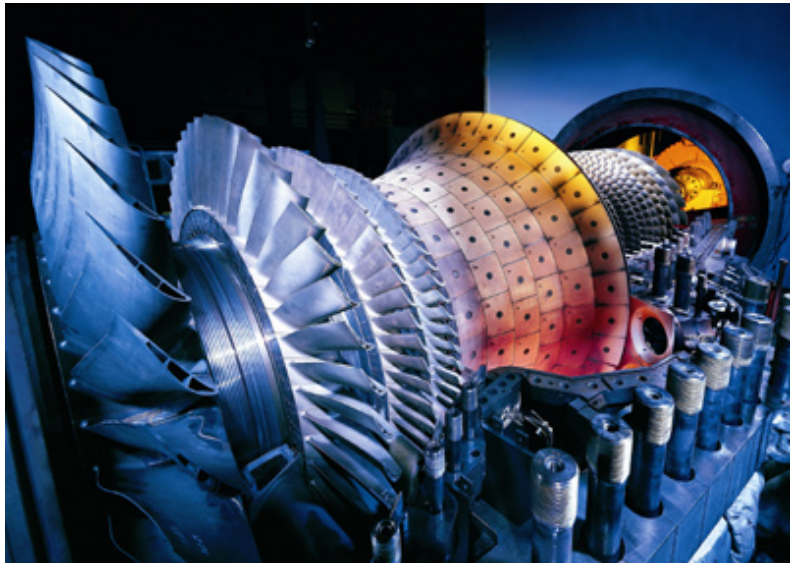

Siemens SGT5-4000F
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Conclusions.

- UK has the capability, skills and resources needed to meet the materials challenge.

- Urgently need to launch a coherent suite of programmes for the 5 and 10 year needs.
  - Needs strategy and long term stable funding sources, 3 years funding for programmes will not work.

- Strategy for materials development to meet the 20 year need needs to be defined and launched (NOT pick a winner and hope) to enable low TRL work to be completed in time.