

# Short presentation of the company Ansaldo Ricerche (ARI)



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- ✍ ARI is involved in different activities in the broad area of production, distribution and use of electric power, including transportation :
  - advanced engineering and technological services
  - development of new products and start-up of new businesses, also through dedicated spin-offs
  - technology transfer services, including the exploitation of public R&D centres technologies into industrial businesses
- ✍ Its structure is based upon 4 technological units :
  - ✍ mechanical and electromechanical (including materials laboratory), combustion and waste, molten carbonate fuel cells, power electronics.
- ✍ It was created in 1984 and it was the corporate R&D centre of former ANSALDO Company.
- ✍ In 1998 the companies previously integrated into ANSALDO (Energy, Transportation and so on) achieved full autonomy, due to the new organisation of Finmeccanica.
- ✍ Ansaldo Ricerche has evolved towards an independent company autonomously operating on the market through sale of services, both to Finmeccanica companies (Ansaldo Energia for gas turbine relating activities) and to third parties.

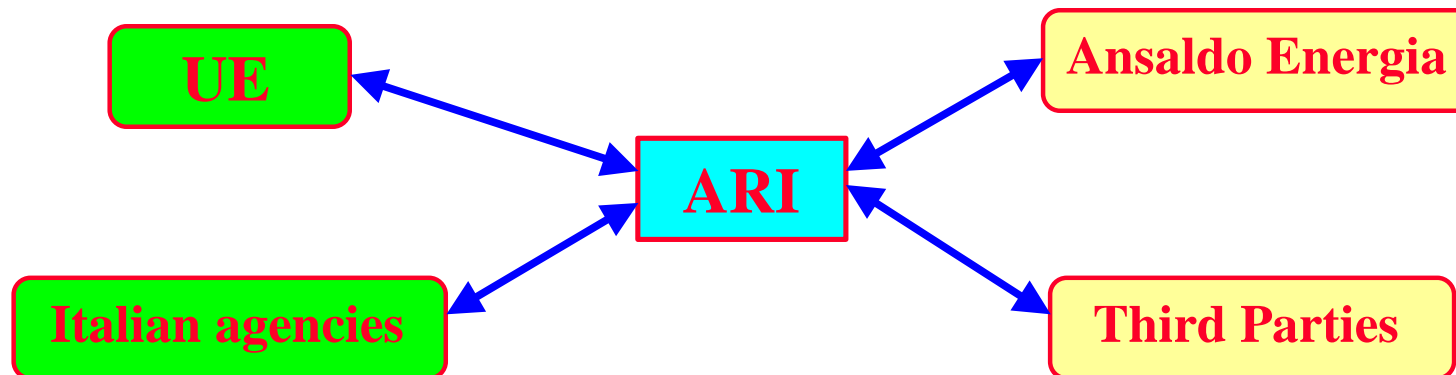
# Gas Turbine research at Ansaldo Ricerche



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## Gas turbines related activities underwent an evolution similar to ARI's general evolution:

-  activity started in 1992, just funded by **Ansaldo Energia** ( at that time AEN began to produce gas turbines)
-  involvement in co-operative research projects (funded by EU and Italian agencies) has been growing quickly, allowing performance of more far-reaching researches and improvement of know-how
-  offering of services to third parties started recently with encouraging success







# Gas Turbine Materials research at Ansaldo Ricerche








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## Funding sources for ARI :

-  CNR (Italian National Council for Research)
-  European Union
-  Italian Government (Department of University and Research, Dep. of Industry)
-  Industrial companies (Ansaldo Energia, Atla )

## Subjects of ARI's gas turbine materials research :

-  CoNiCrAlY+M type coatings (corrosion/oxidation protection, bond coats)
-  Thermal Barrier Coatings
-  CMC materials
-  applications of high temperature brazing of ceramic materials
-  repair technologies

## Other subjects of ARI's research about gas turbines :




-  combustion ( fluodynamic and kinetic calculations, design and test of burners and combustion chambers )

# Gas turbine materials research at ARI : CoNiCrAlY+M coatings







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## **Joint Development Programme Siemens-Ansaldo (94-97):**

-  Funding of ARI from Ansaldo Energia
-  A “family” of different Sicoat coatings has been tested for oxidation, cyclic oxidation in high velocity burner rig, hot corrosion in high velocity burner rig and thermal cyclic fatigue.
-  Main achieved result : Sicoat 2453 emerged as the best new coating together with hints about possible improvements of its composition.

## **COST 522 Gas Turbine Group - WP2 Protective Systems (2000 - on going ):**

-  ARI takes part in the programme on behalf of (and funded by) Ansaldo Energia.
-  Objective (as regards CoNiCrAlY coatings ): development of HVOF process as a less expensive choice for bond coats;
-  Coatings sprayed by Tampere University of Technology and tested at ARI (oxidation)
-  Main results :
  - HVOF coating microstructure is very similar to VPS one;
  - oxidation resistance (up 1000 °C) is very similar too;
  - HVOF coating has a less clean interface with base material;
  - limited internal oxidation has been noticed in HVOF coating, not on VPS one.

# Gas turbine materials research at ARI : Thermal Barrier Coatings



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- ✍ The research effort for the improvement of plasma spraying process for very thick and very porous **Thermal Barrier Coatings** began at ARI in 1994 and it is still on-going.
  - ✍ State of the art at Ansaldo at the beginning : standard dense TBCs ( 300 to 500  $\mu$ m thick, 5 to 10 % porosity )
  - ✍ Today's technology : thickness up to 2 mm with good thermal shock resistance, porosity up to 25 % with 35 % deposition efficiency
  - ✍ Target of ongoing and future research : cost reduction, alternative materials
- ✍ TBC process development is a good example of the ARI's funding strategy for gas turbine materials research :
  - ✍ Initial preliminary activity for state-of-the-art technology acquisition funded by Ansaldo Energia (ARI acting as corporate R&D centre)
  - ✍ Process development for very thick TBCs (to be applied to combustion chambers) within a EU funded project
  - ✍ "Fundamental" research about influence of process parameters on microstructure within a project partially funded by CNR (Italian National Council for Research )
  - ✍ Demonstration activities on to real components funded by Ansaldo Energia
  - ✍ Future activities on alternative materials will be partially funded by Italian government

## TBCs research at ARI : previous projects



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### Brite-Euram project COMBCOAT (1/5/94 to 31/10/98) :

-  Title : Improved plasma sprayed thermal barriers for relevant combustor geometries using enhanced process control and better test techniques.
-  Project co-ordinator : BMW Rolls-Royce (now Rolls-Royce Deutschland ).
-  Partners : Volvo Aero, ARI, Air Liquide, FhG-LBF, Lund University, UMIST, Kvernes Technology, ICETEC, RWTH Aachen, Rolls-Royce.
-  Main achieved results :
  - Optimised spray parameters able to produce thick (up to 2 mm) TBCs with vertical segmentation cracks and high porosity (> 20 %).
  - Thermal cycling life increased by a factor > 100, with respect to thick traditional coatings ( dense, without cracks ).
  - Temperature measurements during spraying developed as process control tool; acoustic emission technique demonstrated its potential.
  - Demonstrator components (both large tiles, small tiles and burner cans) have been sprayed and successfully tested.
  - Preliminary experiments with alternative materials (application at  $T_{\geq 1300}$  °C) performed.

# TBCs research at ARI : previous projects

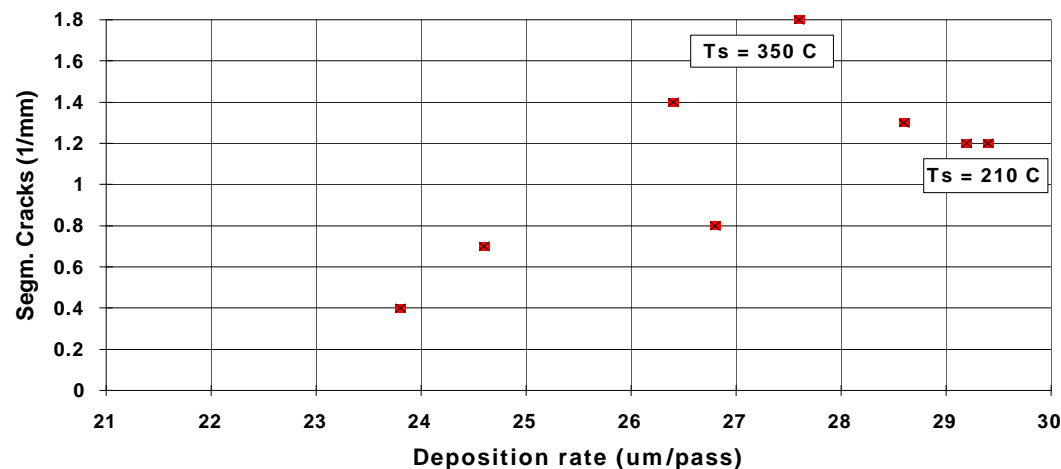


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## ✍ Italian CNR project (1/5/98 to 30/4/99) :

- ✍ Title : Heat shields for gas turbines components
- ✍ Objective/achieved result : improved knowledge of the influence of spraying parameters on coating microstructure

On the right: 1.47 mm thick TBC, 17 % porosity



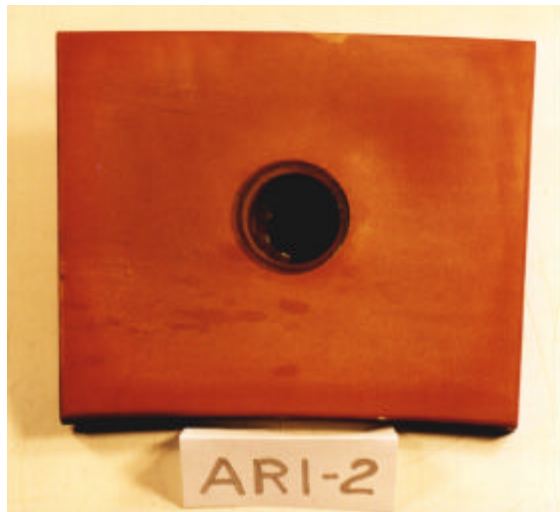
## TBCs research at ARI : demonstration activities on real components



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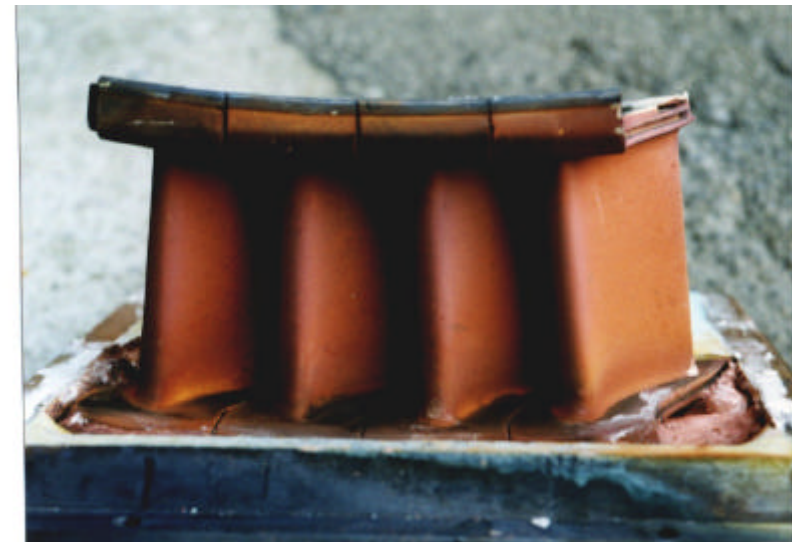
### ✍ Comparative test of commercial and ARI's porous TBCs on combustion chamber tiles :

- ✍ 2 commercial and 2 ARI's tiles a have been tested 600 hours in a burner rig (oxidation in thermal cycling conditions)
- ✍ ARI's TBC showed resistance at least as good as commercial one



### ✍ PNRMIA ( National Research Programme on Innovative and Advanced Materials ) :

- ✍ 4 first stage vanes, coated with a micro-cracked TBC by CSM, have been tested 500 hours in a burner rig (oxidation in thermal cycling conditions)








# TBCs research at ARI : present and future projects







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## **COST 522 Gas Turbine Group - WP2 Protective Systems :**

-  ARI takes part in the programme on behalf of (and funded by) Ansaldo Energia.
-  Objective (as regards TBCs) : porosity  $\geq 25\%$  with  $\geq 40\%$  spraying efficiency.
-  Methodology : simultaneous spraying of polymer and zirconia powder.

## **Special Funding of the Italian Department of University and Research for advanced materials :**

-  Title of the proposal : Development of processes for ceramic coatings
-  Status : expected to start in 2002
-  Co-ordinator : ENEA
-  Objective for ARI : spraying and testing of materials for applications at temperature higher than  $1300\text{ }^{\circ}\text{C}$ .



# Gas turbine materials research at ARI : CMC materials



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- ✍ Since more than 10 years Ansaldo Ricerche is actively involved in research relating to the application of ceramic materials, both monolithic and fibre reinforced, to power generation; early activities about gas turbine applications started in 1994.
- ✍ ARI is a partner in the Cinders project
- ✍ Early research projects about CMC materials for gas turbines have been :
  - ✍ **Joint Development Programme Siemens-Ansaldo (94-97) :**
    - Funding of ARI from Ansaldo Energia
    - 4 different CMC materials have been tested for corrosion (in flowing gas at 3 bars) and for thermal shock resistance
    - Preliminary design of a CMC first stage vane has been performed
  - ✍ **UE Human Capital and Mobility project (95-96) :**
    - Title : Development of Reliable Ceramic Components for Advanced Gas Turbines
    - Main objective : training of young researchers
    - Main technical results :
      - methodology for service representative characterisation of CMC materials
      - plasma sprayed Boron Carbide coatings for Carbon fibre reinforced CMCs

# Gas turbine materials research at ARI : CMC materials

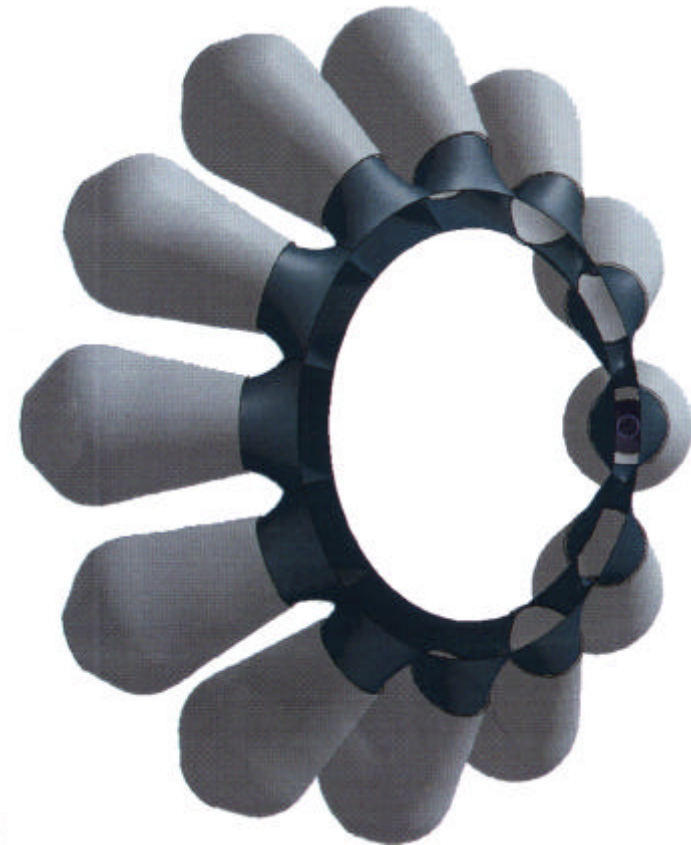


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## Preliminary design of a new combustion chamber with CMC liner :

-  Activity funded by Ansaldo Energia (97-98)
-  “Sandwich-like” three layers structure (CMC for the internal liner+ceramic felt for thermal insulation+metal for external structure).
-  Simplified calculations have been used for the conceptual design.
-  Thermo-fluo-dynamic calculations (performed with the Fluent code) confirmed the preliminary results : the can-annular configuration is promising, as regards fluodynamic behaviour and temperature distribution.
-  Preliminary Finite Element calculations (code Ansys) have been performed, in fast cooling conditions too.
-  Design optimisation is necessary.

## Conceptual design of a can-annular combustion chamber








# Gas turbine materials research at ARI : CMC materials



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## Brite-Euram project “Design CMC” (97-2000):

-  Title : Development of design methodologies for ceramic matrix composites for industrial gas turbines.
-  Coordinator : Alstom Power
-  Objectives :
  - CMC design data for gas turbines
  - design and analysis methodologies with CMC
  - validation through the design, construction and test of a combustor can and a tile
-  Materials : SiCf/SiC CMCs
-  Activities at ARI :
  - procurement of CERASEP N3-1 CMC
  - oxidation test in burner rig
  - thermal shock test of disc shaped samples
  - contribution to design and FE analysis
  - burner rig test of demonstration tile

