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Environnemental challenges in Aeronautics

« Research in Advanced Aeronautics
Combustion Chambers »

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CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

Engine contribution to environmental objectives

Objectives ACARE 2020
(Advisory Council for Aeronautics Research in Europe)

- 50% reduction of noise
- 80% reduction of NOx emission
- 50% reduction of CO2

ATM Contribution

Aircraft Contribution

Engine Contribution

- 6 db Reduction of noise
- 60 to 80% Reduction of Nox
- 20% Reduction of kerosene consumption

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Physical principles for an environmental compromise

Increase the pressure ratio

- Reduction of fuel / CO2 ratio by an enhancement of the energetic efficiency
- Reduction of unburnt HC and CO emissions
- Increase of NOx emissions due to an increase of the combustion chamber temperature
- Increase of the maintenance cost

Increase of the by-pass ratio of the engine

- Reduction of fuel / CO2 ration by an enhancement of propulsive efficiency
- Reduction of noise by reduction of the rotation speed of the fan, the pressure ratio, exhaust velocity of gases
- Increase of weight, shear and maintenance cost

Enhancement of aerodynamics and weight reduction

- Efficiency level already reached
- Reduction of CO2 by enhancing the fuel efficiency and the thrust
- Reduction of noise by reducing the needed thrust
- Reduction of Nox emissions by reducing the combustion temperature

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Research challenges

Development of new physical models for:

- Development of chemical kinetic models (combustion, NOx and particles production ,..)
- Development of numerical tools (mesh, equation solving,.) for chamber design

Need of experimental studies for numerical validation

- Validation of physical models in academic experimental configurations
- Development of adapted diagnostic techniques, using often laser (hostile mediums, weak or any optical acces for measurements (velocity, turbulence, temperature, chemical composition, pressure, noise, location of reactive zones, ..)
- *Full scale tests*

Developpement of new alloys

- Weight reduction
- Material behaviour during thermal cycles

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Identified Research challenges

1. Chemical kinetics
2. NOx formation:
   New Concepts of combustion chambers
   LPP regime Lean premixed prevaporized (Air exces)
   RQL Combustion Rich Quenching Lean
3. Turbulent combustion
4. Chamber design – numerical tool development
5. Wall cooling
6. Fuel atomisation
7. Gas and particle radiation
8. Alternative kerosene
9. Hydrogen or natural gas turbines
10. New combustion modes in aeronautical turbines

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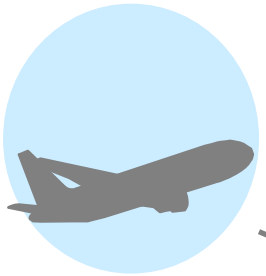
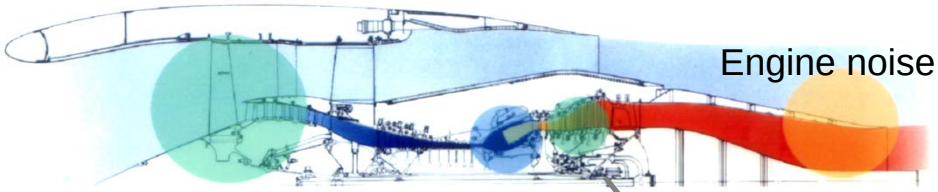
Conclusion : research challenges

- Optimisation of the 2-phase combustion chambers for a reduction of **CO2, NOx, CO and particle emission**
- Optimisation of the **wall cooling** for chambers and turbine **blades**
- Reduction of **noise**



Airframe



Engine noise sources

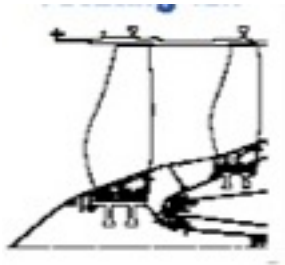
Forward Fan | Aft Fan | Combustor | Low Pressure Turbine | Jet

Documents SNECMA

Nozzle with chevrons

Enhancement of entrance

Contra-rotative fan



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Conclusion : research challenges

- Optimisation of the 2-phase combustion chambers for a reduction of **CO2, NOx, CO and particle emission**
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- Reduction of **noise**
- Development of **new alloys** (weight reduction, material behavior at high temperature, thermal cycles,…)

Composite fan case

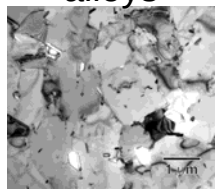
Highly loaded compressor

Light weight Composite mixer

Next-gen RTM composite fan

Ceramic-matrix composite blade

Novel titanium alloys



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