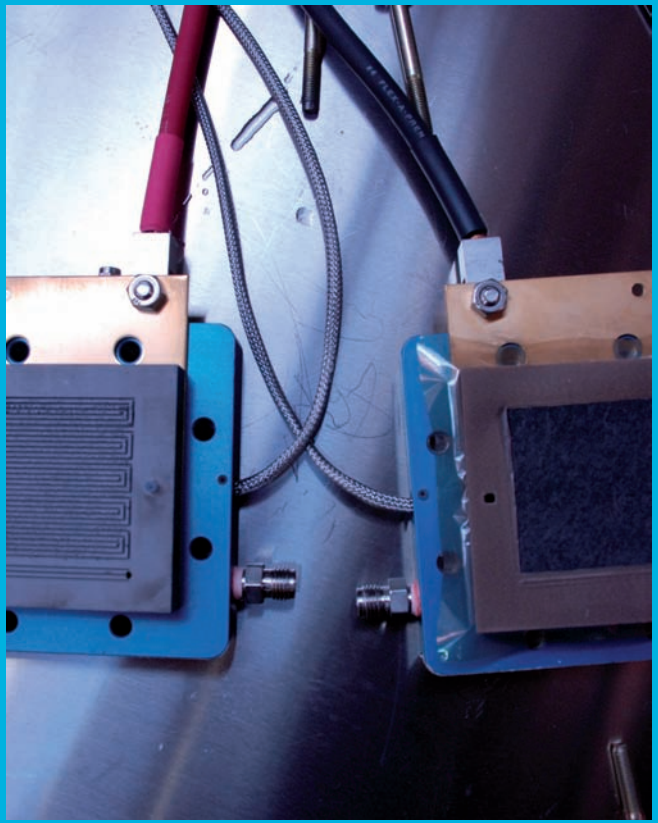
UC3M

RESEARCH GROUPS

GMF

FLUID MECHANICS GROUP

Universidad
Carlos III de Madrid
www.uc3m.es



Three-coil bipolar plate and GDL of the PEM/DAFC fuel cell cathode

The **Fluid Mechanics Group (GMF)** lead by Dr. Antonio Luis Sánchez Pérez is formed by a multidisciplinary team of 19 researches made up of aeronautical engineers, chemical engineers, industrial engineers and graduates in physics. The GMF has expertise in the use of analytical, numerical and experimental techniques for solving current industrial problems relating to fluid mechanics.

All the members of the group have spent long periods of time in internationally renowned research institutes: University of California, San Diego (USA), University of California, Berkeley (USA), Yale University (USA), University of East Anglia (UK), University of Twente (Netherlands), Technische Universiteit Eindhoven (Netherlands) or Von Karman Institute for Fluid Dynamics (Belgium).

Such a distinguished international nature provides the group with a great heterogeneity and allows it to uncover innovative solutions to industrial problems within a wide range of applications.

•LINES OF RESEARCH•

- Combustion
- Multiphase Flows
- Microfluidics
- Biofluid Dynamics
- Fuel Cells
- Heat and Mass Transfer
- Computational Fluid Mechanics
- Detonations and Supersonic Flows.
- Low Density Jet Hydrodynamic Stability
- Steady Streaming in Turbulent Flows
- Dynamics and Stability of Liquid Jets Subjected to the Influence of Gravity

•COLABORACIONES DESTACADAS Y PROYECTOS DE I+D+I•

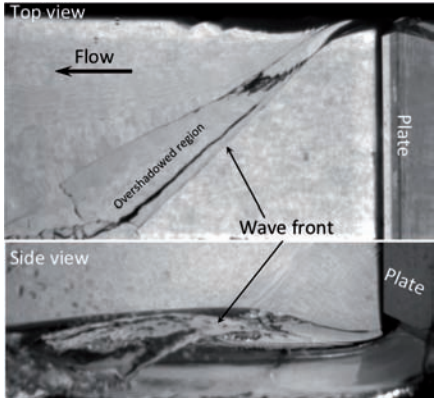
The group works in collaborations with aeronautics companies, temperature control system providers and engineering companies. Its recent collaborators and clients include REPSOL, EADS and Acciona Windpower S.A.

The most relevant R&D&I projects of the group to date are

- "Fundamental Ultra-compact Rotary Engine Combustion Analysis".
  Funding Entity: Ministry of Economy and Competitiveness.
  Date: 2013-2016.

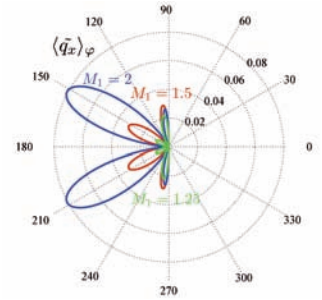
- "Sustainable Combustion Research"
  Funding Entity: Ministries of Science and Innovation.
  Date: 2010-2015.

- "Mechanisms for Generating Micrometric Droplets and Bubbles with Industrial Process, Pharmacology and Medicinal Applications"
  Funding Entity: Ministry of Science and Innovation
  Date: 2011-2014.



A shot of the three-dimensional structure of a breaking wave started from the corner of a plate inside the hydrodynamics tunnel.

· "Multiphase Modeling of Relevant Thermal-fluid Problems in Energy Generation and Exchange Systems with Industrial Application"
Funding entity: Ministries of Science and Innovation
Date: 2011-2014



Acoustic energy flow emitted by an oscillating planar shock wave. The irradiated sound wave intensity increase with the number of Mach, especially in certain preferred directions in which acoustic energy propagation is considerably higher.

· "Development of Predictive tools for Hydrogen Combustion in Gas Turbines".
Funding entity: Autonomous Community of Madrid (Comunidad de Madrid).
Date: 2010-2013

· "Experimental Characterization of Fuel Jet Atomization",
Funding entity: REPSOL
Date: 2012-2013.

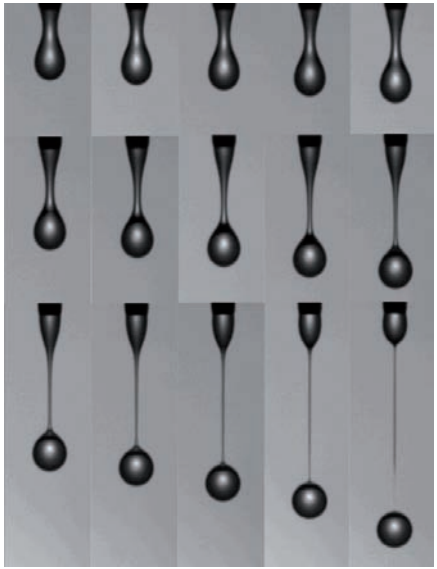
•SCIENTIFIC-TECHNICAL SERVICES•

The GMF offers a portfolio of technical, consultation and training services capable of solving the most challenging problems in the industrial sector with innovative solutions. Some outstanding aspects of the GMF are specifically detailed below:

· High fluid mechanics process numerical calculation capacity of industrial interest, as proven by our collaborations with companies and the scientific articles published in the best scientific publications (Journal of Fluid Mechanics, Physics of Fluids, Combustion and Flame, Journal of Power Sources ...)

· Extensive company training:

1. *"Advanced CFD and Turbulent Modeling Course"*, taught by the members of the GMF. This course was recently given for the members of the design team of the company, Acciona Windpower S.A. Specifically, this 24-hour theoretical-practical course focuses on the general theory of Computational Fluid Mechanics with a special emphasis on turbulence models and their practical implementation using ANSYS FLUENT.



Sequence of images depicting the formation of PDMS silicone oil droplets taken with GMF's high-speed camera.

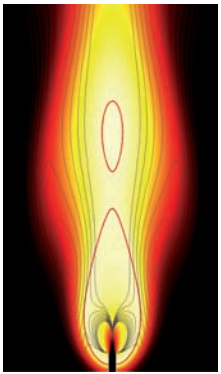
2. *"Master of Systems Integrations for the Aerospace Industry"*. A Masters program sponsored by the company EADS España and the subcontractors of the parent company. This international program is especially designed for students and professionals having interest in aeronautics system integration. More than 300 students have participated in this master which is now in its 4th year. These students have shown great satisfaction after completing the 90 credits forming the master.

· Experimental fluid mechanics process characterization of industrial interest. It is worth highlighting that the work of characterizing fuel-jets performed for the company REPSOL SL.

· Theoretical fluid mechanics process analysis of industrial interest covering aspects as varied as the description of combustion reactions, mathematical modeling of hydrogen/ethanol/methanol/alcohol fuel cells, jet stability, microfluidics and biological flows.

•TECHNOLOGICAL EQUIPMENT•

The GMF has a numerical and experimental laboratory equipped with the most innovative equipment necessary for overcoming any fluid dynamics problem. In addition to the general equipment and installations of the UC3M, the GMF has the following laboratories:



Temperature field resulting from combusting methane jet with air. The photograph includes the stoichiometric surface where the chemical reaction (red line) takes place and the iso-vorticity surfaces (gray lines) responsible for breaking up the flame into two separate regions.

1. Numerical calculation laboratory
   - Computational cluster with 192 2.27 GHz Intel Xeon cores distributed over 21 nodes, with 600GB of RAM and a 12 TB Raid system.
   - Massive data storage systems.

2. Aerodynamics and hydrodynamics measurement laboratory
   - Subsonic aerodynamics tunnel
   - Horizontal hydrodynamics channel with a 2.5 m3 capacity. The test section is 0.7 m in length with a 0.25m x 0.25m square section.
   - 60 x 60 x 100 cm vertical hydrodynamics channel with a variable diameter injection cylinder.
   - Two-component laser Doppler DANTEC anemometry system
   - DANTEC hot-wire anemometry system.
   - High-speed camera with a maximum speed of 1000 images per second.
   - 5 W Argon-Ion laser for illuminating hollow graphene particles for measuring velocity using the PIV technique.

3. Stability laboratory
   - RedLake MotionPro X High-speed cameras which can capture up to 128000 images per second according to the window size.
   - MALVERN droplet particle size analyzer
   - Active and passive vibration isolation test tables
   - Harvard apparatus PhdUltra syringe pump for flow rate control.
   - Tensiometer for measuring surface tension with digital and automatic reading.

4. Fuel cell laboratory
   - PEM (polymer exchange membrane) /DAFC (direct alcohol/methanol/ethanol fuel cell) fuel cell
   - Peristaltic liquid fuel feeding pump.
   - Three-coil, bipolar plate.
   - Light gases distribution and feeding systems.

Velocity field formed by the asymmetric vibration of a sphere in a liquid. Due to the movement of the solid, the fluid is ejected from the sphere surface giving rise to a single velocity field observed in the image.

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IMAGE OF COVER: *Flow*
David Taborda