IFRF Suomen kansallinen osasto - Tekes
III Liekkipäivä
Dipoli, Otaniemi, 31.1.2007

IFRF tänään

Mikko Hupa                                           Leonardo Tognotti
IFRF Headquarters
Pisa/Livorno, Italy
The IFRF now - International

IFRF is a Network of Combustion Related People
Around 1200 people in 23 countries
The IFRF now – Multi-Sector

International Flame Research Foundation (IFRF.NET)

- Power Generation Industry (PGI)
- Cement and Mineral Processing (CMP)
- Metals Production Industry (MPI)
- Petroleum Refining Industry (PRI)
- Fuels and Comburents (FCI)
- Combustion Equipment Manufacturing (CEM)
- R&D Research and Development
- Universities Education-Training (ETG)
- Universities Education-Training (ETG)
Relocation of IFRF

♦ 9 Member Organisations offered to provide a new Director for the IFRF and access to experimental combustion facilities on a pay-as-you-go basis.

♦ Short List Candidates were:
  • CNRS Orleans/Bourges, France (Iskender Gokalp)
  • Gas Warme Institute, Germany (Frank Sowa)
  • Pisa University and ENEL Ricerca, Pisa, Italy (Leonardo Tognotti)
  • Michael Flamme, Essen Germany – Networked R&D Facilities
IFRF Move to Tuscany - concept

- The decision of the IFRF Joint Committee meeting in June 2006 has now been fully realized.

- ‘Not for profit’ foundation (ONLUS) established in Italy and the Dutch Foundation closed (Stichting Internationaal Vlamonderzoek – Stichting IVO)

- The new ONLUS has the same objectives as the former Stichting IVO

- IFRF Joint Committee to retain statutory control of the new ONLUS in a similar fashion to its control of Stichting IVO

- Two separate ‘hosting’ agreements: the IFRF ONLUS and University of Pisa, and IFRF ONLUS and ENEL Ricerca
The structure of the Pisa-Livorno IFRF system

In prospect of hosting IFRF, the Faculty of Engineering and ENEL Research prepared a programme, in order to manage the activities related to IFRF.
Statutes, form and operation of ONLUS:

- ONLUS has the Bank Account
- The Ijmuiden office and its facilities have been moved to Livorno.
- Livorno offices are fully operating (phones, computers)
- One investigator (GC) and a part time secretary (TB) are now there
- The archive and furniture have been successfully relocated
- New cupboards and HW/phones have been purchased
- Archive needs to be partially re-organised (reports)
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<th>Bank</th>
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<td>c/o Presidenza Facoltà di Ingegneria, Via Diotisalvi 2, 56126, Pisa CF: 93059950506 P.IVA: 01807000508</td>
<td>Via Salvatore Orlando 5, 57123 Livorno Italy</td>
<td>Tel: +39 050 511240 Fax: +39 050 511266 e-mail <a href="mailto:info@ifrf.net">info@ifrf.net</a> <a href="http://www.ifrf.net">http://www.ifrf.net</a></td>
<td>IBAN: IT 53 M 06200 14011 000002887345 Cassa di Risparmio Lucca, Pisa Livorno SWIFT:BPALIT3L</td>
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The Spirit of IJmuiden...
The Spirit of IJmuiden...

...in Pisa & Livorno
Faculty of Engineering Pisa

- Ten Departments
- More than 5000 students
- 13 I level (3 years) degree programmes
- 17 II level (3 + 2) degree programmes
Enel Technical Area Research

- 170 Researchers
- 50 Graduates/year
- 2 Research Centers
- 4 Research Stations
- 2 Chemical Laboratories
- 25 M€uro/year

Livorno Experimental Station

Pisa Chemical Lab

Sesta Experimental Station
Relocation of IFRF

– The IFRF is to relocate to Pisa/Livorno after over 50 years at its Corus IJmuiden home

– The new host organisations will be University of Pisa and ENEL Ricerca, with IFRF offices and operations based at ENEL’s Livorno Research Facility

– IFRF will have access to the extensive experimental and computing facilities of ENEL Ricerca and University of Pisa on a pay-as-you-go basis

– Professor Leo Tognotti of Universiy of Pisa will shortly take over as the Director of the IFRF
ENEL “IFRF No 1 Furnace”
IFRF Members Research Program

- Fuels Characterization – Fuels Database
IFRF Isothermal plug flow reactor

natural Gas
Coal inlet

O2,N2

Cooling loops
additional gas option

Pre-combustion

Reactor

O2,N2

Nitrogen quench

Sampling probe

Electrical heating elements

Exhaust

Cyclone

Ash sample
MRP n. 1: development of a solid (coal and secondary) fuel database

Steps:
1. **IFRF Archive rearrangement and updating**
   - **What:** Fuels characterisation databases plus software (combustion sub models etc).
   - **How:** Catalogue and recover paper and electronic records, into a current electronic form

2. **Transfer of IFRF – Isothermal Plug Flow Reactor** from IJmuiden to Pisa: a piece of tradition living

3. **Collect and organise** data from members/literature reviews/existing data base
   - significant experimental work
   - (unpublished data from industrial members)

4. **Produce** new data: reference for model validation
   - use IPFR for specific campaigns on selected fuels (coal-biomass)
   - Co-combustion of coal-biomass in FOSPER
DATABASE OF SOLID FUEL PROPERTIES - SUMMARY

Classes of solid fuels (coals, biomasses, residues, wastes, plastics)

Different origin, composition and properties - Heterogeneous nature

New or revised thermal processes (co-combustion, pyrolysis, gasification)
for energy and/or materials recovery

Need fundamental investigation and a database in very wide intervals (of fuel characteristics, equipment used and operating conditions)

A database for solid fuels should contain:
- fuel characterization (composition, size and morphology vs milling, )
- fuel physical properties (density, cp, surface area)
- devolatilization data (macro-product yields, volatile speciation, kinetics in different o.c., soot generation potential)
- char characterization (of chars obtained in different o.c.)
- char reactivity (for oxidation and gasification
- ash properties (slagging-fouling, inorganic micropollutant generation potential)
IFRF Members Research Program

- Fuels Characterization – Fuels Database
- Modelling – CFD Submodel Developments
LES modelling of combustion systems

DOE–HAT Combustor (PHI=0.58; Tin=700 K; P=13.6 atm)
MRP3 : validation of combustion modelling for practical combustion systems (coal /gas)

1. CFD simulation of reference cases
   ♦ Furnace n.1, fueled with gas-coal
   ♦ IFRF-IPFR internal flow
   ♦ 100-500 kW combustion test rigs (FOSPER?)
   ♦ CFBC
   ♦ GT burners- (instabilities)
   ♦ Flameless combustors
   ♦ Lab-scale burners
     • Kinetic model (reduced- detailed)

   ♦ CFD validation for industrial use:
     • Turbulence model-(RANS, LES)
     • Turbulence-kinetic interaction (Eddy dissipation, Finite rate chemistry, Finite rate chemistry/eddy, dissipation, laminar flamelet with PDF…)
     • Radiation model
     • Particle-flow field interaction
     • Heterogeneous sub-models (particle devolatilisation, oxidation, gasification, soot )
IFRF Members Research Program

- Fuels Characterization – Fuels Database
- Modelling – CFD Submodel Developments
- Micropollutants – particulates
Specific objective of the research

- Set-up of diagnostic techniques on lab-scale gas burners
- Comparison of the results obtained with different techniques
- Fine particulate measurement tests on pilot-scale and semi-industrial scale burners (gas: TAO, CASPER; coal: FOSPER, CIRO)
- Full-scale measurements of fine particles
# Particles Classification

## Fractal Dimension

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<th>Size Ratio</th>
<th>1-1.05</th>
<th>1.05-1.15</th>
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IFRF Members Research Program

- Fuels Characterization – Fuels Database
- Modelling – CFD Submodel Developments
- Micropollutants – particulates
- Fuel Conversion for Hydrogen
IGCC R&D Issues

(1) Feedstock Preparation
- Co-feeding
- Petroleum cokes/residues
- Forest products
- Black liquors
- Carbonaceous wastes

(2) Advanced Gasifier Concepts
- Transport gasifier
- Refractories
- Instrumentation

(3) Air Separation
- Low capital costs
- Low O&M costs
- Process integration

(4) Gas Cleaning
- Particle filters
- Sulfur removal
- Instrumentation/controls
- Reliability/availability/maintenability

(5) Other/Combined Contaminant Control
- Chloride/Alkali removal
- NH₃/NO₂ removal

(6) Coproduction
- Fuels or chemicals conversion performance
- Flexibility and adjustment of syngas composition

(7) Fuel Cells
- Near-zero contaminants
- Integration

(8) Product Gas Separations
- Hydrogen separation
- CO₂ Separation
- CO₂ sequestration

(9) Gas Combustion
- Low Btu gas
- Integration

(10) Trace Emissions
- HAPs measurement & modeling

(11) Sulfur Recovery
- Direct sulfur recovery
- Advanced sulfur recovery concepts
- Utilization

(12) Ash/Slag Disposition
- Disposable solid waste
- Utilization
- By-products

Overall System
- Process simulation
- Instrumentation/control
- Capital cost/product
IFRF activities

- Member Research Programme
- Training courses
- Members’ services
- Membership development
Planning reports: Research & strategy

- *D 0X/h/1*: Proposals of ENEL Ricerca- University of Pisa for the Member Research Programme 2006-2008

- *D 0X/h/2*: Long term research objectives 2007-2009- (Superintendent of Research) *(June 2007)*

- *D 70/h/1*: Instrumentation and diagnostics: present IFRF capabilities and future development (June 2007)
Planning reports: Experimental and Modelling

- D 45/h/1: Programme of work with pulverised fuel on FOSPER- November-December 2006 (November 2006)

- D 07/h/1: Planning of trials at Livorno station for 2007 (December 2007)

- D 45/h/2: Programme of CFD/comprehensive modelling of FOSPER (Furnace # 1) tests (December 2006)
Research reports

- **E 45/h/1**: FOSPER test November -December 2006: results of tests on low NOx coal burner (TEA C and IFRF staged burner) *(February 2007)*

- **E  XX/h/1**: IFRF Isothermal Plug Flow Reactor: results of performance tests after reconstruction in Livorno experimental area *(when ready..)*

- **F 36/h/1**: CFD + comprehensive modelling of Furnace # 1; past IFRF tests and new tests: results of modeling and benchmarking *(May 2007)*

- **F 70/h/1**: State of the art of optical diagnostic for *industrial combustion* characterization and tests: a survey *(June 2007)*

- **F 106/h/x**: IFRF Solid fuel database: *structure, properties and data*; Rev.01 *(July 2007)*
Training/mobility/education

Trained combustion engineers

- World wide
  - over 80 former investigators – European, Japanese, Americans, Australians, Canadians

- European Union:
  - IFRF – ENEL- Cardiff University (EuroFlam)
  - 200 Graduates in 10 years – 30% women
Members’ Services

- IFRF web site,
- Meetings, Conferences
- Databases, reports and publication policy
- Consultancy
- Probe and Instrumentation
Web site “refurbishment”

- Updating and improvement of some portals before the end of the year
- The concept and project of the new web site to be presented at next Join Committee
IFRF Activity - 2006

- **Communications**:
  - Ca 50 MNM published
  - Six Research Reports published

- **Technical Meetings**
  - TOTeM28
    - *Mercury and micro-pollutants*
    - Salt Lake City, Prof Jost Wendt
  - TOTeM29
    - *Characterisation of bio-fuels for co-combustion*
    - Munich, Prof Hartmut Splierhoff
15th IFRF Members’ Conference

Combustion in an Efficient and Environmentally Acceptable Manner’

Invites lectures and keynotes: topics
- Trends in emission limits regulations and environmental-related laws
- Advanced diagnostics in industrial combustion systems-process control and emission measurements
- Combustion processes for carbon capture: towards zero emission plants
- New burner concepts for ultra-low NOX gas (natural-synthetic-bio) combustion-
- Clean coal combustion in power stations: state of the art

- **Workshop 1:** the Member Research Programme: a platform to seek out mutually advantageous opportunities to cooperate in the R&D programmes –
- **Workshop 2:** Solid fuels properties and characteristics: needs and structure of the IFRF database,
15th Members’ Conference
Pisa, Italy
June 13-15, 2007