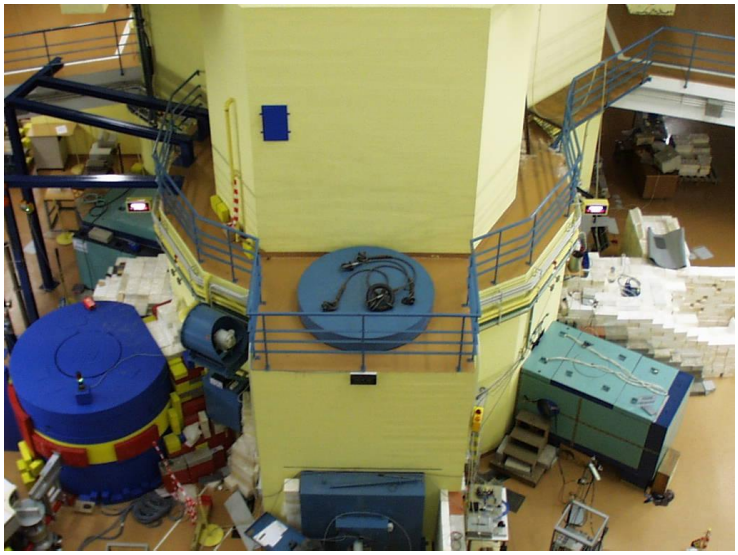
Reactor Sector



Reactor

José Gonçalves Marques

The Portuguese Research Reactor (RPI), as a unique infrastructure in the Iberian Peninsula, houses as well the ***Atmospheric Elemental Dispersion*** and the ***Applied Dynamics*** groups. The RPI also supports activities in the Chemistry Sector, the Physics Sector and in the Department for Radiological Protection and Nuclear Safety. A major step in ensuring the continuation of the operation of the RPI was given this year, through the core conversion to low enriched fuel.

Four young researchers were selected under the CIENCIA 2010 programme, to start working in early 2008. They will strengthen the groups of ***Atmospheric Elemental Dispersion*** (2 researchers), ***Applied Dynamics*** (1 researcher) and ***Reactor Dosimetry*** (1 researcher).

The staff involved in all aspects of the operation and use of the RPI presents its activities under the common headline of ***Operation and Exploitation of the Reactor, Reactor Dosimetry and Reactor Calculations***. Most of the research projects started in 2005, covering the areas of dosimetry, materials science and neutron tomography, are completed or close to completion, bringing new equipments and techniques into routine use.

The ***Atmospheric Elemental Dispersion*** group uses the k_0 INAA technique in the RPI and was the second main user of the reactor in 2007, accounting for 28% of the total irradiation time. The group is dedicated to cycling and impact of trace elements in the atmosphere. It addresses, specifically, the development and application of nuclear techniques, source apportionment and tracking in the atmosphere, chemical speciation, uptake and release of chemical elements in biomonitoring and monitoring, as well as health linkage through epidemiology and nutrition studies. These objectives are approached through research, included mostly in PhD theses. The activities are essentially financed by the Foundation for Science and Technology.

The research performed by the ***Applied Dynamics*** group is mostly concerned by vibration and acoustic problems displayed by components of nuclear and conventional power plants. As such, a significant part of their research results has been motivated and funded by the French *Commissariat à l'Energie Atomique (CEA)* and the Portuguese *Electricidade de Portugal (EDP)*. However, the techniques developed by this group can and have been used to solve problems, both of industrial and fundamental nature, outside the realm of power generation. In spite of being one of the smallest groups in terms of ITN staff, this fact is compensated by an active collaboration with Universities and Research Laboratories, both in Portugal and abroad. The vitality of this group is well demonstrated by their research contracts and publication

Reactor Staff

Researchers

J. G. MARQUES, Princ.
M. C. FREITAS, Princ.
A. V. ANTUNES, Princ.
A. FALCÃO, Princ.
N. P. BARRADAS, Princ. (95%)
A. KLING, Aux. (90%)
A. R. RAMOS, Aux. (90%)

Technical Personnel

J. P. SANTOS, Dosimetry
J. A. M. RIBEIRO, Reactor Operator
J. C. ROXO, Reactor Operator
N. SERROTE, Reactor Operator
R. SANTOS, Reactor Operator
R. POMBO, Radioprotection
F. B. GOMES, Radioprotection
A. RODRIGUES, Technician
V. TOMÁS, Laboratory Assistant (Retired in 2007)
I. DIONÍSIO, Laboratory Assistant

Administrative Personnel

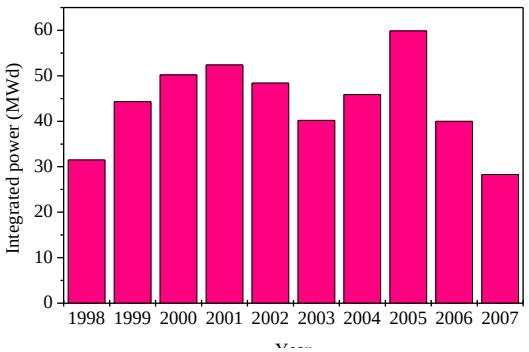
T. FERNANDES, Secretariat

OPERATION AND EXPLOITATION OF THE REACTOR, DOSIMETRY (RPI) AND REACTOR CALCULATIONS

José Gonçalves Marques

The main objective of the Operation and Exploitation of the Portuguese Research Reactor (RPI) is to be able to satisfy the users' needs while conducting all tasks with the assurance that the reactor is operated in a safe and reliable manner by a highly competent and motivated staff. The implementation of such objectives demands a variety of activities, some of which are repetitive in objective and variable in content, while others address specific aspects of the same end situation.

The activities in 2007 were clearly dominated by the preparation for core conversion to low enriched uranium (LEU) fuel and its execution. Regulatory approval for conversion was granted in August and the actual core conversion was done in September and October, following a previously defined program. No loss of performance of the reactor was observed after conversion.



A new state-of-the-art setup for Perturbed Angular Correlation Experiments with short-lived isotopes was installed this year, as well as a setup for monochromatic neutron beams. A setup for neutron tomography suffered a significant delay and is now expected to become operational by the summer of 2008.

The main users of the reactor are described in the Table below.

User	Area	Time (%)
RPI	Dosimetry and Test of Detectors	35.4
	NAA	27.5
	Isotope Production	5.5
Chemistry	NAA	12.2
	Isotope Production	1.2
DPRSN	Isotope Production	4.8
Univ. Lisboa	Isotope Production	12.7
LIP/Lisboa	Isotope Production	0.1
IVIA	Radiation Effects	0.3
Univ. Coimbra	Isotope Production	0.4

The figure to the left indicates the integrated power produced by the RPI in the last 10 years. The decreases observed in 2006 and 2007 are related with the core conversion. In 2006 the reactor was stopped for 2 months, until an extension on the use of HEU was granted by the Department of Energy of the USA; in 2007 it was stopped for 5 months, from the agreed end of use of HEU on May 31, to resuming routine operation at 1 MW with the new LEU core

Research Team

Researchers

J.G. MARQUES, Princ.
A. KLING, Aux. (95%)
N. P. BARRADAS, Princ. (90%)
A. FALCÃO, Princ.
A.R. RAMOS, Aux. (90%)

Students

M.A.F. da COSTA, MSc Student, IST, ITN grant
A. RICO, MSc. Student, FCT, ITN grant

Reactor Operators

J. A. M. RIBEIRO
J. C. ROXO
N. SERROTE
R. SANTOS

Technical Personnel

R. POMBO
F. B. GOMES
A. RODRIGUES
J. S. SOUSA

Collaborators

T. GIRARD, CFNUL
T. MORLAT, Post-doc., CFNUL
F. GIULIANI, Post-doc., CFNUL
A.P. FERNANDES, HSM/CFNUL

Core Conversion of the RPI to LEU Fuel

J.G. Marques, N.P.Barradas, A. Kling, A.R. Ramos, J.P. Santos

Objectives

Core conversion of the RPI to Low Enriched Uranium (LEU) fuel was performed within IAEA's Technical Cooperation project POR/4/016. The core conversion took two years to complete, from the initial feasibility study to the actual core change, done in September 2007. The performance of the new LEU core is identical to that of previous cores built with High Enriched Uranium (HEU).

Results

A feasibility study was performed during 2005 with the assistance of the RERTR program at Argonne National Laboratory. Uranium silicide (U_3Si_2-Al) dispersion fuel with a density of 4.8 g/cm^3 was selected because of its widespread use in research reactors and for the relatively large number of manufacturers. The new LEU standard assembly has a ^{235}U loading of 376 g vs. 265 g for an HEU standard assembly. With this design the core size remained unchanged, at 12 assemblies. The number of plates was kept the same as for the HEU fuel.

The results of neutronic studies, steady-state thermal-hydraulic analyses and accident analyses, made in 2006, demonstrated that the RPI could be operated safely with the new LEU fuel. The IAEA reviewed these studies, as required by the tripartite agreement between the IAEA, Portugal and the USA. Revised documents were submitted in May 2007 addressing the issues raised during review. The IAEA provided a letter of support for the conversion in late June and the licensing body of the RPI approved the conversion in August 2007.

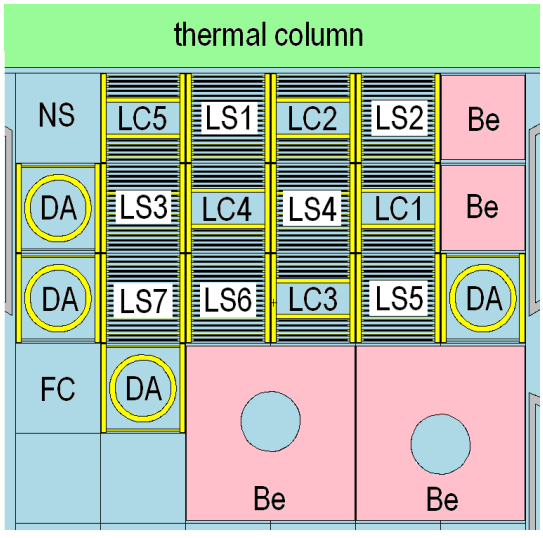


Fig 1. New LEU core, adapted from MCNP model output.

Fig. 1 shows the initial LEU core configuration. LS1 through LS7 are standard assemblies and LC1 through LC5 are control assemblies, NS is a Sb-Be neutron source, FC a fission chamber and the DA are hollow dummy assemblies. The dummy assemblies were introduced in the core in order to improve the thermal hydraulic safety margins

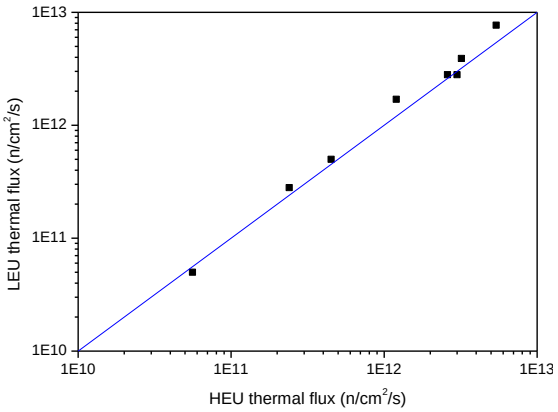


Fig. 2. Thermal neutron flux in pool irradiation positions for the new LEU core vs. a comparable HEU core.

Figure 2 shows a comparison of measured thermal fluxes for the new LEU core and a comparable HEU core. The average ratio between the thermal fluxes measured in the HEU and LEU cores is 0.9 ± 0.3, covering two orders of magnitude of the flux values. From the available data there is no clear loss or gain of thermal neutron flux with the conversion to LEU. Furthermore, the LEU core has 2 additional irradiation positions, inside the hollow dummy assemblies in positions 13 and 54, which have thermal neutron fluxes of 1.9x10^{13} and 1.8x10^{13} n/cm^2/s, respectively.

Gamma dose rates were also measured in all free grid positions, at mid-height of the core, using an ionization chamber. The ratio of HEU to LEU values is 1.1 ± 0.2, in agreement with the expected – as the LEU core has significantly more ^{238}U a higher attenuation should occur.

Work in progress includes the measurement of neutron fluxes and gamma dose rates in the beam tubes and improvements in the as-built MCNP model of the core.

New Spectrometer for Perturbed Angular Correlation Experiments
J.G. Marques, C. Cruz

Perturbed Angular Correlation (PAC) is a well known nuclear technique used in the characterization of materials at a microscopic scale. A state-of-the-art spectrometer for PAC studies using short-lived isotopes produced in the reactor was installed during 2007. The thermal neutron flux available for this application is 2E13 $n/cm^2/s$, which makes it possible to produce in just a few minutes enough activity. No long and bureaucratic transports of radioactive isotopes are necessary, since the analyzing facility is at the reactor. LSO scintillators were used for the detectors. These have higher detection efficiency than the commonly used BaF_2 scintillators, as well as a better energy resolution, although a slightly worse time resolution. Photomultiplier bases, able to handle count rates in excess of 100 kcps, as well as signal processing units, which are not commercially available, were developed locally, which allowed a significant reduction in the number of units and interconnections. The whole electronics for the spectrometer only required two standard NIM bins – which is half of the usually required.

Photon Dosimetry Using Red 4034 Harwell Dosemeters
J.P. Santos, J.G. Marques

The performance of Red 4034 Perspex dosemeters from Harwell Technologies in routine photon dosimetry in mixed fields was evaluated. The dosemeters were irradiated in core grid positions of the RPI under a photon dose rate of the order of 1E4 Gy/h, a thermal neutron flux in the range of 0.2-1.1E11 $n/cm^2/s$ and temperatures below 40 ºC. Red 4034 visibly darkens upon irradiation and this effect, accurately measurable by spectrophotometry, is related to absorbed dose. Thermoluminescence dosemeters and a calibrated ionization chamber were used as comparison. The results show that Red 4034 performs relatively well in mixed fields, having determined photon doses with good linearity up to 50 kGy. A comparison of the three methods applied to determine the photon dose shows an agreement within 10%, which is acceptable for the intended application. Experiments at powers above a few tenths of MW cannot be directly monitored by Red 4034, but the characterization of the irradiation position at full power can be done at a lower power, e.g., 100 kW, and the results extrapolated. We recommend the use of a ^{16}N linear channel to minimize errors in the scaling of the values.

Neutron Tomography at the RPI
A. Rico, J.G. Marques

Neutron radiography is a well established non-destructive analysis method. Compared with X-rays, neutrons have as specific advantages a high interaction probability with hydrogen and a lower attenuation in several heavy elements which are "black" for X-rays. Tomography requires a reasonably high number of 2D images in digital form of the observed object rotated over 180 degrees related to its central axis. With modern CCD cameras it is possible to obtain 2D images in less than one minute, even for modest neutron fluxes of the order of 1E5 $n/cm^2/s$. A setup for neutron tomography will be implemented in beam line E4, through the installation of a removable divergent collimator in the irradiation cavity. The setup includes a ZnS:Ag scintillator screen, a FingerLakes CCD camera with fast readout and a rotary table where the object is placed in front of the beam. The beam will have 20 cm diameter, which is enough for a significant number of applications. Procurement of the major components could only be finished this year. A MATLAB interface for the CCD camera had to be developed, given the instability of the software provided by the manufacturer. This unexpected time-consuming task together with the unavailability of the reactor for 5 months delayed significantly the project, which is now expected to be complete by the summer of 2008.

Stability and Criticality Safety of the RPI Storage Crates for Spent and Fresh Fuel
N.P. Barradas, J.G. Marques

The RPI uses two storage crates that can hold up to 20 assemblies in the pool. The existing criticality studies were extended to include the new fuel assemblies. It was concluded that a full crate filled with HEU assemblies, LEU assemblies, or a mix of these is always sub-critical. As part of the safety studies for reactor conversion, the stability of these crates under earthquake was also studied. We concluded that the center of mass of the crates is not affected by loading of fuel assemblies, and that the forces to which it is submitted during the postulated reference earthquake, as defined by Portuguese Legislation, do not lead to a crate overturn. Accidental criticality due to the reference earthquake is therefore ruled out. The crates for storage of fresh fuel, which have a similar geometrical arrangement regarding criticality, are screwed to the building and thus cannot overturn.

Development of Superheated Droplet Detectors (SDD) for Neutron Dosimetry and Spectrometry Applications

A.R. Ramos, M. Felizardo, T. A. Girard[1], J. G. Marques, A.C. Fernandes[1,2], T. Morlat[1], F. Giuliani[1], Bohumil Jansky[3], Evzen Novak[3]

The objective of the project is to develop inexpensive and ecologically friendly SDD detectors for use in neutron dosimetry and spectrometry. The main objectives accomplished in 2007 were the following: -To fully characterize the SDD response using filtered neutron beams provided by passive monochromators; -To investigate the use of the fabricated SDDs as neutron spectrometers. Following the MCNP simulations performed in 2006, two new passive monochromators were finally built and successively installed in beam port E4 to perform the necessary measurements with the SDDs prepared at RPI. Measurements were performed in May 2007 and again in November 2007, after core conversion. Independent beam characterization was performed with proton recoil detectors in November 2007.

[1] CFN da Universidade de Lisboa, Av. Prof. Gama Pinto 2, 1649-003 Lisboa, Portugal
[2] Hospital de Santa Maria, Av. Prof. Egas Moniz, 1649-035 Lisboa, Portugal
[3] Nuclear Research Institute - Nuclear Power and Safety division- Dep. of Experimental Reactor Physics- Czech Republic

---

SIMPLE Dark Matter Search

TA Girard[1], T.A. Morlat[1], F. Giuliani[1], M. Felizardo, A. R. Ramos, J.G. Marques, G. Waysand[2], H.S. Miley[3], R.F. Payne[3]

This project is a search for evidence of weakly interacting massive particle (WIMP) dark matter. It is based on superheated droplet detectors (SDDs), which because of their thermodynamic thresholds provide an intrinsic background rejection factor of 10^9 comparable to the noble gas experiments. The search is conducted in the Laboratoire Souterrain à Bas Bruit (LSBB: Rustrel, France); it is R&D-supported by the SIMPLE-Lx laboratory at ITN. The response of small volume SDDs based on C_4F_{10}, C_3F_8, C_4F_8 and CF_3I to neutron and γ irradiations was explored in January using Si+Ti filters on the thermal column of the RPI. Previous SDDs being light nuclei C_2ClF_5, their impact has been primarily in the spin-dependent sector of the WIMP-nucleus interaction. A heavy nuclei CF_3I SDD prototype, intended to probe the spin-independent sector and developed at ITN, was tested underground. The results yielded a 10^{-1} pb minimum in the cross section contour at ~ 200 GeV; operated at 37ºC (8 keV recoil threshold energy) with the same result, the contour minimum is improved by $5x10^3$ pb , with the contour minimum shifted to 50 GeV. This is a factor 10 better than the current result, with 25% of the exposure – the difference resulting from using improved acoustic instrumentation able to discriminate microleaks. Also during the year, a C_2ClF_5 standard detector fabricated with agarose demonstrated a factor 2.5 increase in lifetime. A microphone-based electronics was developed, capable of discriminating true nucleation events from the acoustic backgrounds associated with SDD operation (microleaks, trapped N2 gas, fractures…). Development of a "Big Droplet Chamber" in collaboration with Dr. J. Puibasset (Orleans) was initiated in October, with a design goal of 30 g active freon mass and a previously-measured metastable lifetime of order 2 hrs. At the year's end, SIMPLE was accepted into FP7 ILIAS-NEXT as part of WP1/3.

[1] Centro de Física Nuclear, Universidade de Lisboa, 1649-003 Lisbon, Portugal
[2] Laboratoire Souterrain à Bas Bruit, 84400 Rustrel-Pays d'Apt, France
[3] Pacific Northwest National Laboratory, Richland, WA 99352 USA

Improvement of the RPI Radiation Protection Monitoring

A. Kling, A. R. Ramos, J. G. Marques

The monitoring of the radiation levels in the interior of the reactor hall and of radioactive gaseous effluents is of high importance for the safe operation of a research reactor. During the year 2007 the main focus was the modernization of the monitoring within the reactor hall. The existing aging real-time aerosol monitor (Merlin-Gerin CMDB) was replaced by a modern Merlin-Gerin ABPM201L aerosol monitoring system, identical with the one recently installed in the stack. Further, new detectors were acquired that will substitute the existing ionization chambers used for the monitoring of the gamma radiation levels at various points. At present, the development of software for a computer-based readout and data recording of these new detectors is in progress.
According to recommendation made by the control team for the Article 35 of the EURATOM treaty during their visit to the RPI in November 2006 the analysis of the data recorded by the various monitoring systems in the reactor hall and the stack exhaust has been further automated by the development of new programs. Further an additional procedure for integral measurements on aerosols and ^{131}I by gamma spectroscopy in the weekly replaced filters from the stack exhaust monitors has been implemented.

Applied Dynamics

José Antunes

The activities at Applied Dynamics Laboratory (ADL) are devoted to research in nuclear engineering, with an emphasis in the vibratory and acoustic behaviour of mechanical components. Our group started in 1986, with the following objectives: (1) Develop theoretical methods, computer tools and experimental techniques, to solve structural problems in nuclear power station components; (2) Use this state-of-the-art know-how, in order to solve structural problems arising in Portuguese power plants and other industrial facilities.

The first objective has been pursued through extensive international collaboration with our main scientific partner - the French Commissariat à l'Energie Atomique (CEA) / Département de Mécanique et Technologie (DMT). More than one decade of fruitful collaboration is attested by a significant number of published results. Important problems have been solved, such as nonlinear vibrations in steam-generators, flow-induced vibrations of nuclear fuel and stability problems in rotating machinery. Furthermore, new identification techniques have been developed and applied with success to nonlinear dynamical systems.

The second objective has been pursued by starting in 1990 a series of projects with (and for) the Portuguese power supplier Electricidade de Portugal / Companhia Portuguesa de Produção de Electricidade (EDP/CPPE), stemming from actual structural problems in power plants (Sines, Setúbal): These projects enabled us to model and solve vibratory problems arising in rotating machinery, vibro-acoustical problems in boilers and heat-exchangers, as well as structural identification problems. Several computer codes have been developed in connection with these projects.

In recent years we also developed research projects of more fundamental nature, mainly funded through the Portuguese Science Foundation (FCT) research programmes. These projects have been developed in partnership with several Portuguese institutions (Faculdade de Ciências de Lisboa, Instituto Politécnico do Porto, Instituto Politécnico de Setúbal, Instituto Superior Técnico, Universidade Nova de Lisboa), as well as the Université de Paris, Trinity College Dublin and Southampton University. This work, developed in the context of fundamental physics – in particular addressing problems in music acoustics, optimization and structural geology – is centred in modelling nonlinear dynamics and flow-structure phenomena. The methods developed transcend the context of these projects and may be adapted to solve several aspects of industrial problems.

The Applied Dynamics team is mainly concerned with the following scientific fields: structural dynamics, flow-induced vibrations, nonlinear dynamics, vibro-acoustics, experimental methods, signal processing, system identification, structural and acoustical optimization. As a spin-off from our research activities, teaching has been actively pursued on structural dynamics and acoustics - ranging from university level courses in Portugal (Coimbra, Lisbon) to several post-graduation short courses abroad (Paris, Dublin, Cargèse). Also, student and post-doc training, as well as several university thesis (MSc and PhD) have been successfully supervised, for both Portuguese and foreign students. An extensive book on fluid-structure dynamics and acoustics, co-authored by two researchers from CEA and ITN/ADL was internationally published during 2006 and another volume on flow-induced vibrations is currently under completion, to be released early in 2009.

Among the above-mentioned scientific fields one should stress those features which give this small group a distinct profile from others working in structural dynamics in Portugal. Those features are: (1) a proven expertise and output in flow-excited systems and nonlinear vibrations; (2) a complementary theoretical/experimental approach for every problem.

Most of the research projects pursued at ADL have been based on both industry and academic research contracts. Research activities at ADL were internationally recognized by two prizes from the American Association of Mechanical Engineers (ASME).

Research Team

Researchers
J. ANTUNES, Princ.

Post-doc researcher
V. DEBUT

Students
O. INÁCIO (25%) PhD Student, Inv. Professor, IPP, Porto

Collaborators

L. HENRIQUE (15%), PhD, Adj. Professor, IPP, Porto
M. MOREIRA (20%), PhD, Adj. Professor, IPS, Setúbal
M. PAULINO (15%), MSc, Inv. Professor, IPL, Lisboa
R. SAMPAIO (10%), PhD, Adj. Professor, ENIDH, Lisboa

Flow-Induced Vibrations of Tubular Nuclear Components

J. Antunes, X. Delaune[1], P. Piteau[1],L. Borsoi[1]

Objectives

Flow turbulence excitation is a well-known source of structural vibrations, often leading to failures due to fatigue or wear problems. In the context of nuclear facilities, such problems must be addressed with a particular care, for obvious safety reasons, but also due to the increased difficulties of problem-fixing in a radiation-active environment. At ITN/ADL, in close cooperation and under contract with CEA-Saclay, we gained a significant expertise in this area, both theoretically and experimentally. This long-ranging project, now starting its third year, is aimed at the development of up-to-date software to compute the flow-induced vibrations of nuclear components such as fuel rods or steam-generator tubes, due to the turbulence of both axial and transverse flows. Nonlinear vibro-impact and rubbing phenomena between the tubular components and their supports (accounting for gaps and pre-charges) are incorporated in the nonlinear time-domain computational models, in order to enable realistic predictions. Such computations supply the dynamical row data necessary for designing the multi-supported rods and tubes.

Results

During 2006 and 2007, two successive versions of our computer program were developed, the later version incorporating substantial improvements on the time-domain turbulence model, in order to accommodate the important case of local excitations due to non-uniform flow velocity profiles. Substantial original developments have been produced, in order to generate consistent sets of uncorrelated random point-forces to simulate the action of partially correlated turbulence force fields. Our effective computational strategy leads to mathematically exact results if the excitation profile is uniform, or to a negligible error for localized excitations (Figure 1). Furthermore, we proved that the system modal excitations are uncorrelated for uniformly distributed flows, but become strongly correlated for localized flows (Figure 2). Such results are significant when addressing turbulence-excited vibratory responses. A conference paper on these findings has been accepted for presentation and a journal paper is currently being prepared. During 2008, turbulence-excitation issues will be further refined, and the problem of identification of gap-support nonlinearities from remote response measurements will be addressed.

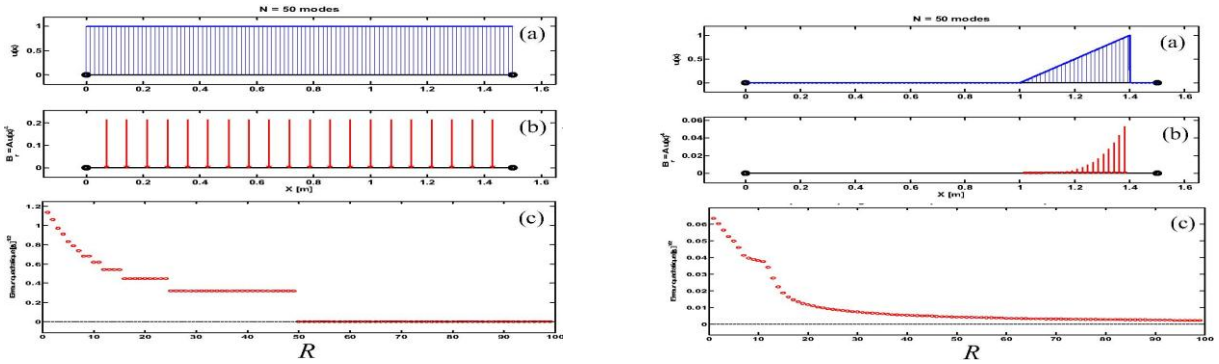


Fig. 1. Uniform and localized velocity profiles – Convergence of the modal excitations as the number of equivalent excitation point-forces increases.

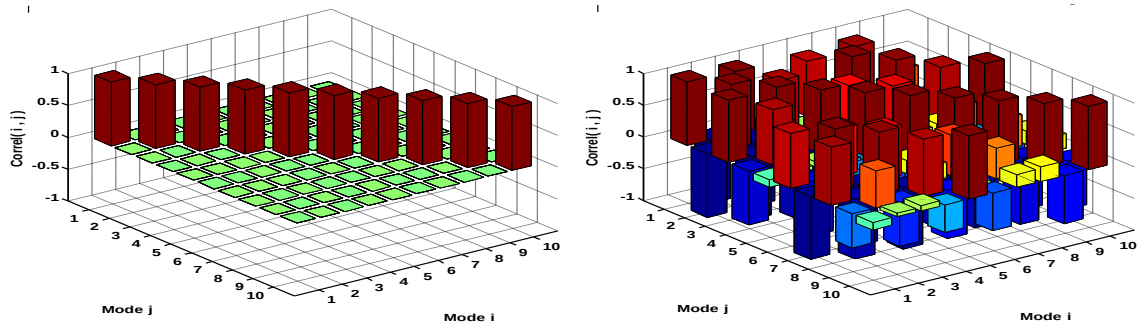


Fig. 2. Uniform and localized velocity profiles – Correlation matrices between the turbulence-generated modal forces.

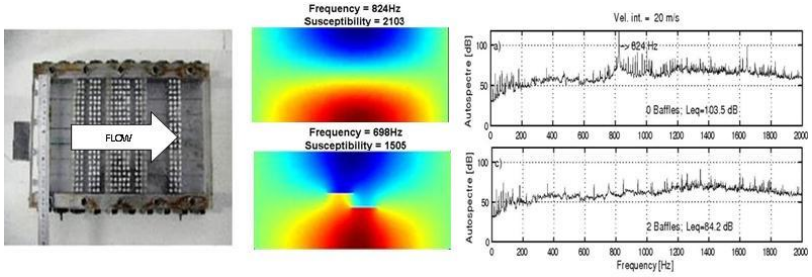
[1] Commissariat à l'Energie Atomique, Laboratory of Dynamical Studies, Saclay, France

Optimization of the Noise Reduction in Tubular Heat Exchangers

M. Moreira, J. Antunes,V. Debut, H. Pina[1], J. Paulino

The interaction between a gaseous flow and the tube banks of heat exchangers can lead to the self-excitation of acoustic resonances. These lead to high-amplitude pressure fluctuations inside the equipment, with the consequent vibratory excitation of structural elements. When the frequencies of the excited acoustic modes near-coincide with the modal frequencies of tubes, high vibratory levels can seriously affect the system integrity. This problem only arises in gaseous heat exchangers, since the typical sound speed in liquids lead to acoustical frequencies typically beyond those of the structural component vibrations. To the present date, in spite of the industry concern by this problem, the physical mechanisms of sound excitation of by cross-flows within tubular banks are not yet fully understood, therefore the available criteria for predicting such flow-acoustic instabilities are not trustfully. Typically, this problem is solved by inserting plates inside the tubular banks (so-called acoustic baffles), in order to inhibit the acoustical instabilities by modifying the acoustic field. However the physical mechanism that renders a given baffle configuration effective or not is still insufficiently known and controversial. The objective of this three years project, funded by a FCT/POCTI grant, is to increase our understanding of the relevant physical mechanisms of aero-acoustic instabilities, and to develop techniques for optimizing the acoustic baffle configurations.

Following the theoretical work developed in previous years, wind tunnel experiments have now been conducted to validate a simplified numerical model of the vortex-excited acoustic field coupled with efficient global optimization methods (simulated annealing and genetic techniques) for the optimal configuration of a given number of acoustic baffles. These experiments suggested an improved form for the optimized functional, results which are currently under publication. Also, additional analytical and experimental work has been developed and published on a closely related problem of industrial interest – the acoustic self-excitation of corrugated pipes under axial flow – leading to an interesting nonlinear phenomenological aero-acoustic model of such systems, time-domain numerical simulations and frequency-domain computations. Overall, two papers and two conference communications were produced from our recent work in this field. Physical understanding of the complex phenomena will be further acquired in the future, by developing suitable CFD computing tools.



Theoretical and experimental results on the aeroacoustic noise induced by wind-tunnel flow across the tube bundles of a power station re-heather model : (1) Reduced scale test model; (2) Acoustical pressure mode shapes of the unstable mode respectively without and using two optimized baffles; (3) Corresponding measured noise spectra.

[1] Instituto Superior Técnico de Lisboa, Department of Mechanical Engineering

Dynamical modelling of nonlinear vibratory and acoustical systems

J. Antunes, O. Inácio, M. Wright[1]

This research started some years ago as a POCTI funded project, an international cooperative effort to develop theoretical methods and numerical techniques for dealing with strongly non-linear dynamical problems, such as involving impacts and friction phenomena. The main objective was the development of modeling techniques for nonlinear multi-modal structures. These techniques have been applied to a paradigmatic problem in nonlinear physics – bowed instruments – but it is mostly triggered by industrial problems of the same nature.

In previous years we developed efficient numerical techniques to predict the nonlinear dynamics and interaction forces of friction self-excited systems. Such detailed computations have been complemented by a strong focus on the linearized analytical models of friction-excited systems. We addressed the case of friction-excited bars and derived a single relevant parameter which controls self-excitation as a function of the contact normal force, sliding velocity and the Coulomb friction law. We then performed extensive parametric analysis from efficient eigenvalue computations of the linearized model, leading to dynamical charts which enable a more clear understanding of the nonlinear limit-cycle regimes. Three papers have been produced from the results obtained.

These techniques where recently extended to the case of bowed strings, with many results published during 2007, and also started theoretical developments to tackle the difficult theoretical problem of predicting the linear instability of friction-excited shells, which is particularly relevant for the understanding of brake squeal phenomena, an effort which will be pursued during the next year. A PhD thesis encompassing our findings of the last years is to be presented at Southampton University early in 2008.

[1] University of Southampton, Institute of Sound and Vibration Reserarch, UK

Atmospheric Elemental Dispersion

Maria do Carmo Freitas

The research is focused on studies of atmospheric environment, nutrition and health. The investigation appeared as a natural application of the potentialities of k_0-INAA (instrumental neutron activation analysis using the k_0-method). The unit activities include six main lines:

Monitoring, Biomonitoring, Quality Control, and Data Handling aiming at characterising areas of Portugal using lichen transplants, air particulate matter collection, and (wet+dry) deposition. The data are analysed for factors aiming at identifying emission sources and the spread of elements through the atmosphere, both locally and by long-range transport. Data analysis methods and their development are very important due to the multielement nature of the analytical technique used. To assure the quality of the data, accuracy and precision studies are being performed, both in biomonitoring and monitoring fields, aiming at better understanding differences found in the results for the same element and sample. Air particulate matter obtained by different air samplers is compared. So-called conventional analytical techniques are applied to complement the research unit's results. Within this activity line, the following are being done: services to industry (monitoring), FCT funded project research (both biomonitoring and aerosol monitoring) and training (one post-doctorate on monitoring and two current PhD theses on biomonitoring).

Epidemiological studies include health related problems. The objective is to link biomonitoring and monitoring to epidemiological studies, at local, regional and European scale. Currently, one PhD and one post-doctorate are dedicated to this subject.

Element Uptake Processes. The group also enters the plant physiology looking for effects on plants due to atmospheric chemical components. The underlying questions are related to the extent in which lichens may reflect the element contents of particulate matter, which may possibly be dominated by its soluble element concentration fractions. This is the subject of one PhD thesis.

Training. The research unit has a strong component in post graduation training.

Services. Analytical services are also provided under request (private companies).

Research Team

Researchers

M. CARMO FREITAS, Princ., Group Leader

Students

H.M. DUNG, Post-doc., FCT grant
D. BEASLEY, Post-doc., FCT grant
M.G. VENTURA, PhD student, FCT grant
R. GODINHO, PhD student, FCT grant
S. SARMENTO, PhD student, FCT grant
B. VIEIRA, PhD student, FCT grant
C. REPOLHO, FCT project fellowship
I.R. KHAN, FCT project fellowship

Technical Personnel

I. DIONISIO, Laboratory assistant

Collaborators

A.M.G. PACHECO, Aux. Professor, CERENA/IST, Portugal
H. TH. WOLTERBEEK, Senior Researcher, The Netherlands
M.M. FARINHA, ISQ, Portugal (on-going PhD)
S. M. ALMEIDA, ISQ, Portugal
A. P. MARQUES (on-going PhD)
A. CRUZ (on-going PhD)

Study of relationships between fine particles and respiratory problems in children of Lisbon basic schools

M.C. Freitas, C.S. Repolho, I. Dionísio, I.R. Khan, H.M. Dung, A.M.G. Pacheco, C.A. Pio[1], C. Alves[1], A. Caseiro[1]

Objectives

37 basic schools of Lisbon city, Portugal followed a questionnaire. The questionnaire contained questions to identify children with respiratory diseases (wheeze, asthma and rhinitis) as well as their nutrition habits, ingested medication, environmental aspects, among others. The questioned children were 5 to 10 years old, and the answers are from June to December 2006. The results are from 1125 children inquired who have shown 26.1% with wheezing symptoms, 9 % with asthma, and 27.5% with rhinitis.[1]

It is attempted to correlate complains of children from four selected schools among the questioned ones children with mass concentration and its chemical composition available in their neighbourhood. The complains concern rhinitis and/or asthmatic symptoms daily reported by the children and their parents; studied particles are of aerodynamic diameter below 2.5 micrometers ($PM_{2.5}$), collected in teflon filters using a Partisol sampler, located at IST/Tech. Univ.

Results

Tables 1 and 2 report: 1) the number of questioned children in the four basic schools, 2) the average number of children of the four schools who answered the daily questionnaires, and 3) the percentage of children who reported rhinitis or asthma. The number of children to report was very scarce, demonstrating the difficulties in getting answer to questionnaires, although the questionnaires went individually to each child home. Comparing the percentage of cases of rhinitis and asthma reported in the selected schools with the whole amount of questioned schools, the values are of the same order of magnitude. More intense symptoms are observed in Spring, also previously observed for the whole set of questioned children.

Fig. 1 shows the daily mass concentrations collected by Partisol, obtained by gravimetric methods. Mass concentrations were often above the regulated value of 20 microgram/cm^3. Two huge amounts of $PM_{2.5}$ were observed in April and May, as well as in January.

The filters were analysed by neutron activation analysis using thermal and epithermal neutron, in normal and Compton modes, short and long irradiations. The chemical elements which could be accessed are: As, Al, Ba, Br, Ca, Ce, Cl, Co, Cr, Cs, Cu, Eu, Fe, K, Mg, Mn, Mo, Na, Ni, Rb, Sb, Sc, Se, Si, Sr, Th, Ti, V, I, In, Mo, Sb, Si, Sr, W, and Zn.

Table 1. Average month percentage of children who declared rhinitis episodes in four selected schools

Month	Nr. inquired children	Nr. Children who answered	Positive rhinitis
April	279	29.5	16.9%
May	279	42.5	27.5%
June	279	45.6	20.7%
July	279	4	4%
August	279	4	11.3%

Table 2. Average month percentage of children who declared asthma episodes in four selected schools

Month	Nr. Inquired children	Nr. children who answered	Positive asthma
April	279	28.5	4.4%
May	279	40.9	4.2%
June	279	43.5	5.2%
July	279	4	0%
August	279	4	0%

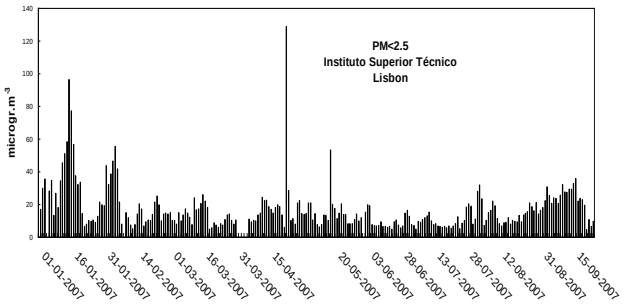


Fig. 1. Mass concentration of $PM_{2.5}$, collected 24 h daily in Teflon filters using a Partisol sampler. Data from January to September 2007. The sampling site is at IST/Tech. Univ. Lisbon.

Published work

I.R. Khan, M.C. Freitas, A.M.G. Pacheco, Particulate matter levels in Portugal (mainland and islands). A preliminary study for outdoor/indoor environment in basic schools, Proceedings, REHVA World Congress Clima 2007 WellBeing Indoors, 10–14 June 2007 Helsinki, Finland, Olli Seppänen & Jorma Säteri (Eds).

M.C. Freitas, H.Th. Wolterbeek, T. Verburg, S.M. Almeida, Effect of Particulate Matter, Atmospheric Gases, Temperature and Humidity on Respiratory and Circulatory Diseases in Lisbon, Proceedings, 100th Annual Conference and Exhibition, A&WMA (Air and Pollution Management), 26-29 June 2007, Pittsburgh, Pennsylvania, USA.

[1] CERENA/IST/Tech. Univ. Lisbon; [2] DAO/Univ. Aveiro

(Bio) Assessment of elemental burden from selected atmospheric particulate matter's (PM's) size classes

R.M. Godinho, M.C. Freitas, H.Th. Wolterbeek[1], T.G. Verburg[1]

The issue of this program is to relate lichen elemental occurrences to elemental occurrences in selected atmospheric size PM. This year work intent to better understand how the lichen constitution may affect element uptake and release, thus influencing the lichen´s memory length, thereby aiming to increase possibilities to improve biomonitoring results, interpretation and comparability. Lichen response to specific element, element toxicity and biomonitor remembrance time can be related with elemental internal spatial distribution. Because of that the elemental microdistributions of thin sections of peripheral and central parts of the foliose lichen F*lavoparmelia caperata* were studied under proton microprobe at ITN. In order to access the potential cation-exchange capacity of the lichen, experiments of pH and metal titration were performed at IRI-TU Delft.

[1] Dep. Radiation, Radionuclide & Reactors Section RIH, Faculty of Applied Sciences, Technical Univ. Delft, The Netherlands.

Biomonitoring of trace element air pollution: links to emission sources and to human health

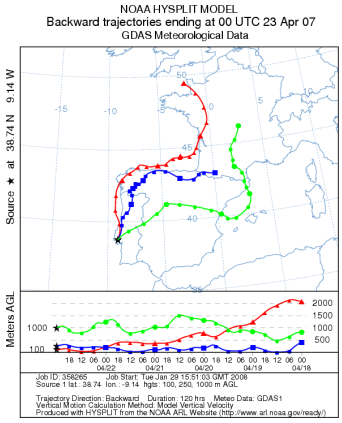
S. Sarmento, M.C. Freitas, H.Th. Wolterbeek[1], T.G. Verburg[1]

The aim of the actual project is to investigate whether and which components and sources of air pollution may contribute to differences in cause-specific mortality in the Portuguese population. This year work focused on the impact of atmospheric aerosol in human health. In this scope data handling has been performed to study the influence of temporal fluctuations both of hospital admissions data and risk factors data on the regression studies.

[1] Dep. Radiation, Radionuclide & Reactors Section RIH, Faculty of Applied Sciences, Technical Univ. Delft, The Netherlands.

Chemical elements in airborne particulates over Angra do Heroísmo, Terceira island, and Pico summit, Pico island, both at Azores (Portugal)

M.C. Freitas, A.M.G. Pacheco, I. Dionísio, A. Lopes[1], P. Fialho[2]



This study deals with aerosol collections from Angra do Heroísmo (sampling height: 74 m), a UNESCO-designated (1983), World Heritage city in Terceira island, Azores. Glass fiber filters with PM10 mass concentrations, sampled by IM from 6 July 2005 to 30 June 2006, were put through instrumental neutron activation analysis for elemental evaluation. Blank contents were taken into account. The urban results from Angra were compared with data obtained near the summit of Pico mountain (sampling height: 2225 m), Pico island, Azores. In Pico, the results show higher medians for most of the chemical element, sodium being an exception (10 times higher in Angra). This may indicate that the atmospheric chemistry of Angra is primarily governed by inputs from marine sources, as expected in an oceanic environment, while influence of long-range transport of anthropogenic elements cannot be ruled out for PM10 composition from remote, high-altitude site.

[1] IM, Portuguese Meteorological Institute, Lisboa, Portugal.
[2] Chemistry and Physics of Atmosphere, Azores University, Terra Chã, Terceira island, Portugal.

The calibration of gamma-ray spectrometers coupled to Compton suppression and fast pneumatic systems for k_0-NAA at the RPI/ITN

H.M. Dung, M.C. Freitas, D. Beasley, I.R. Khan, B. Vieira

A new Compton suppression system for the gamma-ray spectrometer used for neutron activation analysis (NAA) has been set up at the RPI/ITN. The fast pneumatic transfer system, SIPRA, used for short-lived nuclides has recently been changed: its control system upgraded and the linear electronics for the gamma-ray spectrometer replaced by a new Ortec DSPEC module. The calibration of the Compton suppression and SIPRA systems including the characteristics of energy, peak shape and efficiency has been carried out. In addition, the peak-to-total ratios have been calculated for the correction of true-coincidence effect of the gamma-ray spectrometers. In order to check the accuracy of the calibration parameters obtained in this work, some certified reference materials (CRMs) have been analyzed using the k_0-IAEA software and the result has been evaluated and shown.