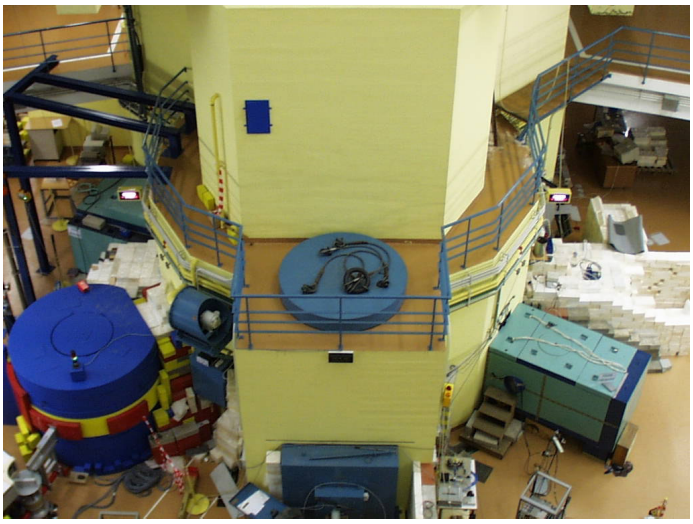
Reactor Sector



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 ***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. The use of the RPI by external users accounted for about 10% of the total irradiation time in 2006.

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, Dosimetry (RPI) and Reactor Calculations***. New research projects started in late 2005 are now well underway, covering the areas of dosimetry, materials science and neutron tomography.

The ***Atmospheric Elemental Dispersion*** group uses the k_0 INAA technique in the RPI and was again the main user of the reactor in 2006, accounting for 25% 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 main laboratory of this group had a significant upgrade in 2006, with the installation of two automatic sample exchangers, which will allow a significant increase in its throughput. This long sought improvement was supported by a specific programme for State Laboratories.

The research performed by the ***Applied Dynamics*** group is mostly concerned with 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 publications

Reactor Staff

Researchers

J. G. MARQUES, Principal Researcher
M. C. FREITAS, Principal Researcher
A. V. ANTUNES, Principal Researcher
A. FALCÃO, Principal Researcher
A. KLING, Auxiliary Researcher (90%)
N. P. BARRADAS, Principal Researcher (90%)
A. R. RAMOS, Auxiliary Researcher (90%)

Technical Personnel

J. S. SOUSA, Dosimetry
J. A. M. RIBEIRO, Reactor Operator
J. C. ROXO, Reactor Operator
N. SERROTE, Reactor Operator
V. PÁSCOA, Reactor Operator, "on leave"
R. SANTOS, Reactor Operator
R. POMBO, Radioprotection
F. B. GOMES, Radioprotection
A. RODRIGUES, Technician
V. TOMÁS, Laboratory Assistant
I. DIONÍSIO, Laboratory Assistant

Administrative Personnel

T. FERNANDES, Secretariat
A. SILVA, Administrative (Retired in 2006)

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

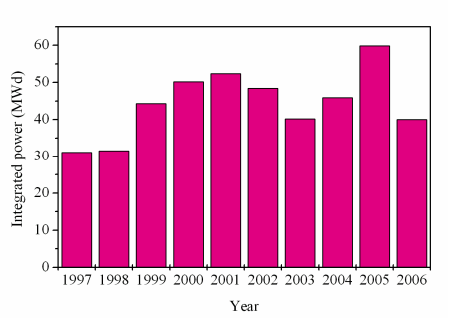
José Gonçalves Marques

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.

An intensive activity in reactor calculations has continued, to prepare the core conversion to low enriched, high density, U_3Si_2-Al fuel. The safety studies were completed this year with assistance from the Argonne National Laboratory (USA). No loss of performance of the reactor is expected after conversion.

The laboratory for fabrication of Superheated Droplet Detectors installed in 2004 was in full use, with three research projects funded by FCT.

Significant improvements were made in the signal to noise conditions for the Emission Channelling and Blocking setup. Fast electronics was developed for a state-of-the-art setup for Perturbed Angular Correlation Experiments with short-lived isotopes.



The programme for testing of electronic components and circuits under fast neutron irradiation for CERN was completed. Two setups, for neutron tomography, and another for monochromatic neutron beams, are being prepared, to share this beam line without significant changes to the existing installation.

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

User	Area	Time (%)
RPI	NAA	25.3
	Dosimetry and Test of Detectors	17.3
	Other (training, etc)	0.1
Physics	Radiation Effects	17.8
	Neutron Scattering	8.1
Chemistry	NAA	15.4
	Isotope Production	3.1
DPRSN	Isotope Production	4.2
Univ. Lisboa	Isotope Production	7.6
LIP/Lisboa	Isotope Production	0.5
	Radiation Effects	0.1
IVIA	Radiation Effects	0.3
Univ. Coimbra	Isotope Production	0.1
Univ. Porto	Isotope Production	0.1

The figure indicates the integrated power produced by the RPI in the last 10 years. A clear increase in the use of the reactor is seen since 1999. The integrated power for 2006 was 40 MWd, lower than the previous year, but close to previous years. This decrease reflects a somewhat lower NAA activity at ITN due to the renewal of the laboratories as well as a significant period of no-operation of the reactor until an agreement was reached with the US on a prolongation of the use of the current fuel.

Research Team

Researchers

J.G. MARQUES, Principal Researcher
A. KLING, Auxiliary Researcher (90%)
N. P. BARRADAS, Principal Researcher (95%)
A. FALCÃO, Principal Researcher
A.R. RAMOS, Auxiliary Researcher (90%)

Students

A. FERNANDES, Post-doc, ITN, FCT grant
M.A.F. da COSTA, MSc Student, IST, ITN grant

Reactor Operators

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

Technical Personnel

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

Collaborators

T. Girard, CFNUL
Tomoko Morlat, Post Doc, CFNUL
Franco Giuliani, Post Doc, CFNUL

Core Conversion of the RPI to LEU Fuel: Safety Analyses

J.G. Marques, N.P.Barradas, A. Kling, A.R. Ramos, J.E. Matos[1], J.G. Stevens[1], E.E. Feldman[1], J.A. Stillman[1], F.E. Dunn[1], M. Kalimullah[1]

Objectives

The core conversion of the Portuguese Research Reactor (RPI) to Low Enriched Uranium (LEU) fuel will be performed within IAEA's Technical Cooperation project POR/4/016. This project was approved in the end of 2004, with financial support from the US and Portuguese governments. The safety analyses for core conversion [1] were made by ITN and the RERTR program at Argonne National Laboratory.

Results

LEU uranium silicide (U_3Si_2-Al) dispersion fuel with a uranium density of 4.8 g/cm^3 was selected because of its widespread use in research reactors and for the relatively large number of existing manufacturers. The procurement of the assemblies was made by the IAEA in 2006, based on the feasibility study made in 2005.

An extensive study was completed in 2006, addressing the reactor design, performance and safety analyses that would enable conversion of the reactor fuel from HEU to LEU. Documents that were reviewed by ANL as bases for the design and safety evaluations were the RPI Operating Limits and Conditions (OLC), design drawings, and historic analyses of the facility. All of the additional information and data needed to construct the reactor models and perform the analyses were provided by ITN. The methods and codes that were utilized have been qualified by extensive conversion analysis experience and international benchmark. Accident analyses were completed for a number of postulated initiating events, following the recommendations in the 2005 edition of the Safety Requirements for Research Reactors of the IAEA (NS-R-4).

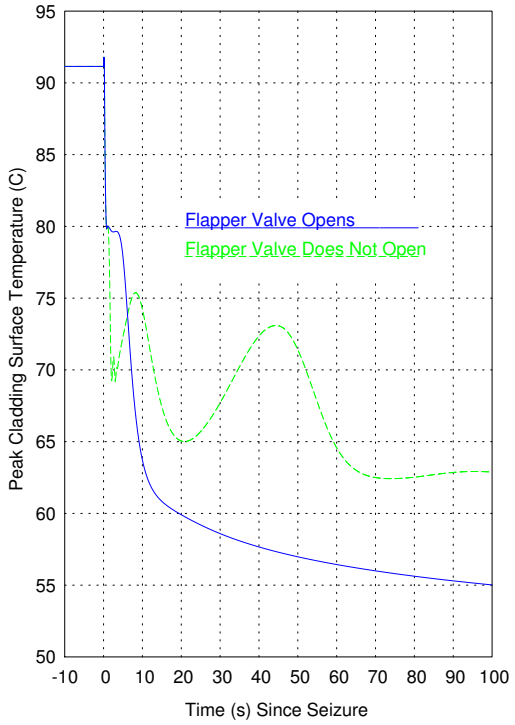


Fig 1. *Peak cladding surface temperature as function of the time after primary pump seizure.*

Figure 1 shows the peak temperature of the fuel cladding as function of time after a postulated seizure of the pump of the primary cooling system, with the reactor working at the nominal power of 1 MW. A failure of the fastest acting safety shutdown system was also considered. Peak cladding surface temperatures of about 93 ^oC were reached before the scram was initiated. The maximum temperatures attained in all simulated transients are far below the safety limit of 530 ^oC for the fuel and cladding temperatures recommended by the US Nuclear Regulatory Commission and show that the LEU core can be adequately cooled by natural convection.

The results of neutronic studies, steady-state thermal-hydraulic analyses, accident analyses, and revisions to the OLC demonstrate that the RPI can be operated safely with the new LEU fuel assemblies. The conversion is expected to occur in 2007.

Published work

J.E. Matos, J.G. Stevens, E.E. Feldman, J.A. Stillman, F.E. Dunn, K. Kalimullah, J.G. Marques, N.P. Barradas, A.R. Ramos, A. Kling, Core Conversion Analyses For the Portuguese Research Reactor, *Proc. Int. Meeting on Reduced Enrichment for Research and Test Reactors,* Cape Town, South Africa, 2006, Argonne National Laboratory, Paper 5-1.

[1]RERTR Program, Argonne National Laboratory Argonne, IL USA 60439

Fast Neutron Irradiation of Electronic Circuits

J.G. Marques, A.C. Fernandes, J.A. Agapito[1], F.J. Franco[1], Y. Zong[1]

Temperature measurement is a key issue in the LHC facility at CERN, as it will be used to regulate the cooling of the superconductor magnets. The signal conditioners for cryogenic thermometry are expected to receive a fast neutron fluence of the order of 2E13 n/cm^2 during a 10 year period, as well as a gamma dose of 500 Gy, and this can affect the operation of commercial circuits used in their construction. The operating conditions of the circuits are simulated using a fast neutron irradiation facility built in the RPI in 2000. The irradiation of components for CERN was concluded in 2006. The same facility was used to irradiate seeds for IVIA (Spain) and motion sensors for LIP (Lisboa). The use of their facility will continue in 2007-2009 in the framework of FP6 Integrated Infrastructure Initiative for Materials Testing Reactors Innovations (MTR-I3) that started in October 2006.

[1] Universidad Complutense de Madrid.

Development of Signal Processing Units 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 project is underway to install at the Portuguese Research Reactor a state-of-the-art spectrometer for Perturbed Angular Correlation studies using short-lived isotopes produced in the reactor. This is one area where a medium power reactor (1 MW) can be competitive at the European level. The thermal neutron flux available for this application is 2E13 n/cm2/s, which makes it possible to produce in just a few minutes enough activity to analyze the sample. No long and bureaucratic transports of radioactive isotopes, which hamper the use of short-lived isotopes, are necessary, since the analyzing facility is at the reactor. High count rate 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. Surface mounted ECL logic circuits were used for the signal processing units, which allowed a high integration scale, with a significant reduction in the number of units and interconnections. The spectrometer is expected to be ready in the Spring of 2007.

The SIMPLE Project

T.A.Girard[1], F.Giuliani[1], T.Morlat[1], J.I.Collar[2], D.Limagne[3], G Waysand[3,5],J.Puibasset[3],H.S. Miley[4],M Auguste[5], D. Boyer[5], A. Cavaillou[5], J.G. Marques, C. Oliveira, A.C. Fernandes[1,6], A.R. Ramos, M. Felizardo, R.C. Martins[7]

During 2006 a new underground (210 mwe) SDD fabrication station was made operational in the Laboratoire Souterrain à Bas Bruit. Initial testing consisted of the fabrications of two each CF3I SDDs and two each R-115 devices, all of which were installed in the deeper (1500 mwe) GESA site and operated (one of the R-115 devices remains running, to determine if underground fabrication increases the device lifetime). The radio-assays of detector construction materials, and of LSBB rock samples collected during the MAY/2006 mission, have been completed at PNNL via low-level α- and γ-spectroscopy. The U/Th contamination of the gel, measured at the level of $\leq$0.1 ppb, yields an overall α background of < 0.5 evts/kgfreon/d; the same levels were observed with the glass of the detector containment. A new DAQ electronics, based on a new high-quality Panasonic MCE-200 electret microphone cartridge with adaptive electronics (PGA2500), continued to undergo testing. In this design, the electronics have been removed from close proximity to the microphone to outside the detector itself. Extensive studies of the new instrumentation were made, involving variations of the SDD volume, refrigerant, temperature & pressure, and droplet size. Response studies of new SDDs based on C4F10, CF3I, C4F8 and C3F8 were initiated using the Si+Ti (155 keV) filtered neutron beam column on the RPI thermal port. A new C4F10 device was made without the addition of heavy salts to density match the gel and refrigerant; two prototypes were delivered to PICASSO in July as part of the MOU between projects, and their response tested.

[1] Centro de Física Nuclear, Univ. Lisboa, [2] Dep. Physics, Univ. Chicago, USA, INSP, Univ. Paris, [4] Pacific Northwest Nat. Lab., Richland, USA, [5] Lab. Souterrain à Bas Bruit, France, [6] Hospital de Santa Maria, Portugal, [7] Dep. Electronics, Instituto Superior Técnico, Portugal

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Test of the Emission Channeling Experiment with Neutron Induced Reactions

P. Marques, A. Kling, J. G. Marques

Emission channeling is a powerful tool for the investigation of structural properties of crystalline materials. In contrast to the classical method using radioactive probe atoms incorporated in the lattice, the set-up at RPI uses charged particles arising from thermal neutron induced nuclear reactions. Channeled particles leaving the crystal are detected by a two-dimensional position sensitive detector located about 60 cm from the target. In the course of the installation of the set-up in 2006 first experiments with a thermal neutron beam from RPI were performed. Charged particles arising from the ^{6}Li(n,τ)α reaction induced by thermal neutrons impinging on a lithium niobate crystal were detected by the position-sensitive detector for the first time. It was possible to increase strongly the number of charged particles produced and detected by optimizing the alignment of the beam with the target and by the reduction of the noise level in the data acquisition system.

Optimization of Filtered Neutron Beams for the Calibration of Superheated Droplet Detectors at the RPI

A.R. Ramos, F. Nascimento[1], A.C. Fernandes[2,3], M. Felizardo, T. Morlat[2], J. G. Marques, F. Giuliani[2], T. A. Girard[2], J. A. Paixão[1]

The neutron spectrum from a nuclear reactor covers a wide energy range, from meV to several MeV. Beams of quasi-monochromatic neutrons can be generated by filtering neutrons emerging from the core with suitable materials, such as Fe (for 24 keV neutrons) and Si (144 keV and 54 keV). These materials have windows in their neutron cross sections, so that neutrons corresponding to these windows are transmitted, whereas neutrons with other energies are attenuated. We have performed an MCNP simulation study of passive monochromators of Si+S and Si+Ti for the production of quasi-monochromatic neutron beams of 54 keV (Si+S) and 144 keV (Si+Ti) at the E4 beam tube of RPI. The simulations allowed the purity versus intensity of the neutron beams to be optimized, within the geometrical constraints of the beam port. The passive monochromators will be used to study the detector response of Superheated droplet detectors (SDDs) prepared in the new SDD lab of RPI.

[1] Univ. Coimbra, Fac. Ciencias & Tecnol, Dept. Fis.,3004-516 Coimbra, Portugal
[2] CFN da Universidade de Lisboa, Av. Prof. Gama Pinto 2, 1649-003 Lisboa, Portugal
[3] Hospital de Santa Maria, Av. Prof. Egas Moniz, 1649-035 Lisboa, Portugal

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Development of a CF3I SDD for Spin-INdependent Dark Matter Searches

T. Morlat[1], M. Felizardo, A. R. Ramos, J.G. Marques, F. Giuliani[1], T. A. Girard[1]

The direct detection of DM relies in measuring the nuclear recoil produced by their elastic scattering off target nuclei. In the case of WIMPs (DM non-relativistic hypothetic particles) of m ~ GeV to TeV, the nuclear recoil energy is in the range of 1-100keV. Due to the low critical energy (Ec) of CF3I e.g. Ec(30ºC)=10.8keV, Ec (20ºC)=33keV increasing to Ec(0ºC)=525 keV, this refrigerant is a good device for either spin dependant (target nuclei=fluorine) and spin independent (target nuclei=Iodine) searches. Heavy CF3I SDDs have never been made before because of the high density of this refrigerant liquid (2 g/cm3) hence require the R&D of a suitable chemistry for device fabrication. Recently a CF3I droplet suspension prototype has been made by using a matrix more viscous than usual. Although the process result is a homogeneous distribution of micron-sized CF3I droplet, improvements are still needed to increase the lifetime of this device.

[1] Centro de Física Nuclear, Universidade de Lisboa, 1649-003 Lisbon, Portugal

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Neutron Tomography at the RPI: First Steps

J G. Marques, A.R. Ramos P. Marques, A. Rico

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 (typically 200) in digital form of the observed object rotated over 180 degrees related to its central axis. With the advent of 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/cm2/s. A setup for neutron tomography will be installed at the RPI. It will be implemented in beam line E4, currently being used for the irradiation of electronic components, through the installation of a removable divergent collimator in the irradiation cavity. The setup includes a ZnS:Ag scintillator screen, a Finger Lakes Proline CCD camera with fast readout and a rotary table where the object to be analysed is placed in front of the beam. The beam will have 20 cm diameter, which is enough for a significant number of applications. After some initial difficulties, the beam collimator is ready for field tests. The setup is expected to be ready in the summer of 2007.

Modernization of the RPI Stack Exhaust Monitoring

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

The monitoring of airborne radioactive effluents is of high importance for the safe operation of a research reactor and the basis for the determination of the radiological impact on the environment. During the year 2006 a main focus was the reinforcement of redundancy of the RPI stack monitoring and the modernization of the existing AIRMON-91 system. The redundancy of the stack exhaust monitoring has been improved by the acquisition and installation of a Merlin-Gerin ABPM201L aerosol monitor. In addition to the existing unit in the AIRMON-91 monitor the new system enables to distinguish alpha- and beta-activity in the aerosol. Further its automatically advancing filter band allows it to work for long periods autonomously. The refurbishment of the AIRMON-91 monitor included the replacement of the quantometer for the flow measurement and the obsolete programmable logic controller by a modern one. These modifications assure that the monitoring of radioactive gaseous effluents from the RPI continues to be performed in a reliable manner.

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 Praxis XXI and POCTI 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 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.

Among the above-mentioned scientific fields one should stress those features which give our small group a distinct profile from others working in structural dynamics in Portugal. Those features are: (1) a proven expertise and scientific 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. Researcher

Post-doc researcher

V. DEBUT

Students

O. INÁCIO (25%) PhD Student, Inv. Professor (1)
(1) IPP, Porto

Collaborators

L. HENRIQUE (15%), PhD, Adj. Professor (1)
M. MOREIRA (20%), PhD, Adj. Professor (2)
M. PAULINO (15%), MSc, Inv. Professor (3)
R. SAMPAIO (10%), PhD, Adj. Professor (4)
(1) IPP, Porto
(2) IPS, Setúbal
(3) IPL, Lisboa
(4) ENIDH, Lisboa

Optimization of the Noise Reduction in Tubular Heat Exchangers

M. Moreira[1], J. Antunes,V. Debut, H. Pina[2], J. Paulino[3]

Objectives

The objectives 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.

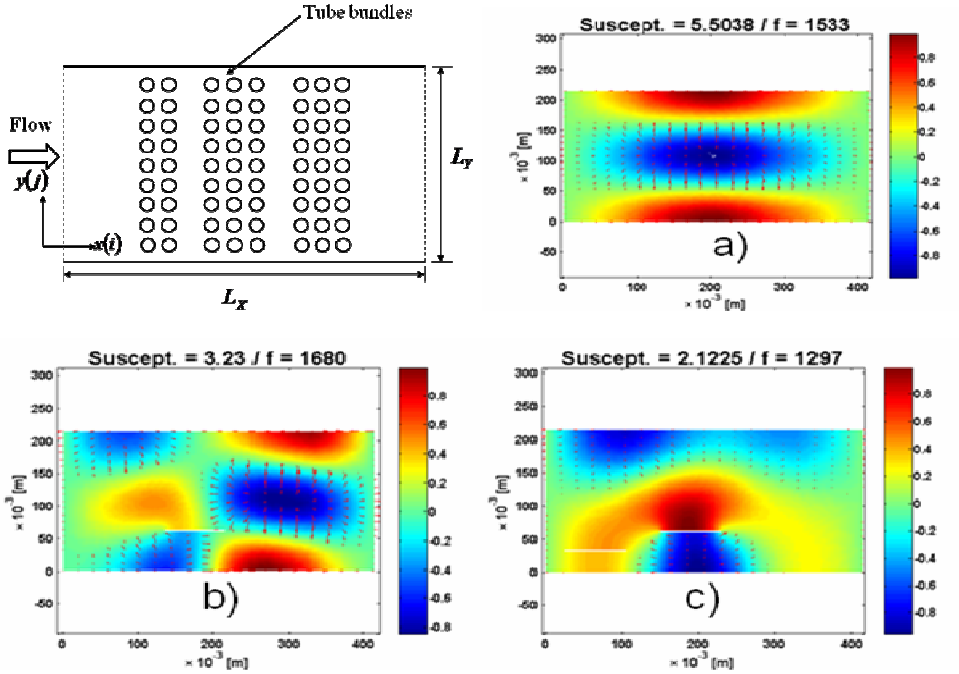
Results

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.

A simplified numerical model of the vortex-excited acoustic field has been coupled with two efficient global optimization methods (simulated annealing and genetic techniques) for the optimal configuration of a given number of acoustic baffles. Wind-tunnel experiments are currently being prepared in order to validate our theoretical results. Furthermore, analytical and experimental work has been developed on a closely related problem – acoustic self-excitation of corrugated pipes under axial flow – implying delicate and time-consuming tests. A paper has already been published on the mentioned results and a number of other papers will be published in the near future.

Published work

M. Moreira, J. Antunes, M. Paulino, V. Debut, H. Pina, Optimization of baffle configurations to prevent aeroacoustic instabilities in heat exchangers: A preliminary study, *Internoise 2006*, 3rd – 6th December 2006, Honolulu, EUA.



Laboratory model and acoustic modeshapes of the modes with largest susceptibility to instability, respectively with no baffles (a), 1 optimized baffle (b) and 2 optimized baffles.

[1] Instituto Politécnico de Setúbal, Escola Superior de Tecnologia, Dep. Mathematics
[2] Instituto Superior Técnico de Lisboa, Depa. Mechanical Engineering
[3] Instituto Superior de Engenharia de Lisboa, Dep. Mechanical Engineering

Flow-Induced Vibrations of Tubular Nuclear Components

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

Turbulence-induced vibration 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 are 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 with CEA-Saclay, we gained a significant expertise in this area, both theoretically and experimentally.

During 2006, under contract, a new research project has been started with CEA, in order to develop an up-to-date computer program to predict the flow-induced vibrations of nuclear components such as fuel rods or steam-generator tubes, namely due to the turbulence of both axial and transverse flows. Most important, nonlinear vibro-impact and rubbing phenomena between the tubular components and their supports (accounting for gaps and pre-charges) must be incorporated in the nonlinear time-domain computational model, in order to enable realistic predictions. Then, computations supply the dynamical row data necessary for designing the multi-supported rods and tubes, with respect to wear and fatigue.

The first version of our program has been developed at ADL during 2006, as intended, and the software is currently being numerically validated at CEA. During 2007 – and possibly the following years – this project will continue, in order to refine several aspects of the modelling techniques. In particular, an improved model of the turbulence field (random in both time and space) will be developed.

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

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Dynamical modelling of nonlinear vibratory and acoustical systems

J. Antunes, O. Inácio[1], M. Wright[2]

This research started a few 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 can be easily adapted to industrial problems of the same nature.

In recent years, coupling of vibratory and acoustical systems has also been addressed, namely through the point of view of dynamical optimization. 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 in 2006 by a strong focus on the linearized analytical models of friction-excited systems. More specifically, we addressed the case of friction-excited bars and derived the 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 fast eigenvalue computations of the linearized model, leading to results which enable a more clear understanding of nonlinear limit-cycle regimes.

We recently extended these techniques to the case of bowed strings – with results to be published during 2007 – and plan to also study the case of friction-excited shells, which is particularly relevant for the understanding of brake squeal phenomena. During 2006 five papers have been published, with results from our recent work in this field. A PhD thesis encompassing our findings of the last years is to be presented at Southampton University shortly.

[1] Instituto Politécnico do Porto, ESMAE, Laboratory of Music Acoustics
[2] University of Southampton, Institute of Sound and Vibration Reserarch, UK

Atmospheric Elemental Dispersion

Maria do Carmo Freitas

The research in this field 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). Through the re-equipment project with FCT and a technical cooperation with IAEA, new facilities were installed aiming at the automatization, the optimization and introduction of new variants of NAA. Compton suppression and prompt gamma facilities, as well as automatic sampler changers and renewal of the detection systems in the fast pneumatic system, are goals which were initiated. As applications, taking advantage of the available equipments, the main lines are:

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 (three current PhD theses on biomonitoring). Collaborations with Universities are also on-going, namely with Azores University, Aveiro University, IST/Lisbon Technical University, and Évora University.

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 is 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.

Nutrition. The group is increasing the investigation in nutrition studies through a PhD thesis aiming at a better knowledge of selenium in the Portuguese diets. Selenium is a nutrient, which should be included in the human organism within a very narrow mass a mount range, otherwise severe diseases should be expected. Also nutrition contents in spices and rice originated from Sri Lanka are still being studied, following a IAEA fellowship. Honey analysis is being surveyed for Azores islands and Portugal mainland, a more complete study is now taken in Algarve region.

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

Services. Analytical services are also provided under request (private companies, public services).
It is hoped that the new variants and automatization initiated in 2006 and to be finalized in 2007, will bring an increasing number of analytical services.

Research Team

Researchers

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Technical Personnel

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Collaborators

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Development, Automatization and Optimization in Activation Analysis

M.C. Freitas, I. Khan, D.G. Beasley

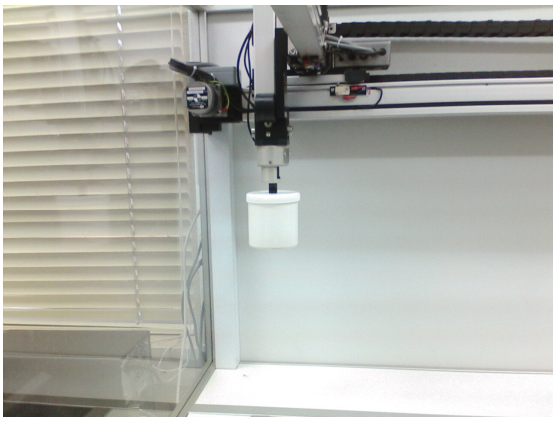
Objectives

Within re-equipment project (REEQ/1075/FIS/2001), a Technical Cooperation with IAEA (POR/6/004) and POCI/AMB/55878/2004, several equipments were acquired aiming the full development, automatization and optimization of existing systems. This includes automatization in gamma spectrometry, modernization of the fast pneumatic system usually designated by SIPRA, introduction of Compton suppression in gamma spectrometry, implementation of PGAA (prompt gamma activation analysis), and automatic filter changing.

Results

The following figures show one of the two ASC2 automatic sampler changers acquired from Ortec. Each has autonomy for 48 samples to be measured in sequence automatically. The samples are in cylindrical containers which are automatically positioned for gamma spectrometry measurement.

Samples can be positioned at different distances from the germanium detector by placing rings. Gamma spectra in digital form enter the k_0 IAEA program for direct calculation of the concentrations. A Partisol Plus sequence air sampler was also acquired to collect either PM10 or PM2.5 in sequence with autonomy for 16 filters. It is running at IST, and is shown in a figure below.



Steps were done to modernize the SIPRA system, as well as to finish the implementation of PGAA. Equipment for Compton suppression is partially at ITN, the remainder will come early 2007.

Published or in press work:

M.C. Freitas, A.M.G. Pacheco, M.A. Bacchi, I. Dionísio, S. Landsberger, J. Braisted, E. de Nadai Fernandes, Compton suppression INAA performance in determining trace and minor element contents in raw food items*, J. Radioanal. Nucl. Chem*. (in press).

M.G. Ventura, M.C. Freitas, A.M.G. Pacheco, T. van Meerten, H.Th. Wolterbeek, Selenium content in selected Portuguese foodstuffs, *Eur Food Res Technol* (in press).

Issmat Khan*, Internal report* on ASC2 functioning.

D. G. Beasley, *Internal report* on SIPRA functioning

(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 studied the short and long time element accumulation behavior of transplants of *Parmelia caperata* lichen thalli exposed at an atmospheric polluted area compared with total deposition. It was concluded that the lichen (transplant) elemental content does not unequivocally represent the average environmental availability of the exposure period. Reflection characteristics depend on the element, the lichen species, and the lichen physiological conditions. Resuming, lichens do not act like a measuring instrument; but present information on ambient element availability, somehow biased by biological effects. This result means that the design of a biomonitor experiment should involve transplants of similar and well-defined initial condition: here may be thought of similar morphology, well-characterized initial contents, and comparable physiological status quo. During the exposure, along with the lichen element content, lichen physiological parameters should be monitored throughout.

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Biomonitoring of trace element air pollution: links to emission sources and to human health
S.F.M. Sarmento, M.C. Freitas, H.Th. Wolterbeek[1], T.G. Verburg[1]

The aim of the 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 is being achieved by means of cross-sectional comparisons between the regions that compose the territory of Continental Portugal. It is generally believed that some aspects of the chemical composition of air pollution are more important than others in triggering health effects and that present air pollution indicators such as PM are mere surrogates for these more active agents. This health study profits from the unique advantage provided by atmospheric biomonitoring in allowing high spatial sampling density over wide areas, and the fact that it allows determination of the concentration of numerous chemical elements, which in turn allows the use of multivariate statistical techniques such as factor analysis to identify and characterize emitting sources.

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Studies for the Evaluation of Selenium Levels in Typical Constituents of Portuguese Diets
M.G. Ventura, M.C. Freitas, V. Stibilj[1], A.M.G. Pacheco[2]

Selenium speciation methods with low detection limits are required to the accurate species quantification and identification. Atomic fluorescence spectrometry coupled to hydride generation was used to the determination of selenium species in fish samples (work developed at Jozef Stefan Institute, Ljubljana, Slovenia). Selenium daily intake was evaluated on small Portuguese population groups according to the duplicate portion method. The fast pneumatic system available on the Reactor facility was used to the determination of total selenium content in collected food samples through the short-lived nuclide ^{77m}Se.

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Impact of Atmospheric Aerosol in Human Health
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Questionnaires were distributed in basic schools of the city of Lisbon, concerning asthmatic, rhinitis, nutrition and environmental habits. The answers are being inter-correlated and correlated to an air sampler of PM2.5 placed at IST. It is known that particles, in particular the finest one, cause respiratory problems. This work aims to study the effect of PM2.5 and its composition in a school population. Sofar around 800 students were questioned in approximately 40 basic schools. Around 30% of the children present asthmatic and/or rhinitis.

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