INSA
CENTRE VAL DE LOIRE

4ième COLLOQUE

« ANALYSE VIBRATOIRE EXPERIMENTALE »

Blois, 18, 19 et 20 Novembre 2014

PROGRAMME

http://ave2014.sciencesconf.org

AVE2014

4ième Colloque « Analyse Vibratoire Expérimentale »

Programme

18, 19 et 20 Novembre 2014, Blois, France

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Organisé conjointement par l'INSA Centre Val de Loire et le Laboratoire de Mécanique et Rhéologie (LMR), Campus de Blois

Sous l'égide du Groupe Scientifique et Technique Vibrations et Bruit (GST 14) de l'Association Française de Mécanique.

Présentation

Après le succès de 2012, le colloque international francophone sur l'Analyse Vibratoire Expérimentale revient pour sa quatrième édition en 2014 en intégrant les approches combinées essais / calculs !

La part de plus en plus croissante de l'analyse vibratoire dans les différents secteurs d'activité de l'aéronautique à l'automobile en passant par l'usinage, la maintenance ou le génie civil, font de ce rendez-vous une nécessité. Les méthodes ont elles aussi connu un essor important. En effet, l'analyse vibratoire n'est plus un simple outil complémentaire. Elle est la base de nombreuses techniques puissantes qui permettent de sonder les structures, voire l'intérieur même des matériaux durant leur service, de détecter les défauts et les endommagements et de suivre leur évolution en temps réel, …

Objectifs

Ce colloque a pour objectif de réunir des scientifiques issus de l'Industrie, de Grands Organismes Nationaux et de Laboratoires Universitaires intéressés par les développements récents de l'analyse expérimentale des structures en dynamique.

Ce thème doit être compris dans un sens assez large, il concerne :

1) Les progrès de l'analyse vibratoire expérimentale ;
2) les informations que l'on peut tirer de ces analyses.

De manière non exhaustive, les thèmes suivants sont attendus:

- Développements de l'analyse modale expérimentale : Méthodes stochastiques, précision des méthodes, ... ;
- Impact des nouveaux matériels : Capteurs de vibrations à grand champ, Vibrométrie laser, Interférométrie Speckle, Méthodes d'exploitation liées à ces matériels, Vibro-thermographie, … ;
- Processus instationnaires : méthodes temps-fréquence, ondelettes, ... ;

- Recalage de modèles éléments finis ;
- Détection de changements de structures, Approche par l'identification modale, Localisation de défauts, Détection, ... ;
- Vibrations de systèmes à symétrie de révolution : Applications au diagnostic précoce de défaillance: turbines, rotors, roulements, ... ;
- Vibrations non-linéaires : détection, caractérisation, ... ;
- Chaîne vibratoire en boucle fermée : spécification d'essais et contrôle vibratoire, … ;
- Applications vibro-acoustiques : interaction fluide-structure, contrôle acoustique, localisation des sources, ...

Ce colloque balaiera un champ assez vaste, dont l'élément fédérateur sera l'exploitation de mesures expérimentales et garantira un échange fructueux entre les acteurs du domaine, industriels, chercheurs et praticiens.

Ce colloque rassemblera plus de 130 participants (chercheurs, étudiants et industriels) autour de 3 conférences plénières d'experts internationaux dans le domaine : le Pr David J. Ewins (UK), le Pr Nuno Maia (PT), le Pr Jean-Claude Golinval (BE) et une conférence invitée Pr Ioan D. Landau (FR), 18 conférences thématiques dont 50% des conférenciers sont étrangers (Algérie, Belgique, Canada, Italie, Maroc, Portugal et UK).

Ce colloque hébergera le salon professionnel **ASTELAB** organisé conjointement avec l'ASTE regroupant des exposants référents dans le domaine de l'analyse vibratoire expérimentale et des essais en environnement comme Actidyn, Alliantech, DEWEFRANCE, HBM n-code, HGL Dynamics, IMV, Intespace, LMS Siemens, m+p international, PCB Piezotronics, Polymesure, Texys international et Viaxys.

Cet évènement important pour le monde de la recherche en mécanique vibratoire se tiendra du 18 au 20 Novembre 2014 à l'INSA Centre Val de Loire et le Laboratoire de Mécanique et Rhéologie, Campus de Blois.

L'accueil de ce colloque à Blois offre à la ville un rayonnement international dans le domaine de la recherche mais également une visibilité touristique importante. Les conférenciers bénéficieront ainsi d'une visite guidée de la vieille ville de Blois, d'un dîner de gala dans la

salle des trophées du Château de Cheverny avec une animation autour des vins de Cheverny précédé d'une visite du Château de Cheverny ainsi qu'une visite « insolite » du Château de Blois pour clôturer le tout.

Plus d'informations sur le site : http://ave2014.sciencesconf.org.

Partenaires

Comités

Comité d'organisation

R. Serra *(INSA* Centre Val de Loire */ LMR)* – ***Président du comité***

M.-L. Gobert *(INSA* Centre Val de Loire */ LMR)*

G. Pattier *(INSA Centre Val de Loire / Direction de la Recherche et Valorisation)* - **secrétariat**

A. Bhuddi, G. Gautier (Doctorants du LMR)

Etudiants de 5ième Année de l'option PMAT du Département Génie des Systèmes Industriels de l'INSA Centre Val de Loire.

Comité scientifique

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Les articles retenus seront publiés dans un numéro thématique « Analyse Vibratoire Expérimentale » de la revue ***MATEC Web of Conferences***, éditée par EDP Sciences et publié fin 2014 - début 2015.

La revue ***MATEC Web of Conferences*** est actuellement indexée et référencée par : CAS, DOAJ, Engineering Village, Google Scholar, INSPEC, Scopus et Thomson Reuters.

Programme du Colloque

Le comité d'organisation du colloque a souhaité allongé la durée du colloque plutôt que dédoubler des sessions en parallèle. Les conférences thématiques seront en langue française et d'une durée de 20 minutes. Chaque présentation sera suivie de 10 minutes de questions / discussion.

Une synthèse du colloque, en vue de dégager les axes de recherche et de développement futurs, l'orientation du colloque et l'évolution des structures associatives clôturera les débats à l'occasion d'une **Table ronde**.

PROGRAMME	
Mardi 18 Novembre 2014	
8h – 9h00	Accueil et enregistrement des participants
9h30 – 9h30	**Discours d'ouverture**
9h30 – 10h30	**Conférence plénière**
	Pr David EWINS
10h30 – 11h00	**Pause Café - Visite exposants**
11h00 – 12h00	**Session 1**
	Identification Modale
12h00 – 14h00	**Déjeuner - Visite exposants**
14h00 – 15h00	**Session 2**
	Analyse Modale
15h00 – 15h30	**Pause Café - Visite exposants**
15h30 – 17h00	**Session 3**
	Approches combinées Essais / Calculs
17h15 – 18h15	**Visite du Vieux Blois**
18h15 – 19h15	**Cocktail de Bienvenue à la Mairie de Blois**

PROGRAMME

Mercredi 19 Novembre 2014	
8h – 9h00	Accueil et enregistrement des participants
9h00 – 10h00	**Conférence plénière**
	Pr Nuno MAIA
10h00 – 10h30	**Pause Café - Visite exposants**
11h00 – 12h00	**Session 4**
	Applications industrielles
12h00 – 14h00	**Déjeuner - Visite exposants**
14h00 – 15h00	**Session 5**
	Contrôle actif des vibrations
15h00 – 15h30	**Pause Café - Visite exposants**
15h30 – 16h30	**Session 6**
	Nouveaux matériels / Essais vibratoires
17h15 – 18h30	**Visite du Château de Cheverny**
18h45 – 19h45	**Animation « Maison des Vins de Cheverny »**
20h00 – 23h30	**Dîner de GALA**

Jeudi 20 Novembre 2014	
8h – 9h00	Accueil et enregistrement des participants
9h00 – 10h00	**Conférence plénière**
	Pr Jean-Claude GOLINVAL
10h00 – 10h30	**Pause Café - Visite exposants**
11h00 – 12h00	**Session 7**
	Surveillance vibratoire et diagnostic
12h00 – 14h00	**Déjeuner - Visite exposants**
14h00 – 15h00	**Session 8**
	Surveillance vibratoire et diagnostic
15h00 – 16h00	**Table ronde**
	Discussions et synthèse du Colloque
16h00	**Clotûre du Colloque**
16h15 – 17h15	**Visite « insolite » du Château de Blois**

Liste des Participants

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Actes des colloques AVE et ASTELAB

L'intégralité des actes des colloques AVE2014 et ASTELAB2014 sont disponibles sur la clé USB, fournie au moment de l'inscription, dans les répertoires respectifs :

- « ***Actes_du_Colloque_AVE2014*** »
- « ***Actes_du_Colloque_ASTELAB_2014*** ».

Les documentations des EXPOSANTS sont également disponibles sur la Clé USB fournie.

Accès WIFI

L'INSA Centre Val de Loire ne proposant plus le réseau EDUORAM, un accès WIFI a été mis en place sur les salles des conférences (grand amphi, petit amphi et Atrium).

Le nom du Réseau, votre identifiant et votre mot de passe (personnels et uniques) vous ont été fournis au moment de l'inscription en échange de la signature de la charte informatique.

Ce code permet un accès à tous les ports ouverts avec une garantie de bande passante minimale de 20Mb/20Mb en fibre optique. Seuls les protocoles Bi Torrent, Malware et Spyware sont bloqués.

Après la procédure de connexion classique à un réseau WIFI et avant toute utilisation d'internet, vous devez vous identifiez. Pour cela, lancez un navigateur internet (Internet explorer, Firefox, Safari, Opera, …), une fenêtre d'authentification va apparaître, ne tenez pas compte des informations de sécurité et faites « Poursuivez avec ce site ».

Repas et Dîner du colloque

Les repas de midi seront pris au **Restaurant « Le Saint Jacques »** qui se trouve à 200m de l'INSA Centre Val de Loire – Campus de Blois en direction de la gare.

Un cocktail de bienvenue, en présence de *Catherine MONTEIRO, Maire adjoint en charge des affaires internationales,* sera offert par la **Mairie de Blois** et sera précédée d'une visite guidée du « Vieux Blois » depuis la place du chateau.

Le Dîner du Gala se déroulera dans la *Salle des Trophées* du **Château de Cheverny** et sera précédé d'une visite du Château par deux guides nationaux et d'une animation par la Maison des Vins de Cheverny.

Une visite « insolite » est proposée par la **Mairie de Blois** le jeudi à partir de 16h, le nombre de places est limité à 19 personnes. Une inscription est obligatoire.

Lundi 17 Novembre

**** *Programme détaillé du colloque AVE2014*

16h30 - 19h	*Accueil et enregistrement des participants*
	Installation des exposants

Programme détaillé du colloque AVE2014

Mardi 18 Novembre - Matinée

8h00 - 9h00 Accueil, enregistrement des participants et petit-déjeuner

***9h00 :* Ouverture du Colloque**

- Monsieur le Directeur de l'INSA Centre Val de Loire, Pr J M. Castelain,
- Monsieur le Vice-Président de l'Agglopolys, M. Pierre Olaya,
- Monsieur le Président de l'ASTE, M. Merlet,
- Monsieur le Responsable de l'Axe Vibrations au LMR, Pr J.-M. Mencik
- Monsieur le Président du Comité d'organisation, R. Serra

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9h30 Conférence plénière – *Keynote lecture*

Président Pr Nuno MAIA (U. T. Lisbonne / IST - Portugal)

« FUTURE DIRECTIONS IN EXPERIMENTAL STRUCTURAL DYNAMICS?»

Pr David J. EWINS (Imperial College / U. Bristol - UK)

David Ewins studied Mechanical Engineering at Imperial College and then undertook PhD research at Cambridge University, sponsored by Rolls-Royce. He was appointed Professor of Vibration Engineering at Imperial in 1983 and set up the Centre of Vibration Engineering in 1990 with support from Rolls-Royce and was the founding Director of the Vibration UTC in 1990. He has held Visiting Professor appointments in France, Switzerland, USA and Singapore, where he was Temasek Professor from 1999 to 2002. He served as Pro Rector (International Relations) at Imperial College from 2001 until 2005. Professor Ewins was appointed as Director of the Bristol Laboratory for Advanced Dynamics Engineering (BLADE) at Bristol University in July 2007.

His research interests span a wide range of structural dynamics topics, and include efforts to bring about an integration of the experimental, mechanical and theoretical methods that represent the whole spectrum of essential technologies.

Currently, there is a focus on the appropriate representation of joints on interfaces in the dynamic analysis of real engineering structures and he is Chair of the new ASME Research Committee established to co-ordinate international efforts in this area. His industrial application areas are primarily aerospace and defence with longstanding collaboration with Rolls-Royce, AgustaWestland and the Ministry of Defence. He is Chairman of the EU CleanSky Scientific and Technological Advisory Board (STAB) and a member of Rolls-Royce MSAB and others.

He is a Fellow of the Royal Society, the Royal Academy of Engineering, the Indian Academy of Engineers and the Society for Experimental Mechanics.

Abstract

This lecture presents a high-level overview of Experimental Structural Dynamics at a time when supercomputers and the simulations made with them are attracting more and more attention and credibility – albeit not always justified. Dramatic increases in computation speed and capacity have shifted attention away from experimental techniques which, in effect, have not enjoyed corresponding improvements to those apparent in simulation. The lecture considers Philosophy, Strategy and Progress in the area of interest. The need for integration of experimental with theoretical and numerical methods is emphasized, and proposed as an essential feature for future directions of all three areas. Combinations of theoretical, numerical and experimental methods lead to the technologies of Identification, Simulation and Validation. Current major challenges which are seen as obstacles to further progress are reviewed and prioritized in an attempt to devise a strategy for the future development of structural dynamics as a whole, with a special interest here in the experimental aspects. The third section looks in some detail at a small number of key experimental techniques which are expected to evolve as major approaches to the enhancement of experimental structural dynamics. These include: testing of structures with non-linear characteristics, the need to target the most critical data to be measured and to focus effort on those, and the need to change the balance of numbers of measured DOFs and measured frequency components.

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10h30 - 11h00 : Pause - Visite des stands **ATRIUM**

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Session 1 : IDENTIFICATION MODALE – *Modal Identification*

Président Pr Luigi GARIBALDI (Politecnico di Torino / DIMEAS)

11h00 New developments for experimental modal analysis of aircraft structures

J. VAYSSETTES, G. MERCERE

This article presents an identification algorithm dedicated to the modal analysis of aircraft structures during flight-tests. More specifically, this algorithm was designed to process short duration tests carried out with multi-input excitations. The identification problem is solved in the frequency domain and the limit effects are considered so as to avoid transient effects with short data sequences. To minimize the effects of the noise, a non-linear gradient-based optimization method is used. Its performance is improved by the use of an appropriate overparametrised matrix fraction description. Because the cost function to be minimized is no convex, this method is however sensitive to the initialization. For this reason, an iterative instrumental variable method is used to find an initial estimate. This one gives a value of the cost-function sufficiently close to its global minimum so as to ensure a fast convergence of the optimization. Thus, the algorithm presented in this article is a combination of two iterative methods that gives accurate mode estimations even with high level of noise, as shown on an illustrative example.

11h30 Modal parameter identification from output data only

J. LARDIES

To identify the modal parameters of a vibrating system from output data only we use a state space model and usually two approaches are considered: the block Hankel matrix and its shifted version and the block observability matrix and its shifted version. It is shown in the communication that these two approaches give the same results even in the noisy data case. We present numerical and experimental results, which prove the effectiveness of the procedure.

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12h00 - 14h00 Déjeuner au Restaurant « Le Saint Jacques »

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Mardi 18 Novembre – Après-midi

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Session 2 : Analyse modale – *Modal Analysis*

Président Pr Joseph LARDIES (U. Franche-Comté / FEMTO)

14h00 Vibration characterization procedure of piezoelectric ceramic parameters

***Y. MEYER*, R. LACHAT**

To integrate new functionalities inside the mechanical structures for active vibration control, mechatronic, energy harvesting or fatigue management, it's necessary to develop a real fully distributed set of transducers and to include them at the heart of composite materials. To reach this goal, it's absolutely necessary to limit the cost of the numerous transducing elements with respect to the global system cost and, in the same time, to well-known the electromechanical behavior of theses transducers in order to well-design the system controller. In this paper, an experimental non-destructive procedure based on the analysis of anti-resonance and resonance frequencies of the transducers is proposed for determining the material coefficients of interest. This measurement process is applied to low-cost thin disks made of piezoceramics.

14h30 Spectrum construction for non stationary vibration: Application to a moving flexible robot

V.-H. VU, M. THOMAS, Z. LIU, B. HAZEL

This paper presents a method for constructing spectrum in non-stationary vibration using time series vector autoregressive model. A modal classification criterion and a modal amplification factor are introduced based on the eigen-decomposition of the block data matrix. The classical spectrum computation can be therefore modified to amplify only the physical modes and lighten the computation induced modes. In combination with a sliding window technique, it is shown that the method provides a clear, lightweight spectral representation of non stationary vibration. Application on the vibration signals measured from a moving flexible robot along a given trajectory shows the effectiveness and applicability of the method. The technique is integrated in the online modal surveillance software call STAR (Short Time AutoRegressive).

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15h00 - 15h30 Pause - Visite des stands ATRIUM

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Session 3 : Approches combinées Essais / Calculs – *Numerical / Experimental combined approach*

Président Pr Thierry TISON (Univ. Valenciennes / LAMIH)

15h30 Numerical and experimental assessment of railway-induced ground vibrations generated by IC/IR trains in Brussels

***G. KOUROUSSIS*, O. VERLINDEN**

Nowadays, the rising demand for new railway networks in Brussels is associated to discomfort and disturbance felt by the neighborhood. This problem is a major concern of inhabitant surrounding rail infrastructure and causes part of the delay in the Brussels RER network construction. The present paper focuses on the vibratory nuisances generated by domestic trains in Brussels region. A compound experimental/numerical analysis is presented, based on recent investigations on line L161 between Brussels and Luxembourg. A specific site was chosen due to the presence of a singular rail surface defect which induces large ground vibrations when trains pass over. The effect of this defect is examined by means of free field ground vibrations measured during the passing of an AM96 unit, and completed by numerical results obtained from a numerical model. For this assessment, a fully 3D numerical prediction model is built, based on a two-step approach which combines multibody analysis of the vehicle and finite element analysis of the track and surrounding ground. Calculated high ground vibrations stem from singular rail surface defects. The prediction model is validated first and then used to quantify the gain brought by fixing of rail surfaces, with a reduction of local defects.

16h00 Operational modal analysis with uncertainty quantification for SDDLV-based damage localization

***M. DÖHLER*, L. MARIN, L. MEVEL, D. BERNAL**

The Stochastic Dynamic Damage Locating Vector (SDDLV) approach is a vibration-based damage localization method based on a finite element model of a structure in a reference state and output-only measurements in both reference and damaged states. A stress field is computed for loads in the null space of a surrogate of the change in the transfer matrix at the sensor positions, where the null space is obtained based on the identified modal parameters in both structural states. Then, the damage location is related to positions where the stress is close to zero. The localization results of this generic approach are perturbed by mainly two sources: modal truncation (not all modes of the structure are available) and modal parameter identification errors (estimation is subject to statistical uncertainties). In this paper, we show how damage localization with the SDDLV approach is improved by taking into account the estimation uncertainties of the underlying identified modal parameters.

16h30 Variability effects on automotive brake squeal prediction

A. RENAULT, F. MASSA, B. LALLEMAND, T. TISON

The objective of this paper is to discuss the effect of different kinds of variability such as material properties, interface and boundary conditions and geometric characteristics on squeal prediction of an industrial automotive brake system. Firstly, a focus on the quantification of experimental uncertainty and parametric variability is presented. Secondly, an updating of numerical model of brake components is performed by considering a nominal FE model and associated realistic variability. Finally, numerical simulations are performed for specific combinations of input parameters, identified experimentally. The aim is to highlight the variability effects on complex frequency and transient results and to identify the most significant parameters useful for robustness analysis.

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17h15 – 18h15 **Visite guidée du Vieux Blois – Départ devant la Place du Château de Blois *offert par la Mairie de Blois***




18h15 : **Cocktail de bienvenue à L'Hôtel de Ville *offert par la Ville de Blois* en présence de Madame Catherine MONTEIRO, Maire adjointe en charge des affaires internationales.**


Mercredi 19 Novembre - Matinée

8h00 - 9h00 Accueil, enregistrement des participants et petit-déjeuner

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9h00 Conférence générale - *Keynote Lecture*

Président Pr Marc THOMAS (ETS / DYNAMO - Canada)

« ON THE IDENTIFICATION OF THE STRUCTURAL DAMAGE FROM VIBRATION TESTING»

Pr Nuno MAIA (U. T. Lisbon / IST - Portugal)

Nuno Manuel Mendes Maia obtained his bachelor's and master's degrees (1978 and 1985, respectively) in mechanical engineering from Instituto Superior Tecnico (IST), University of Lisbon. He received his PhD in mechanical vibrations (1989) from Imperial College, University of London, UK. He had his habilitation in mechanical engineering (2001) from Instituto Superior Tecnico, University of Lisbon. Prof. Maia has authored and co-authored two textbooks and more than a hundred and fifty scientific publications in international journals and conference proceedings on the subject of modal analysis and structural dynamics.

He is an associate editor of the Shock and Vibration Journal, a member of the Society for Experimental Mechanics (SEM), a member of the International Institute of Acoustics and Vibration (IIAV), and of the Portuguese Society of Acoustics (SPA), where he is responsible for the area of vibrations.

He has participated and coordinated various national and international research projects in the area of modal analysis and structural vibrations and has been responsible for the organization of the International Conference on Structural Engineering Dynamics (ICEDyn), since 2002.

His current research interests are modal analysis and modal testing, updating of finite element models, coupling and structural modification, damage detection in structures, modeling of damping, transmissibility in multiple degree-of-freedom systems, and force identification.

Abstract

The identification and real time monitoring of structural damage is a matter of paramount importance nowadays, as possible failures and interruption in the normal operation of a structure for large periods of time may imply very high costs. Dedicated damage detection techniques that are based on variations of the dynamic behaviour of a structure can be very appealing, mainly due to their non-destructive nature. In the last two or three decades, many techniques have been developed at various levels, namely to detect the existence of damage, to localize it and to quantify its severity. Naturally, one of the biggest challenges is to detect the damage at the earliest possible stage. In the present lecture one shall discuss the effectiveness of several indicators for the detection, localization and relative quantification of damage. The examples that are presented are based on simulated numerical data and also on experimental data that has been collected from tests undertaken on a small laboratory structure.

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10h00 - 10h30 : Pause - Visite des stands **ATRIUM**

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Session 4 : APPLICATIONS INDUSTRIELLES - *Industrial applications*

Présidente Dr Sophie SIEG-ZIEBA (CETIM)

10h30 Bi-objective robust optimization of machined surface quality and productivity under vibrations limitation

M. A. SAHALI, R. SERRA, I. BELAIDI, H. CHIBANE

In this contribution, a bi-objective robust optimization of cutting parameters, with the taking into account uncertainties inherent in the tool wear and the tool deflection for a turning operation is presented. In a first step, we proceed to the construction of substitution models that connect the cutting parameters to the variables of interest based on design of experiments. Our two objectives are the best machined surface quality and the maximum productivity under consideration of limitations related to the vibrations and the range of the three cutting parameters. Then, using the developed genetic algorithm that based on a robust evaluation mechanism of chromosomes by Monte-Carlo simulations, the influence and interest of the uncertainties integration in the machining optimization is demonstrated. After comparing the classical and robust Pareto fronts, A surface quality less efficient but robust can be obtained with the consideration of uncontrollable factors or uncertainties unlike that provides the deterministic and classical optimization for the same values of productivity.

11h00 An auto-balancer device for high spin-drying speed (LoWash Project)

C. CLERC

Auto-balancing or active control balancing can be efficient solutions for high speed rotors with changing unbalance like washing machines in spin-drying mode. For the LoWash EU project, which aims to build a high performance washer-dryer, such a balancing system has to be prototyped for high spin-drying speeds. The system is based on two trolleys rolling in a ring linked to the drum. A specific solution is developed for deleting the disadvantages at low speed inherent to this kind of system. Analytical and multi-body models are first made for understanding the mechanisms, highlighting the driving parameters and drawing the final design of a first prototype which is inserted in a washing machine drum. A specific instrumentation is used: the residual unbalance is measured thanks to a set of accelerometers mounted on the tub, while the mobile masses behavior is observed thanks to a large aperture swift camera. The test results highlight both the auto-balancer efficiency and the multi-body model relevance. According the theory, the balancing is efficient when the rotation frequency is significantly greater than the hanging frequencies. A washer-dryer prototype including the auto-balancer and other innovations (thermal exchange and insulation) will be tested in operating conditions. The conclusion deals with the industrial application opportunities and the potential improvements.

11h30 Bearing Fault Detection Using Motor Current Signal Analysis Based on Wavelet Packet Decomposition and Hilbert Envelope

Y. IMAOUCHEN, R. ALKAMA, M. THOMAS

To detect rolling element bearing defects, many researches have been focused on Motor Current Signal Analysis (MCSA) using spectral analysis and wavelet transform. This paper presents a new approach for rolling element bearings diagnosis without slip estimation, based on the wavelet packet

decomposition (WPD) and the Hilbert transform. Specifically, the Hilbert transform first extracts the envelope of the motor current signal, which contains bearings fault-related frequency information. Subsequently, the envelope signal is adaptively decomposed into a number of frequency bands by the WPD algorithm. Two criteria based on the energy and correlation analyses have been investigated to automate the frequency band selection. Experimental studies have confirmed that the proposed approach is effective in diagnosing rolling element bearing faults for improved induction motor condition monitoring and damage assessment.

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12h00 - 14h00 Déjeuner au Restaurant « Le Saint Jacques »

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Mercredi 19 Novembre – Après-midi

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Session 5 : CONTROLE ACTIF DES VIBRATIONS – *Active control of vibrations*

Président Pr Serge DOS SANTOS (INSA Centre Val de Loire)

14h00 Adaptative active vibration isolation - A control perspective

I. D. LANDAU, T.-B. AIRIMITOAIE, A. CASTELLANOS-SILVA, M. ALMA

In many classes of applications like active vibration control and active noise control, the disturbances can be characterized by their frequencies content and their location in a specific region in the frequency domain. The disturbances can be of narrow band type (simple or multiple) or of broad band type. A model can be associated to these disturbances. The knowledge of the disturbance model as well as of the compensator system is necessary for the design of an appropriate control system in order to attenuate (or to reject) their effect upon the system to be controlled. The attenuation of disturbances by feedback is limited by the Bode Integral and the "water bed" effect upon the output sensitivity function. In such situations, the feedback approach has to be complemented by a "feedforward disturbance compensation" requiring an additional transducer for getting information upon the disturbance. Unfortunately in most of the situations the disturbances are unknown and time-varying and therefore an adaptive approach should be considered. The generic term for adaptive attenuation of unknown and time-varying disturbances is "adaptive regulation" (known plant model, unknown and time-varying disturbance model). The paper will review a number of recent developments for adaptive feedback compensation of multiple unknown and time-varying narrow band disturbances and for adaptive feedforward compensation of broad band disturbances in the presence of the inherent internal positive feedback caused by the coupling between the compensator system and the measurement of the image of the disturbance. Some experimental results obtained on a relevant active vibration control system will illustrate the performance of the various algorithms presented.

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15h00 - 15h30 : Pause - Visite des stands **ATRIUM**

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Session 6 : NOUVEAUX MATERIELS – *New materials* / ESSAIS VIBRATOIRES EN ENVIRONNEMENT – *Environmental vibratory tests*

Président Dr Christian CLERC (VIBRATEC)

15h30 Design and test of a novel accelerometer made-up of an optical-fiber embedded within a polymer resin

P. TIHON, O. VERLINDEN, G. KOUROUSSIS, P. MEGRET, M. WUILPART

This paper presents a transducer for an optical-fiber accelerometer based on a polarization analysis. The transducer is made up of a fiber section embedded within a resin placed between two metallic pieces. Due to the acceleration, the resin is crushed between the metallic pieces, deforming the fiber section and inducing birefringence in the latter. This birefringence modifies the light polarization state, which can be used as an acceleration measurement. The sensor characteristics (sensitivity and resonance frequency) are numerically and experimentally determined. Sine accelerations at 120 Hz with amplitudes going from 5 m/s² to 13 m/s² have been successfully measured. The resonance frequency for the transducer crushing mode is above 5000 Hz, but low-frequency vibration modes exist, disturbing the measurements.

16h00 Characterization of random Gaussian and non-Gaussian stress processes in terms of extreme responses

B. COLIN

In the field of military land vehicles, random vibration processes generated by all-terrain wheeled vehicles in motion are not classical stochastic processes with a stationary and Gaussian nature. Nonstationarity of processes induced by the variability of the vehicle speed does not form a major difficulty because the designer can have good control over the vehicle speed by characterizing the histogram of instantaneous speed of the vehicle during an operational situation. Beyond this non-stationarity problem, the hard point clearly lies in the fact that the random processes are not Gaussian and are generated mainly by the non-linear behavior of the undercarriage and the strong occurrence of shocks generated by roughness of the terrain. This non-Gaussian nature is expressed particularly by very high flattening levels that can affect the design of structures under extreme stresses conventionally acquired by spectral approaches, inherent to Gaussian processes and based essentially on spectral moments of stress processes. Due to these technical considerations, techniques for characterization of random excitation processes generated by this type of carrier need to be changed, by proposing innovative characterization methods based on time domain approaches as described in the body of the text rather than spectral domain approaches.

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16h45 Départ en BUS depuis l'INSA pour le Château de Cheverny

17h15 – 18h15 Visite guidée du Château de Cheverny

18h30 – 19h30 : Animation autour des VINS de CHEVERNY.

20h00 – 24h00 : Repas de GALA dans la « Salle des Trophées » du Château de CHEVERNY

Au cours du Repas :

- *Remise du **Prix de l'AFM GST Vibrations & Bruit pour la meilleure communication** par Roger SERRA représentant le Professeur Emmanuel FOLTÊTE, coordinateur du GST Vibrations & Bruit de l'AFM*

- *Remise des **Prix Essais & Simulations pour la meilleure approche combinée calcul / essai** par Monsieur Olivier Guillon, Rédacteur en chef de la revue Essais & Simulations*

- *Remise du **Prix Robert-Houdin pour la contribution la plus originale** par Monsieur Benoît SIMONNIN, vice-président AGGLOPOLYS en charge de l'enseignement supérieur*

Jeudi 20 Novembre - Matinée

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8h00 - 9h00 Accueil - enregistrement des participants et petit-déjeuner

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9h00 Conférence générale - *Keynote Lecture*

Président Pr Luigi GARIBALDI (Politecnico di Torino / DIMEAS)

« On the Use of Principal Component Analysis for Parameter Identification and Damage Detection in Structures»

Professor Jean-Claude GOLINVAL (U. Liège / LTAS - BE)

Jean-Claude Golinval graduated in Mechanical Engineering in 1980 and received his Ph.D. in 1989 from the University of Liege (Belgium). He was appointed Professor of Vibration Engineering at the University of Liege in 1991 where he set up the laboratory of Vibrations and Identification of Structures (LTAS-VIS).

His field of expertise lies in the theoretical and experimental modal analysis of structures and rotating machines. His current research interests are structural vibrations, identification of linear and nonlinear structures, structural damage detection and model updating.

From 1997 until 2001, he coordinated the European COST Action F3 in « Structural Dynamics » (European Co-operation in the Field of Scientific and Technical Research). The topics of this Action were model updating, structural health monitoring and damage detection, and identification of nonlinear mechanical systems. He also coordinated a one-week training course in 2009 at the University of Liege in the framework of the SICON Marie Curie Action on Vibration Testing, Identification of Linear and Nonlinear Systems. He served as Head of the Department of Aerospace and Mechanical Engineering at the University of Liege from 2006 until 2009. Since 1991, he authored and co-authored more than two hundred scientific publications in international journals and conference proceedings.

He is a Fellow of the American Society of Mechanical Engineers (ASME) and the Society of Experimental Mechanics (SEM). From 2005 until 2011, he was Associate Editor of the "Journal of Vibration and Acoustics and the Design Engineering Division" of the ASME.

Abstract

Modal analysis is used extensively for understanding the dynamic behaviour of structures as well as for structural health monitoring or damage detection based on output-only measurements. In this presentation, a different approach based on principal component analysis is considered. Principal component analysis (PCA), also called proper orthogonal decomposition (POD), is a multi-variate statistical method that aims at obtaining a compact representation of the data. In the present paper,

PCA (POD) is used for three purposes, namely damage detection, structural health monitoring and identification of nonlinear parameters. The key idea of PCA is to reduce a large number of measured data to a much smaller number of uncorrelated variables while retaining as much as possible of the variation in the original data. To this purpose, an orthogonal transformation to the basis of the eigenvectors of the sample covariance matrix is performed, and the data are projected onto the subspace spanned by the eigenvectors corresponding to the largest eigenvalues. This transformation has the property to decorrelate the signal components and to maximize variance. The first problem to which PCA is applied here is the damage detection problem. When applied to vibration measurements, it can be shown that the basis of eigenvectors (called the proper orthogonal modes) span the same subspace as the mode-shape vectors of the monitored structure. Thus the damage detection problem may be solved using the concept of subspace angle between a reference subspace spanned by the eigenvectors of the initial (undamaged) structure and the subspace spanned by the eigenvectors of the current (possibly damaged) structure. The second problem concerns structural health monitoring of civil engineering structures when environmental effects (e.g. the influence of the variation of the ambient temperature) have to be removed from the structural changes. In this case, PCA may be applied on identified modal features (e.g. the natural frequencies) to separate the changes due to environmental variations from the changes due to damage sources. This procedure is illustrated on the example of a real bridge located in Luxembourg. The third problem is related to the estimation of nonlinear parameters using model updating techniques. In this case, the most interesting property of PCA is that it minimizes the average squared distance between the original signal and its reduced linear representation. When applied to nonlinear problems, PCA gives the optimal approximating linear manifold in the configuration space represented by the data. The linear nature of the method is appealing because the theory of linear operators is still available. However, it should be borne in mind that it also exhibits its major limitation when the data lie on a nonlinear manifold.

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10h00 - 10h30 : Pause - Visite des stands **ATRIUM**

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Session 7 : SURVEILLANCE VIBRATOIRE ET DIAGNOSTIC – *Vibration-based condition monitoring*

Président Dr Roger SERRA (INSA Centre Val de Loire / LMR)

10h30 Monitoring gears by vibration measurements: Lempel-Ziv complexity and Approximate Entropy as diagnostic tools

M. KEDADOUCHE, M. THOMAS, S.-A. TAHAN, R. GUILBAULT

Unexpected failures of industrial gearboxes may cause significant economic losses. It is therefore important to detect early fault symptoms. This paper introduces signal processing methods based on approximate entropy and Lempel-Ziv Complexity for defect detection of gears. Both methods are statistical measurements exploring the regularity of a vibratory signal. Applied to gear signals, the parameter selection of and calculation are first numerically investigated, and appropriate parameters are suggested. Finally, an experimental study is presented to investigate the effectiveness of these indicators. The results demonstrate that and provide alternative features for signal processing. A new methodology is presented combining both Kurtosis and for early detection of faults. The results show that this proposed method may be used as an effective tool for early detection of gear faults.

11h00 Robustness of railway rolling stock speed calculation using ground vibration measurements

G. KOUROUSSIS, D. CONNOLLY, O. LAGHROUCHE, M. FORDE, P. WOOKWARD, O. VERLINDEN

Evaluating railway vehicle speed is an important task for both railway operators and researchers working in the area of vehicle/track dynamics, noise and vibration assessment. The objective of this paper is to present a new technique capable of automatically calculating train speed from vibration sensors placed at short or long distances from the track structure. The procedure combines three separate signal processing techniques to provide high precision speed estimates. In order to present a complete validation, the robustness of the proposed method is evaluate using synthetic railway vibration time histories generated using a previously validated vibration numerical model. A series of simulations are performed, analysing the effect of vehicle speed, singular wheel and rail surface defects, and soil configuration. Virtual conditions of measurement are also examined, taking into account external sources other than trains, and sensor response. It is concluded that the proposed method offers high performance for several train/track/soil arrangements. It is also used to predict train speeds during field trials performed on operational railway lines in Belgium and in UK.

11h30 Elaboration of an implementation approach of the condition-based maintenance using vibration analysis

E. M. SEMMA, A. MOUSRIJ, H. GZIRI

Vibration analysis is a powerful and widely used tool in industry for monitoring rotating machinery. Despite the possibilities offered by the measuring equipment of vibration through technological progress, companies which practice condition-based maintenance using vibration analysis (VBM) show performance below expectations in terms of machine availability. Our job then is to develop an approach for the implementation of the VBM taking into consideration the keys to success and avoiding the causes of failure. We carried out an analysis of 30 years of practice of the VBM within a large Moroccan company in the chemical industry, through a collective approach called DCA (in French applied short diagnosis) and a survey among national and international experts in the field of the VBM. The synthesis of these studies has led us to propose a comprehensive and structured approach that comes in 5 phases: inventory, feasibility studies, preparation phase, implementation phase and evaluation phase and improvement.

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12h00 - 14h00 Déjeuner au Restaurant « Le Saint Jacques »

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Jeudi 20 Novembre – Après-midi

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Session 8 : SURVEILLANCE VIBRATOIRE ET DIAGNOSTIC – *Vibration-based condition monitoring*

Président Pr Marc THOMAS (ETS / Dynamo - Canada)

14h00 Subspace-based damage identification of roller bearing

G. GAUTIER, R. SERRA, J.-M. MENCIK

This study presents a frequency-band subspace-based damage identification method for faults diagnosis in gearbox. The main purpose is to obtain a dedicated damage sensitive feature in the frequency range where the damage is expected to appear. The proposed method is validated using the data collected from bearing run-to-failure tests. The result demonstrates that the method can detect bearing defects at an early stage of development and therefore diagnostic is possible.

14h30 Stochastic Resonance algorithms to enhance damage detection in bearing faults

***R. CASTIGLIONE*, L. GARIBALDI, S. MARCHESIELLO, E. DETOMA**

Stochastic Resonance is a phenomenon, studied and mainly exploited in telecommunication, which permits the amplification and detection of weak signals by the assistance of noise. The first papers on this technique are dated early 80s and were developed to explain the periodically recurrent ice ages. Other applications mainly concern neuroscience, biology, medicine and obviously signal analysis and processing. Recently, some researchers have applied the technique for detecting faults in mechanical systems and bearings. In this paper, we try to better understand the conditions of applicability and which is the best algorithm to be adopted for these purposes. In fact, to get the methodology profitable and efficient to enhance the signal spikes due to fault in rings and balls/rollers of bearings, some parameters have to be properly selected. This is a problem since in system identification this procedure should be as blind as possible. Two algorithms are analysed: the first exploits classical SR with three parameters mutually dependent, while the other uses Woods-Saxon potential, with three parameters yet but holding a different meaning. The comparison of the performances of the two algorithms and the optimal choice of their parameters are the scopes of this paper. Algorithms are tested on simulated and experimental data showing an evident capacity of increasing the signal to noise ratio.

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15h00 - 16h00 Table ronde

Présidents Roger SERRA / Nuno MAIA

Pistes de réflexions / Discussions :

- Création d'un club des expérimentateurs / modélisateurs ?
  - Réseau AVE ?
  - Création d'une Base de données essais ouverte
  - Création de briques logiciels d'analyse vibratoire
  - Plateforme d'échange des pratiques pédagogiques,
  - Pilotage / Positionnement
- Publications / Communications :
  - Mise à jour des Documents Techniques de l'Ingénieurs
  - Numéro thématique bi-annuel dans la Revue M&I
  - Ouvrage collectif dans la Collection FOCUS (Hermès)
- Future du colloque :
  - Session thématique au Congrès Français de Mécanique
  - Format du colloque sur 3 jours mais avec une session unique
  - 1 jour de formation par un partenaire avant le colloque
  - Elargissement à la communauté numérique, AVE deviendrait AVEN ?

…**autres à préciser**

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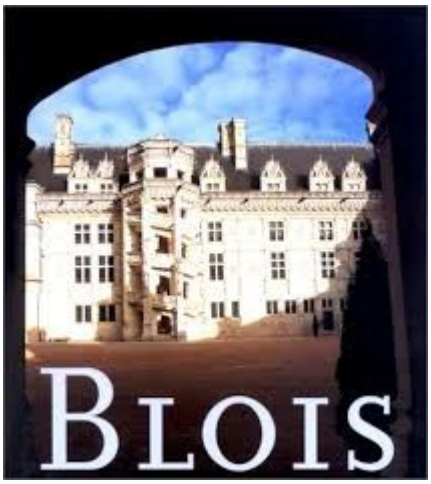
16h00 Conclusion du colloque suivie d'une visite « insolite » du Château Royal de BLOIS


BLOIS

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A vos agendas

2014

CMMNO'2014 - http://cmmno2014.sciencesconf.org/
4th International Conference on Condition Monitoring of Machinery in Non-Stationary Operations / 15-16 Décembre (Lyon)

2015

IMAC2015 - http://sem.org/CONF-IMAC-TOP.asp
IMAC XXXIII A Conference and Exposition on Structural Dynamics (Florida)

ICEDyn 2015 - http://www.icedyn.net/
International Conference on Structural Engineering Dynamics (Lagos)

ICSV22 - http://icsv22.org/
22nd International Congress on Sound and Vibration (Firenze)
Structured session: T08.SS03 - Vibration-based Condition Monitoring

DAMAS 2015 - http://www.damas.ugent.be/DAMAS.htm
11th International Conference on Damage Assessment of Structures (Ghent)

CFM2015 - http://cfm2015.sciencesconf.org
XXIIe Congrès Français de Mécanique (Lyon)
Session S10 - vibrations et vibro acoustique

ICoEV 2015 - http://www.icoev.org
IFTOMM International Conference on Engineering Vibration 2015 (Ljubljana)

Surveillance 8 - http://surveillance8.sciencesconf.org
8th issue of the Surveillance Conference series (Roanne)

Informations pratiques

Hébergement (à proximité)

* IBIS Budget (ex Etap' hotel)

** Anne de Bretagne

Hotel de France et Guise

Hotel Renaissance

Hotel Saint Jacques (Tarif préférentiel aux conférenciers)

IBIS Centre

Le monarque

Louise de Savoie

*** Best Western

IBIS Style

Le Médicis

**** Holyday Inn

MERCURE

Activités (à proximité)

Château de la Loire : Château Royal de Blois, Domaine National de Chambord, Domaine de Chaumont sur Loire, Château de Cheverny, … et beaucoup d'autres encore (lien)

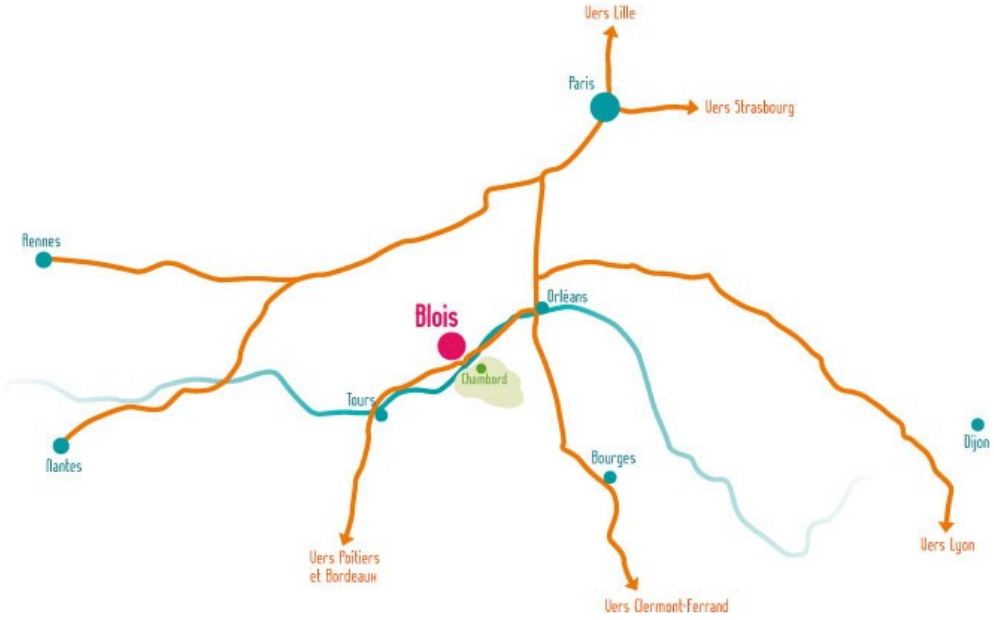
Château du Clos Lucé : Découvrez la dernière demeure de Léonardo Da Vinci

Golf : Golf de La Bosse, Golf de La Carte, Golf de Cheverny

Mets & Vins : Maison du vin sur la Place du Château à Blois, Domaine de la charmoise (Henry Marionnet), Maison des vins de Cheverny, Biscuiterie de Chambord, Biscuiterie St Michel, …

Spectacle : Maison de la Magie

Plan d'accès



<u>Depuis PARIS par autoroute :</u>

Prendre l'A10 - Direction Orléans/Tours Sortie 17 – Blois *187 km - 2h00 environ*

<u>Depuis TOURS par autoroute :</u>

Prendre l'autoroute A10 direction Blois – Orléans Sortie 17 – Blois *60 km - 45 mn environ*

<u>Depuis LE MANS par la route nationale</u>

Prendre la N157 Direction Orléans - Vendôme – Blois Puis quelques km après Saint Calais, suivre la D957 Direction Blois *110 km - 1h40 environ*

<u>Depuis BOURGES par autoroute et routes départementales</u>

Prendre A71 Direction Vierzon - Orléans, sortie 4 Salbris Prendre la D923, Direction Neung - Bracieux – Blois *120 km - 1h30 environ*

<u>POUR TOUS</u>

Arrivée à Blois, suivre les indications Blois Château - Centre ville, puis **Gare SNCF,** puis suivre le fléchage « ***INSA CVL*** **».**

Nous sommes installés à <u>200 m de la gare</u>, 3 rue de la Chocolaterie (bâtiment en brique rouge avec un grand parvis) et suivre le fléchage.

INSA CENTRE VAL DE LOIRE

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