EWGAE 2018

33rd European Conference on Acoustic Emission Testing

12-14 September 2018
Senlis France

www.ewgae2018.com

Abstracts Book

European Working Group on Acoustic Emission

With the collaboration of

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EWGAE 2018

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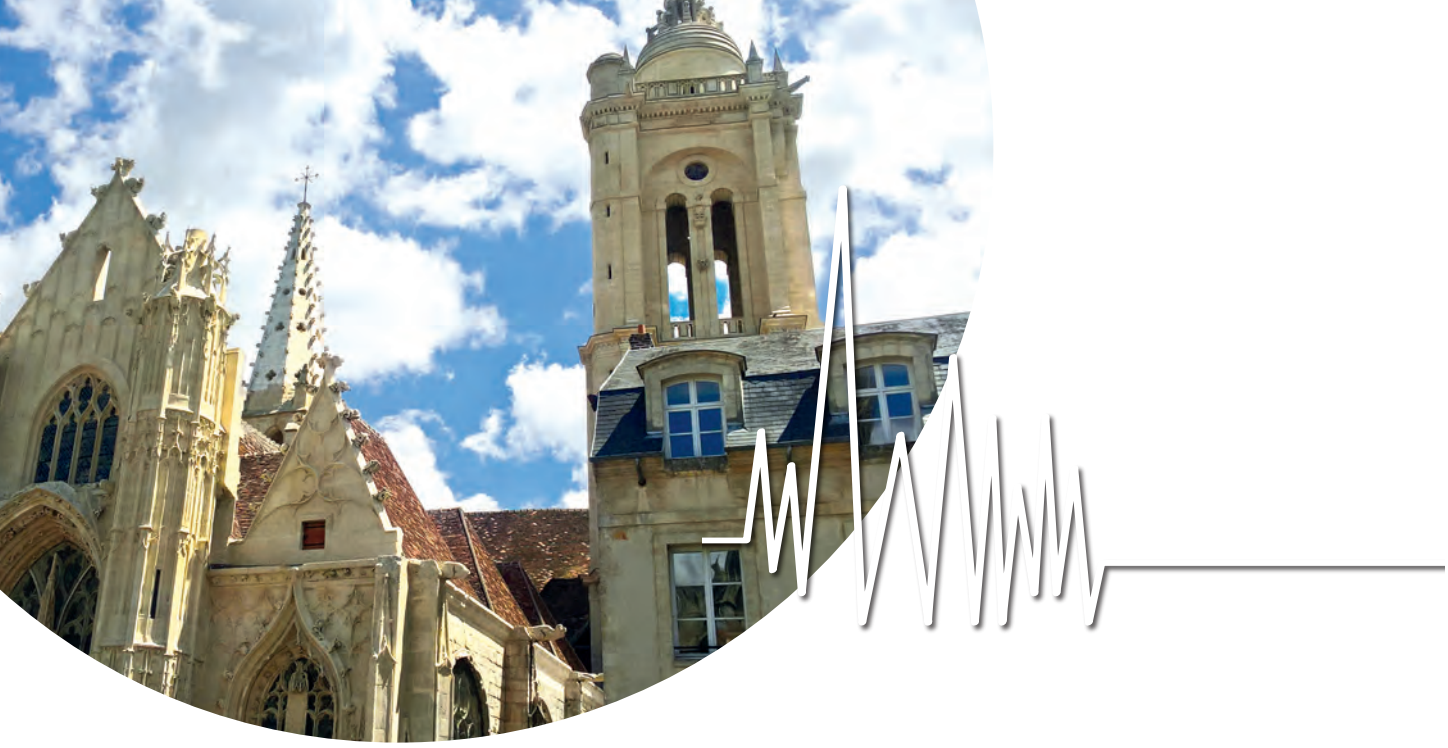

The European Working Group on Acoustic Emission

The European Working Group on Acoustic Emission (EWGAE) was formed in 1972 by a number of people throughout Europe who were already engaged in acoustic emission research. At that time, Acoustic Emission research was performed in England by Adrian Pollock at Cambridge Consultants, by Don Birchon at the Admiralty Materials Laboratory, by Peter G. Bentley at Risley Engineering and at the Materials Laboratory of the U.K. Atomic Energy Authority, by Brian Harris at the University of Sussex; in Germany by Jürgen Eisenblätter and Peter Jax at Battelle Institut; in France by P. F. Dumousseau at CETIM, by Madame Nicole Chretien and E.G. Tomachevsky at Centre d'Etudes Nucleaires de Saclay, Commissariat a l'Energie Atomique; in Italy by M. Mirabile at Centro Sperimentale Metallurgico in Rome; in Denmark by Arved Nielsen at the Research Establishment Riso, Danish Atomic Energy Commission; in The Netherlands by J.C.F. DeKanter at the Technische Hogeschool Delft. (This list may not be complete.)

The first European meeting on the subject was the "Institute of Physics Conference on Acoustic Emission" which was organized by Adrian Pollock and held in March 1972 at Imperial College in London. Fifteen papers from throughout Europe and USA were presented. The success of this conference established both the interest and the need for forming a working group. Consequently, Pollock and Birchon organized the European Stress Wave Emission Working Group, which held its first meeting in November 1972, at the Admiralty Materials Laboratory in England. During their second meeting at Battelle-Institut in September 1973, the group formally adopted their present name, European Working Group on Acoustic Emission. The original letterhead logo was designed by Patricia Preston, graphics designer at Cambridge Consultants. During the late 1970s and early 1980s, the Codes Subgroup of EWGAE published 5 codes of practice.
In 1991, the work of this group was taken up by a new working group on AE (WG7) within TC138, the Technical Committee for NDT within CEN. This working group is comprised of national representatives who have been nominated by their respective National Standards Institutions. The first Convenor of WG-7 was Emilio Fontana of CISE, Italy. After his retirement in 2003, Peter Tscheliesnig of TÜV Austria was appointed and is currently serving as Secretary of the group. Mr Tscheliesnig announced his retirement from convenorship during the WG7 meeting held in Málaga (Spain) in September 2017. As new Convenor, Mr Gerald Lackner of TÜV Austria has been elected over the voting booth system of CEN and the national standardization committees in January 2018.

The following EWGAE conferences were held since 2000: Senlis/Paris, France (2000); Prague, Czech Republic (2002); Berlin, Germany (2004); Cardiff, UK (2006); Krakow, Poland (Sept. 2008); Vienna, Austria (2010); Granada, Spain (2012); Dresden, Germany (2014) and Prague, Czech Republic (2016) and the increasing desire to exchange ideas and experience is reflected in the number of delegates: 99, 108, 150, 100, 121, 143,125, 127. AE Testing in Europe is now well established in several important areas of proof testing, in-service monitoring, corrosion and leak detection. Development of the technology continues to be driven by the needs of the industry to reduce inspection and maintenance costs while preserving its assets and personnel safety. The advancement of PC technology has positively influenced new developments in hardware and software for powerful and user-friendly testing equipment.

During the group's business meeting held on September 10, 2010, a new Constitution was approved and signed, which, among other issues, established a regulated system of Official Members of the EWGAE. Currently the number of members is 91.

Following the Constitution, in the business meeting held on September 4 in Dresden (Germany), a new Executive Committee was elected:
- Ireneusz Baran (Poland) - Chairman
- Antolino Gallego (Spain) - Secretary
- Hartmut Vallen (Germany) - Treasurer
- Catherine Herve (France) - Deputy Chair
- Gerald Lackner (Austria) - Deputy Secretary
- Markus Sause (Germany) - Deputy Treasurer

EWGAE is a constituent part of the International Institute of Innovative Acoustic Emission (IIIAE), within which EWGAE representatives are:
- Peter Tscheliesnig (Austria) - Representatives of EWGAE in IIIAE Steering Committee
- Hartmut Vallen (Germany) - Representatives of EWGAE in IIIAE Steering Committee
- Antolino Gallego (Spain) - Representatives of EWGAE in IIIAE Steering Committee
- Gerd Manthei (Germany) - Associated Editor of EWGAE in IIIAE

In the month of May 2018, the international acoustic emission community received the sad news of the passing away of one of the founder and promoter of EWGAE, Dr. Adrian Pollock. The group EWGAE unanimously releases its condolences to their relatives, friends and colleagues, for such an irreparable loss. EWGAE community wants to thank Dr. Pollock for having been a promoter of this group and its conference, as well as for having been a mentor to so many people within the scientific community of acoustic emission, both in the academy as in the business sector.
The group also wants to recognize its enormous human condition, which was reflected during its last participation in an EWGAE conference, held in 2012 in Granada (Spain). During the closing ceremony, the EWGAE community still remembers and appreciates its brilliant speech about the first days of this group, when ESWEWG was founded as the predecessor of EWGAE. Thank you for the pleasant speech delivered at the closing ceremony of EWGAE-30 in Granada! This speech, promoted by Mr. Hartmut Vallen, Chairman of EWGAE in 2012, and Mr. Antolino Gallego, Chairman of Conference, included a great surprise when Mr. Vallen received from the hands of Dr. Pollock the original tape and 5 CDs with the records of the speeches of the Inaugural ESWEWG Meeting from the 29th to the 30th. November 1972. The CDs are in good condition and safe as a symbol of his enormous legacy.

In homage to Dr. Adrian A. Pollock

Friend and mentor, a great man, a teacher of thousands, and a beloved member of the AE community worldwide

One of the main founders of our european organization EWGAE

Commitees

Local organizing committee

C. Hervé *(Cetim)*
C. Cardoen *(Cetim)*
M. Cherfaoui *(Cetim / Cofrend)*
F. Dubreuil *(Cetim)*
E. Melin *(Cetim)*
F. Kervendal *(Cetim)*

Scientific committee

D. Aggelis *(Greece)*
A. Anastasopoulos *(Greece)*
P. Benes *(Czech Rep.)*
J. Bohse *(Germany)*
I. Baran *(Poland)*
A. Brunner *(Switzerland)*
M. Chlada *(Czech Rep.)*
M. Cherfaoui *(France)*
M. Enoki *(Japan)*
C. Di Fratta *(Italy)*
S. Elizarov *(Russia)*
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C. Grosse *(Germany)*
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B. Reuben *(UK)*
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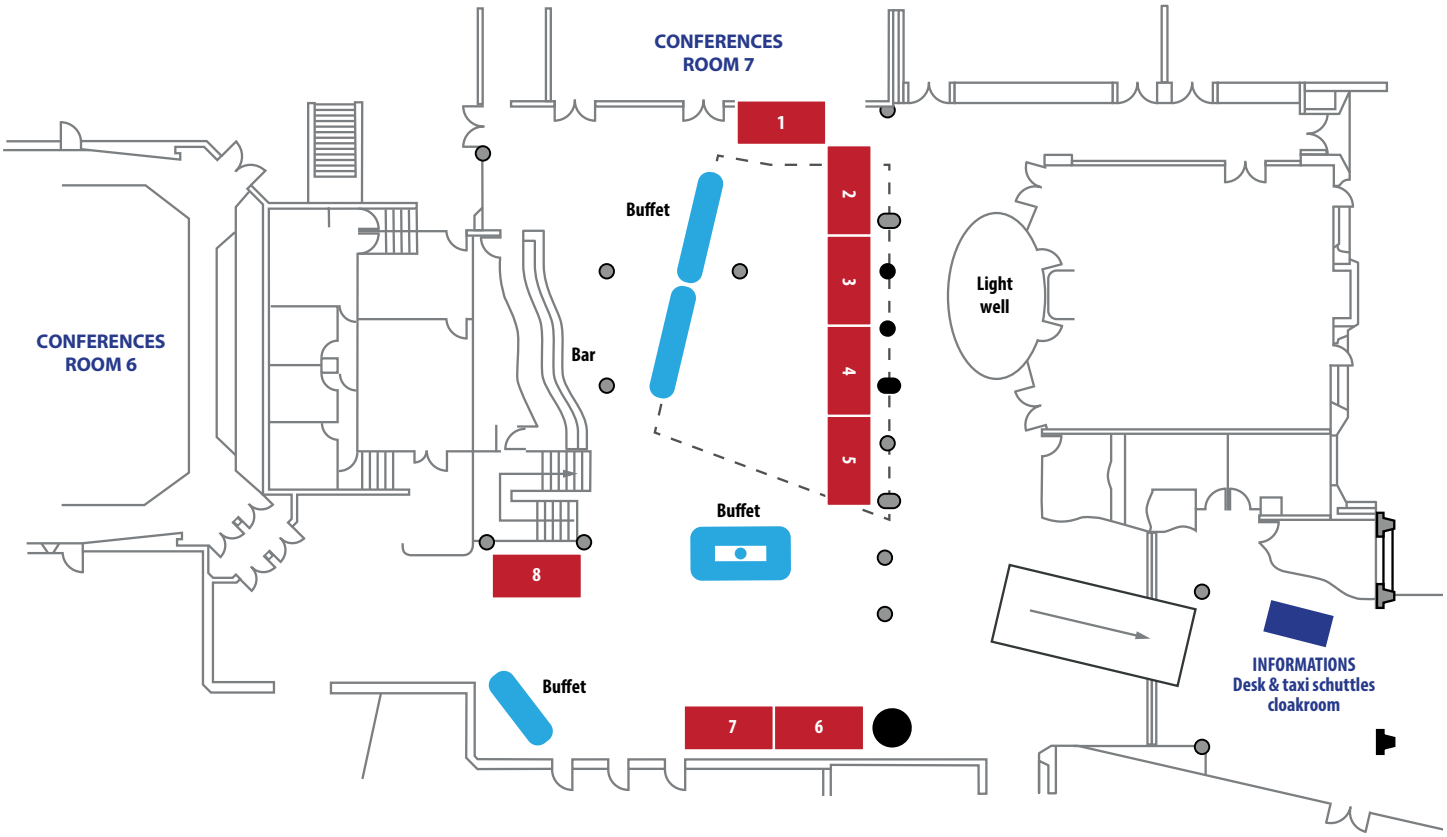
T. Shiotani *(Japan)*
E. Suárez *(Spain)*
T. Thenikl *(Germany)*
P. Theobald *(UK)*
P. Tscheliesnig *(Austria)*
H. Vallen *(Germany)*
E. Verstrynge *(Belgium)*
A. Vinogradov *(Russia)*
S. Wakayama *(Japan)*
M. Wevers *(Belgium)*
Y. Yoshida *(Japan)*

Event Map



1	MISTRAS	4	DEWESOFT	7	ACTEMIUM NDT
2	QINGCHENG AE INSTITUTE	5	INTERUNIS - IT	8	CETIM
3	DIGITAL WAVE CORPORATION	6	VALLEN		

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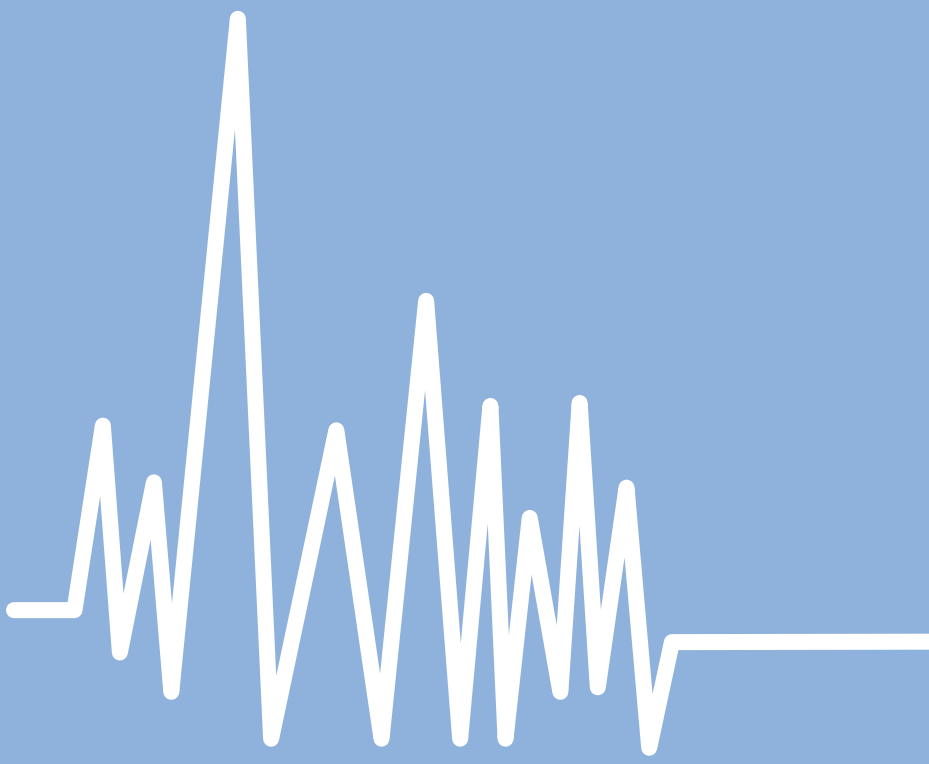
Signal processing - Equipment and Software III

Civil Engineering

Source Location

Keynotes

Room 6
Time: 10:00 - 11:00
Date: 12th September 2018



42 - Acoustic Emission method at the integrated structural health monitoring systems - the past, the present, the future

Igor Razuvaev

Alcor Corp., Dzerzhinsk, Russian Federation

Abstract

In the report the review of application of method AE for monitoring of technical condition dangerous plants in nuclear power, chemical and a petroleum-refining industry is made. The basic directions of development the AE method in monitoring - sensors on another physical principles, wireless systems, application of the Big Data are considered.

86 - Acoustic Emission work over the last 10 years and relationship with Industry 4.0

Mohammed Cherfaoui

Cetim, Senlis, France

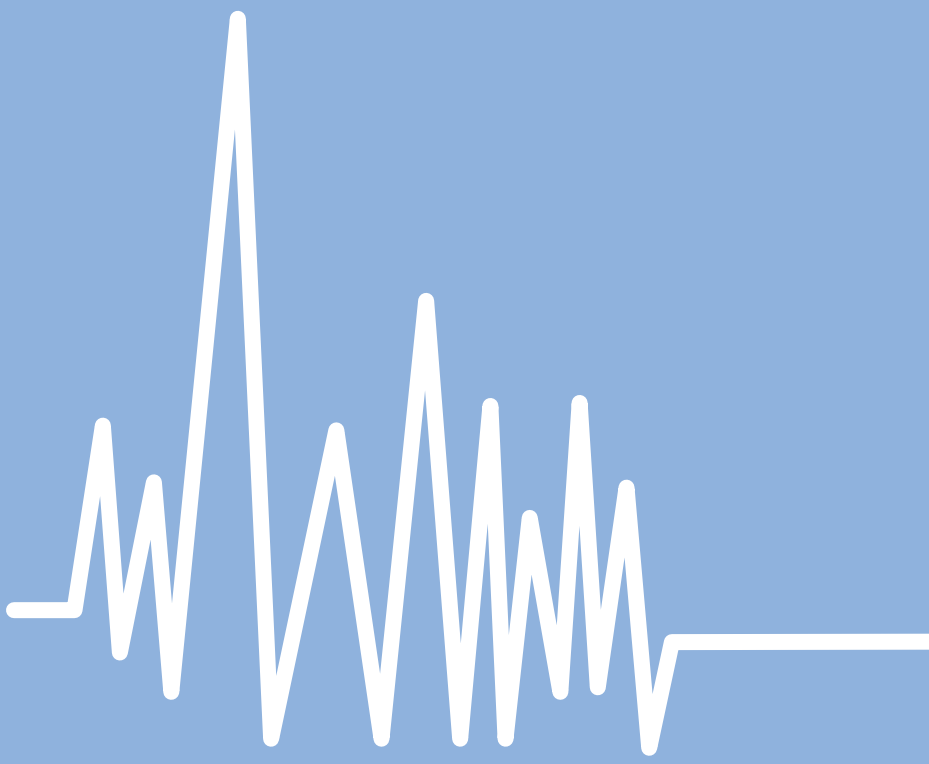
Abstract

In this presentation we analyze publications at the international level. The presentations are analyzed in relation to the themes and technologies recommended in industry 4.0, or industry of the future in France. The methodology followed relate to the following themes: Big Data, artificial intelligence, sensor, signal processing, maintenance...

A more specific analysis will be carried out at European level: actors and origins of publications...

Poster Session
Short Presentation

Room 6
Time: 11:20 - 12:20
Date: 12th September 2018



16 - Acoustic Emission energy for condition monitoring of RC waffle slab structures subjected to bidirectional ground seismic motions

Chihab Abarkane[1], Elisabet Suárez[1], Francisco Rescalvo[1], Amadeo Benavent-Climent[2], Antolino Gallego[1]

[1]Universidad de Granada, Spain. [2]Universidad Politécnica de Madrid, Spain

Abstract

The present work deals with monitoring of reinforced concrete (RC) structures by means of the acoustic emission method, when they are subjected to bidirectional seismic simulations (X-Y) with a shaking table.

The RC specimens consisted in three columns connected to a 3x3m^2 waffle slab. Two specimens were tested without hysteretic dampers, while one of them had six hysteretic dampers (three at the ground floor and three at the first floor). A proper filtering process of AE signals was conducted to avoid the influence of secondary source mechanisms like friction. After that, the accumulated energy of AE signals was successfully compared with the plastic strain energy released by concrete cracking of the specimen.

The AE location analysis shows a concentration of activity and intensity at the bottom of columns and the waffle slab-column connections.

This result is in good agreement with the damage observed by visual inspection. Moreover, the AE analysis shows that higher activity occurs when the maximum velocity of the ground motion is reached, instead of the acceleration.

20 - Characterization of failure mechanisms in the wood-CFRP interface by means of Acoustic Emission during pull-off tests

Francisco J. Rescalvo, Antonio Aguilar-Aguilera, Chihab Abarkane, Elísabet Suárez, Antolino Gallego

University of Granada, Spain

Abstract

Reinforcement of timber elements has been traditionally performed with metals, which leads to an increase of structural weight along with other adaptability and durability limitations. More recently, some innovative solutions using carbon-fiber composite (CFRP) as reinforcement are become more popular due to its low weight and high strength. One of the major shortcomings of this solution is the lack of knowledge about the physical behavior of the wood-resin-CFRP system, which is of great importance in order to guarantee the stress transmission between both materials and avoid delamination.

In this context, the paper presents the results of a large amount of types of CFRP and resins applied on old timber specimens extracted during rehabilitation process of a historical building of the University of Granada, subjected to the adherence pull-off test.

Tests were continuously monitored by a multi-resonant acoustic emission (AE) sensor, while ulterior AE data analysis involved the filtering of AE signals with the root-mean square of the waveforms, and damage mechanisms characterization with its spectral ratio calculated on the main resonances of the sensor. Results prove that this evaluation is able to distinguish between the failure of the wood base-element and the failure between the layers of the wood-resin-CFRP system.

28 - Features of Acoustic Emission in double-walled elements of vessels pressure in the presence of cracks

Igor Rastegaev[1], **Alexey Chugunov**[2]

[1]Togliatty State University, Russian Federation. [2]Profil' Ltd, Togliatty, Russian Federation

Abstract

We discuss the ability to detect the cracks in the elements of the double-walled pressure vessels, using the acoustic emission (AE) method based on practical results obtained during integrity testing of the reactor for hydrotreatment of diesel fuel with a crack in the sleeve of the connecting pipe.

Possible AE sources are analyzed on the basis of comparison of the stress-strain state of the reactor containing the crack in the sleeve with AE data coupled with additional information obtained by other nondestructive testing (NDT) methods. It is found that the crack could be detected only by considering fine AE features, which are not considered in the standard AE practice. It is shown that the fluid flow through the crack reveals itself in the form of AE with the approximately constant amplitude level and with duration that increases with pressure.

The issue concerning the lack of quantitative criteria for reliable identification of leaks with different intensity is discussed since it that does not allow using the AE technique alone without reference to independent NDT methods. The approaches and recommendations are proposed towards AE identification of leakage through the crack of subcritical (non-propagating). These approaches are discussed in detail.

37 - Multiparametrical big data processing for Acoustic monitoring

Alexey Samokhvalov

DIAPAC Ltd., Moscow, Russian Federation

Abstract

Acoustic monitoring is characterized by big data flow needing continuous analysis and automated processing. The information in acoustic-emission (AE) monitoring can be divided for primary (directly registered) and secondary (processed by algorithms).

The latter included AE location, spectral analysis, clustering etc. Algorithms have much influence on the composition and quality of secondary information. Two types of data centers could be distinguished: (1) acoustic system channels; (2) geometric locations. Due to continuance of AE monitoring it is reasonable to build geometrical models with fixed number of vertices ("mesh models"); vertices in model serve as centers of data accumulation. The greatest interest in monitoring is represented by historical graphs (time-bases series, trends).

The number of series is very large: large number of data centers multiplied by the number of analyzed parameters. Therefore, at AE monitoring it is necessary to review and analyze very large number of time-based series, consequently the problem of data visualization raises, which leads to the application of certain grouping methods (clustering). Our experience allowed select effective ways to build geometrical models of monitored objects, AE localization algorithms, clustering and data visualization for the purposes of AE monitoring.

44 - About new AE criteria of cracking in metal objects

Igor Razuvaev, Evgeny Suchkov
Alcor Corp., Dzerzhinsk, Russian Federation

Abstract

In the report it is discussed new AE criterion of an estimation of the intensity of cracking in the metal objects, based on the analysis of statistical distribution of the parameters of AE signal. Results of researches of behavior of this criterion on real industrial objects are shown.

46 - Damage detection for linear pneumatic actuators using Acoustic Emission

Houssam Mahmoud[1], Pavel Mazal[1], Frantisek Vlasic[2], Miroslav Jana[3]

[1]Brno University of Technology, Brno, Czech Republic. [2]Center of Technical Diagnostics DAKEL, Brno, Czech Republic. [3]Policske strojirny a.s., Policka, Czech Republic

Abstract

This paper presents criteria to find distinctive differences that determine whether the cylinder is damaged or undamaged using acoustic emission. The study concentrates on the analysis, investigation, performance, practical constraints, and the new applications of the pneumatic actuators.

Signal analysis sheds light on the relationship between root mean square (RMS) of acoustic emission signal, displacement and time to describe the movement of piston related with behaviour of the signal during progress and retreat strokes. The quality of the cylinder was determined by the calculation of the total value of RMS in different stages of the working cycle.

In particular, number of undamaged pneumatic cylinders were tested by acoustic emission, after that artificial defects were made in the same cylinders. Distinctive differences between damaged and undamaged cylinders were defined by the number and distribution of the counts, and comparing maximum signal between progress and retreat stroke. The obtained signals from two sensors and one sensor were compared.

47 - The parameters of Acoustic Emission signal proposed to identification of damaged and undamaged cylinders

Vladislav Richter, Houssam Mahmoud, Pavel Mazal, Vendula Kratochvilova

Brno University of Technology, Czech Republic

Abstract

This paper proposes the parameters that are used by acoustic emission to define damaged and undamaged cylinders. The main aim of the paper is to supplement the already approved methodology for damage identification of pneumatic cylinders by other type of cylinders. Pneumatic cylinders can be diagnosed using acoustic emission method due to a different response to different types of artificially created defects. Acoustic emission sensors are very sensitive to any change in the measurement configuration. Therefore, it is important to find appropriate acoustic emission signal parameters that are least affected by the above effects.

The most frequently evaluated signal parameters are root mean square (RMS) of acoustic emission signal over time. Due to the high sensitivity of acoustic emission method, it is possible to describe the differences in responses of intact cylinder and cylinders with artificially created defect. Similarly, signal development can be monitored with increasing number of monitored cylinder cycles. These observations confirm that acoustic emission method can be used to identify damage on pneumatic cylinder.

58 - Identification of damages in composite materials during registration of Acoustic Emission signals by piezoelectric and fiber-optic sensors

Oleg Bashkov, Ilya Bashkov, Anton Bryansky, Tatiana Bashkova

Komsomolsk-on-Amur State University, Russian Federation

Abstract

The criteria for the destruction of composites are not fully understood. When evaluating the damage, it is important to determine the type of failure. For the analysis, such parameters of acoustic emission (AE) as amplitude, frequency, energy and others are used. When operating an object, it is important to know the moment of occurrence of a certain type of failure under unknown load. For this it is necessary to use two or more AE parameters.

The second problem is that the signals recorded by the new type of distributed fiber optic sensors differ in different parameters from the signals detected by the piezoelectric sensors.

The work is devoted to the analysis of AE signals recorded by fiber-optic sensors in polymer composite materials.

As a result of the study were analyzed AE signals from various sources (destruction of fibers, binder). We used for analysis the separation of AE signals into frequency components by wavelet transform.

It was determined that to evaluate various types of damage can be used amplitude, energy and frequency parameters of AE signals. When evaluating the parameters of AE signals, it is necessary to take into account the distributed and local character of the arrangement of fiber optic and piezoelectric sensors, respectively. The length of fiber-optic sensors requires a separate approach for the correct location and identification of sources at the monitoring site.

This work was supported by the Russian Scientific Foundation, project no. 16-19-10149.

62 - FEM based simulation of Acoustic Emission monitoring on oil offshore pipelines

Héctor Calás, José Manuel Martin, Miguel Pelaez, Elena Cabellos

Tecnatom, Madrid, Spain

Abstract

Deep-sea leaks still raise concerns in the oil and gas industry, given that, unrelated to leak severity and its associated economic impact, this also carries a social worrying environmental impact hard to quantify in economic terms. One of the main goals in offshore pipeline monitoring is small and medium scale leakage early detection repairs, leading to maintenance smart scheduling.

Acoustic emission (AE) testing is deemed as one of the strongest contenders in the field of NDT (Non-Destructive Testing) for continuous monitoring on this kind of pipelines. Its implementation can be cost-efficient, with a detection reach between local and global scale, providing precise localization of existing leaks, as well as other critical locations that might be further examined using other local NDT techniques.

In this work, we introduce various Finite Element Method (FEM) based models to simulate acoustic emission sources in an offshore pipeline, considering useful approximations to physical constraints and operating conditions. The model is used to determine relevant frequency range and noise sources impact in that range, asserting monitorization viability. In addition to that, we present the required specifications for a monitorization system in offshore pipelines, including sensorization, conditioning, digitalization, storage and data post-processing.

Towards critical point identification, we analyze AE events being broadcasted along the pipe structure, meanwhile for alarm triggering on existing leaks. We also analyze waves propagating through the fluid, employing advanced de-noising techniques through transformation, leakage localization and AE source clusterization by machine learning techniques.

74 - In-situ control of additive manufacturing process by Acoustic Emission

Guillaume Perrin[1], Jonathan Frechard[2], Philippe Verlet[3], Christophe Grosjean[4], Daniel Maisonnette[4], Julien Delgado[1], Fan Zhang[1]

[1]Cetim, Senlis, France. [2]BeAM Machines, Strasbourg, France. [3]VLM Robotics, Mios, France.
[4]Cetim, Saint Etienne, France

Abstract

Considering the rapid growth of attention and investments around additive manufacturing (AM), organizations have highlighted a significant barrier to a wider deployment of this manufacturing technology, namely the lack on controls and patches during processing of industrial pieces.

This problematic is here treated through the "I AM SURE" FUI project led by BeAM, with the support of industrial partners (AIRBUS, NAVAL GROUP, THALES), SMEs (VLM, POLYSHAPE), the French Rapid Prototyping Association (AFPR) and R&D laboratories, including CETIM, CEA-LIST and LNE.

A state-of-the-art of promising in-situ NDT technics is provided in this paper, the main one being acoustic emission (AE). Extensive tests have been performed more particularly on Laser Metal Deposition (LMD) machines to determine the adaptability of this testing to harsh environments and intense background noises generated by the process.

Main results and innovations are presented here, including contact and contactless instrumentations, multi-technics correlation, defects identification and localization, monitoring of the process drifts and tracks for a possible feedback system on LMD machines. It is concluded on the promising results arising from these preliminary developments. Implications for the control of real industrial cases are discussed.

89 - Features of Acoustic Emission in double-walled elements of vessels pressure in the presence of cracks

Igor Rastegaev[1], **Alexey Chugunov**[2]

[1]Togliatti State University Russian Federation. [2]Profil' LTD, Togliatti, Russian Federation

Abstract

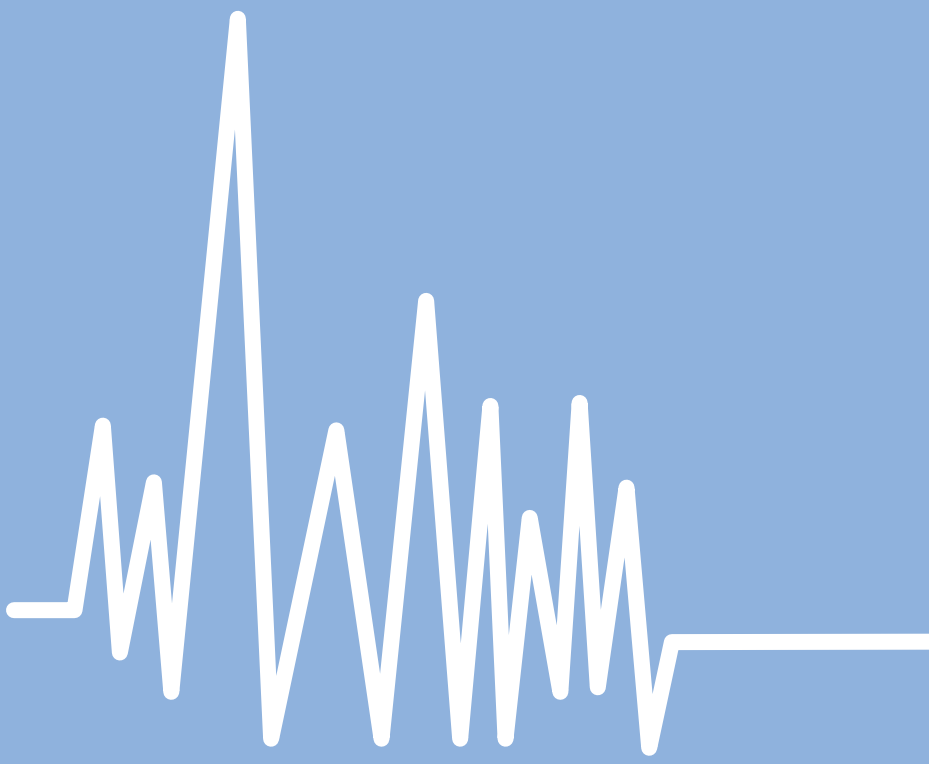
We discuss the ability to detect the cracks in the elements of the double-walled pressure vessels, using the acoustic emission (AE) method based on practical results obtained during integrity testing of the reactor for hydrotreatment of diesel fuel with a crack in the sleeve of the connecting pipe.

Possible AE sources are analyzed on the basis of comparison of the stress-strain state of the reactor containing the crack in the sleeve with AE data coupled with additional information obtained by other nondestructive testing (NDT) methods. It is found that the crack could be detected only by considering fine AE features, which are not considered in the standard AE practice.

It is shown that the fluid flow through the crack reveals itself in the form of AE with the approximately constant amplitude level and with duration that increases with pressure. The issue concerning the lack of quantitative criteria for reliable identification of leaks with different intensity is discussed since it that does not allow using the AE technique alone without reference to independent NDT methods. The approaches and recommendations are proposed towards AE identification of leakage through the crack of subcritical (non-propagating). These approaches are discussed in detail.

Monitoring in process

Room 6
Time: 13:40 - 15:20
Date: 12th September 2018



19 - Combination of vibration analysis & Acoustic Emission measurements to better characterize damage and mechanical behavior of aerospace high speed gear box

Yoann Hebrard[1], **Alain Proust**[2], **Mehdi Batel**[2]

[1]SKF, Valence, France. [2]Mistras Group, Sucy en Brie, France

Abstract

The aerospace industry focus on a low-emission and quite air traffic, and on the conservation of natural resources and our environment. The end-use consumer and environmental policy requirements for aircrafts of the next generation translate into components with higher temperature and speed. Furthermore, new instrumentation technics are needed to closely monitor rolling contact during testing of the next generation of aero engine bearing to check its behavior under the new application condition.

Vibration analysis for condition assessment and fault diagnostics is widely used nevertheless interpretation and correlation of collected data is often cumbersome. That is why combination of both techniques giving different types information in two different frequency band can help to understand the behavior of new gear box. This study propose a correlation between low and high frequency signals with different strategy of signal acquisition a processing.

Real time transient analysis with feature extraction can be done in parallel with streaming acquisition. Then pattern recognition of individual AE signal is possible and can be correlated with more traditional analysis based on "multiple chocks" vibration analysis.

Continuous monitoring of and aging gear box is giving genuine information on no stationary regime and also time of stabilization. Long term experiment are conducted on damaged and defect free gear boxes at several rotating speed and loading level.

79 - Advanced condition monitoring system using Acoustic Emission and vibration analysis technique

Dong-Hyun Kim

Rectuson, Co., LTD., Chang Won, Korea

Abstract

Condition Monitoring System for rotating machinery with accelerometer is widely used in industrial field. This system has within 10 kHz feature frequency and it have limitation for early fault detection.
This technique can simultaneously provide not only applicable to middle or high speed rotating machines range from 20kHz to 200kHz, but also applicable to low speed, heavy duty rotating machines range from 2Hz to 20kHz like bearing and gear. Acoustic emission technique is higher sensitivity than vibration when AE sensor is far away from object.

Especially, acoustic emission can also be used for monitoring crack propagation, lack of lubrication, bad sealing, and impact signal like spalling of bearing or gear, so this can be available predictive maintenance.

35 - Acoustic Emission for *in situ* monitoring of laser processing

Sergey shevchik, Tri Le Quang, Bastian Meylan, Kilian Wasmer
EMPA, Thun, Switzerland

Abstract

Laser processing is an important technology in industrial manufacture. Today, a standard quality monitoring of the processed workpieces mainly relies on costly X-ray or time consuming post mortem methods. The commercially available *in situ* and real-time monitoring units are also accessible and rely on optical measurements or high resolution imaging of the process zone. Unfortunately, their performance is greatly affected by the plume, formed during the overheating of the material. This limits the detection of defects (e.g. pores) formed inside the workpiece.

To bypass the aforementioned limits, we focus on acoustic measurements that are the derivatives of the shockwaves, generated inside the workpiece directly during processing. The measurements are conducted using a high sensitive piezo sensor. The acoustic signals are analysed further by state-of-the-art signal processing. This included a compartment of wavelets and Fourier decompositions, followed by machine learning. The developed methodology is realized in a hardware unit that operates in pseudo real-time. The unit was tested on real welds with various materials.

The welding experiments were performed using spot weld, Stepless High-speed Accurate and Discrete One-pulse Weld (SHADOW). The tests were carried out at different laser powers that are closely related to the weld quality. The *in situ* quality control unit demonstrated the capability to classify the weld quality with a confidence level ranged between 82% and 95%. Due to the similar light-matter interaction phenomena, the presented approach and apparatus can also be applied for monitoring other laser-processing technologies, namely: ablation, cutting, drilling and additive manufacturing.

72 - Monitoring of stamping by Acoustic Emission (AE)

Abdelkrim Saidoun, Catherine Hervé

Cetim, Senlis, France

Abstract

The optimization of the shaping processes (stamping, fast cutting, forming, spot welding, machining ...) and the quality of the production are very important in the field of industry. CETIM has been increasingly asked to propose solutions to improve the quality of production while not slowing it down. In this context, MOST "Monitoring of Stamping" has been developed, an online acoustic emission control system that guarantees the quality of production in real time.

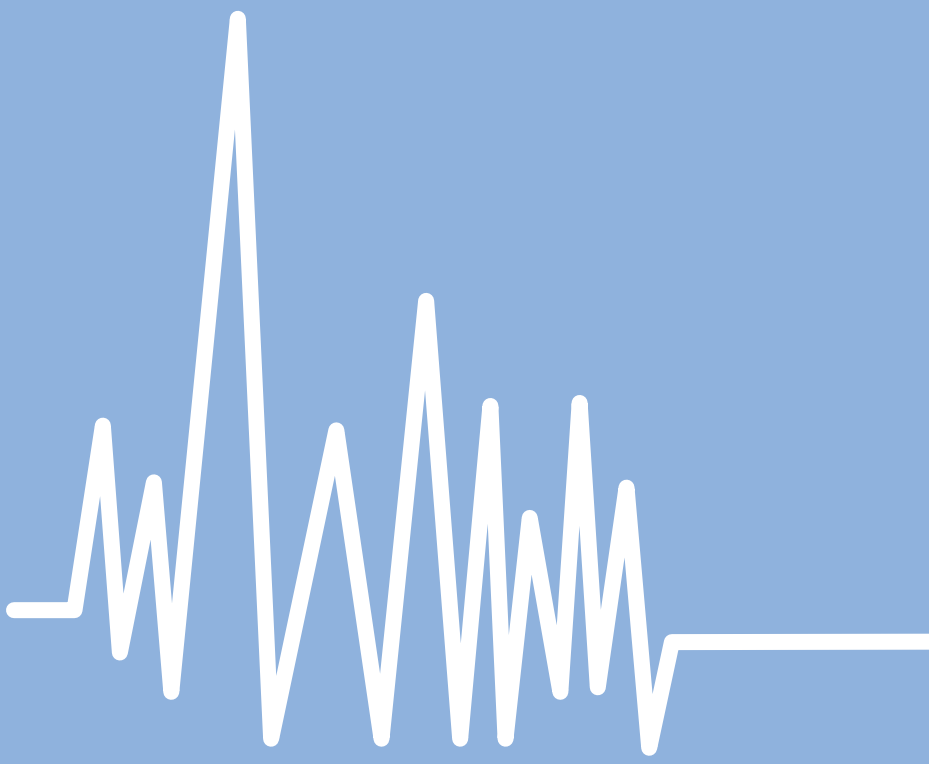
The main defects that occurred during the stamping process are the sheet tears. In order to test the reliability of the MOST system for the detection of this type of defect, various feasibility tests have been carried out on the presses of industrial stamping.

As a first step, MOST has been tested on various types of representative defects that have been created voluntarily by manufacturers (either by stopping lubrication or by changing the depth punch / mesh …). All of these defects have been detected by MOST in real time.

The next step consists on a long-term test, in order to check the performances of MOST under the real conditions of a stamping process.

Advanced Composites - I

Room 7
Time: 13:40 - 15:20
Date: 12th September 2018



06 - Modelling of fiber break as Acoustic Emission Source in SFFT: comparison with experimental results

Zeina Hamam[1], Nathalie Godin[1], Claudio Fusco[1], Thomas Monnier[2]

[1]Univ Lyon, INSA de Lyon, MATEIS UMR 5510, F-69621, Villeurbanne, France.
[2]Univ Lyon, INSA de Lyon, LVA EA677, F-69621, Villeurbanne, France

Abstract

The objective of this work is to build a quantitative relationship between the fiber break as source of Acoustic Emission (AE) and the detected signal by unravelling the effect of each stage of the AE acquisition chain. For this purpose, an AE modelling is carried out using the Finite Element Method and then the simulation is compared to experimental results of Single Fiber Fragmentation Test (SFFT).

The SFFT is used in order to produce preferential fiber break. It is carried out on dogbone shape specimens made from epoxy/amine matrix and a long carbon fiber T700 embedded in this resin. Two different types of transducer are used in order to gather information on a wider frequency bandwidth. The analysis of detected signals shows an important dependency of distance between transducer and source on the frequency content of signals. In this case, high frequency content for the signal associated to fiber breakage is not validated for all signals.

For the modeling part, the entire geometry of the specimen is modelled. The geometry is subjected to a tensile loading. The fiber breakage occurs by separating the nodes forming fracture faces. The numerical out-of-plane velocities are collected on the specimen surface. The sensor is taken into account by its transfer function, which is experimentally determined by the reciprocity method. After being validated, the FE model is used to study the effects of different parameters on the signal, such as specimen geometry, the propagation medium and the location of the failure.

14 - Acoustic Emission monitoring of adhesively bonded wood joints under quasistatic and cyclic fatigue mode II flexure loads using end-notch-flexure specimens

Andreas J. Brunner[1], **Gaspard Clerc**[2], **Peter Niemz**[2]

[1]Empa, Dübendorf, Switzerland. [2]BFH, Bern University of Applied Sciences, Biel/Bienne, Switzerland

Abstract

Adhesive bonding is becoming more and more important for manufacturing structures made from wood. For designing such structures, the performance of adhesives has to be evaluated under quasi-static and cyclic fatigue loading as well as under corresponding fracture loads. The performance of wood glued beams under quasi-static loading is fairly well understood, but their cyclic fracture behavior remains still largely unknown.
There are indications from standard tensile shear tests with several types of adhesive that the performance ranking of adhesives under cyclic fatigue loading may differ compared with that observed in the same test under quasi-static loads. Hence, it is of interest whether this is also the case for quasi-static and cyclic fatigue mode II shear fracture. For the mode II shear fracture tests, adhesively bonded joints with wood adherends are prepared with two different adhesives.

A rather brittle (phenol resorcinol formaldehyde) and a rather ductile (one component polyurethane) system are compared for their performance under quasi-static and cyclic fatigue mode II shear fracture loads. For the fracture tests a set-up with four-point end notched flexure specimens is being used, analogous to testing of adhesively bonded polymer composites joints and polymer composite laminates.

Selected fracture tests were monitored by acoustic emission for assessing damage evolution due to the mode II in-plane shear fracture loads. The acoustic emission monitoring initially contributed to identifying shortcomings of a first test set-up. The discussion will focus on the comparison between two different types of adhesive and between quasi-static and cyclic fatigue fracture loads.

17 - Acoustic Emission analysis during bending tests of timber beams reinforced with carbon fiber composite

Francisco Rescalvo, Chihab Abarkane, Elísabet Suárez, Antolino Gallego

University of Granada, Spain

Abstract

This paper proposes the monitoring of old timber beams with natural defects (knots, grain deviations, fissures and wanes), reinforced with carbon composite materials (CFRP). Reinforcement consisted of the combination of a CFRP laminate strip and a CFRP fabric discontinuously wrapping the timber element.

Monitoring considered the use and comparison of two types of sensors: strain gauges and multi-resonant acoustic emission (AE) sensors. AE data analysis propose two main steps: 1) A filtering of signals based on the root mean squared of the waveforms; 2) The use of partial spectral ratio corrected by the attenuation characteristics of the material, to identify damage mechanisms.

Results demonstrate that: 1) the mechanical behaviour of the beams can be considerably improved by means of the use of CFRP (160% in bending load capacity and 90% in stiffness; 2) Acoustic emission sensors provide valuable information for damage assessment and its location during operation in real wood structures.

23 - Frequency-Amplitude class of Acoustic Emission for different fracture mechanisms in C/SiC composite

Denghong Xiao[1], Yong Gao[1,2], Liang Jin[1], Fanchao Meng[1], Naitian Li[1], Xiaohong Zhou[1], Zongkai Tong[1], Bo Jiang[3], Tian He[2]

[1]Beijing Electro-Mechanical Engineering Institute, Beijing, China.
[2]Beihang University, Beijing, China. 3Shenyang Aerospace Xinguang Group Co., LTD, Shenyang, China

Abstract

Acoustic emission (AE) registration is a useful methodology, which allows "hearing" and registering damage during loading of a specimen or a part. It is a challenge to determine connection between acoustic emission (AE) events and the corresponding damage modes. In the present study AE events registered during static loading of a C/SiC laminate are correlated to actual damage. The friction and cracks in the C/SiC laminate and localized delimitations are distinguished.

AE events are classified according to the amplitude and centroid frequency of the signal into high frequency ,low frequency – low amplitude and low frequency – high amplitude clusters. The first (high frequency) AE events are assumed to be connected to friction. The second (low frequency – low amplitude) are assumed to be connected to formation and propagation of cracks, and the later (low frequency – high amplitude) are assumed to be connected to fiber breakage.

The study validates use of Frequency-Amplitude class of AE for identification of damage models in C/SiC laminates and find out the load when each damage model first emerge.

24 - Mechanical behavior and Acoustic Emission technique for detecting damage in C/SiC structure

Yong Gao[1,2], **Liang Jin**[1], **Bo Jiang**[3], **Zongkai Tong**[1], **Denghong Xiao**[1], **Xiaohong Zhou**[1], **Naitian Li**[1], **Fanchao Meng**[1]

[1]Beijing Electro-Mechanical Engineering Institute, Beijing, China. [2]Beihang University, Beijing, China. [3]Shenyang Aerospace Xinguang Group Co., LTD, Shenyang, China

Abstract

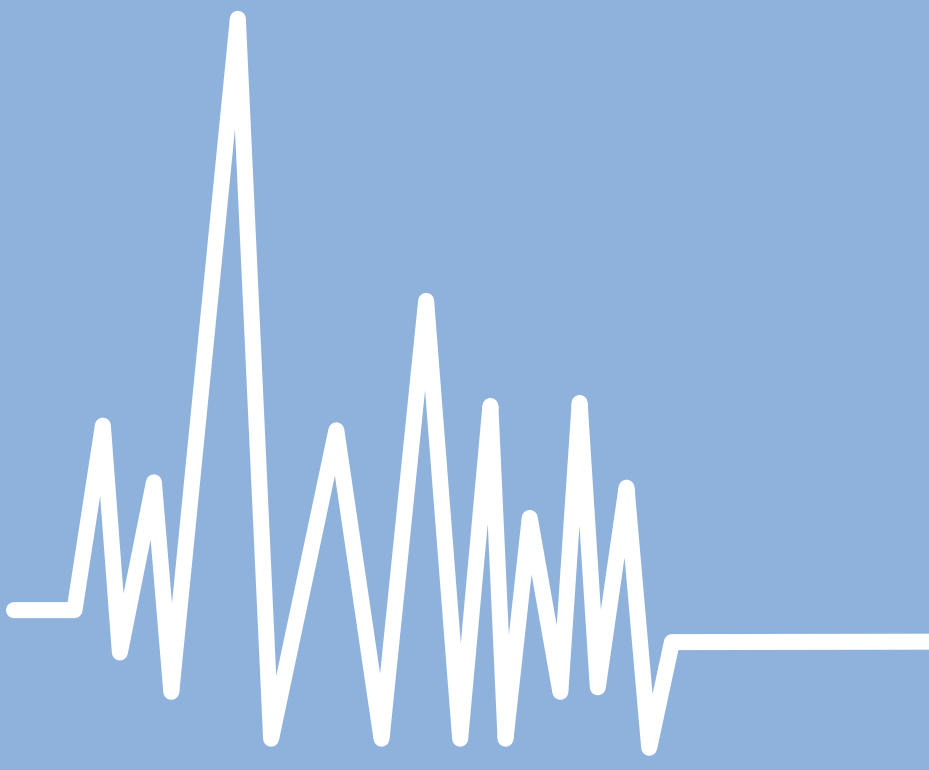
The present study investigates the mechanical behavior under static loading and assesses damage by the acoustic emission method of a C/SiC composite material. Acoustic emission signals in C/SiC structure can be used for monitoring the state of item in the loading.

The recorded signal includes information which can be associated with different events, such as the formation and propagation of cracks, appearance of cracks and so on. One of the major challenges in analyzing these acoustic emission signals is to identify parts of the signal which belong to such an event and discern it from noise. In this contribution, a wavelet packet decomposition within the framework of multiresolution analysis theory is considered to analyze acoustic emission signals to investigate the failure of C/SiC structure.

By applying the wavelet packet transform a method for the extraction of single events in static loading test is proposed. The extraction of such events at several stages of the test permits a classifica-tion and the analysis of the evolution of cracks in the C/SiC structure.

Monitoring metallic structures

Room 6
Time: 15:40 - 17:40
Date: 12th September 2018



27 - Study of a steel railway bridge with defects under various load conditions

Maren Nowak[1], **Igor Lyasota**[2], **Ireneusz Baran**[1]

[1]Office of Technical Inspection, Cracow, Poland. [2]Cracow University of Technology, Poland

Abstract

The railway steel bridges in Poland are tested mostly by visual diagnosis and after that by other NDT method. One of useful NDT method for evaluation of large structures with defects is acoustic emission method. For the correct uses of it, it is important to determine the method of the analysis, the AE criteria and the relationship between the condition and the activity of the failure with the conditions and values of the operational load of the bridge structure. For this purpose the project funded by National Centre for Research and Development was realized by specialists from different companies.

During project realization, the tests on railway steel bridges for collection of AE data were performed and also other methods were used.

The some of tests were carried out at a controlled moving train at different speeds but some of that during normal bridge operation.

In this paper the results of AE test and analysis with standard and additional parameters and also other results like videos and metallography with use of portable equipment will be presented.

29 - Damage monitoring on a steel truck trailer using parameter-based analysis of Acoustic Emissions

Joao Vitor Pimentel[1], Rolf Klemm[1], Munip Dalgic[2], Andree Irretier[2], Karl-Ludwig Krieger[1]

[1]University of Bremen, Institute of Electrodynamics and Microelectronics (ITEM), Germany.
[2]Leibniz Institute for Materials Engineering (IWT), Bremen, Germany

Abstract

The structural health of a solid body can be monitored by detecting acoustic emissions (AE) that indicate the occurrence and propagation of fractures. Continuous monitoring is possible with vibroacoustic sensors that generate electric signals in response to structure-borne sound. However, damage detection and identification in real time imposes performance challenges on the sensor system that must be solved so that the sensor system can acquire and process the signal of interest.

In this work, piezoelectric sensors were connected to the prototyping unit MicroLabBox (dSPACE) to continuously monitor a steel trailer structure subjected to fatigue tests. From previous tests on sample structures, signals in a frequency region around 500 kHz were expected to be associated with the emergence of cracks. At the required sampling frequencies, it was not possible to record, display or transmit the measurement data for external or post-processing. A parametric analysis was therefore carried out, whereby the vibrations were processed in 5-ms bursts. In such an implementation, the raw measured data is never made available. It could nevertheless be processed in real-time in order to calculate parameters that allowed damage monitoring. If the first signal processing stage detected a possible AE, further parameters were calculated to classify the event.

The paper describes the parametric analysis used for online monitoring of the structure under test. The hardware implementation of the sensor system is described and results are compared with post-processed results of raw data to validate the online analysis.

31 - Data processing and interpretation at AE monitoring

Tatiana Petersen, Alexey Samokhvalov, Wenceslaus Chernigovski, Dmitry Kurnosov

DIAPAC Ltd., Moscow, Russian Federation

Abstract

One of the characteristic features of AE monitoring in comparison with laboratory or field testing is the presence of plurality of additional acoustic sources of transient signals. These signals can relate not necessarily to interferences but to "useful" sources, as well, or be a determinate noise, carrying relevant information on processes occurring in the object.

Therefore, one of the objectives was to extract all available information stored in the data and use it for the purposes of integrity and condition monitoring. The monitored objects are chemical reactors of polypropylene (PP) production whose main failure risk is caused by the following mechanisms: loss of functionality of auxiliary mechanisms and formation of PP agglomerates. Accordingly, in addition to a common AE approach, the analysis was performed of both continuous background noise occurring from mixing of microscopic PP particles and impulse interferences caused by impacts of oversize agglomerates. The study included spectral and correlation analysis, digital filtering and modeling. In particular, AE technique was developed that allows the extraction of very low modulation frequencies, responsible for breaking of rotating parts from the noise.

Another processing procedure was designed to detect the beginning of agglomeration. It includes analysis of signal internal structure, in particular, the analysis of sample distribution function within the frame of a single/several waveform. The results obtained by simultaneous noise diagnostics and traditional AE monitoring using the same data acquisition channels show the advantages of the proposed general-purpose approach and directions for future research in the field of AE monitoring.

49 - Structural health monitoring using Acoustic Emission on metallic components in industrial plants

Gerald Lackner, Heribert Marihart, Gert Schauritsch

TÜV Austria, Vienna, Austria

Abstract

Structural health monitoring (SHM) is a method to safeguard the integrity of metallic components or component assemblies during service. This process involves a continuous or periodic measurement, the extraction or selection of degradation-relevant data and the statistical analysis to determine the actual state of the system condition. Acoustic emission (AE) monitoring detects and locates potential defects in plant components like piping and pressure vessels. An essential advantage of acoustic emission is that it allows assessing the components regarding evolving defects, leaks or even active corrosion during operation. Therefore, acoustic emission qualifies excellently as a tool for structural health monitoring.

The sensors of the monitoring system have to be mounted at preselected positions of the metallic structure and a tailored data analysis programme evaluates the incoming signals to provide a reliable statement regarding the structural health. Individually designed alarm and warning criteria enable corrective actions to prevent that the observed degradation evolves to failure.

In order to meet the requirements of customers from the oil and gas industry or the energy generation industry, TÜV AUSTRIA developed a monitoring technique for hot and cold surfaces including a methodology for collecting, transferring, storing and evaluating the measuring data.

This paper contains case studies where structural health monitoring with acoustic emission is used to provide an alternative to the regular requalification procedure of the monitored metallic pressure equipment.

51 - Acoustic Emission Testing on a rail bridge

Heribert Marihart, Gerald Lackner, Michael Posch
TÜV Austria, Vienna, Austria

Abstract

Acoustic Emission Testing (AT) is used to safeguard the integrity of metallic components of rail bridges during operation. The test procedure involves a continuous or intermittent measurement, the selection or extraction of relevant data including system-specific parameters and their statistical analysis to determine the actual state of the considered rail infrastructure. Acoustic emission (AE) monitoring detects and locates potential defects on rail bridges like active crack propagation or friction processes. A crucial benefit of acoustic emission is that it allows assessing the bridge components regarding evolving defects, active cracks during dynamical train crossings. Therefore, acoustic emission qualifies excellently as tool for online bridge monitoring.

The sensors of the monitoring system have to be mounted at preselected positions of the metallic structure of the defined bridge components and consequently tailored data analysis software evaluates the incoming signals to provide a reliable statement regarding their current state. Additional data, like strain measurements or information about train length or total weight could be used to estimate the temporal damage potential of the observed or measured operation conditions.

The results of acoustic emission testing can be additionally used to estimate repairs and / or modifications of load-bearing components regarding their lifetime.

This paper presents a case study of an online monitoring measurement of a rail bridge with acoustic emission to demonstrate the universal applicability of the technology.

83 - Novel AE monitoring of hydrogen induced damaged vessel and real time alarms. A case study

Dimitrios Papasalouros, Konstantinos Bollas, Ioannis Ladis, Eleftherios Aerakis, Athanasios Anastasopoulos, Dimitrios Kourousis

Mistras Group Hellas ABEE, Athens, Greece

Abstract

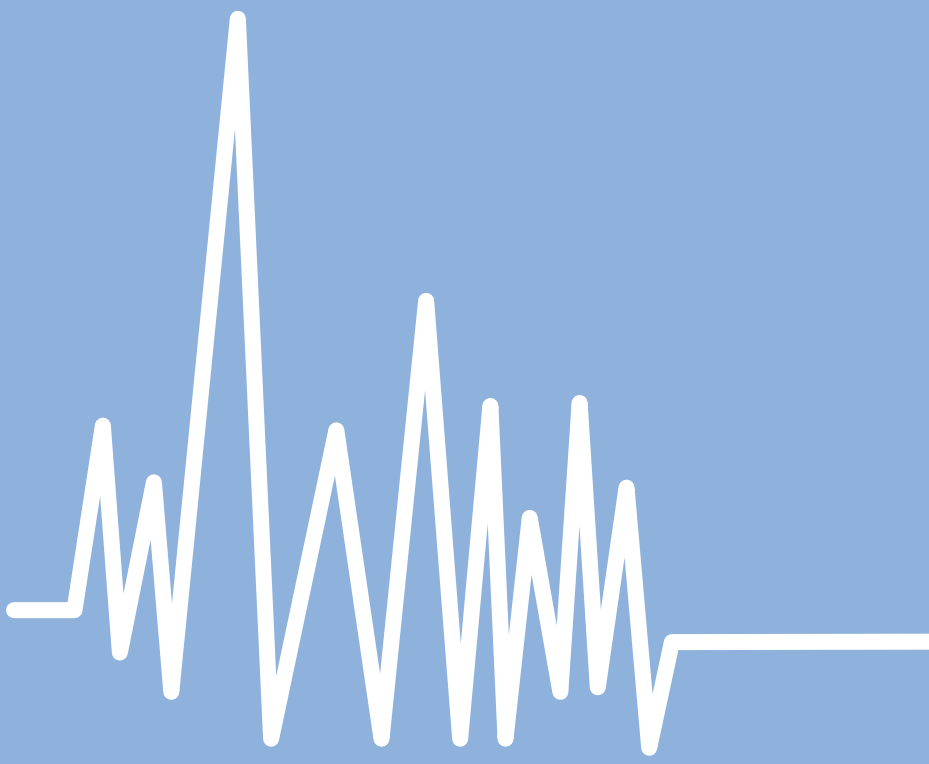
Hydrogen induced cracking (HIC) damage is a common damage mechanism, expected typically in vessels in severe wet H2S service. It can occur at relatively low temperatures, as the atomic hydrogen is concentrated at the impurities within the steel. The occurring damage is mostly cumulative and it can be manifested in various types such as blistering, step-wise cracking or stress-oriented cracking.

As such, the qualitative and quantitative evaluation of structural integrity of any vessel possibly suffering from wet hydrogen damage is of great concern from a safety, environmental and financial point of view. In the present paper, results of the application of real-time AE monitoring of a HIC damaged area of a thick-walled amine absorber in severe wet H2S service are presented. The damaged area was found during a routine UT inspection.

UT and AE trials were performed in order to fine-tune and maximize the effectiveness of the application. This resulted in a unique correlation database from which monitoring criteria were developed, that greatly maximized the AE location performance and minimized the false alarms due to the noisy environment. Major benefits of the AE monitoring application include an overall increase of health and safety, as well as minimum down-time for the refinery until a full vessel replacement becomes possible.

Advanced Composites - II

Room 7
Time: 15:40 - 17:20
Date: 12th September 2018



26 - Dynamic Acoustic Emission for the characterization of the nonlinear behavior of composite materials

Xiaoyang YU[1], Mourad Bentahar[1], Silvio Montresor[1], Charfeddine Mechri[1,2]

[1]LAUM, Le Mans, France. [2]CTTM, Le Mans, France

Abstract

Previous work has shown that damaged composite materials generally exhibit a nonlinear hysteretic behavior. To quantify the nonlinear activity, we propose to monitor slow dynamics tests using acoustic emission (AE). The experimental approach aims to highlight the link between the AE signals and the conditioning/relaxation of the materials under test. The damaged composite materials (polymer concrete, glass/epoxy composite ...) are driven at high level bending resonance during conditioning.

Recorded AE signals exhibit a frequency content orders magnitude higher than the resonance frequencies (few hundreds Hz), which makes easier the separation between AE activity and vibration. During slow dynamics tests, the recorded AE signals are analysed using wavelet transform and compared with the AE signals recorded during the mechanical tests on the composites materials.

Results show that AE signals obtained during slow dynamics tests and during mechanical tests are comparable (amplitude, frequency content …), which offers a good opportunity to use AE on already damaged materials with possibilities of linking micro-mechanisms to macroscopic observation.d.

55 - The influence of source depth and source-to-sensor distance on the AE signal characteristics of damaging events in thin-walled CFRP laminates

Benjamin Kelkel, Julia Vogtmann, Martin Gurka

Institut für Verbundwerkstoffe, Kaiserslautern, Germany

Abstract

The identification of damaging events in fiber-reinforced plastics (FRP) based on their acoustic emissions (AE) has been a vivid field of research for more than 25 years. Damage classification has been carried out by correlating damage patterns with single or multiple features from the time and frequency domain of the corresponding AE. Features such as maximum amplitude, peak frequency and Weighted peak frequency were used as indicators to distinguish between the various damaging events in FRP.

However, classification results among authors partly contradicted each other and transferability of results has therefore been questioned. Besides the differences in measurement equipment (e.g. sensor, amplifier) and specimen design (e.g. geometry, layup) the effect of source depth and source-to-sensor distance on the resulting signal characteristics has been pointed out as another possible cause for the ambiguity in classification results.

In this study, acoustic emissions are systematically produced in various depths and distances to the AE sensors during quasi-static tensile testing of bidirectional CFRP laminates with 0/90/0 and 90/0/90 layup in order to investigate the influence of source depth and source-to-sensor distance on the signal characteristics of fiber and matrix fracture. The results underline the impact of source depth and source-to-sensor distance on the resulting AE features and visualize the limitations of AE for damage classification in CFRP.

57 - Acoustic Emission behaviour on CFRP with curved fibers

Yoshihiro Mizutani[1], **Takeshi Ashizawa**[1], **Nobuyuki Toyama**[2], **Akira Todoroki**[1]

[1]Tokyo Tech., Tokyo, Japan. [2]AIST, Tsukuba, Japan

Abstract

Application of CFRP to the industrial field is expanding and acoustic emission testing (AT) is utilized for some applications. In this paper, possible problems that may cause when AE testing is applied to CFRP components with curved fibers are discussed based on the previous author's paper about ultrasonic propagation in CFRPs.

It was concluded that the AE amplitude has a potential to be highly affected by the location of AE sensors on the components. It is also noted that general AE source location algorithm cannot be applied for this kind of materials in some cases since shortest path from AE source to AE sensor are varied with the position on the components.

63 - Experimental investigation of the damage mechanisms in interlock reinforced composites based on AE data analysis

Mohamed Kharrat[1], Gurvan Moreau[2], Zoheir Aboura[3]

[1]Mistras group, Sucy-en-Brie, France. [2]Safran Composites, Itteville, France.
[3]University of Technology of Compiègne, France

Abstract

The damage scenarios of interlock composite materials were investigated using a multi-instrumentation especially in the vicinity of the first significant damage. This instrumentation that was deployed for tracking damage initiation and development includes Acoustic Emission (AE), video-microscopy, Digital Image Correlation, and micro-tomography. Besides, a multi-variable AE data analysis approach was developed for discriminating between the signal classes representing the different AE sources.

This includes an unsupervised classification technique to perform AE data clustering without a priori knowledge. The AE clusters were labeled according to the damage mechanisms using the experimental observations taken on different specimens and tests. The collected clustered data served to build a learning database used for constructing a supervised classifier, which is useful for an automatic recognition of the AE signals. Several materials with different ingredients were tested under various solicitations in order to supply the learning database.

The methodology presented in this work was useful to refine the threshold of the first significant damage and to highlight the damage mechanisms around this threshold. The obtained signal classes were assigned to the main mechanisms. The isolation of a "noise" class helped to discriminate between the signals emitted by damages without resorting to localization or to modify the acquisition threshold. This approach was validated on different material configurations. For the same material and the same type of solicitation, the identified classes are reproducible and little disturbed. The constructed supervised classifier was pretty well able to predict the labels of the classified signals.

73 - Use of AE for characterization of damage mechanisms in composite accumulator

Oriane Colas[1], Christophe Briançon[1], Catherine Hervé[2], Alain Houssais[3]

[1]Cetim, Nantes, France. [2]Cetim, Senlis, France. [3]Parker Olaer, Colombes, France

Abstract

This study presents the results of a collective study performed at Cetim for industrials of the hydraulic transmissions profession. The purpose is to develop an accumulator in composite material, carbon fiber and thermosetting resin, and to characterize the behavior of this accumulator by both static and cyclic pressure tests.

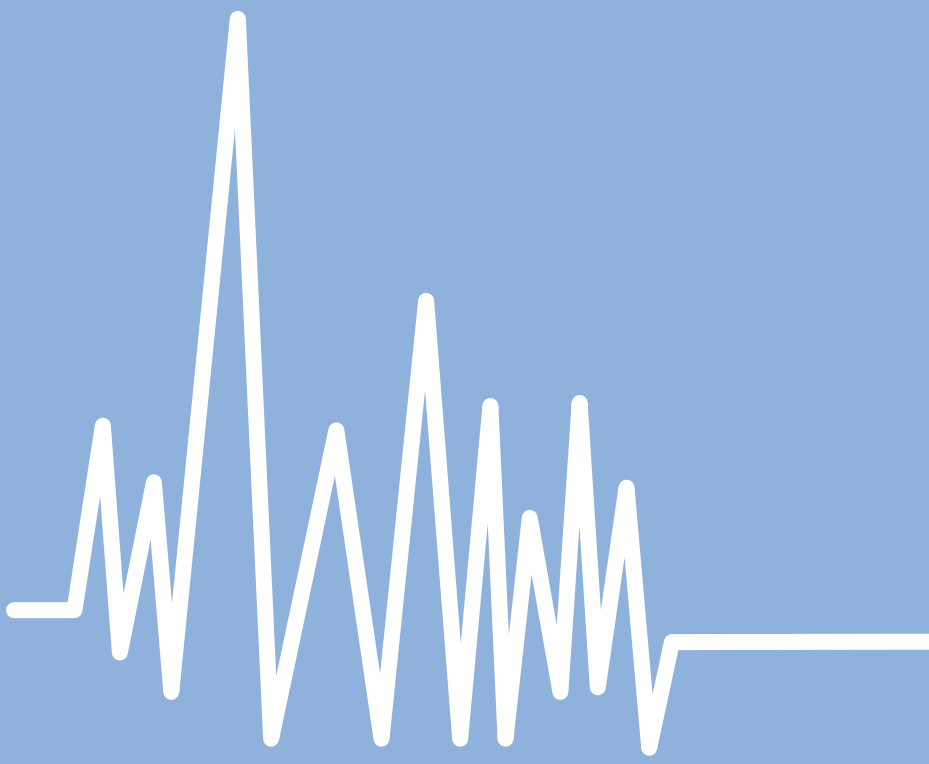
The knowledge of damage mechanisms evolution occurring during these tests is studied through Acoustic Emission monitoring combined by strain gages measurements.

The results of AE monitoring are compared to the failure criteria used in the design model in order to correlate the different damage mechanisms occurring in each layer with the AE signals detected.

Further mechanical tests were performed on samples taken from accumulators tested at different pressure level. Visual observations with video camera combined to AE data recording during these tests validated the identification and the progression the different damage mechanisms in the different layers.

Signal Processing Equipment and Software - I

Room 6
Time: 9:00 - 10:20
Date: 13th September 2018



40 - Continuous recording and wireless transmission of AE waveforms by battery powered sensor nodes

Kaita Ito[1], **Manabu Enoki**[2]

[1]National Institute for Materials Science, Tsukuba, Japan. [2]The University of Tokyo, Japan

Abstract

AE streaming i.e. continuous recording of AE waveform is effective for monitoring under a noisy environment such as materials processing because an optimized digital noise filter can be designed from the real measurement result. For real-time denoising of AE streams, a PC-level high performance CPU and a number of cables are needed for power supply and communication for conventional AE streaming. However, complicated cabling among the measurement equipment, amps and sensors often disturb the materials processing. Therefore, a wireless AE streaming system is strongly demanded.

In this study, such a wireless system was developed. A battery-powered small sensor node continuously acquires AE waveform and transmits it to a base station via broadband wireless network such as IEEE802.11ac (Wi-Fi). The whole waveform analysis is conducted in the base station which includes a high performance computer. An in-process defect monitoring during friction stir welding (FSW) was conducted as a test of the developed system.

AE sensors were attached to the FSW machine and moved on the specimen. Four channels AE stream with 2 MHz of sampling frequency and 14 bit resolution was acquired, transmitted and analyzed in real-time. AE events due to joining defect were successfully detected and located. The measurement noise in the developed wireless sensor node was much lower than the conventional wired system because the sensor nodes were electrically insulated.

45 - Research the comparative sensitivities of fiber-optic sensors and piezoelectric sensors for detection of Acoustic Emission waves

Han Htoo Khun[1], Oleg Bashkov[1], Valerii Zaikov[1], Roman Romashko[2], Ilya Bashkov[1]

[1]Komsomolsk-on-Amur State University, Russian Federation. [2]Institute of Automation and Control Processes FEB RAS, Vladivostok, Russian Federation

Abstract

Aims: To research and modeling the comparative sensitivities of fiber-optic sensors and piezoelectric sensors for detection of acoustic emission waves and analyze the type of acoustic wave propagation in the metal and composite materials.

Methods: Using the Abaqus commercial software modeling and comparatives sensitivities the localized sensors and distributed sensors with the different type of source excitations. Research the experimental results and modeling results of the localized sensors and distributed sensors. For experiment in the sample source of excitation are excited in the different places from the optical fiber sensors and piezoelectric sensors. Sensors are placed in the different places of the sample. The signals of the AE were excited by different types of source in various places of the plate.

Results: The arrangement of optic fibers with respect to the AE source is not localized. Fiber optical sensors are distributed sensors. This needs to be taken into account when choosing the procedure for calculating the location of AE sources. Fiber optical sensors are wideband sensors and have a more linear amplitude-frequency response as compared with piezoelectric sensors. The spectrum of acoustic waves detected by fiber optical sensors in the longitudinal and transverse directions differs for a plate having various dimensions and different directions. This is because the group Lamb wave excites various modes of oscillations in the plate. The results of research Lamb wave propagated in metal and composite materials depend on the type of source excitations.

96 - Phased Array Modal Acoustic Emission (PA-MAE™)

Brian Burks

Digital Wave Corporation, Centennial, USA

Abstract

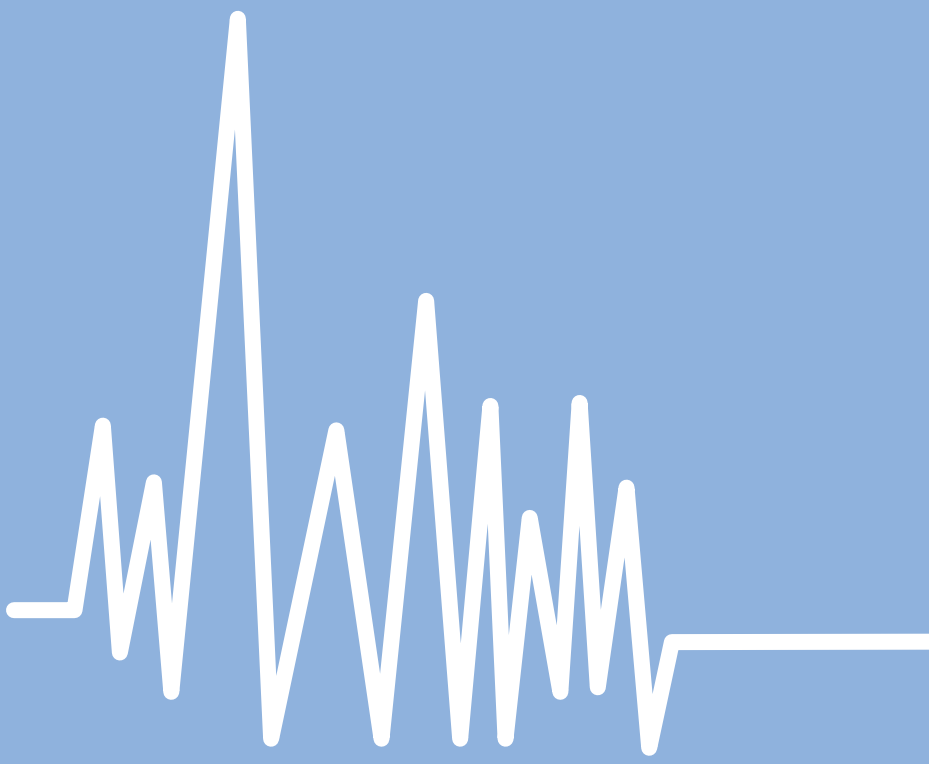
In this work a novel measurement methodology known as Phased Array Modal Acoustic Emission (PA-MAETM) is described, and the advantages detailed. In the measurement methodology, multiple elements are positioned in a tightly packed arrangement and sense the same waveform with minimal effects of dispersion present due to the tightly packed nature of the array.

Each received waveform is time shifted into a coherent time basis (established by a designated reference element within the array), and the signals summed into a composite waveform; the resulting composite waveform possessing an increased signal-to noise ratio (SNR) as the electronic noise associated with the electronic amplification is uncorrelated white noise and cancels. Computationally efficient digital signal processing (DSP) algorithms have been implemented into hardware so that time coherency between elements may be established in a real-time fashion, enabling the increased SNR to be utilized in the measurement and creating a system with improved dynamic range and sensitivity over traditional single element measurement systems.

Examples of the increases in signal sensitivity and SNR which are realized through the PA-MAE measurements are detailed. The increase in signal sensitivity and SNR may be leveraged to increased sensor-spacing in highly attenuative wave propagation measurements. Furthermore, it is shown that accurate source location from a single array is possible. Finally, a discussion of the computational expense and improvements in SNR and dynamic range with increasing number of elements is provided, as well as physical aspects related to optimized array design.

Advanced Composites - III

Room 7
Time: 9:00 - 10:20
Date: 13th September 2018



01 - Modal Acoustic Emission analysis of mode-I and mode-II fracture of adhesively-bonded joints

Alasdair Crawford, Mohamad Ghazi Droubi, Nadimul Faisal

Robert Gordon University, Aberdeen, United Kingdom

Abstract

Acoustic emission (AE) testing has previously been demonstrated to be well suited to detecting failure in adhesively-bonded joints. In this work, the relationship between the fracture-mode of adhesively-bonded specimens and the acoustic wave-modes excited by their failure is investigated. AE instrumented Double-Cantilever-Beam (Mode-I fracture) and Lap-Shear (Mode-II fracture) tests are conducted on similar adhesively-bonded aluminium specimens.

Linear source-location is used to identify the source-to-sensor propagation distance of each recorded hit, theoretical dispersion curves are used to identify regions of the signal corresponding to the symmetric and asymmetric wave modes, and peak wavelet-transform coefficients for the wave-modes are compared between the two fracture-modes. It is demonstrated that while both fracture-modes generate AE dominated by the asymmetric mode, the symmetric mode is generally much more significant during Mode-II fracture than Mode-I.

While significant scatter and overlap in results prevents the ratio of peak-wavelet transform coefficients from being a robust single classifier for differentiation between fracture-modes in most cases, other modal analysis methods, or integration of this parameter into multi-parameter methods in future work may result in more reliable differentiation. Understanding of the wave-modes excited by the different fracture-modes also has implications for source-location, as identification of the correct modes is critical for selection of suitable wave velocities.

02 - On use of signal features for Acoustic Emission source identification in fibre-reinforced composites

Markus G. R. Sause

University of Augsburg, Germany

Abstract

In the past, many approaches were proposed to perform the task of acoustic emission based source identification in fibre-reinforced composites. Almost all identification attempts make use of feature values to act as representation of the recorded acoustic emission signals. The typical features are classified in two primary categories, one to express the intensity / energy of the signal and one to describe the frequency characteristic of the signal.

Both categories are used to classify signals into microscopic failure mechanisms such as matrix cracking, fibre breakage and many more. To this end, various approaches used either energetic or frequency features or a mix of both. This contribution takes a closer look at the relationship between acoustic emission signals and their feature values and assesses their relation to acoustic emission source mechanics. This provides guidance on the reliability of acoustic emission features for source identification procedures and points out some key aspects for successful classification attempts.

03 - Damage diagnostic and lifetime prognosis for ceramic matrix composite with Acoustic Emission during long-term mechanical tests at intermediate temperature

Nathalie Godin, Pascal Reynaud, Gilbert Fantozzi

INSA of Lyon - MATEIS, Lyon, France

Abstract

Damage of composite materials is a key factor in the durability in service. It is therefore essential to define the most suitable damage indicators and to develop models to estimate the Remaining Useful Lifetime (RUL) from analysis of precursor events resulting from damage. Acoustic emission is relevant to the development of the PHM (Prognostic and Health Management) because it allows knowing the state of damage of a composite structure in real time.

This work is dedicated to lifetime prediction using AE for long-term tests on CMC during static and cyclic fatigue tests. New indicators of damage have been defined, based mainly on acoustic energy analyses. In this context, an equivalent energy of AE sources is defined in order to eliminate effects of attenuation due to propagation distance. These indicators highlight critical times (around 50 % of the composite lifetime) allowing an evaluation of the remaining lifetime. A linear correlation is observed between these critical times and the lifetime duration.

For a prognostic phase, the results obtained with this empirical law are compared to those obtained with a power law such as a Benioff law. Moreover, the clustering of acoustic emission, using a random forest approach, makes possible to identify the mechanism responsible for this critical time. For the static fatigue test, the critical time around 50 % correspond to the delayed failure of fibres. Moreover, the determination of the acoustic signature and characteristic time is linked to testing conditions and specimen geometries. Therefore, sizes effects are investigated with modelling works.

04 - Combination of synchrotron computed tomography and Acoustic Emission measurements for cyclic loading of fibre-reinforced composites

Philipp Potstada[1], Sebastian Rosini[2], Mark Mavrogordato[2], Ian Sinclair[2], S. Mark Spearing[2], Markus G. R. Sause[1]

[1]University of Augsburg, Germany. [2]University of Southampton, United Kingdom

Abstract

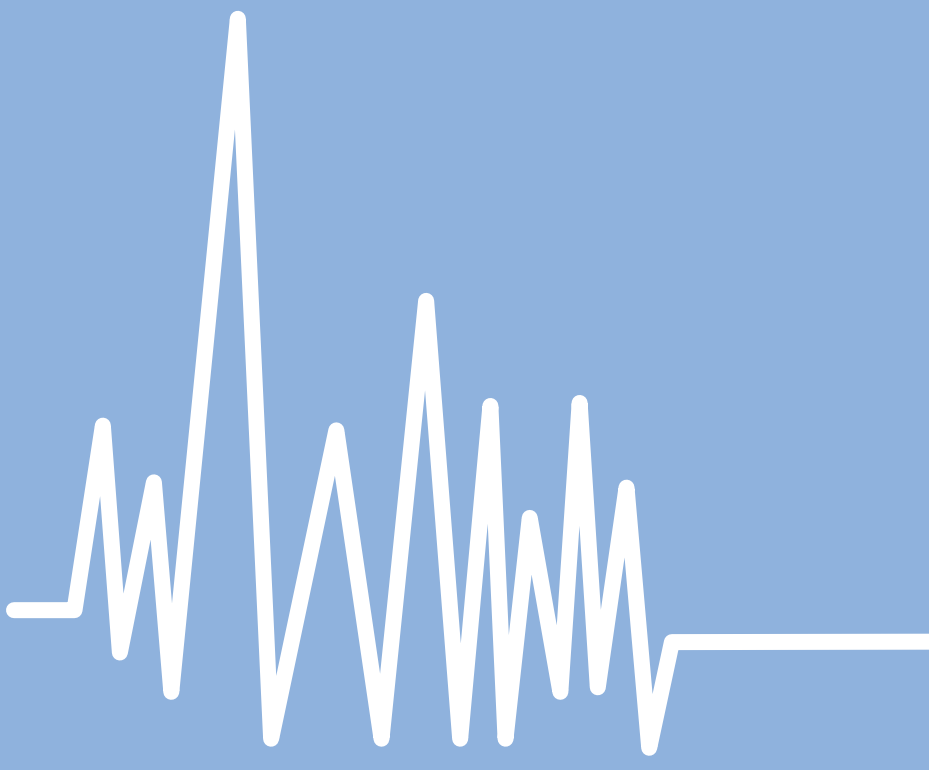
During incremental load-unload cycles of fibre-reinforced materials, the re-initiation of acoustic emission below the previously reached load is frequently observed. This is known as the Felicity effect and its physical origin has been discussed in the community for several decades. The principal explanations for this effect are the rubbing together of existing crack faces which thus act as tribological acoustic emission sources or the initiation of new damage because of material stress-relaxation during the unloading phase.

We conducted combined acoustic emission measurements and high-resolution synchrotron computed tomography experiments on a carbon fibre / epoxy prepreg system. Samples were prepared as double-edge notched tensile specimens with [±45 0 ±45], [0 903 0] and [90 03 90] layups. At a voxel resolution of 1.625µm, we were able to visualize the growth of damage as a function of applied load/unload steps in a sequence of volume images.

With the simultaneously acquired acoustic emission signals, this allows identification of the origin of the source volumetrically, as three volumes were taken per load step *in situ*. These investigations are part of an ongoing measurement campaign and represent a first interpretation towards the physical origin of the early acoustic emission onset in fibre-reinforced materials. This provides a first step to reveal the origin of the Felicity effect in fibre-reinforced materials.

Monitoring Composites/ Different applications

Room 6
Time: 10:40 - 12:20
Date: 13th September 2018



48 - Structural Health Monitoring of composites structures by Acoustic Emission analysis

Lars Schubert, Eberhard Schulze, Robert Neubeck, Bianca Weihnacht

Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Dresden, Germany

Abstract

Fiber reinforced composites are often used in actual light weight structures applications like structural components for automotive or rotor blades for wind turbine power applications. The reliability of those components are of great importance for safety relevant areas. The lifetime of the components are affected by damages like fibre cracking or delaminations which can lead to early failure of the overall structure.

The acoustic emission testing is well accepted for static or dynamic testing of fiber composite components since fiber breaks and delamination processes cause high energetic acoustic emissions. The challenge lies in the application of the method during field measurement tests like filtering any indications caused by the noisy environment and the development of special condition monitoring hardware which allows the instrumentation of rotating wind turbines.

Damage evaluation parameters like the weighted peak frequency were evaluated during tensile lab test and full-scale fatique tests and subsequently transferred to real operation of wind turbines. Results from field operation of several systems on wind turbine power blades will be presented and discussed.

68 - Structural Health Monitoring of composite aerospace structures with Acoustic Emission

Martin Lehmann, Andreas Bueter, Oliver Schwarzhaupt, Conchin Contell Asins

Fraunhofer LBF, Darmstadt, Germany

Abstract

While composite materials have many advantages due to their lightweight potential impact events or foreign object damage (FOD) is critical for composite and many other aerospace structures. FOD can lead to unscheduled maintenance in the cases of hail damage, tool drop, ramp rash or even loss in the cases of tire debris (Concorde) or insulation debris (Columbia Shuttle). Impact damage reduces the static load capability and the fatigue life of a structure. The cost of an Aircraft on ground is about 40 k$ per hour. Thus a decision on unscheduled inspection and repair or a return to flight must be taken fast and responsibly. Non-destructive inspection combined with Finite Element Analysis is the state of the art. Novel fast SHM tools can support the necessary decision making process.

Impact damage generates characteristic acoustic signals that can be detected and analyzed by acoustic emission systems during the event. This was investigated in the Clean Sky Program by Fraunhofer LBF. A fast but simple analytical model was developed that can analyze the extracted acoustic features. This model was trained with 50 composite plates clamped to simulate a stringer bay each.

The specimen were subjected to different impact energies and locations and corresponding AE features, damage sizes as well as the compression load after impact were derived from these tests. After this training the system could analyze impact events in near-real-time and present estimations on impact energy levels, location, damage size, mechanical properties, delamination growth as well as the remaining fatigue life.

36 - Post-harvest Acoustic Emission in angiosperm leaves

Sabine Rosner
BOKU, Vienna, Austria

Abstract

Knowledge about drought sensitivity of tree species is of high importance regarding global warming. Trees transport water from the roots to the leaves in small conduits in a meta-stable state, meaning that the water columns are likely to break when the drought stress increases. The stress release after breakage of the water columns produces acoustic emission (AE) in the high frequency range. Plants respond by closing the stomata of their leaves, which prevents further loss of conductivity.

However, if a leaf looks wilted, this does not mean that it has also lost all of its hydraulic conductivity. Recent studies reveal that the water conducting system of leaf veins is less vulnerable than previously thought; a high proportion of veins lose water after wilting. It is also suggested that the susceptibility to embolism and hydraulic decline of leaves are strongly linked to the conduit diameters of the leaf veins. In the present study, the AE hit rate and AE features of dehydrating angiosperm leaves were related to anatomical features of the leaf veins of six different angiosperm species.

Three distinct AE activities were detected, where the first showed the highest peak amplitudes. This first hit rate peak comes presumably from moisture loss in the main leaf vein, whereas the following two peaks were attributed to leaf wilting and moisture loss in the minor leaf veins. The results are discussed regarding the species specific reaction to drought stress and the potential applications of this method for continuously monitoring of drought stress.

53 - Mechanical and Acoustic Emission characterization of lime-based masonry constituents

Naveen Shetty[1], Georgios Livitsanos[2], Dimitrios Aggelis[2], Danny Van Hemelrijck[2], Martine Wevers[1], Els Verstrynge[1]

[1]KU Leuven, Belgium. [2]Vrije Universiteit Brussel, Belgium

Abstract

This paper deals with an improved representation of the progression of damage in masonry materials under cyclic loads using the acoustic emission (AE) technique. Stress-strain relations are a familiar concept in engineering which detail the elastic-plastic behavior of the material. During AE monitoring, AE activates with the increase of stress and initiation of micro fracture due to local changes in the material structure.

The population of AE events registered at an increasing stress levels, from elastic to plastic, and finally to failure, provides information on the structure's integrity. In the present study, the test specimens include one type of clay brick and four different types of mortar. One set of experiments focuses on individual brick and mortar beams under three-point bending and another set of experiments focuses on masonry couplets under compression.

Under cyclic incremental loading, Kaiser and Felicity effects are examined. Load and Calm ratios are used to quantify the damage progression in the different materials. In conclusion, a correspondence was observed between the AE based damage and the zones of the stress-strain curves. This investigation provides an overview of AE-based damage indices for masonry and its constituents.

22 - Characterization of particle impacts using Acoustic Emission

Eric Serris, Lorenzo Carrillo, Andrea Valentini

Mines Saint-Etienne, France

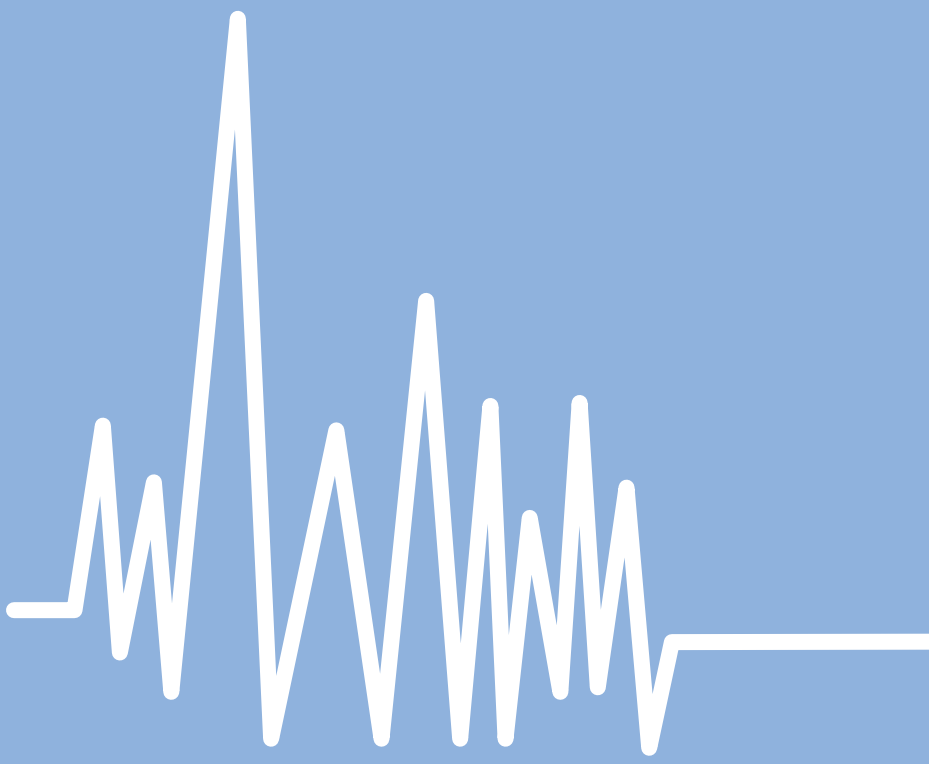
Abstract

Acoustic emission has been successfully applied for monitoring a large variety of solids elaboration processes. In order to know the applicability of this technique in an industrial process such as grinding, mixing or also fluidized bed, we need to initially study the impacts of particles on different material surfaces. Namely, these will aim to simulate the industrial vessel walls.

A wide range of powders will be examined and the Hertz law will be applied to characterize the impact of particles. The influence on the acoustic emission of particle size and speed will also be explored in this study.

Material characterisation

Room 7
Time: 10:40 - 12:20
Date: 13th September 2018



32 - The sound of metal: Acoustic Emission during the deformation of commercially pure titanium

Nick Goossens, Marc Seefeldt, Martine Wevers

KU Leuven, Belgium

Abstract

Acoustic emission (AE) was monitored *in situ* during in-plane tensile deformation of a commercially pure titanium plate. Different load orientations were considered: parallel to the rolling direction (RD), transversal direction (TD) and under an angle of 45 degrees (45D) with RD. The AE event rate, peak amplitude, signal duration, rise time and ring-down counts were monitored during deformation. Orientation dependent mechanical behavior, AE signal characteristics and microstructural evolution was observed and correlated to the difference in texture and twinning phenomena.

The intensity and characteristics of AE signals in RD and 45D do not change considerably during deformation, which was attributed to the continuous nucleation and growth of compression twins. Anomalous AE behavior in TD was observed, showing two distinct peaks. All signal parameters show significantly decreased values during a first peak, which was correlated to massive nucleation of small tensile twins. These tensile twins disappear with increasing strain, indicating the end of the first peak.

The second peak is comparable to the plateau behavior in RD and 45D and occurs during necking. Compression twinning is dominant, but limited to the necking zone. An unfavorable textural effect in TD has been identified, which hinders the formation of compression twins during the homogeneous deformation, as opposed to RD and 45D, resulting in anomalous AE behavior. The acoustic emission technique proves to be a complementary technique to electron diffraction as it allows monitoring and identifying the twinning modes of commercially pure titanium *in situ*.

38 - Analysis of kinking and twinning behavior in mg alloys by AE clustering method

Manabu Enoki, Kengo Tamura, Takayuki Shiraiwa

The University of Tokyo, Japan

Abstract

LPSO (Long Period Stacking Ordered Structure)-Mg alloy has both low density and high strength, and it is expected to be applied to transport equipment. However, it is necessary to evaluate the deformation and fracture behavior in order to use it as a structural material. Acoustic emission (AE) signals were analyzed and classified using several machine learning methods to evaluate the deformation mechanism of various LPSO-Mg alloys.

It is difficult to identify AE signals due to each deformation mechanism in extruded materials consisting of two phases, α-Mg phase and LPSO phase. In this study, the high-speed camera was used to directly observe the kink deformation in LPSO phase and the twinning deformation in α-Mg phase.
The compression tests were carried out, and AE signals during tests from sensors attached to the jig were continuously measured and recorded using Continuous Wave Memory (CWM) developed in our laboratory.

Surface motion of specimens was captures using a high-speed camera using the AE signal as a trigger. Based on the recorded AE signals corresponding to kink deformation and twinning, AE behaviors of different extruded LPSO-Mg alloys were successfully classified into the kinking and twinning by machine learning methods.

39 - Non-threshold Acoustic Emission analysis of damage evolution in pipe segments of steel S355J2H under bending load

Franziska Baensch, Wolfram Baer, Peter Wossidlo, Abdelkarim Habib

Bundesanstalt für Materialforschung und prüfung (BAM), Berlin, Germany

Abstract

Four-point bending tests were carried out to analyze the acoustic characteristics of damage development in pipe segments made of steel, grade S355J2H, being 2.5 m long with an outer diameter of 168 mm and 16 mm wall thickness. To induce stable crack growth, the pipe segments were pre-damaged by a 90°circumferential notch in the middle of the pipe length.

While the pipe was quasi-statically loaded, microscopic damage and plastic deformation accumulated to form a macroscopic crack that grew through the pipe wall until leakage. For acoustic emission (AE) monitoring, four broadband sensors of type VS 900 M were mounted close to the notch. Continuous AE signal detection was performed by the non-threshold method. Advantages and disadvantages of the non-threshold AE monitoring compared to a commonly employed method analyzing only signals exceeding a predefined threshold are discussed.

The results of AE analysis are compared to additional information on the crack growth detected by the direct current potential drop (DCPD) technique. These studies were carried out in the course of the interdisciplinary research project AGIFAMOR, Ageing infrastructures – distributed acoustic monitoring of pipes at BAM.

71 - Galling detection by Acoustic Emission (AE) according to ASTM G98

Abdelkrim Saidoun[1], Catherine Hervé[1], Yanming Chen[1], Thibault Lesage[2]

[1]Cetim, Senlis, France. [2]Université de Compiègne, France

Abstract

For many mechanical companies, galling detection remains an important issue because it can occur in many mechanisms (bearings, transmissions ...) and thus lead to serious failures with consequences both in terms of production and in terms of people and machines safety. The diagnosis and identification of galling are made through facies observations and profilometry analysis (according to ASTM G98). When contact surfaces are not visible or easily accessible, it is not possible to actually know the state of galling. It is therefore important to have a method capable of performing a reliable diagnosis without having to stop or disassemble considered machines. Acoustic emission is a monitoring method for detecting the start of this physical phenomenon between two surfaces and also to follow it evolution.

Feasibility tests with CETIM tribology team have demonstrated the potential of this method and also assess possibilities to develop a detection criteria based on AE features. Experimental principle consists of applying a load on a pin which is slowly rotate to a fixed plate (360°). The galling threshold is determined from the pressure at which there is a first material transfer on friction surfaces.

The obtained results show the potential of the AE for the detection of the galling threshold. Furthermore, the correlation of AE measurements with the EBSD[1] method (graphically showing grain orientation and size of grains before and after testing) revealed two types of galling : catastrophic and tolerant galling.

[1] EBSD (Electron Backscattered Diffraction)

84 - Acoustic Emission method in nanoindentation and scratch test

Radim Ctvrtlik, Jan Tomastik, Vaclav Koula, Martin Drab

ZD RPETY –DAKEL, Praha, Czech Republic

Abstract

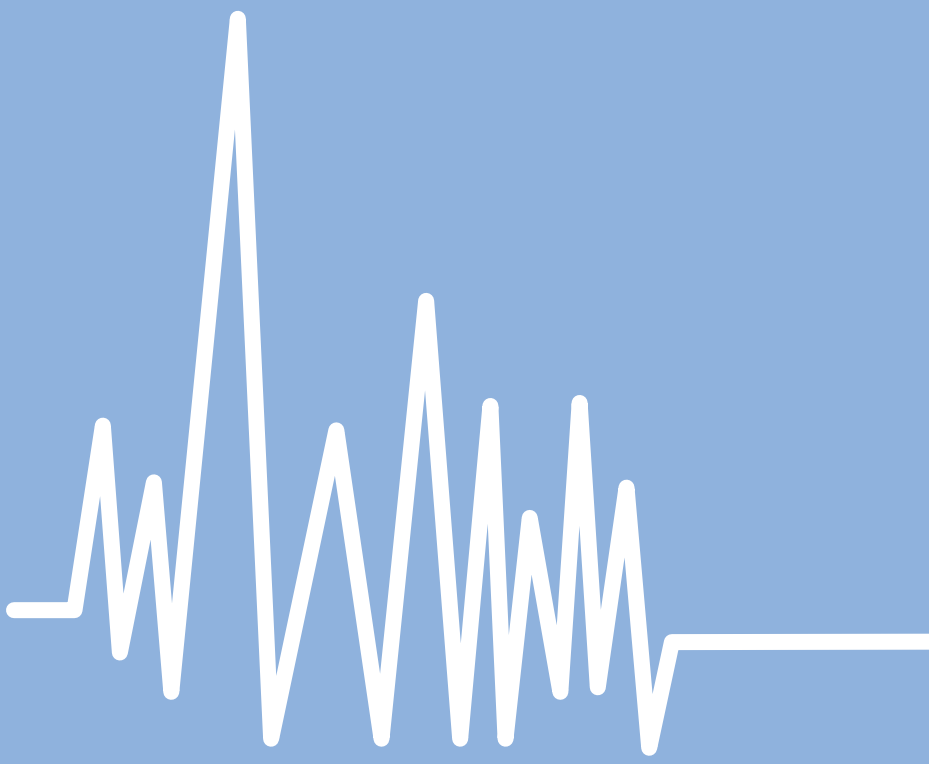
Evaluation of nanoindentation and scratch test mainly relies on the analysis of depth-load-time records. This approach has been proven to be sufficient in most cases for a variety of materials (thin films, micro-objects, composites, bulk). However there are many situations where indentation curves or scratch depth-load-time records do not provide sufficient information for a complex understanding of the deformation response of the material. Although microscopic observation of the residual indents or scratches extends the tests' evaluation it does not elucidate the dynamics of the process or phenomenon studied, especially for non-transparent materials. On the other hand the recording of the acoustic waves can overcome this drawback and offers a nondestructive way of obtaining complementary information.

Acoustic waves emitted during the mechanical tests at the nano-micro scale are a rich source of information about the deformation behavior of the tested material. This holds especially for the initiation and propagation of cracks in the tested surface or coating in particular. Hence analysis of acoustic emissions provides a better understanding and more complex interpretation of the results obtained by the nanoindentation and scratch test.

The strength of the AE method will be demonstrated for hard protective SiCN coatings deposited on silicon explored via scratch test. Combination of AE and nanoindentation will be presented for silicon and various types of glasses including hardened glass. In both cases the analysis of AE events will be correlated with standard approaches.

Corrosion

Room 6
Time: 13:40 - 15:20
Date: 13th September 2018



11 - AE monitoring and three-dimensional observation of stress corrosion cracking from corrosion pits

Kaige Wu[1], Kaita Ito[2], Ippei Shinozaki[3], Manabu Enoki[1]

[1]Department of Materials Engineering, The University of Tokyo, Japan. [2]National Institute for Materials Science, Tsukuba, Japan. [3]Research Laboratory, IHI Corporation, Yokohama, Japan

Abstract

Stress corrosion cracking (SCC) is a complicated three-dimensional (3D) process involving both electrochemical and mechanical phenomena. The source mechanism of acoustic emission (AE) behavior during SCC development is still not well understood. In this work, AE monitoring combined with 3D characterization using X-ray computed tomography (X-ray CT) were proposed to investigate the SCC of an initially smooth sample of SUS420J2 stainless steel exposed to both a 0.6% constant strain and a neutral sodium chloride droplet at room temperature.

Cracks were observed to originate from corrosion pits. Further 3D observation of the inner geometry of cracks indicated that cracks preferentially attacked the mouth, rather than the bottom, of the corrosion pit. It was also observed that by the path of crack propagation existed several interior corrosion pits which may play a critical role in crack growth.

AE signals were detected during SCC evolution and characteristics of AE events were associated with crack initiation and propagation. K-means clustering analysis grouped the AE events into three clusters. With in-situ surface observation and 3D images of cracks, hydrogen bubble evolution, plastic deformation around the crack tip, and the crack propagation were considered as the possible AE source mechanisms during the SCC.

12 - Effects of media degradation on the Acoustic Emission detection

Luigi Calabrese, Massimiliano Galeano, Edoardo Proverbio
Department of Engineering, University of Messina, Italy

Abstract

The use of analysis techniques such as Acoustic Emission (AE) for corrosion damage detection is a well-established practice with remarkable ability to discriminate the different corrosion forms (uniform, localized, stress corrosion cracking...). The versatility of this technique also relies on the possibility to elaborate numerous data analysis techniques, in order to obtain an improved interpretability of the results.

The assumption that the acquired waveforms are strictly related to the originally emitted AE bursts is at the basis of the reliability of the technique. Notwithstanding, many phenomena occurring during time can undermine such assumption. Surface, bulk defects or changes in stress distribution, could in fact influence recorded AE waveforms. All these phenomena introduce signal distortions, potentially affecting the reliability of the technique. The aim of this work is to establish the effects of the surface or bulk defects on the acoustic waveforms excluding the effects of the stress distribution.

Tests were carried out using martensitic steel (17-4PH) samples in SCC test (ASTMG48). The acquisition of periodically calibrating artificial AE bursts, to evaluate the effect of the modification of the transmission medium, was carried out.

The elaboration of the information acquired from real-calibrated data has been used to properly evaluate and define acoustic event clusters. Experimental evidence shows how trough the analysis of the calibrating AE bursts it is possible to evaluate the degradation degree of the specimen, and to asses the level of reliability of the acquired AE waveforms.

18 - Application of Acoustic Emission measurements to monitor the initiation and the propagation of single or multiple Stress Corrosion Cracks (SCC)

Omar Al Haj[1], Alain Proust[1], José Bolivar[2], Marion Fregonese[3]

[1]Mistras Group SAS, Sucy en Brie, France. [2]Cetim, Nantes, France. [3]Mateis Lab, Villeurbanne, France

Abstract

The aim of this study is to monitor initiation and propagation of single or a colony of intergranular SCC defects using the AE. The main goal is a better understanding behavior and propagation of multiple cracks for a better evaluation of the influence of cracks interactions on failure process. For nuclear applications, the final aim is to propose new integrity criteria.

Experimental tests were performed using mill annealed and sensitized samples of alloy 600, which were immersed in a 0.01 M of potassium tetrathionate solution. The experiments were also monitored by in-situ digital image correlation (DIC) and electrochemical noise (EN) measurements.

Three stages were identified in the propagation and the growth of both a single crack and a colony. During stage I, no crack was detected and the main AE was related to intergranular corrosion (ISCC) and/or anodic dissolution.

Stage II was characterized by surface crack propagation induced by anodic dissolution. The AE signals recorded during this phase were generated by ISCC processes.

During stage III, the interactions between the cracks became more intense (coalescences) with an implication of plastic strain (macro cracking, plastic deformation,…). Such processes were identified as the source of AE activity during this last stage.

The implementation of AE technique coupled with DIC and EN measurements contributed to the understanding of mechanisms involved in short stress corrosion cracks interactions which was determinant for the modeling of the colony behavior.

MATETPRO ANR-12-RMNP-0020 (ECCOFIC). Thanks to LaMCoS, Institut of Corrosion, Andra, AREVA, P. Combrade.

64 - Acoustic Emission from gas bubble nucleation and breaking away from a flat surface

Volodymyr Kietov[1], Marcel Mandel[1], Lutz Krüger[1], Alexei Vinogradov[2]

[1]Institute of Materials Engineering, TU Bergakademie Freiberg, Germany.
[2]Norwegian University of Science and Technology - NTNU, Trondheim, Norway

Abstract

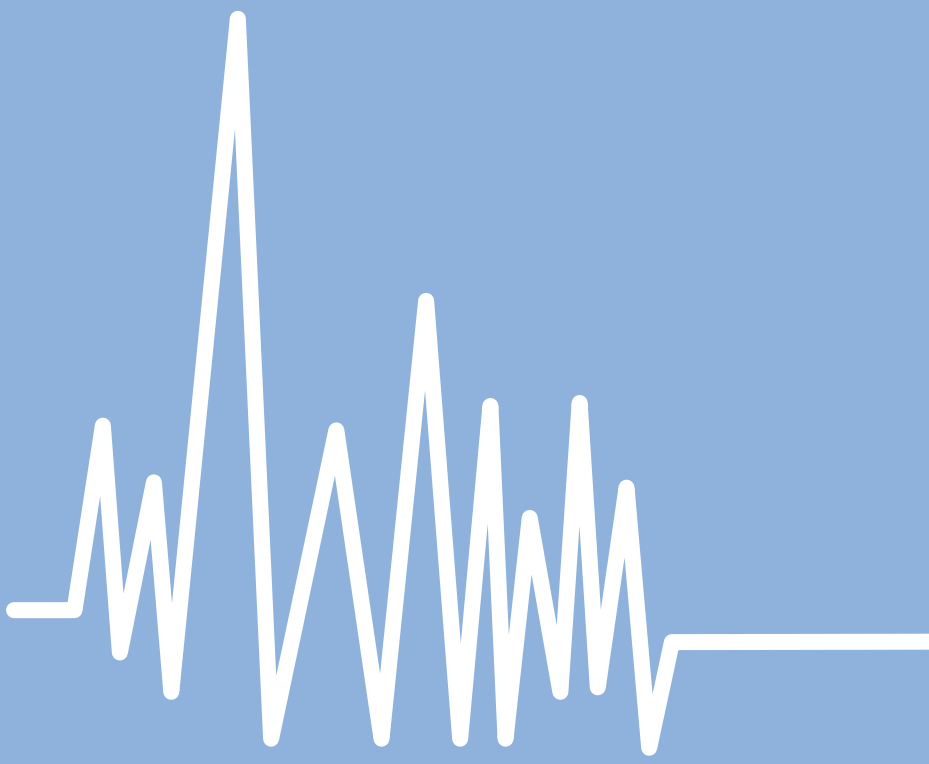
Gas evolution is an important source of acoustic emissions (AE) in many chemical and electrochemical reactions. Specifically, AE accompanies gas evolution during uniform and pitting corrosion of metals. Therefore, monitoring of gas evolution provides valuable information on degradation processes and their rates during corrosion.

In the present work, gas evolution on a steel surface was investigated in detail to get the deeper insight into the properties of AE sources. The polished surface of the plane steel sample was used as an electrode for water electrolysis. Evolution of hydrogen and oxygen bubbles was filmed via a long-distance microscope with the high-speed-camera operating at a frame rate up to 100 000 fps.

The processes of bubbles nucleation, merging and breaking away from the surface were observed and analysed frame by frame. The possible sources for acoustic emissions are associated with merging and breaking away of gas bubbles. The characteristic futures of the AE generated by gas evolution were estimated.

Pressure Vessels

Room 7
Time: 13:40 - 15:20
Date: 13th September 2018



69 - Application of AE technique and thermography for assessment of sludge volume inside crude oil storage tanks

Ireneusz Baran, Tomasz Dunaj, Marek Nowak
Office of Technical Inspection (UDT), Warszawa, Poland

Abstract

When crude oil is stored in large tanks, invariably high-molecular-weight organic sediments (paraffin) are deposited but the resulting sediments contains also solid particles (sand, silt, corrosion products, etc.) and also water. After some period of in-service of tank, these deposits build up to form a sludge, which causes a reduction in the storage capacity. These high in hydrocarbons a valuable raw material could be proper recovered and recycled back to the refining process.

Therefore, it is significant to know the sludge characteristics shape and volume to define the best form of treatment (maintenance of tank for control of level of sludge) and removal method (in case of out of service and opening of tank). In this paper will be presented AE technique and thermography for assess of level, volume and shape of sludge inside storage tank. The use of thermography to assess the level of sludge along the storage tank shell is already a known method and described many times in various publications.

AE technique is used in this case in different way than normally purposes. There is used specific layout of sensors on the wall and roof of the tank. The sensors generate of AE pulses according to established algorithm, which allows to record AE signals were caused the waves propagation and waves reflection (including from sludge) in storage product between sensors. Under measured differences in time of wave propagation are evaluated heights of sludge in various points inside on the bottom of tank.

75 - New edition of GEA guideline for Acoustic Emission Testing of pressure equipments

Christophe DIGiulio[1], **Catherine Hervé**[2]

[1]Air Liquide Industrie, Bagneux, France. [2]Cetim, Senlis, France

Abstract

To master over time the integrity of the equipment and ensure operational safety, in service inspections are carried out periodically in compliance with regulatory requirements and / or professional rules of supervision.

Acoustic emission, now performed industrially for more than thirty years, is currently the only technique which, when applied in a suitable methodology enables to control an equipment in a global way regardless of the nature of damage that could be identified.

The AFIAP, only national entity bringing together the main parties involved in the pressure equipment: administration, manufacturers, users, technical centers, notified bodies, NDT provider organizations, mandated to a working group called "Acoustic Emission Group " the development of a" good Practice Guide for the acoustic emission.

This guide, which is officially recognized by the French administration, incorporates the requirements of the available standards and the experience gained by the professionals of this method.

It consists of general basis and annexes, each relating to a family of equipment. It is applicable in the context of the French legislation for the in service monitoring of pressure equipment.

Previous editions of this guide were published in 2004 and 2009 with an enlargement to new annexes.

This new edition which is the subject of this presentation, takes into account the feedback over all these years of use and integrates new additional annexes, allowing extending the scope of this requalification method.

07 - Acoustic Emission study of pressure vessels material degradation processes after long-term operation in the refinery industry

Igor Lyasota, Tomasz Ryncarz, Barbara Kozub
Cracow University of Technology, Cracow, Poland

Abstract

The paper presents results obtained from the complex destructive laboratory investigations on real pressure vessels' carbon steels after long-term operation in the refinery industry. Tested materials contained structural defects. Detailed metallographic tests and static tensile tests were realized firstly. Then, complex tensile tests with acoustic emission signals registration, and material microstructure changes observation by light microscopy were conducted.

The correlations between acoustic emission signals parameters and material microstructure damage during the tensile tests were developed. At the next stage, the destructive pressure tests with acoustic emission recording of real cylindrical pressure vessel were realized. The vessel has been operated in the refinery industry for 45 years. A lot of corrosion damages were present on the inner surface of the vessel shell as a result of long-term operation.

The material's microstructure of some shall plates was coarse-grained, which arose from improper heat treatment during plates manufacturing. The investigations, presented in this paper, were realised within the project of LIDER VII Programme financed by the National Centre for Research and Development of Poland.

15 - Use of Acoustic Emission for inspection of various composite pressure vessels subjected to mechanical impact

Fethi Dahmene[1], Olivier Bardoux[2], Sylvie Bittendiebel[1], Pierre Blanc-Vannet[2], Noémie Alexandre[3], Fabien Nony[3], Michal Barcikowski[4], Agnieszka Maldachowska[4], Maciej Panek[4], Per Sheggem[5], Andreas Echtermeyer[6], Kaspar Lasn[6]

[1]Institut de Soudure, Yutz, France. [2]Air Liquide, Les Loges en Josas, France. [3]CEA, Le Ripault, France. [4]Wroclaw University of Technology, Wroclaw, Poland. [5]Hexagon Composites, Raufoss, Norway. [6]Norwegian University of Science and Technology, Trondheim, Norway

Abstract

Motivated by the emerging hydrogen mobility uses, especially the need for storing a high amount of energy, type IV composite pressure vessels have become a state-of-the-art technology for high pressure hydrogen. They comprise a non load-bearing liner, generally made of plastic and assembled with metallic bosses, around which a carbon fibre-epoxy composite is wound.

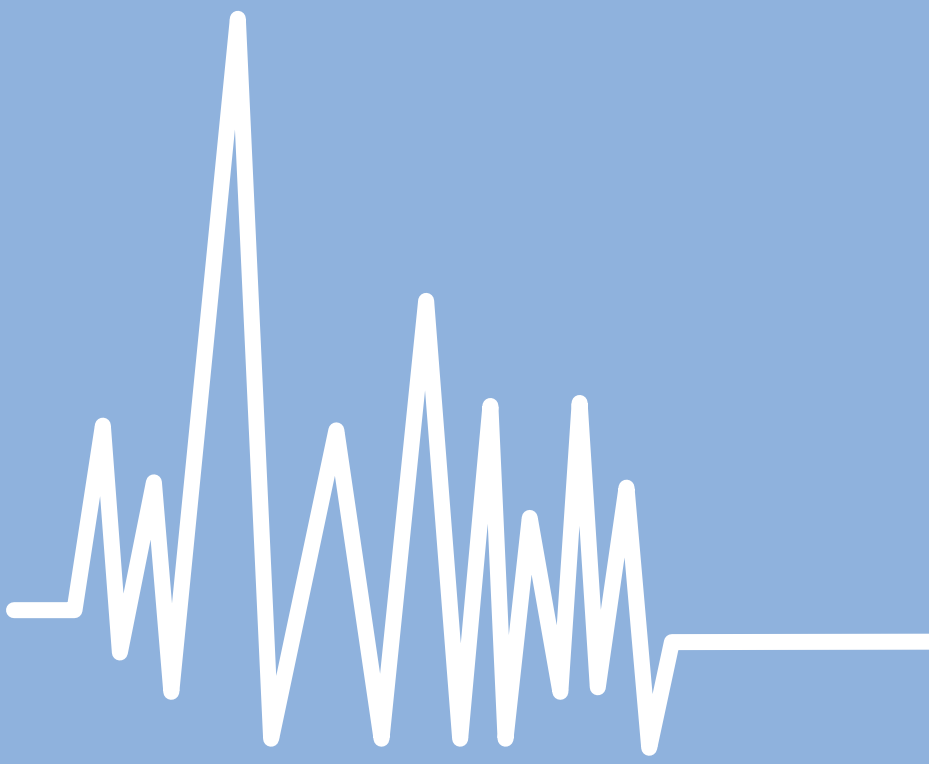
Though such vessels can already be operated safely, there is a lack of knowledge concerning their residual performance after a mechanical impact. There is a need for associated non destructive examination (NDE) methods, able to assess whether a cylinder is still fit for service after impact.

The FCH-JU funded pre-normative research project HYPACTOR was set up to investigate the damage created in type IV pressure vessels by mechanical impacts, and then the use of Acoustic Emission to build rejection criteria during inspection.

The methodology was to combine several AE tests on healthy and impacted vessels and correlate the results with residual performances. The developped criteria were applied to a wide database of Type IV composite vessels with different sizes, design specifications and working pressures. The validation was carried out on 114 hydraulic tests on healthy and impacted vessels. Results have demonstrated a capacity to differenciate damaged cylinders from healthy ones, with some small influence of the number of pressure cycles between impact and inspection.

Signal Processing Equipment and Software - II

Room 6
Time: 9:00 - 10:40
Date: 14th September 2018



30 - Detection and identification of low-amplitude Acoustic Emissions during plastic deformation under indentation and scratch testing

Alexey Danyuk[1], **Dmitry Merson**[1], **Alexei Vinogradov**[1,2]

[1]Togliatti State University, Russian Federation.
[2]Norwegian University of Science and Technology, Trondheim, Norway

Abstract

The acoustic emission (AE) technique is unique in that it enables real-time monitoring of processes of plastic deformation and fracture in materials by receiving signals originating from the entire volume of the testing. The price paid for the high sensitivity of the AE method is well known – the AE signal is buried into the electric noise: the higher the gain the higher the noise. This noise is a natural physical limit of the sensitivity of the method. In this paper, we overview the factors that interfere with the detection and identification of AE signals of very low amplitude.

For probing these factors, the indentation and scratch testing were used as these testing methods are gaining popularity in modern laboratory and industrial practice. The low-amplitude AE arises in these tests from the sources caused by plastic deformation in small volumes loaded locally in the micrometer scale. Procedures for of analyzing and suppressing the external noise and the noise from testing equipment are proposed and discussed. Results of detection of AE events with low signal-to-noise ratio (SNR) during scratch testing of pure polycrystalline metals are presented.

The efficiency of proposed algorithms for noise reduction and SNR improvement by AE digital signal processing is demonstrated on the examples of (1) wavelet-based "Phase Picker" signal detection algorithm, (2) spectrum noise gating procedure (Audacity), (3) spectral and energy signal analysis. In this way, the AE technique has been proven to be a viable and versatile tool for investigations of local deformation mechanisms *in situ*.

33 - When AE (Acoustic Emission) meets AI (Artificial Intelligence) II

Kilian Wasmer, Fatemeh Saeidi, Bastian Meylan, Tri Le Quang, Sergey A. Shevchik

Empa - Swiss Federal Laboratories for Materials Science and Technology, Thun, Switzerland

Abstract

Acoustic emission (AE) is an effective method to monitor and control the quality in different technical processes, including tribology and fracture mechanics. However, in highly dynamic processes, the processing of AE signals is very burdensome. At the same time, artificial intelligence (AI) has been considered as a new and powerful tool to overcome both: the complexity of the large data processing with a reasonable computational time. In this contribution, we will present two examples from completely different process where AE techniques are combined with AI in order to make a significant step forward in process monitoring and quality control.

To start with, in additive manufacturing, which has been at the center of attention in recent years, we will demonstrate that the combination of AE with AI makes possible to detect several types of defects, including pores..

With the second example, we will prove that the combination of AE with AI is a very promising approach for *in situ* and real-time monitoring of electrical discharge inside natural rocks.

65 - AE fracturing modes classification by means of shear tensile source model

Matěj Petruzalek[1], Tomas Lokajicek[1], Tomas Svitek[1], Petr Kolar[2], Zuzana Jechumtalova[2], Jan Sileny[2], Petra Adamova[2]

[1]Institute of Geology of the Czech Academy of Sciences, Prague, Czech Republic.
[2]Institute of Geophysics of the Czech Academy of Sciences, Prague, Czech Republic

Abstract

A shear-tensile crack (STC) is presented as a suitable source model for acoustic emission (AE) events. The experimental data comes from an uniaxial compression test realized on the Westerly granite specimen using a 14 channel AE monitoring system. The advantage of the STC against the traditional MT is: (i) it is a physical source – contrary to MT, as STC describes straight the simple fracture modes anticipated inside the loaded sample, namely the shear-slip and both the opening and closing tensile crack, (ii) it is simpler, described by less parameters (5 instead of 6 for the unconstrained MT), which is essential in solving the inverse problem. Proposed STC procedure was tested on 38 AE events selected in the range of 50 – 98% of uniaxial compressive strength.

Compare to the MT model, the STC model showed similar fit of the input data while providing by far smaller confidence regions. That means more certain determination of mechanism orientation but mainly the highly improved reliability of the decomposition components. Thus use of STC model allow, besides other things, to better distinguish between tension and shear type of AE events, which may be a crucial in recognizing approaching failure.

The application of STC model proved to be useful in recognizing threshold of unstable microcracking and indicative in determination of failure plain orientation. The AE crack length was found to be slightly above the range of the largest grains. The principle stresses orientation, inverted from the STC mechanisms, corresponded to stress conditions of uniaxial compression test.

21 - AE sensor sensitivity verification using a stimulated motion verified by laser-vibrometry

Hartmut Vallen

Vallen Systeme GmbH, Icking, Germany

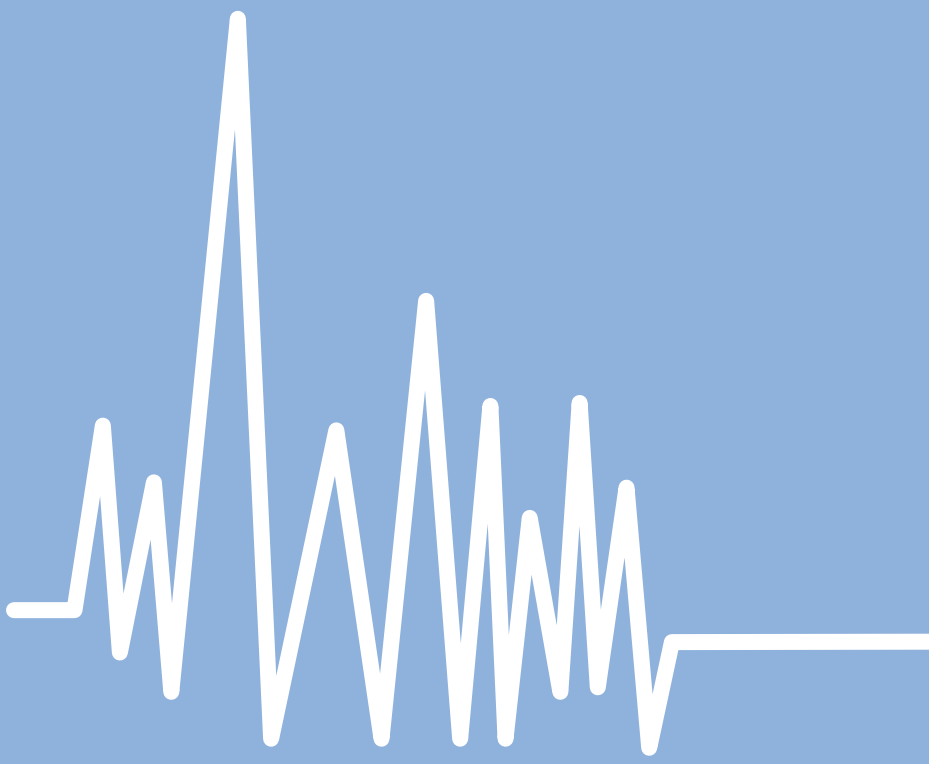
Abstract

This presentation describes work in progress towards a practicable procedure for obtaining the receiving sensitivity spectra of an AE sensor under test (SUT) using a face to face (F2F) setup or a small transfer block. The sensitivity shall be expressed as the ratio of the SUT's voltage output spectrum divided by the input motion spectrum. The input motion spectrum shall be stimulated by a commercially available ultrasonic probe (Olympus V104) used as transmitter sensor (T).

The motion generated by the transmitter under repeatable conditions has been measured in absolute units of velocity by using a Scanning Laser Vibrometer (Polytec PS 400) at 161 points in an area of 25.3 mm diameter at the transfer block as well as at the active face of the transmitter in free-air condition.
For obtaining the sensitivity the SUT output has to be divided by the measured velocity averaged over the size of the SUT's sensitive area.

Signal Processing Equipment and Software - III

Room 7
Time: 9:00 - 10:40
Date: 14th September 2018



76 - Method for assessing the likelihood of fatigue crack detecting

Vera Barat[1], **D.V Chernov**[1], **S.V. Elizarov**[2]

[1]National Research University "MPEI", Moscow, Russian Federation.
[2]Llc Interunis-IT, Moscow, Russian Federation

Abstract

An estimation of the probability of defect detection (POD) is an actual task of acoustic emission (AE) testing. Despite the fact that AE testing is the most sensitive method of NDT, the POD is difficult to estimate. The probability depends on a set of random factors also not directly related to the size of the defect. The probability of detecting defects is currently being studied by many researchers, but the proposed approaches are not yet applied in practice.

In the frame of this work, the method allowing to estimate the probability of fatigue crack with help of AE testing method was developed. This method allows to calculate the probability of fatigue defect detection taking into account the following factors: the stage of defect growing, the distance between AE source and sensor and the noise level.

78 - Statistical non-parametrical algorithm for Acoustic Emission impulses detection adapted on the basis of modal analysis approach

Vera Barat, D.A. Terentyev, Serguei Elizarov
Interunis-IT LLC, Moscow, Russian Federation

Abstract

Among many methods of NDT the acoustic emission testing is one of the most complicated in the field of data processing. The raw data volume could be as big as several terabytes whereas the noise part in it is generally about 90-99%. So the upgrading of AE impulse detection methods is a critical task. Threshold method is a convenient one, as it is simple for realization, but it has substantial drawbacks, such as inaccuracy of measured arrival time and other AE parameters.

This method easily provides low level of false detections, i.e. type I statistical errors. But if the noise level is high then it leads to high level of type II statistical errors, i.e. undetected AE impulses. Threshold-free algorithm, based on signal detection theory, would allow to substantially decrease the level of missed AE impulses as the level of false detections is set. Efficiency is provided by method intellectualization, as detection of AE impulses is based on its typical waveforms. Development of such an algorithm has a main problem in great variability of AE impulse parameters; it is induced in general by unknown acoustic waveguide through which the signal propagated.

Prior uncertainty complexes the algorithm development and increases imprecision. This work overcomes uncertainty by modelling of several thousand AE signals propagated in plates or cylindrical pipes and received by sensors at different distances from AE sources with different spectra as well as with different Lamb S- and A-modes or Pochhammer-Chree F-, L- and T-modes ratios. Modal analysis approach was used for acceleration of modelling because it is an effective analytical method based on the expansion of the forcing terms acting in the waveguide into the set of its proper modes. Modal analysis is a mathematically exact technique that leads to a closed form integral equation for the elastic fields in the waveguide, and which incorporates in a natural way the issue of mode selectivity, offering insight on the physics of waveguide behaviour.

For each modelled signal its AE parameters, such as rise time, rise angle and others, were calculated. Statistical non-parametric algorithm for AE impulses detection against noise background was developed. It reveals the change of signal parameters in two near moving windows in time domain. The time windows scale and degree of statistic parameters difference were set adaptively on the basis of modelled AE parameters values. In comparison with threshold method, probability of impulse detection has increased by 20% at the same level of false detections, and location error has decreased by 1.5 times.

80 - CFRP failure mechanisms detection using traditional and modal AE equipment's features

Chris Rowland

Pancom Ltd, Huntingdon, United Kingdom

Abstract

CFRP designs are gradually replacing metal structures because of better weight to strength ratios and their directional strength properties. However, these complex structures involve multidirectional fibres, laminated layers and sandwich cores, all of which will have their unique acoustic emission (AE) signatures when failure occurs. It is the author's option that neither of the two current commercial AE systems available can discriminate between all the possible failure modes. This paper shows a technique to combine the attributes of the two types of AE system's features to accomplish detection of the failure modes.

One type of AE equipment (known as traditional AE equipment) utilises high sensitivity resonant sensors with a narrow upper frequency bandwidth. This approach to AE testing for composite structures provides a reasonable accurate location of the source of the event (using a single fixed velocity setting) plus a severity indicator, i.e. the Felicity Ratio (FR). Although this AE equipment can discriminate between in-plane mechanisms such as fibre breakage and matrix cracking by using pattern recognition, it cannot separate the out-of-plane de-lamination and the in-plane cracking mechanism.

The alternative, Modal Acoustic type equipment monitors both the low and high frequency of the AE regimes, hence showing the prevalence of both the in-plane and out-of-plane wave modes, thereby discriminating between cracking and delamination mechanisms. The disadvantage of this equipment is the requirement for a true wide band sensor, with an inherent 30dB reduced sensitivity compared to a resonant sensor. This reduction of sensitivity plus the acceptance of the two wave modes of different velocities inhibits good location analysis, although zonal location is attainable.

It is shown in this paper that both features of present day AE types can be obtained from the traditional AE equipment alone to realise the benefits of location, severity and discrimination between cracking and delamination. Two applications of the technique are shown in detail for CFRP specimen AE testing of a) a car design structure b) a structure representing designs used on racing yachts.

82 - Application and Analysis of AE signals based on the EEMD-FastICA method

Yu Jiang[1], Feiyun Xu[2], Zhong Yang[1], Jiming Yu, Bingsheng Xu[3]

[1]College of Intelligent Science and control Engineering, Jinling Institute of Technology, Nanjing, China.
[2]School of Mechanical Engineering, Southeast University, Nanjing, China.
[3]Nanjing Tech University, Nanjing, China

Abstract

Identifying weak fault signals from strong background noise is a difficult problem in AE signal processing. Based on the commonness of AE signals, the characters of propagation, attenuation and scattering model of AE signals and the influence of noise on fractal dimesnsion of AE signal are analyzed by using the EEMD-fastICA method (ensemble empirical mode decomposition and optimized Independent Component Analysis).

Firstly, the AE model are created to produce the complicated AE signals, and then AE signals are self-adaptive decomposed into a number of intrinsic mode functions (IMFs) by using EEMD algorithm. Secondly, the main feature IMFs signals are extracted as the effective AE source signal by optimized Fast-ICA method and the interference noises are removed. Finally, the simulation and test are implemented in order to validate the efficiency of the proposed method. The experimental results indicate that the proposed EEMD-FastICA method has the ability to reduce the interference noises.

10 - Evaluation of localized corrosion using Acoustic Emission signals: wavelets denoising and random forests classification

Nicolas Morizet, Marion Frégonèse, Nathalie Godin, Junlei Tang, Bernard Normand

INSA of Lyon - Mateis, Villeurbanne, France

Abstract

This work aims at proposing a novel approach to classify acoustic emission (AE) signals deriving from corrosion damage monitored in a noisy environment. Since AE signals associated to crevice corrosion are characterized by low energy content, they are hardly distinguishable from those generated by the environmental noise.

Thus, an in-depth work has been realized to preprocess the corresponding waveforms, including wavelet denoising. The whole approach combining the waveform preprocessing and Random Forest supervised classification has been implemented.

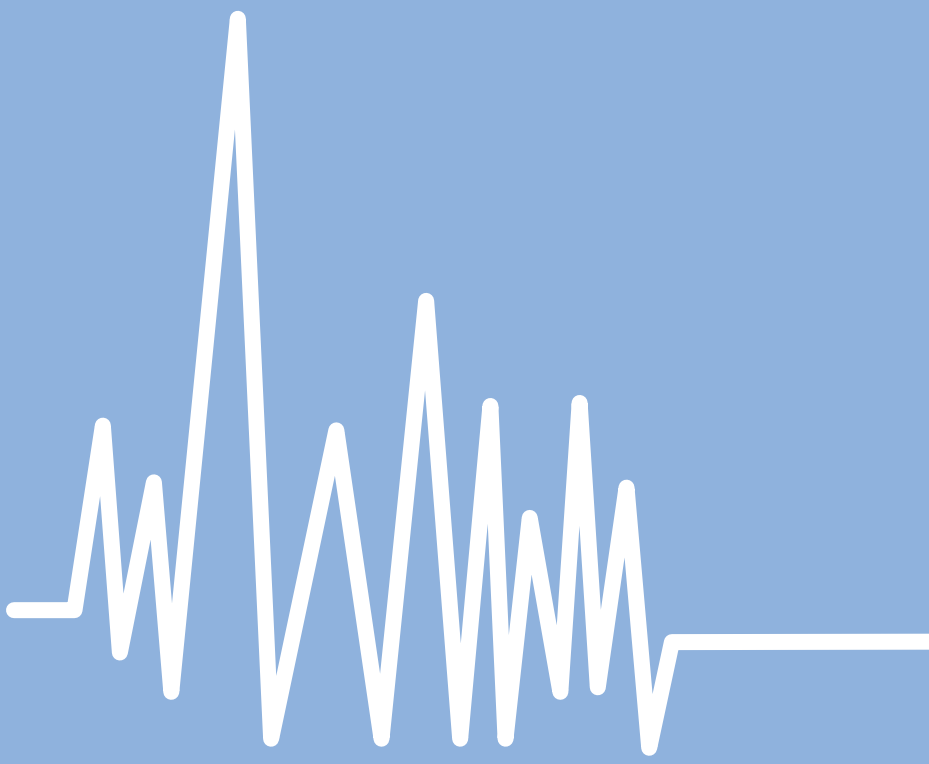
To validate this new methodology, synthetic data were first used throughout an in-depth analysis, comparing Random Forests (RF) to the k-Nearest Neighbor (k-NN) algorithm, in terms of accuracy and speed processing. These data were also used to test the robustness to mislabeled signals in the training set.

Then, tests on real cases involving noise and crevice corrosion were conducted on 304L stainless steel. In order to build up various data sets, pH, temperature, NaCl concentration and H2O2 addition were screened to obtain controlled crevice corrosion for some experiments and no corrosion for the others. The open circuit potential was continuously recorded.

Results show that this approach was also very promising on real data, especially for its reliability, performance and speed, which are serious criteria for corrosion monitoring in the chemical industry. In order to take into account the industrial reliability constraint, a decision rule called security voting has been implemented as a confidence level (set to 70%), and reinforced the final decision process taken by the majority voting.

Civil Engineering

Room 6
Time: 11:00 - 12:40
Date: 14th September 2018



09 - Acoustic Emission measurements during a tensile fatigue test in reinforced concrete

Gerd Manthei, Manuel Koob, Jens Minnert

THM Technische Hochschule Mittelhessen, Gießen, Germany

Abstract

In a research project, which was funded by the German Federal Ministry of Education and Research (BMBF), acoustic emission (AE) measurements were carried out during a tensile fatigue test on a plate-shaped reinforced concrete specimen to investigate the fatigue behaviour of an embedded steel anchor with a clothoid-shaped form in reinforced concrete. The results of AE measurements show that the AE activity begins immediately after starting dynamic loading.

Due to the limited location accuracy, the located AE events are not identified on fracture planes, but are cloud-like distributed in zones of the high stresses on the left and right edges of the steel anchor. During the test 9,132 AE events could be located using the longitudinal (P wave) and transverse (S wave) wave onsets. The locations of the AE events let suggest that microcracks occur due to the form-closed connection between the concrete and the steel anchor under fatigue stress.

59 - The estimation of particle size distribution of 3D soil sample under one-dimensional compression test by AE method

Sha Luo, Erdin Ibraim, Andrea Diambra

University of Bristol, United Kingdom

Abstract

Particle breakage plays an important role in not only the process of construction but also the life-circle of practical geotechnical applications. The crushing process of particle induce changes in the soil's particle size distribution (PSD) and alters the stiffness and strength of a granular soil, while significant volumetric contraction is associated. However, the real-time monitoring of the PSD is still problematic due to the accessible character of geotechnical structures.

Therefore, the non-destruct method, Acoustic Emission (AE) technique, was applied. Based on our previous study on single soil particle (silica type) and 2D soil sample in 1D compression test, we proved the possibility to use AE method to detect and represent the soil particles mechanical behaviour. In this paper, we further employed the AE method into the PSD estimation of 3D soil sample under 1D compression test.

The process of this research is to dynamic link the PSD of the soil samples with AE signals, at the meantime, compare and validate by stopping the sample at different stage and measure the PSD with traditional method (sieving); finally, inductive inference of the estimation method by relevant AE signals was achieved. It shows AE method works in the dynamic reflection of 3D soil sample under 1D compression, and further supports the real-time monitoring of the PSD in the practise geotechnical structure.

77 - Test of bending reinforced concrete structures by means of Acoustic Emission method

Serguei.V. Elizarov[1], **V. Bardakov**[1], **A.I. Sagaidak**[2]

[1]Interunis-IT LLC, Moscow, Russian Federation. [2]JSC SIC Construction, Moscow, Russian Federation

Abstract

People pay more and more attention to the reliability and safety of existing infrastructures (bridges, stadiums etc). Many of these objects were built during the second half of the last century and in some cases are in poor state. As the result increased security requirements are produced to this kind of objects. One of the main structural elements of these objects is reinforced concrete beams which are under bending loads. Traditionally, the technical state evaluation of reinforced concrete structures was carried out based on visual inspection or periodic test. However, these kinds of inspections do not allow to fix sharp changes in the construction state between inspections. They are time consuming, and also have low validity. In this regard, the relevant task is monitor of such objects. The Acoustic Emission (AE) is the promising method that can rise to this task.

In the course of this work, a number of experimental studies on test of reinforced concrete beams with three-point bending cyclically increasing loading until destruction were carried out, with accompaniment by AE. Summary, 6 reinforced concrete beams were tested. The beams had different composition, strength, type of reinforcement and as the result failure load. In addition, composites with fibrous concrete were investigated.

The data analysis obtained during experiments consisted of two stages. At the first stage, the results were evaluated in accordance with existing methods and approaches for evaluation the integrity and structural state of reinforced concrete structure by means of AE. Based on obtained results, advantages/disadvantages and correctness of applicability of existing methods and approaches were determined.

At the second stage, the results were evaluated based on independent analysis. At that, own approaches to data analysis and evaluation of the integrity and structural state of bending reinforced concrete structures by AE method were proposed.

81 - Assessment of infrastructures by rainy induced AE tomography with wave velocity and attenuation rate

Tomoki Shiotani[1], Katsufumi Hashimoto[1], Nobuhiro Okude[1], Clement Granier[2], Kazuo Watabe[3], Hidefuji Takamine[3]

[1]Kyoto University, Kyoto, Japan. [2]imdm-infra consulting, Vevey, Switzerland.
[3]Toshiba Corporation, Kawasaki, Japan

Abstract

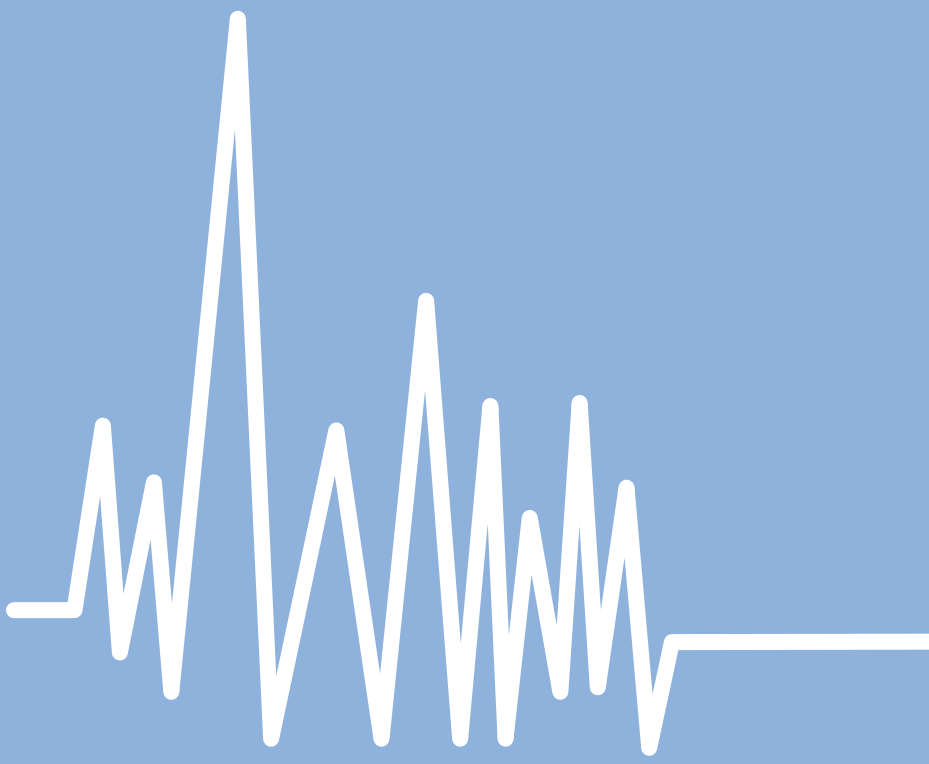
Cumulative progressive failure of materials can be interpreted by acoustic emission activity through AE monitoring; however, momentary AE monitoring on the way to the eventual failure could not explain the past failure activity. The authors have thus studied tomographic approaches enabling visualization of past failure activity.

As for the conventional tomographic approaches, it is crucial to excite reference waves at designated points. In this study, rainy induced AE activity is used as the excitations. Internal conditions of the materials are represented by wave velocities and energy attenuation of elastic waves. Besides it is crucially important to implement ray trace of elastic wave propagation considering diversion of waves in tomographic approaches for limited numbers of excitations. In this study, as numerous rain droplets could be hit on the objective surface, the computation will be implemented assuming the linear-path propagation.

Through the study, it is resulted that internal condition can be evaluated by rainy induces AE tomography, and the resultant wave features assuming the waves' propagation linearity is compatible to that of conventional AE tomography in consideration of wave diversion.

Source Location

Room 7
Time: 11:00 - 12:40
Date: 14th September 2018



34 - Contouring geodetically accurate Acoustic Emission sources via kernel density estimates

Petr Gális, Václav Kůs

Department of Mathematics, FNSPE, CTU in Prague, Czech Republic

Abstract

We deal with numerical model of localization of acoustic emission (AE) sources on real complex solid bodies. Our approach is based on exact geodesic curves on 3D vessels composed of several parametrized surfaces. The numerical computations are provided via Finite difference, Newton–Raphson, and Fixed-point iteration methods applied to geodesic equations acquired from differential geometry theory. To speed up computations, some technical improvements and optimizations are proposed.

The variable propagation velocity and also the case when the geodesic curve has to bypass a given obstacle there is also included into the model. These techniques are employed in the real experimental setup on bodies with higher geometrical complexity. The results (localization maps) of AE localization principle using length (ΔL) or time (ΔT) differences, obtained by means of geodesics, are then processed through the two-dimensional Kernel probability density estimates executed directly on the 3-D surfaces, which give us the most probable areas of the AE source positions on the main body.

The placement of piezo-ceramic AE sensors is outside the central part of the vessel because it can be inaccessible due to possible high temperature or radioactivity, such as in the case of nuclear power station health monitoring. This outward position of all AE sensors can result in a dispersed AE wave detected, or attenuated because of welded intersections of different surfaces. Thus, the Change-point analysis of AE signals is also discussed in order to obtain the most precise arrival times of AE events, which is crucial for ΔT / ΔL localization.

41 - Analysis of AE source location precision for general sensor configurations

Milan Chlada, Jan Kober, Zdenek Prevorovsky

Institute of Thermomechanics of the CAS, v. v. i., Prague, Czech Republic

Abstract

Proper sensor placement is the crucial step and a premise for precise AE source location estimate. Optimal sensor configuration in cases of complex structure shapes is one of AE expert challenges. It leads to numerical analysis of relations between the signal arrival chronology and the coordinates of emission sources.

Using the algorithm for finding the shortest ways in discretely defined bodies it is possible to design three parallel tools how to evaluate problematic areas, namely the location sensitivity, similarity and ambiguity maps, available even for non-continuous or anisotropic materials. Analogically to Global Positioning System, location of AE sources meets the geometrical dilution of precision (GDOP) phenomena. Similarly to GDOP parameter, recently introduced sensitivity map shows critical regions characterized by strong sensitivity of location results to signal arrival time changes or errors.

Remaining two mentioned methods illustrate the topology of arrival time differences space and possible ambiguities of source location. To check the numerical forecast of location capabilities of given sensor configuration, theoretical results were reviewed with the data measured during real experiment.

54 - Time reversal localization of continuous and burst AE sources under noise

Zdenek Prevorovsky, Josef Krofta, Jan Kober, Milan Chlada, Milan Mracko

Institute of Theromechanics CAS, Prague, Czech Republic

Abstract

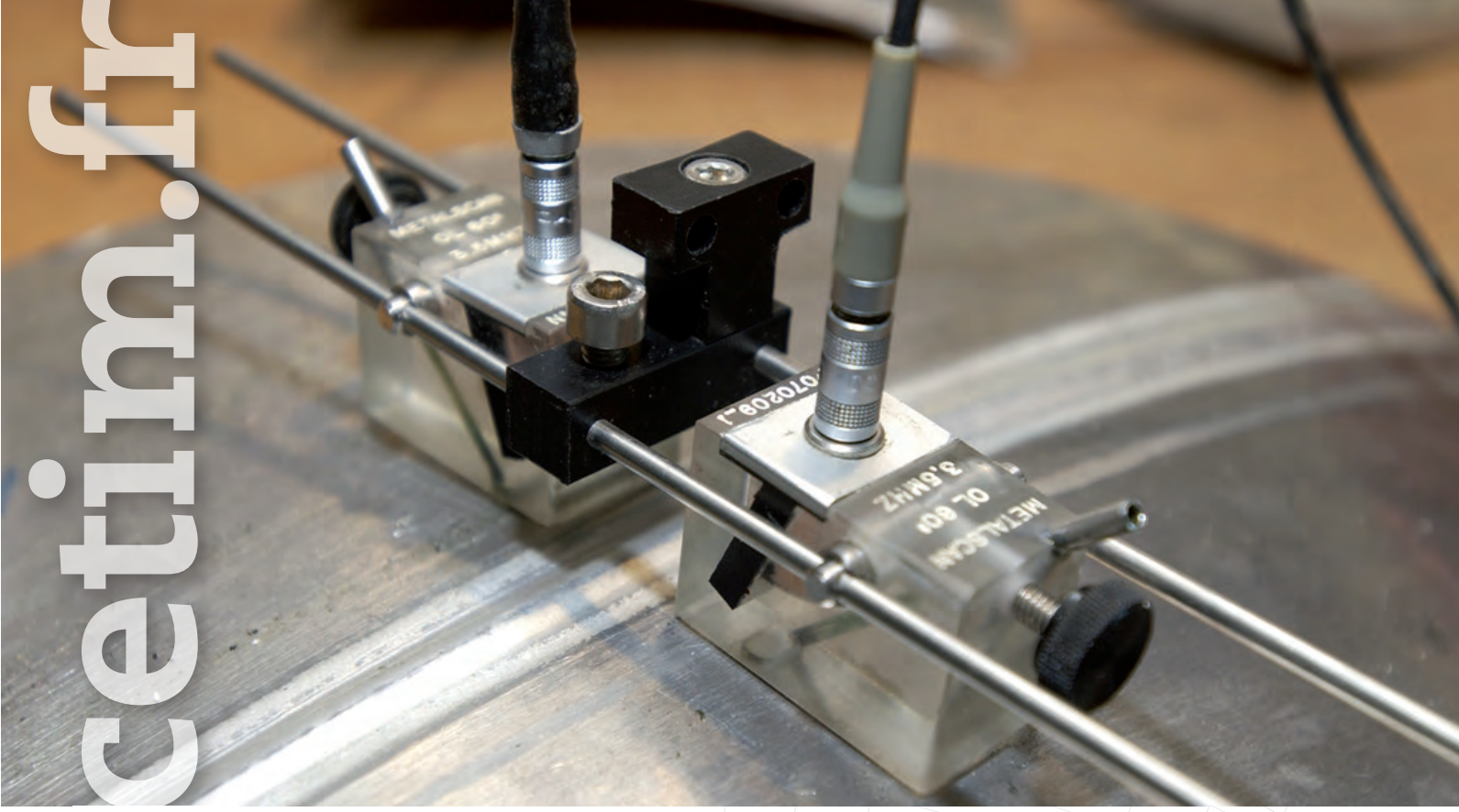
Time reversal (TR) processing of acoustic and ultrasonic signals is effective tool for complicated problems solution in NDT /E and structural health monitoring. TR enables space-time focusing of elastic wave and thereby relatively easy location and partial reconstruction of both burst and continuous acoustic emission (AE) sources. AE source location problems come up in situations with high external noiser, with wave dispersion in thin-wall structures, and wave velocity changes in complex structures with welds, flanges, branches, etc. Localization problems in such cases mostly require large sensor arrays and sophisticated signal processing and filtration.

A new solution with using TR approach is suggested in this paper. This approach allows planar location of burst AE sources with only one transducer, and continuous AE sources with two transducers, both under high background noise from other sources. TR procedure is in this paper applied to long random noise signals for the first time.

Suggested method was experimentally verified by simulated burst and continuous AE sources on a steel plates and pipes, and thin Al-plate with many holes. Source location results certified high robustness of suggested approach. Need of detailed scanning of a region around a pre-localized source constitutes certain disadvantage of that method. Numerical simulations shown that scanning can be omitted by inserting experimental TR signals into the computer model of monitored structure ("digital twin") and perform the source location in the model. Localization accuracy of suggested procedure proved by LDV was about one mm, which is better than the wavelength and transducer aperture.

Authors

Notes



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