Abstracts of the 30th International Congress on Condition Monitoring and Diagnostic Engineering Management (COMADEM 2017) – Part 3

The 30th International Congress on Condition Monitoring and Diagnostic Engineering Management (COMADEM 2017) was hosted by the University of Central Lancashire in Preston and Grange-Over-Sands during 10th to 13th July 2017. Well over 70 papers were presented by academic and industrial researchers from different parts of the world. The following areas were covered: Modelling, Analysis and Optimization; Sensor Technology and Damage Detection; Monitoring, Diagnosis, Prognosis and Health Management; Maintenance Engineering, Risk, Safety Assessment and Management; End User Applications and Maintenance in Industry; Advanced Signal Processing and Big Data; Special Session on “Tribotronics”; Special Session on Intelligent Condition Monitoring. Parts 1 and 2 are published in the October 2017 and April 2018 issues. In this issue some of the abstracts of the papers presented at the conference are covered.

1. Experimental Model-Based Approach to Integrated Prognostic and Health Management of a Non-Linear Liquid Level System
   Ali A G Al-Khafaji1, Roger I Grosvenor
   Corresponding author: Ali A. G. Al-Khafaji (al-khafajiaa@cardiff.ac.uk)

   Abstract: As far as a journal bearing is concerned, the vibration is a common problem. This paper aims at investigating frequency response function (FRF) of a journal bearing under various operating conditions. A dynamics model is developed for the journal bearing considering the effect of the Fluid Film. Modal analysis and harmonic response analysis are conducted. Both natural frequency and FRF of the fluid-solid coupled system are calculated. The distribution of natural frequencies of the journal bearing depends on the stiffness of the fluid film that is also related to the operating conditions. Moreover, a journal bearing test rig is established and the resonances signals are collected from the bearing housing under different radial loads. The experimental results agree well with the trend deduced from the theoretical analysis.

   Keywords: hydrodynamic force, fluid-solid coupled system, modal analysis, frequency response function

2. Effects of the Fluid Film on the Frequency Response Function of the Structure of Journal Bearings
   Yang Kang, Hao Zhang, Dongzhen, Zhanqun Shi, Fengshou Gu
   Corresponding author: Dr. H. Zhang (zhanghao@hebut.edu.cn)

3. Misalignment Identification Based on Dynamic Time Warping Method for Planetary Gearbox
   Zhaoyang Shen, Haiyang Li1, Dong Zhen, Hao Zhang, Zhanqun Shi and Fengshou Gu
   Corresponding author: d.zhen@hebut.edu.cn

   Abstract: Condition monitoring (CM) and fault diagnosis of gearbox has gained great attention in industrial applications, and the main techniques widely applied for CM mainly relies on the mechanical vibration. However, the measured vibration signals are normally with low signal-to-noise ratio (SNR) and non-stationary in real practices. It leads to difficult fault detection with high accuracy using vibration signals. This paper proposes a new fault diagnosis method based on dynamic time warping (DTW) for planetary gearbox fault detection using mechanical vibration. DTW is an effective method to align two dissimilarity signals for analysis by stretching and compressing the two dispersed signal sequence in the time domain. So it can be used to reduce noise and extract the fault features as well from the measured vibration signals. Therefore, the characteristics of the measured vibration signals can be improved, and more accuracy detection results can be obtained. The performance evaluation results using both simulated and experimental data shown that the proposed method can enhance the characteristics of vibration signals in the time domain, and the root mean square (RMS) values of the processed signals by DTW were calculated for the misalignment fault identification. It demonstrates that the proposed method can detect the planetary gearbox misalignment faults with different degrees effectively.

   Keywords: Planetary gearbox, Misalignment, Dynamic time warping, Root Mean Square.

4. Effect of Manufacturing Method of a Centrifugal Fan Hub on its Heat Dissipation Characteristics
   James Swinton, Taher Eshaafi, Taimoor Asim, John Irons, Rakesh Mishra
   Corresponding author: J. Swinton (JamesSwinton@halifax-fan.com)

   Abstract: As the process temperature of a fan system increases, the amount of heat that gets transmitted to the bearings and/or motor increases. If this is not accounted for, it can lead to catastrophic failure. The main heat conduction path is through the shaft, and certain mechanisms must be considered when looking for new solutions. These include; how heat is transmitted through the shaft or increasing the thermal resistance of the shaft, and dissipating heat as it is conducted
through the shaft. These aspects must always be considered in addition to the impact of the manufacturing complexity. In the present study, an existing heat dissipation arrangement is reviewed and replaced by a new design which reduces the time taken to machine the part, and ultimately the overall cost of the product. Computation Fluid Dynamics (CFD) based techniques have been used to numerically simulate the designs under operating conditions, and the resulting heat transfer through the shaft compared with respect to the heat dissipation properties. The results demonstrate that although the new design is less effective at dissipating heat, it provides a substantial cost reduction compared to the existing design, while substantially reducing the impact of the design on various aspects of production.

Keywords: CFD, Heat Transfer, Centrifugal Fan

5. Abrasive spur gear wear prediction model: Utilization of the statistical design experiments
Surapol Raadnui & Kitisak Wangwira
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Abstract: In extreme spur gear abrasive wear conditions some of the tooth damages such as pitting are not the main type of teeth flank failure any more. For certain abrasive wear limits of teeth flanks, experimental results were presented by statistical parameters. In this particular work the abrasive wear of spur gear lubricated with simulated contaminant was performed. An experiment was carried out which simulates the operation of spur gears in contaminated SiC media. A statistical model and statistical parameters are suitable for the development of abrasive wear model of tested gear pairs. Design of Experiment (DOE) was utilized against the background of spur gear abrasive wear, a multiple correlation model with a limited test conditions was anticipated in this particular paper. The effect of SiC concentration, applied load and sliding distance was statistically and physically analyzed in detail.

Keywords: Design of Experiment; Spur Gear; Three-body Abrasive Wear; Tribology; Wear Modeling Analysis

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Abstract: Condition monitoring and predictive maintenance are gaining importance amongst researchers and practitioners. Many technical systems, however, do not get to profit from the growing amount of knowledge in these fields. The reason lies in the lack of high quality monitoring data, largely due to the reluctance of system owners to invest in monitoring equipment and data processing. This leads to a vicious circle that limits the applicability of condition based maintenance. The need for simple yet effective schemes for data-driven maintenance optimization motivated the present research. This paper demonstrates the development of such a scheme for maintenance optimization of marine vessels based on the readily available data, thereby lowering the entry barrier for ship operators and promoting future improvements of the data quality. The approach combines data-driven with physical modeling, and uses the models as an input for a constrained optimization algorithm based on linear programming and a Monte-Carlo-based uncertainty analysis. The algorithm allows for a gradual enhancement of the data-driven component upon acquisition of more and better data.

Keywords: Condition Based Maintenance, Decision Making, Modelling and Optimization, Degradation Modelling, Uncertainty analysis.

7. Detecting Bearing Faults using an Ensemble Average Autocorrelation Based Stochastic Subspace Identification
Yuandong Xu, Pieter A. van Vuuren, Xiaoli Tang, Fengshou Gu, Andrew Ball
Corresponding author: Yuandong Xu (Yuandong.xu@hud.ac.uk)

Abstract: Envelope analysis plays an important role in the field of bearing faults detection. Since the development of this technique, the determination of optimal bands has been a prior challenge. Fast Kurtogram (FK) is an outstanding approach to select an optimal band for further analysis; however, fast Kurtogram is not robust enough to withstand the influence of white noise and large aperiodic impulses. Hence, a more robust method is introduced to extract the narrow bands for envelope analysis, which is ensemble average autocorrelation based stochastic subspace identification (SSI). The detector performs well in denoising and highlighting the periodic impulses owing to the outstanding characteristics of autocorrelation function and stochastic subspace identification. Considering the results of simulation study and experimental evaluation, it can be concluded that the proposed method is more effective and robust to detect bearing faults than fast Kurtogram.

Keywords: fault detection, ensemble average autocorrelation, SSI.
8. Theoretical Elucidation of Pass Frequency for Multi flaws in a Roller Bearing and Precise Diagnosis method using Sequential Diagnosis by Support Vector Machine
Yuto Mizushima, Luyang Song, Shyohei Ota and Peng Chen
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Author: Roller bearing is an important part in rotating machinery, which supports rotating shaft in the machine. Accordingly, it is important to monitor the condition of roller bearing in various operations for preventing the bearing damages. The fault types that often occur in roller bearings are outrace flaw, inner race flaw and roller element flaw. Although the theory and method for diagnosing one flaw in the roller bearing have been established, the precise diagnosis method for identifying the locations of multi-flaws in a roller bearing has not been clarified theoretically yet. Therefore, in this study, the method for precisely diagnosing multi-flaws in a roller bearing is proposed as follows. Firstly, it is theoretically proved that the pass frequency used for diagnosing single flaw can be used for diagnosing multi-flaws. Moreover, in order to confirm the accuracy of the theory, the spectrum of the artificial envelope waveform for the bearing multi-flaws is compared with that of the data obtained from experiments. It was found that the pass frequencies caused by bearing multi-flaws are the in both the cases of theory and experiments. Secondly, intelligent diagnosis method based on support vector machine is proposed for automatic diagnosis. The dedicated symptom parameter are not required when using SVM. This is an advantage when the proposed is applied for online diagnosis. Finally, the sequential diagnosis method is proposed for discriminating the conditions of bearing, such as normal or abnormal, outer race flaw or others, inner race flaw or rolling element flaw. The efficiency of the method is verified by practical flaw diagnosis of bearings with multi-flaws.

Keywords: Rolling bearings, multi-flaws, symptom parameter, sequential diagnosis, support vector machine

9. Monitoring Shaft Fatigue Failure Using an Online System
Ahmed N-s Abufroukh, Ahmed Onsy, Ian Sherrington
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Abstract: Shafts are used in almost all mechanical applications were rotational movement takes place between elements. However, shafts are prone to material defects physical damage and fatigue, which may cause catastrophic failure. The four main types of shaft failure for properly designed devices are corrosion, wear, overload and fatigue. Fatigue is common and often occurs when various load is applied over many cycles, the subsequent stress leads to cracks or fractures. This paper will outline an online monitoring system for monitoring fatigue failures in shafts. It will suggest that, along with the use of adequate sensors, online monitoring approaches, used with predictive or proactive maintenance strategies, can facilitate the development of failure detection system. This system has been validated using test apparatus developed by the authors who have demonstrated the ability of the system to detect developing fatigue failure in shafts. The following sections will review the investigation, which it is argued support the development of an Online Monitoring System to monitor shaft failures.

Keywords: Fatigue Failures, Condition Monitoring, Fracture, Catastrophic Failures, Online Active System

10. Bearing Fault Feature Detecting Based on Nonlocal Means Denoising
Yanxue Wang, Shuilong He and Suofeng Zhang
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Abstract: Defective rolling bearing response is often characterized by the presence of periodic impulses, which are usually immersed in stochastic noise. In order to more effectively identify incipient defect, nonlocal mean denoising is applied to extract features in this work. The performances of nonlocal mean denoising are evaluated in comparison with wavelet threshold denoising, translation invariant wavelet denoising and the second generation wavelet denoising. Vibration signals acquired from bearings with defect in the outer raceway, inner raceway and rolling element fault, respectively, extracted availably based on the proposed approach. Experimental results show that the proposed approach is feasible and effective to detect roller bearing faults from vibration signals.

Keywords: Nonlocal means denoising, feature detection, denosing, rolling bearing, fault diagnosis.
11. A Self-Adaptive AE Signal Classification Method on Energy Domain
Yong Zhou, Da Wang, Li Lin
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Abstract: This paper presents a self-adaptive data analysis method on acoustic emission (AE) signals which are generated by the fracture test on the rotation shaft. When collecting AE signals from the fracture test, it is easy to get some kinds of noise signals, such as lead-off signal and whacked signal. And considering the high sampling rate on AE signal collection, it is necessary to find an effective method to intelligently pre-process this huge data. So this paper uses the empirical mode decomposition (EMD) to find the particular features of the AE signal. The proposed analysis method consists of feature extraction using the EMD method and fault classification using the artificial neural network (ANN) technique. Using EMD method to decompose the sample signals, it obtains some intrinsic mode function (IMF) components. IMFs can be used to calculate a carefully designed feature vector which contains energy entropy, energy distribution and total energy. In the fault classification, these energy feature vectors of different kinds of signals are used as inputs to train the ANN. Experimental results indicated that this analysis method can accurately identify the AE signals caused by the fracture test on rotation shafts from some kinds of noise signals produced at the same time. So this analysis method can be used in the acoustic emissions collection and identification.

Keywords: Empirical mode decomposition; Elman neural network; Feature extraction; Fault diagnosis; Energy entropy.

12. Research of Optimal Placement of Sensor for Wind Turbine Based on Immune Algorithm
Zhongyue SONG, Haiyang Li, Hao Zhang, Dong ZHEN, Zhanqun SHI
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Abstract: Signal acquisition is a prerequisite for fault analysis and diagnosis, but also the necessary condition in the fault diagnosis of wind turbine gearbox. At present, the most mature method is vibration signal analysis method, however, because the internal structure of the gearbox can not be destroyed, it can only lead to vibration sensor installed on the external wall of the gearbox. The gearbox arrangement of sensors will directly influence the quality of diagnostic accuracy, using immune algorithm to solve the problem of sensor arrangement in fault diagnosis of wind turbine, construct the gearbox vibration source coordinates, calculate the optimal transmission path of vibration transmission. To determine the best measuring point and provide an effective method for sensor arrangement.

Keywords: Immune algorithm, Points for sensor layout, Layout optimization, Wind turbines

M. Hemmer, T.I. Waag, K.G. Robbersmyr
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Abstract: Rolling element bearings (REBs) are key components in most rotating machinery. Large, slow-rotating REBs found in heavy industrial applications like offshore drilling equipment, steel- and paper mills and wind turbines are the topic of this paper. In such applications, bearings are normally non-redundant components, meaning bearing failure will cause system downtime. Execution of unplanned, on-site maintenance may be costly, time-consuming and difficult or even impossible. Implementation of condition-based maintenance strategies is a means to reduce total lifecycle costs by improving utilization of component lifetime while maintaining system availability. Condition monitoring systems capable of early, reliable detection and diagnosis of incipient faults is necessary for the planning of maintenance actions in due time. In this paper, novel and established condition monitoring methods are surveyed for this purpose. Prominent challenges are speed variations, non-stationary behavior, and low signal-to-noise ratio. Advanced signal processing methods, including order tracking and resampling from time to angular domain, higher order statistics, and cyclic spectral analysis are presented. Methods for data acquisition and maintenance decision making are also discussed. A discussion of the surveyed methods and suggestions for future research concludes the paper.

Keywords: Slow-rotating machinery, Condition Monitoring, Advanced Signal Processing, Large Roller-element Bearings, Diagnosis

14. Design and Development of a Multipurpose Test Apparatus for Intelligent Lip Seals
Corresponding author: Wilbert Sinza (wsinzara@uelan.ac.uk)

Abstract: This paper describes the design of a novel test apparatus for the development of intelligent lip seals. The intelligent lip seal will include sensors, actuators and intelligent control, allowing it to react optimally to changing scenarios (such a device is also called a tribotronic system). Intelligent sealing systems offer the potential for improved function and better maintainability, with benefits including extended component life, reduced friction and wear, lower power consumption and real-time duty information. Conventional test apparatus is not ideal for developing intelligent
mechanical sealing components as they lack the flexibility to test a wide range of sealing challenges and have limited data collecting capabilities. The new test apparatus includes sensors for the measurement of shaft torque, oil temperature, vibration, shaft speed and lubricant leakage. A transparent tube is used to enable visualization of the shaft-seal counterface and other phenomena associated with the shaft-seal contact. The seal housing is repositionable to allow axial offsets between the shaft and the seal. This will allow the testing and development of seals capable of mitigating leakage or reducing friction in the presence of misalignment. The test apparatus also supports variable shaft speeds, lubricant temperatures, lubricant pressures and interchangeable shafts with varying surface roughness in order to carry out testing under a range of conditions.

Keywords: lip seal, intelligent machines, test apparatus

15. An Intelligent Maintenance System for Driverless Vehicles
J. T. Philip, A. Onsy, M. R. Varley
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Abstract: The UK Department of Transport states that most road accidents are caused by human error. Several car manufacturing companies are now involved in research that aims to address this issue through the development of commercial driverless vehicles employing intelligent systems. Driverless vehicle research has been principally concerned with satisfying the requirements of level five of the Society of Automotive Engineering (SAE, USA) J3016 automotive automation standard; a standard that will improve commuter satisfaction and vehicle performance. However, many outstanding issues still need to be addressed, such as on-road safety and integration. Significant efforts are being made to advance current technology in order to create cost effective and robust driverless technology, which is expected to increase in the coming years. Additionally, an Intelligent Management System for Driverless Vehicles (IMSDV) is becoming a necessity as it is an intricate combination of Advanced Driver Assistive Systems (ADAS) management with an added intelligence algorithm that consists of various decision-making parameters, depending on a priority-based hierarchy. This resulted in research being conducted which focused on driverless vehicles in order to create a platform for testing, by developing a ‘Driverless Pod’ with intelligent systems suited for the advance of a complete IMSDV. The paper introduces a new ‘Driverless Pod’ that has been developed and evaluated as an experimental test bench used to validate an IMSDV. The Pod incorporates several subsystems including different sensors, actuators and controllers, all of which are similar to those used in commercial driverless vehicles. Current development integrates both hardware and software. Further publications will detail two monitoring subsystems for the driverless vehicle steering system and vehicle wheel/tyre condition. A new and intelligent algorithm for driverless vehicle management that addresses health, safety and maintenance issues in relation to driverless vehicles will then be developed. These developments will be validated in three stages: laboratory testing, workshop testing and on the Driverless Pod.

Keywords: Multi-Disciplinary; Advanced Driver Assistance Systems (ADAS); Intelligent Management for Driverless Vehicle Systems (IMSDV).

16. The Way Cyber Physical Systems will Revolutionise Maintenance
Corresponding author. E. Jantunen (email: erkki.jantunen@vtt.fi)

Abstract: The way maintenance is carried out is altering rapidly. The introduction of Cyber Physical Systems (CPS) and cloud technologies are providing new technological possibilities that change dramatically the way it is possible to follow production machinery and the necessity to carry out maintenance. In the near future, the number of machines that can be followed from remoteness will explode. At the same time, it will be conceivable to carry out local diagnosis and prognosis that support the adaptation of Condition Based Maintenance (CBM) i.e. financial optimisation can drive the decision whether a machine needs maintenance or not. Further to this, the cloud technology allows to accumulate relevant data from numerous sources that can be used for further improvement of the maintenance practices. The paper goes through the new technologies that have been mentioned above and how they can be benefitted from in practice.

Keywords: Condition Based Maintenance (CBM), Cyber Physical Systems (CPS), Overall Equipment Effectiveness (OEE), e-maintenance, Internet of Things (IoT)
17. Nuisance Attribute Projection Based Channel Compensation Technique and its Application in Bearing Performance Degradation Assessment
Huiming Jiang, Jin Chen, Guangming Dong
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Abstract: During condition monitoring, the sampled data covers not only information about the health state or fault degree, but also information about the sample channel. The information about the sample channel is nuisance attribute for the condition monitoring. However, it induces different information for different channels, which influences the performance of the condition monitoring system. In this paper, the nuisance attribute projection (NAP) based channel compensation technique is introduced. NAP can filter out the effect of nuisance attributes in feature space through projection. Performance degradation assessment method based on hidden Markov model and NAP is proposed. The results of experimental data show that NAP can effectively improve the accuracy and robustness of the performance degradation assessment system.

Keywords: Nuisance attribute projection, Channel compensation, Performance degradation assessment, Hidden Markov model, bearing, Projection

18. Dynamic State Recognition Using CNN-RNN Processing Pipeline
E. R. Anas and B. J. Matuszewski
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Abstract: The paper describes a novel method for detecting motion using a software pipeline model consisting of Convolutional Neural Network ‘CNN’ followed by Recurrent Neural Network ‘RNN’. The method can be useful to monitor a sequence of events and provide a decision of action completion. The CNN, generally, provides a sufficient information about the object states but without information describing temporal dependence between these states. By introducing an RNN network after the CNN, the software could utilize the temporal information about the system present in the successive observations. To prove the concept, the human’s eye blink action is used as an example. The training procedure consists of a CNN first trained on eye images to detect the distinctive eye states. Subsequently, the eye status probability values predicted from the trained CNN divided into short sequences contain the temporal information describing the blink action. Finally, a multilayer RNN has been trained on these sequences to detect the eye blink events. The adopted RNN model shows a capability to capture relevant temporal information even when different CNNs, trained on the same datasets, are used. More specifically, the proposed method has achieved 93%/94% and 98%/98% recall/precision on the Eyelink8 and Talking Face datasets respectively.

Keywords: Motion detection, Monitoring, Deep Learning, Eye Status Detection, Eye Blinking Rate Estimation.

19. Study on Feature Extraction of Bearing Incipient Weak Fault Based on Dictionary Learning
Guangming Dong, Jin Chen, Haodong Yuan
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Abstract: Rolling element bearings are frequently used in rotary machinery, but they are also fragile mechanical parts. Hence, exact condition monitoring and fault diagnosis for them plays an important role of ensuring machinery’s reliable running. Timely diagnosis of early bearing faults is desirable, but the early fault signatures are easily submerged in noise. This paper focuses on the application of dictionary learning and sparse representation methods on bearing fault feature extraction and fault diagnosis. Two dictionary learning methods: K-SVD and shift-invariant dictionary learning (SIDL) are studied. The K-SVD algorithm takes its name from singular value decomposition (SVD), which is used for one atom update and repeated for K times during the dictionary learning stage. K-SVD is one appealing method because of its efficiency. SIDL reconstructs signals using basis atoms in all possible time shifts. SIDL is very suitable to extract periodic impulses. Simulation and experimental bearing signals are used for demonstration and comparison of fault feature extraction based on K-SVD and SIDL.

Keywords: Feature extraction; sparse representation; Dictionary learning; Shift-invariant dictionary learning; K-SVD.

20. The Impact of Effective Prognostic Techniques (Predicting Remaining Useful Life) on Successful Implementation of Total Productive Maintenance in the Power Industry
A.Y. Alseiari and P. Farrell
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Abstract: The power industry has recognised the significance of implementing Total Productive Maintenance (TPM) as a maintenance strategy to enhance its proactive techniques and improve power asset reliability. Successful power utilities have sufficient failure data that predicts accurate times to failure of their power assets, based on condition monitoring techniques. Power transformers are the most expensive elements and their faults are particularly costly.
Therefore, detection of power transformer failures at an early stage is important to assure reliable and efficient operation. The aim of this research is to investigate the critical role of prognostic techniques and how they can drive successful implementation of TPM in the power industry through planned maintenance pillar. The research presents an innovative technique for early fault detection and diagnosis in power transformers based on paper degradation analysis. This method uses measurements obtained from a power distribution industry in the Abu Dhabi of the degradation factor of power transformer paper insulation (degree of polymerisation - DP values) over time, from condition monitoring data that is obtained through dissolved-gas analysis (DGA). The mathematical exponential model uses degradation measurements DP values of paper insulation for multiple power transformers to extrapolate these measurements over time, and hence predicts potential failure times before they occur. This is based on a prognostic technique that utilises ReliaSoft's Weibull++ software. The results of this research show that successful implementation of TPM in the power industry can be achieved through appropriate techniques of predictive maintenance within the planned maintenance pillar of TPM, thus increasing availability, performance, quality and reliability rates by preventing sudden failure of power transformers.

**Keywords:** Total Productive Maintenance (TPM); Condition Monitoring (CM); Predictive Maintenance (PdM); Dissolved-Gas Analysis (DGA); Degradation Analysis; Remaining Useful Life (RUL)

### 21. Fault Diagnosis of a Polymer Electrolyte Membrane Fuel Cell using Bayesian Network

**L. Mao, L. Jackson, B. Davies**

**Corresponding author:** Dr L. Mao *(l.mao@lboro.ac.uk)*

**Abstract:** In this paper, a Bayesian network of a polymer electrolyte membrane (PEM) fuel cell is developed for fault diagnosis, which consists of several fuel cell failure modes relating to the fuel cell components via various failure mechanisms. In order to better utilize the Bayesian network in practical PEM fuel cells, an extra sensor layer is added to the Bayesian network, as the variation in sensors can be obtained directly from fuel cell tests. The relationship between added sensors and fuel cell failure modes can be determined based on previous studies, while their conditional probabilities can be calculated using fuel cell degradation rates due to different failure modes. To validate the effectiveness of developed the fuel cell Bayesian network, a case study of fuel cell flooding is investigated, the fault diagnosis is carried out by monitoring the variation in the sensors. Results demonstrate that the flooding can be successfully identified by monitoring the sensor measurements from the PEM fuel cell system.

**Keywords:** PEM fuel cell, system fault diagnosis, Bayesian network.

### 22. Weighted Narrowband Envelope Spectrum and its Application to Bearing Fault Diagnosis

**Jie Duan, Tielin Shi, Jianping Xuan, Hongdi Zhou**

**Corresponding author:** Tielin Shi *(email: tlshi@mail.hust.edu.cn)*

**Abstract:** The Program [1] is based on the kurtosis of the envelope spectrum amplitudes of the narrowband demodulated signal, and has been proved practical and powerful in bearing fault diagnosis. However, kurtosis is very sensitive to large random impulses that are frequently encountered in industrial applications. So the narrowband with maximum kurtosis may not be associated with the bearing fault. Meanwhile, the key issue of bearing fault diagnosis is to detect the bearing’s characteristic frequencies rather than eliminate all noises. So a novel method is presented by combining the envelope spectra at different frequency bands for the bearing fault diagnosis in this paper. The Jarque–Bera statistic, a combination of kurtosis and skewness, is used to detect the existence of impulses in the envelope spectrum. These narrowband envelope spectra with larger Jarque–Bera statistics are selected, and weighted mean of the sequence of envelope spectra is calculated as the weighted narrowband envelope spectrum. Then the weighted spectrum can be used to determine the types of bearing faults by identifying its characteristic frequencies. The effectiveness of the proposed method in bearing fault detection is validated using some real signals.

**Keywords:** bearing fault diagnosis, narrowband amplitude demodulation, Jarque–Bera statistic.
COMADEM International is inviting technical papers for the 31st COMADEM congress on condition monitoring which will be held in sunny South Africa. Authors are invited to submit original, unpublished research on condition monitoring and diagnostic engineering management to be presented to the global condition monitoring forum at this conference. All contributions will be peer reviewed and all accepted papers will be published in the conference proceedings. Selected papers will be considered for publication in the online version of the International Journal of COMADEM. Industrial exhibitors are encouraged to exhibit their latest products and services.

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- Submission of abstracts: 12 January 2018
- Notification of acceptance of abstracts: 2 February 2018
- Submission of full papers: 30 March 2018
- Notification of acceptance of full papers: 27 April 2018
- End of early bird registration: 11 May 2018
- Conference: 2 – 5 July 2018

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CONTENTS

Guest Editorial

Dynamic State Recognition Using CNN-RNN Processing Pipeline
Essa R. Anas and Bogdan J. Matuszewski; UK

Study on Feature Extraction of Bearing Incipient Weak Fault based on Dictionary Learning
Guangming Dong, Jin Chen, and Haodong Yuan; PR China

Condition-Based Maintenance Decision Making: A practical approach for Marine Vessels
Lilach Goren Huber, Simon Kunz, and Marcel Dettling; Switzerland

Experimental Model-Based approach to Integrated Prognostic and Health Management of a Non-Linear Liquid Level System
Ali A G Al-Khafaji and Roger I Grosvenor; UK and Iraq

The Impact of Maintenance Duration on the Downtime of an Offshore Wind farm - Alternating Renewal Process
Helene Seyr, Anne Barros, and Michael Muskulus; Norway

An Investigation into Vibration Response for Condition Monitoring of Reciprocating Compressor based on Modulation Signal Spectrum Analysis
Usama Haba, Khaldoon Brethee, Osama Hassin, Fengshou Gu, and Andrew D. Ball; UK and Libya

Theoretical Elucidation of Pass Frequency for Multi-flaws in a Roller Bearing and Precise Diagnosis Method Using Decision Tree and Support Vector Machine
Yuto Mizushima, Liuyang Song, Shyohei Ota, and Peng Chen; Japan

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