LETTERS

COMADEM - A Concept for the Future

George J.Trmal

University of the West of England
Faculty of Engineering
Coldharbour Lane
Bristol BS16 1QY
ENGLAND

Dr George J. Trmal graduated from the Czech Technical University in Prague in 1960. He worked for 10 years in the Czech Machine-Tool Industry, mostly in R & D. He then came to England and worked in grinding research at the University of Birmingham, where he obtained his Ph D. In 1978 he joined Bristol Polytechnic, where he became a Reader.He continued his research in grinding but his interests expanded onto such areas as computer simulation, condition monitoring, signal processing and vibration and noise analysis. He has written over 70 papers that were published in Journals and Conference Proceedings.
In 1993 he chaired the Organizing Committee of the COMADEM Conference.

Introduction

The 5th International Congress on Condition Monitoring and Diagnostic Engineering Management, COMADEM, was held in Summer 1993 at the University of the West of England, Bristol. The 1994 COMADEM Conference was held in New Delhi.

What is COMADEM? It is more than a conference or an exhibition. It is a whole area spanning many disciplines. It involves sensing of relevant parameters, monitoring, evaluating data, and presenting the information in the most suitable form as a basis for decisions. The concept can be applied to such diverse fields as machinery maintenance, manufacturing processes, quality assurance, repairs of electronic equipment and medical engineering. The concept is not new. Skilled and responsible operators of the past always monitored the processes and machines to be sure that the product would meet the quality criteria. In the current moves towards automation, the procedure must be made more formally. At the same time the developments in sensing technology and signal processing have opened up a wide range of possibilities.

It is the development of new sensing methods and computerised signal processing and interpretation as well as the application of the concept to new areas which makes the COMADEM exciting. It is the possibility of enormous savings in the cost of maintenance, repairs and lost business wihich makes the COMADEM concept extremely useful. In addition to the reduced cost connected with failures, deeper understanding of the process gained by monitoring often leads to changes in design, in an effort to 'design the problems out'.

The Conference

The COMADEM conferences provide an annual review of the 'state-of-the-art' in the field and attract a wide audience with varied interests. The conferences attempt to promote condition monitoring and diagnostic management methods in all relevant areas, bring together the researchers and practicing industrial engineers to discuss achievements, possibilities and problems.

Concepts

Each year the conference attracts some papers dealing with conceptual issues and the 1993 conference was no exception. Drake and Harrison [1] described a method for selecting the most suitable technique using the Analytic Hierarchy process. It sounds complicated but it is a common sense approach. Decide on criteria and on their importance and assess how the available methods satisfy these criteria. The method could form a basis of an Expert System. G.A.King [2] identified a problem of high computational intensity and

suggested the use of parallel computing languages and distributed operating systems as a way forward. Harris [15] explained the principles of neural networks application in the COMADEM field. The paper set the scene for a number of papers in this new and exciting area.

Neural Networks

O'Brian and Reeves [16] described and compared several types of neural networks in monitoring applications considering such criteria as possible misclassifications and the ease and speed of training the system. Harris and Wilkinson [17] described an application of neural networks in an automated NDT system, Azzam et al [31] combined the neural networks with the vibration analysis system for detection and diagnosis of helicopter faults. Javed and Littlefair [18] described the neural networks based system for condition monitoring of rotating machinery, Ball and Worden [19] used the neural networks approach for reducing the noise content in the monitored signal and revealing hidden features. Using the neural networks approach when the system can be trained to develop its own method is definitely useful. However, other authors concentrated on signal evaluation using logical analysis of the signal.

Signal Analysis

McFadden and Wang [22] used the Gabor spectrogram to represent a tooth meshing vibration of a gear. Image processing techniques were used to detect faults by analysing patterns in the energy distribution in the time-frequency domain. Zheng and McFadden [23] described the use of parameter identification technique to obtain characteristic parameters: frequency, damping, amplitude and phase. The technique provides a way of relating the signal to quantitative properties of the gear fault. Staszewski and Tomlinson [24] applied a moving window procedure to a vibration signal to detect high frequency impulses, characteristic of local gear faults. Luo and Kuhnel [25] introduced the grey relational grade analysis for use with grey system theory and applied it to the detection of gearbox

faults. Trmal and Johnson [21] discussed various parameters for evaluation of acoustic noise and vibration signals. They characterised the parameters on the basis of their sensitivity and repeatability and defined a criterion of reliability combining the two. An alternative to vibration and noise analysis, analysis of debris found in the lubricant, was also represented.

Debris Analysis

Hunt [6] compared two methods for assessing machine health: wear debris analysis and vibration analysis. He provided a number of well-documented examples and argued for the combination of both methods. Kirk and Stachowiak [7] described fractal image analysis, computer-aided statistical analysis of size, shape, texture and other properties of wear particles. This detailed and meaningful information cannot be obtained by laborious manual analysis and requires computerised approach. The same authors [8] applied the fractal image analysis to the debris contained in synovial fluid of arthritic joints. They claimed that the fractal image analysis is a powerful tool in the study of wear mechanism of arthritic joints.

Manufacturing Processes

Quality of the product produced by the machining process depends to a large degree on the changing state of the cutting tool. Shi Hong and Allen [26] determined that the vibration energy in the high frequency band was characteristic of the tool wear and could be used in adaptive control of the process. Moore and Pei[27] used vibration signals to determine cutting edge wear and fracture in milling. They showed that both edge fracture and wear could be detected during the process. Smith [28] provided a review of recent research work and discussed the available industrial systems in tool condition monitoring.

Databases

Often there is a need for long-term storage of monitored data.

This need arises in maintenance planning as well as in quality inspection, where it is necessary to evaluate long term trends. Rao et al [29] described the design and construction of a pilot Oracle database for a condition monitoring system. Savage [9] described methods for organising large quantities of raw data so that they could provide a comprehensive support for planning and management of improvement efforts.

Applications

One of the interesting features of COMADEM conferences are papers describing practical applications of monitoring and solution of specific problems. Carr [32] described the development of a diagnostic system at Rolls Royce. The system is based on engine vibration and runs on a PC. It identifies necessary corrective actions for engines rejected in acceptance tests. Alexandru et al [20] described a fault detection and diagnosis system for an automatic NDT application. The system is used in quality inspection and handles large amount of data. The speed of evaluation is of great importance. The system has been fully developed and can be considered as part of CIM.

Most interesting are the imaginative applications of COMADEM principles to new areas. Hoddell, Savage, Long et al [10, 11] describe the development of life tracking system for citrus fruit. The system monitors the fruit during the transport phase and combines the information with the fruit characteristics and post and pre harvest history stored on a database. Chrpova and Nemecek [12] presented an interesting application of monitoring noise and vibration in the needle punching process of non-woven textiles. The optimisation of the needle punching process and maximum needle life can be achieved on the basis of analysis of the monitored data. Hill [3] proposed to apply the principles of monitoring and assessment of reliability to the rating of suppliers. In the climate of JIT philosophy, this approach has considerable saving potential. Baker, Noroozi and Hope [30]

described an on - line system for monitoring the concentration of light fuel oils in a water discharge. Another paper concerned with environmental problems was presented by Khan [33] and dealt with monitoring of vegetation condition using meteorological satellite data. Other interesting applications include monitoring of stability of tipping vehicles [13] and early warning and diagnosis of faults in aircraft mechanical systems [14].

Education

A.D.Ball [4] described the design of a degree course module dealing with plant monitoring and diagnostics. This module was introduced in acknowledgment of the need for modern measurement and analysis methods in industry. T.M.Phan et al [5] introduced a new teaching programme for the French Education Scheme. The programme is concerned with monitoring the working functions of machines and it is intended for training colleges on the Higher Technical Certificate level. The feedback from students and teachers reflects favourably on the interactive nature of the programme.

It is impossible to mention all the authors whose interesting presentations contributed to the success of the conference and apologies are due to those who are not included in this review.

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