Discourse on the Dissertation Thesis

Identification of Changes of Acoustic Emission Parameters as a Result of Mechanical Damage of Machinery Components

Libor Nohál

"Swim against the stream! It´s hard, but it is a way, how to reach more than the others."

Radomír Zbožínek Sr.

This presentation is co-financed by European Social Fund and The Czech Republic State Fund.

INVESTSMENTS IN EDUCATION DEVELOPMENT

CONTENTS

- Introduction
- State of art
- Critical analysis
- Goals of research and methodology
- Current stage of project
- Bibliography

This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

INVESTSMENTS IN EDUCATION DEVELOPMENT

INTRODUCTION – THEME

Supervisor: doc. Ing. Pavel Mazal, CSc.

Identification of changes of acoustic emission signal parameters as a result of mechanical damage of construction

This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

INVESTSMENTS IN EDUCATION DEVELOPMENT

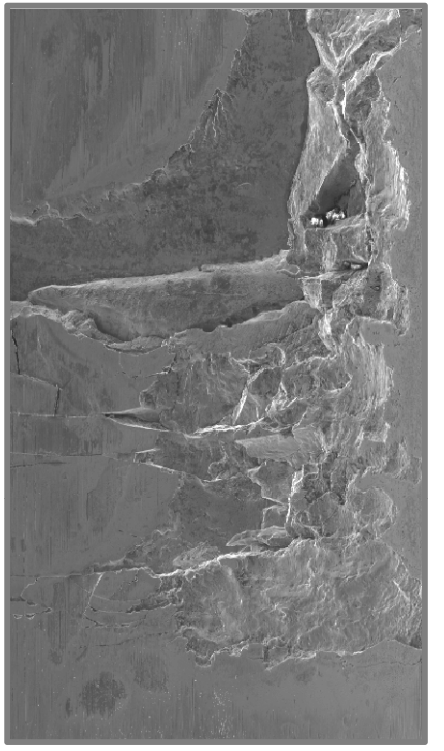
INTRODUCTION

- Limit state of surface damage (contact fatigue)
- Parameter analysis – traditional method
- Time × Frequency × Time-frequency domain

Aim of dissertation: simple evaluation of contact fatigue

Contact fatigue:

- Contact fatigue tests (specimen)
- Bearing testing
- Gearbox testing



Pitting

This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

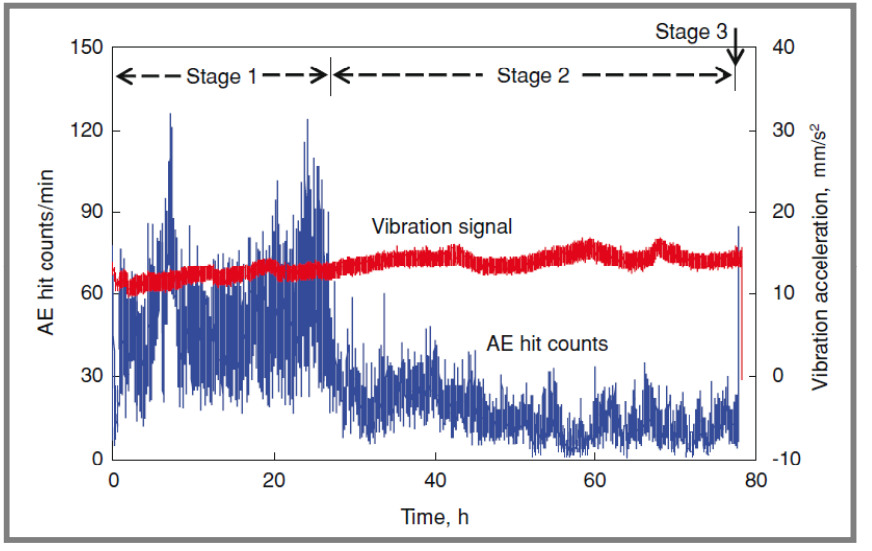
INVESTSMENTS IN EDUCATION DEVELOPMENT

STATE OF ART - Contact fatigue test

A study on incipient damage monitoring in rolling contact fatigue process using acoustic emission

RAHMAN, Z. et al. 2008

- RCF tests
- Counts rate, energy parameters
- AE, vibration, FFT, temperature, Torque, Load
- Stage 1 - running-in state
- Stage 2 – steady-state condition
- Stage 3 - surface degradation state



AE hit counts rate and its corresponding vibration signal

This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

STATE OF ART - Gearbox testing

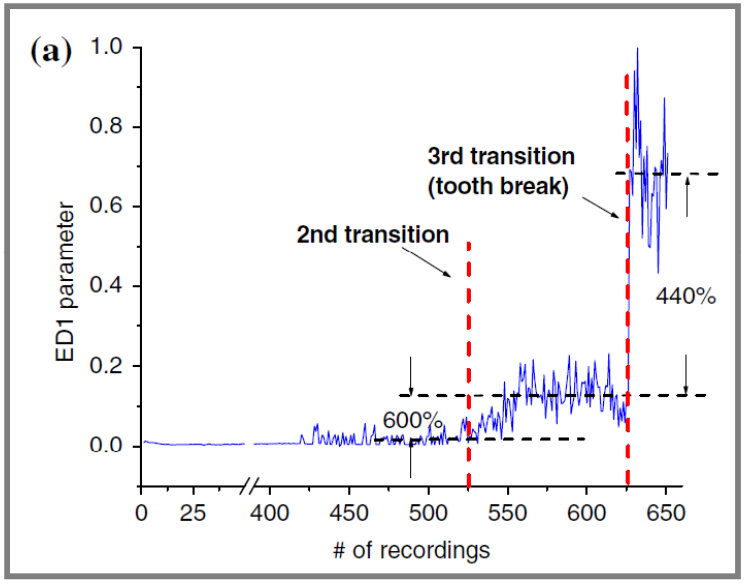
Condition monitoring of a single-stage gearbox with artificially induced gear cracks utilizing on-line vibration and acoustic emission measurements

LOUTAS, T. H. et al. 2009

- AE, vibration, temperature
- Discrete wavelet transform (db10)

→wavelet-based parameters

- 24 Conventional parameters (frequency and time domain)
- Early stages of the test - AE



Parameters evolution during the test

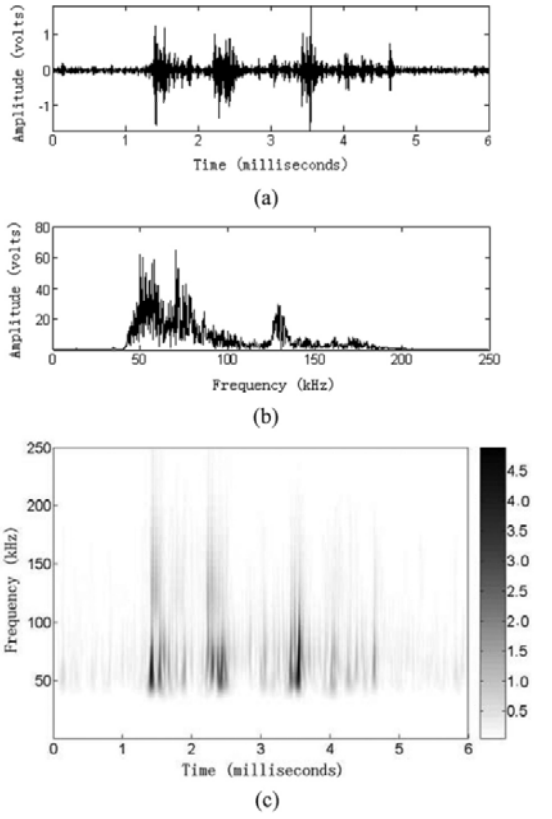
This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

STATE OF ART - Bearing testing

Observation of time-frequency characteristic of the acoustic emission from defects in rolling element bearings

HE, Y. et al. 2010

- Deep-groove ball bearing
- Continuous wavelet transform - qualitative analysis (Morlet)
- Discrete wavelet transform - quantitative analysis.
- Time-frequency characteristics
- Energy distribution analysis (DWT)

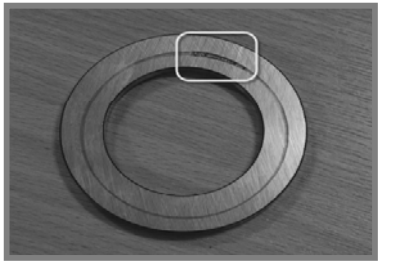


(a) original AE; (b) FFT spectrum; (c) scalogram

This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

INVESTSMENTS IN EDUCATION DEVELOPMENT

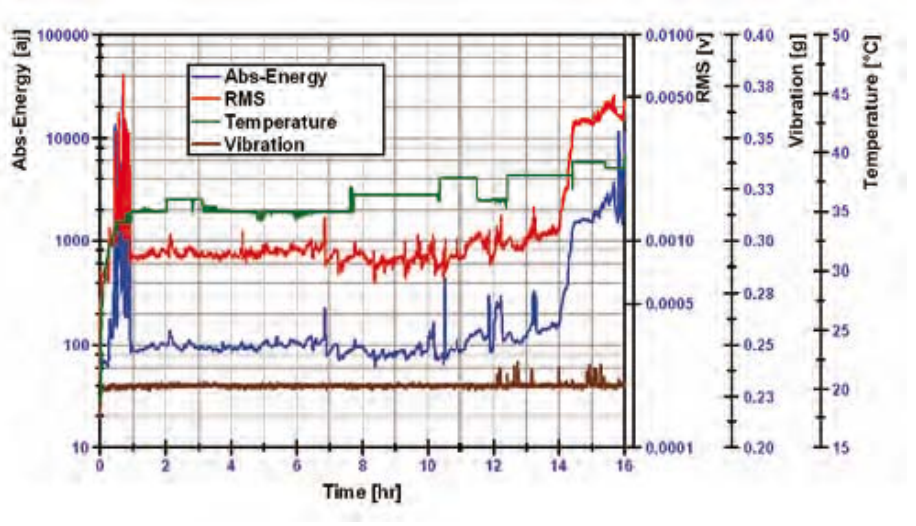
STATE OF ART - Bearing testing



Detecting the onset, propagation and location of non-artificial defects in a slow rotating thrust bearing with acoustic emission

ELFORJANI, M. and MBA, D.; 2008

- AE; Vibration; Temperature
- AE = [Abs-Energy, RMS, ASL, Amplitude, Counts]
- Correlating AE and natural defect
- 1 type of material



Observations of a run-to-failure bearing test

This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

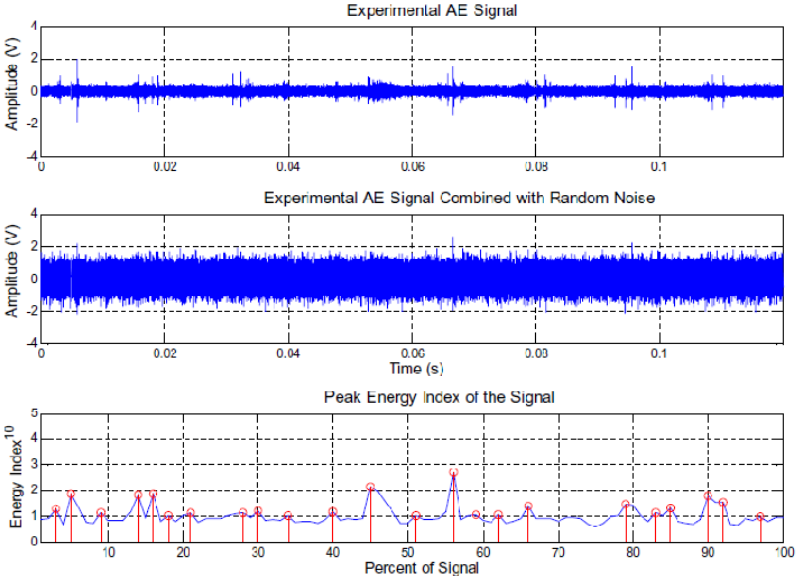
INVESTSMENTS IN EDUCATION DEVELOPMENT

STATE OF ART - Bearing testing

Energy Index technique for detection of Acoustic Emissions associated with incipient bearing failures

KHAMIS, R. et al. 2010

- Energy Index (EI) technique
- Kurtosis × EI
- Minimum SNR = 0.25
- Burst signal identification



EI and signal

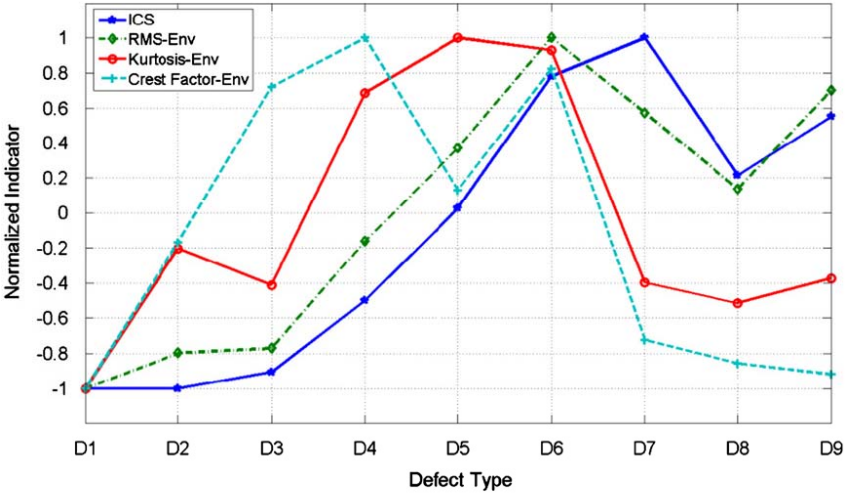
This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

STATE OF ART - Bearing testing

Cyclostationarity of acoustic emissions (AE) for monitoring bearing defects

KILUNDU, B. et al. 2009

- Cylindrical roller
- Envelope spectrum × Cyclostationarity
- Effective envelope analysis = larger defect
- ICS indicator × RMS, Kurtosis, Crest factor
- Outer race defect



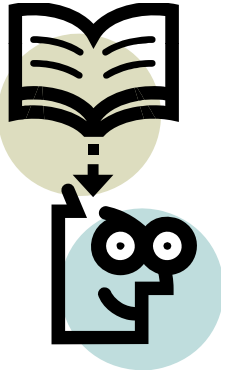
Comparison of normalized values from the envelope signals

This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

INVESTSMENTS IN EDUCATION DEVELOPMENT

CRITICAL ANALYSIS

- Basic parameter RMS
- Transient and Non-stationary signals → time-frequency analysis
- Wavelet transform, Hilbert-Huang transform, STFT, statistical methods
- AE - more sensitive to environmental condition
- Novel parameters of acoustic emission signal
- AE suitable for detection of incipient defect



This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

INVESTSMENTS IN EDUCATION DEVELOPMENT

GOALS OF RESEARCH AND METHODOLOGY

Determination of AE parameters suitable for the identification of formation and propagation of contact damage and build an advanced evaluation algorithm

Methodology

- ❖ AXMAT unit
- ❖ Tests of specimens (various material) → bearings
- ❖ Continuous sampling technology
- ❖ Parameters selecting (AE, vibration, temperature)

This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

INVESTSMENTS IN EDUCATION DEVELOPMENT

CURRENT STAGE OF PROJECT

Theoretical part:

Literature review and evaluation

Formulation of objectives

Definition of experiments

Methods and tools selection - parameters

Practical part:

Conduct experiments

Processing measured data - algorithm

Final part:

Formulation of conclusion

Publishing the dissertation

This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

INVESTSMENTS IN EDUCATION DEVELOPMENT

BIBLIOGRAPHY

Ziaur Rahman, Hiroaki Ohba, Takashi Yamamoto & Takeo Yoshioka (2008): A Study on Incipient Damage Monitoring in Rolling Contact Fatigue Process Using Acoustic Emission, Tribology Transactions, 51:5, 543-551.

T.H. Loutas, G. Sotiriades, I. Kalaitzoglou, V. Kostopoulos: Conditionmonitoring of asingle-stagegearbox with artificially induced gear cracks utilizing on-line vibration and acoustic emission measurements, Applied Acoustics, Volume 70, Issue 9, September 2009, Pages 1148–1159

He, YY Zhang, XM Friswell, MIAF He, Yongyong Zhang, Xinming Friswell, M. I.Observation of time-frequency characteristics of the acoustic emission from defects in rolling element bearings Insight - Non-Destructive Testing and Condition Monitoring, Volume 52, Number 8, August 2010 , pp. 412-418(7)

ELFORJANI, M. AND MBA, D. Detecting the onset, propagation and location of non-artificial defects in a scow rotating thrust bearing with acoustic emission. Insight, May 2008, vol. 50, no. 5, p. 264-268.

AL-BALUSHI, K.R., ADDALI, A., CHARNLEY, B. AND MBA, D. Energy Index technique for detection of Acoustic Emissions associated with incipient bearing failures. Applied Acoustics, Sep 2010, vol. 71, no. 9, p. 812-821.

KILUNDU, B., CHIEMENTIN, X., DUEZ, J. AND MBA, D. Cyclostationarity of Acoustic Emissions (AE) for monitoring bearing defects. Mechanical Systems and Signal Processing, Aug 2011, vol. 25, no. 6, p. 2061-2072.

This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

INVESTSMENTS IN EDUCATION DEVELOPMENT

PUBLICATIONS 2011

ČERNÝ, M.; MAZAL, P.; NOHÁL, L. Potencials of sap flow evaluation by means of acoustic emission measurements. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis. 2011. 59(6). p. 1 - 6. ISSN\~1211-8516.

NOHÁL, L.; MAZAL, P. Identifikace poškození součástí automobilové převodovky metodou akustické emise. In NDE for Safety / Defektoskopie 2011. 2011. Brno, ČNDT, VUT v Brně. 2011. p. 107 - 114. ISBN 978-80-214-4358-7.

VLAŠIC, F.; NOHÁL, L.; GEJDOŠ, P.; MAZAL, P. Detekce únavového poškozování v konstrukčních materiálech využitím metody akustické emise. In NDE for Safety / Defektoskopie 2011. 2011. Brno, CNDT, VUT. 2011. p. 207 - 214. ISBN 978-80-214-4358-7.

MAZAL, P.; PAZDERA, L.; NOHÁL, L.; TOPOLÁŘ, L.; GRUM, J. Acoustic emission in quality control of materials and processes monitoring. 1. Ljubljana, Slovenija, University of Ljubljana. 2011. 60 p. ISBN 978-961-90610-8-4.

NOHÁL, L.; MAZAL, P. Investigation of Fatigue Process in Aluminium Alloys Using Nondestructive Methods. In VIth Workshop "NDT in Progress". Brno, CNDT, VUT. 2011. p. 193 - 198. ISBN 978-80-214-4339-6.

NOHÁL, L. Aplikace měřicího zařízení kontinuálně snímající signál akustické emise. In 52. Konference kateder částí a mechanismů strojů s mezinárodní účastí - sborník referátů. 2011. Ostrava, Vysoká škola báňská - Technická univerzita Ostrava. 2011. p. 170 - 173. ISBN 978-80-248-2450-5.

VLAŠIC, F.; MAZAL, P.; NOHÁL, L.; LIŠKUTÍN, P. Acoustic emission method and x-ray diffraction as instruments for evaluation of material degradation. In Metal 2011 - 20th Anniversary International Conference on Metallurgy and Materials. 2011. Ostrava, Tanger, Ostrava. 2011. p. 123 - 124. ISBN 978-80-87294-22-2.

This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

INVESTSMENTS IN EDUCATION DEVELOPMENT

Thank you for your attention!

This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228

INVESTSMENTS IN EDUCATION DEVELOPMENT