A SYSTEMATIC ACADEMIC PROGRAM FOR PREPARATION OF ACOUSTIC EMISSION SPECIALISTS

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ABSTRACT

Research and diagnostic work in the field of Acoustic Emission (AE) requires a multidisciplinary knowledge in many scientific and technological areas. Nevertheless, currently, there are neither dedicated academic programs for preparation of AE specialists nor recommended practices for a self-study. As a result, preparation of new specialists in the field of AE is incomplete and time consuming.

In this work, we present a methodological, systematic approach for the preparation of AE specialists in academy which covers the main subjects of theoretical and technological education. This is done by structurizing and mapping the field of acoustic emission science and by assembling, based on this structure, an outline of a practical academic program. The complexity and the volume of the program is equivalent to a program of typical Master of Science degree in mechanical or material engineering and can be used by academic institutions or AE companies for preparation of highly skilled personnel for research and diagnostics by AE.

KEY WORDS

Acoustic Emission, Education, Training.

INTRODUCTION

Acoustic emission is a complex discipline that integrates different scientific and technological fields [1]. To the best knowledge of the authors, currently there no dedicated academic programs specifically developed for the field of Acoustic Emission. The existing ASNT practices [2], [3] establish minimum topical outline requirements for qualification of AE testing personnel but they do not cover necessary topics in material science and methods of data analysis. Also, the ASNT topical outline is more technique rather theory or research oriented and does not provide division by volume and time necessary for study of different topics.

Today, academic study and research of AE is relatively small despite its huge potential comparing with other non-destructive test (NDT) methods like ultrasonics. Usually, AE is studied on introductionary level in the frame of a course on NDT. In many cases, different university laboratories that are using AE testing in their research do not provide any formal education on this subject at all. Also, it is difficult to fit AE studies to the existing academic frames due to its interdisciplinary character.

Therefore, dedicated preparation of AE specialists in academy requires development of a trans-faculty or trans-department program while most of the education can be done in the frame of mechanical or material engineering departments. The level and the volume of the proposed program is equivalent to the typical education for Master of Science degree. Due to the complexity of the AE science and multiple related subjects, it is necessary to keep a good balance between the depth of studies and number of covered subjects. Of course that this can lead to certain compromises, but once a student acquires a good academic basis, he will able to complete knowledge himself later.

In this work we develop a possible academic program for AE education that includes both scientific and technological aspects of AE and combining theoretical and practical studies. It development requires structurizing and mapping the AE science and then based on this structure to assemble a list of academic courses balanced in volume and time. First, we define a structure of the subjects of this program.

STRUCTURE OF THE PROGRAM

The AE science can be divided on two main parts: theoretical and technological. The theoretical part includes AE fundamentals (the AE phenomena, sources of AE, wave propagation, models etc.) and material science (material types, properties, failure mechanisms, fracture mechanics and etc.), see Figure 1. The technological part can be divided on three main subjects: apparatus, applications and methods of data analysis.

Figure 1. AE education program subjects.

AE fundamentals

AE fundamentals, one of the core subjects, include 6 topics: AE phenomenon, types of AE, sources of AE, wave propagation theory, AE effects and models and knowledge base (see details in Figure 2). This subject has to be studied after studying material science, fracture mechanics, wave propagation, and dynamic behavior of materials. Generally, a course on AE fundamentals can cover in great detail all relevant topics during one semester with 13 lectures of 3 hour duration.

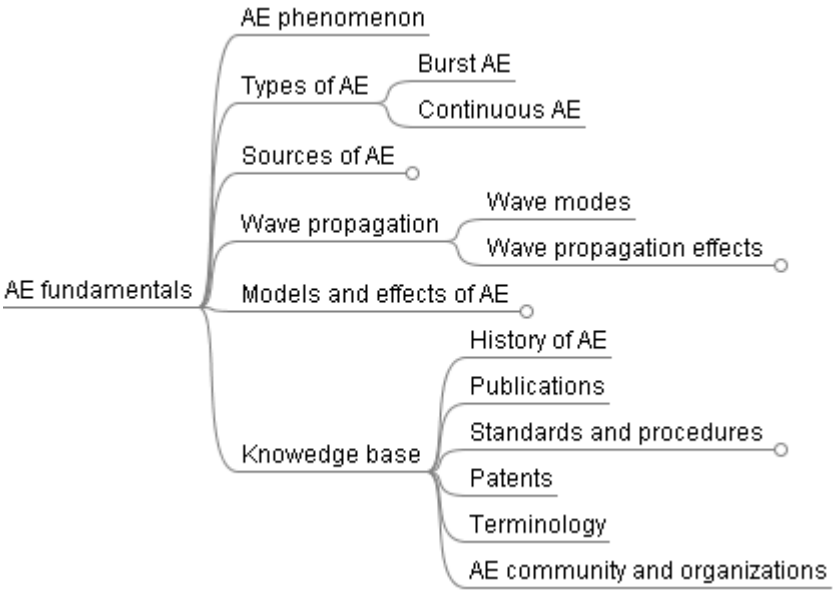

Figure 2. Topics of AE fundamentals.

Material science

Acoustic Emission is a phenomenon that accompanies deformation and fracture processes in materials. AE characteristics are directly dependent on material type, their properties and condition. This is a reason that comprehensive knowledge of material science is essential for AE specialists. The study needs to cover multiple topics related to nature of materials, their properties, mechanical and environmental behavior, manufacturing, failure mechanisms, fracture mechanics and testing methods (see topics in Figure 3). Material science is very wide and time consuming subject for study. In the frame of the recommended academic program, the theoretical knowledge can be given by at least three semester-long courses: two courses in material science and one in fracture mechanics.

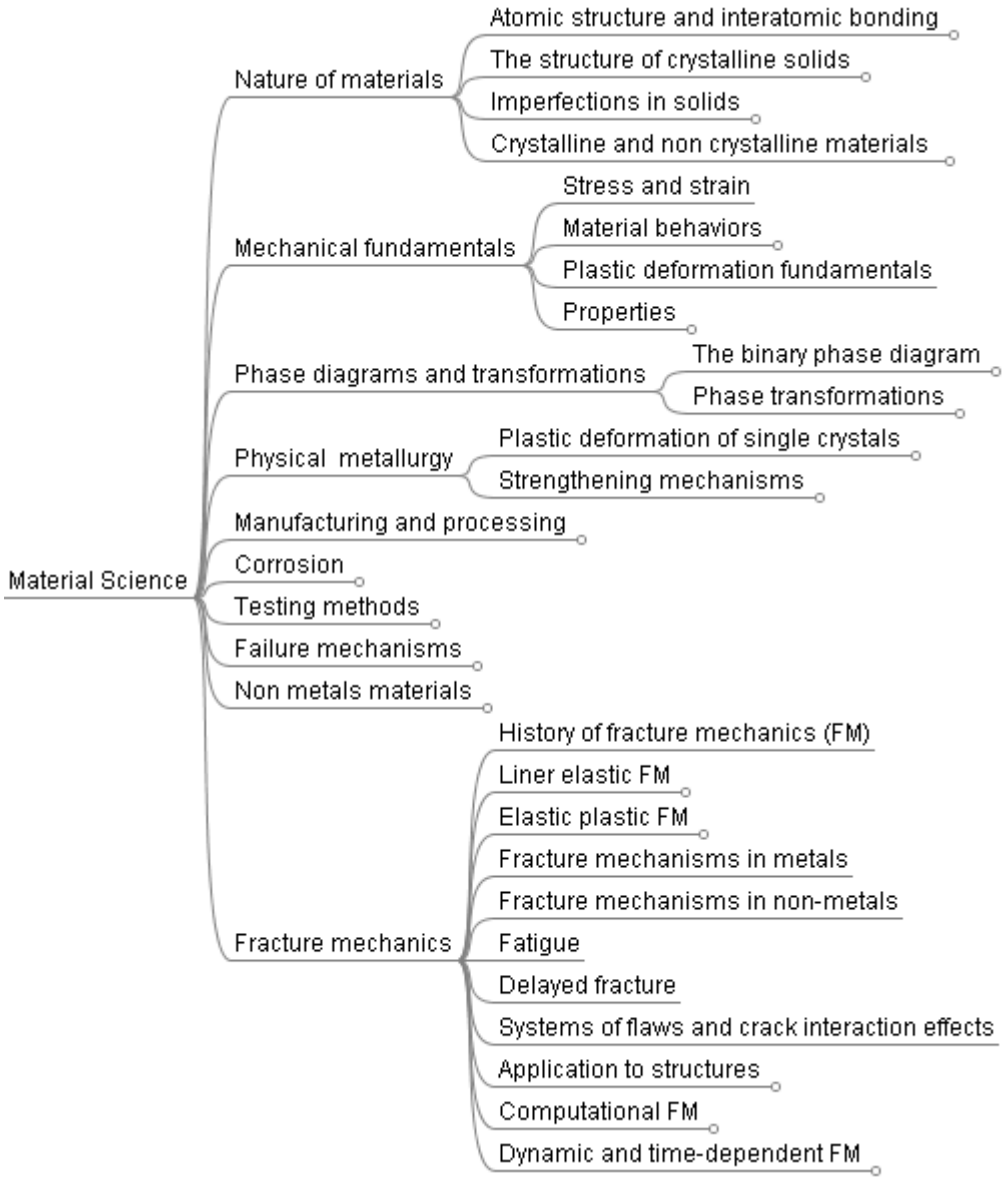

Figure 3. Topics of material science subject.

AE apparatus

AE apparatus subject describes principals and methods for AE sensing, processing and collection of data. Also, it covers topics related to selection and operation of appropriate equipment for performing AE examinations (Figure 4). Study of AE apparatus should combine theoretical and practical classes.

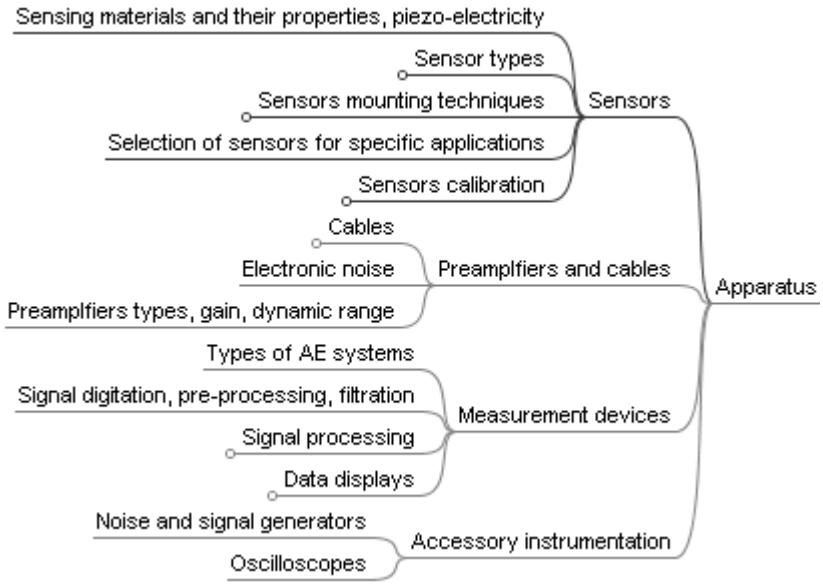

Figure 4. Topics of AE apparatus subject.

Applications

The subject of applications describes approaches and methods for developing procedures and other aspects related to performing AE examinations, other non-destructive examination (NDE) techniques, and confirmation of AE findings. Structure of this subject is presented in Figure 5. Applications subject is closely related to AE apparatus and therefore they might be given together in a semester-long theoretical course along with training and laboratory classes. Topics related to other NDE methods can be given in a separate course.

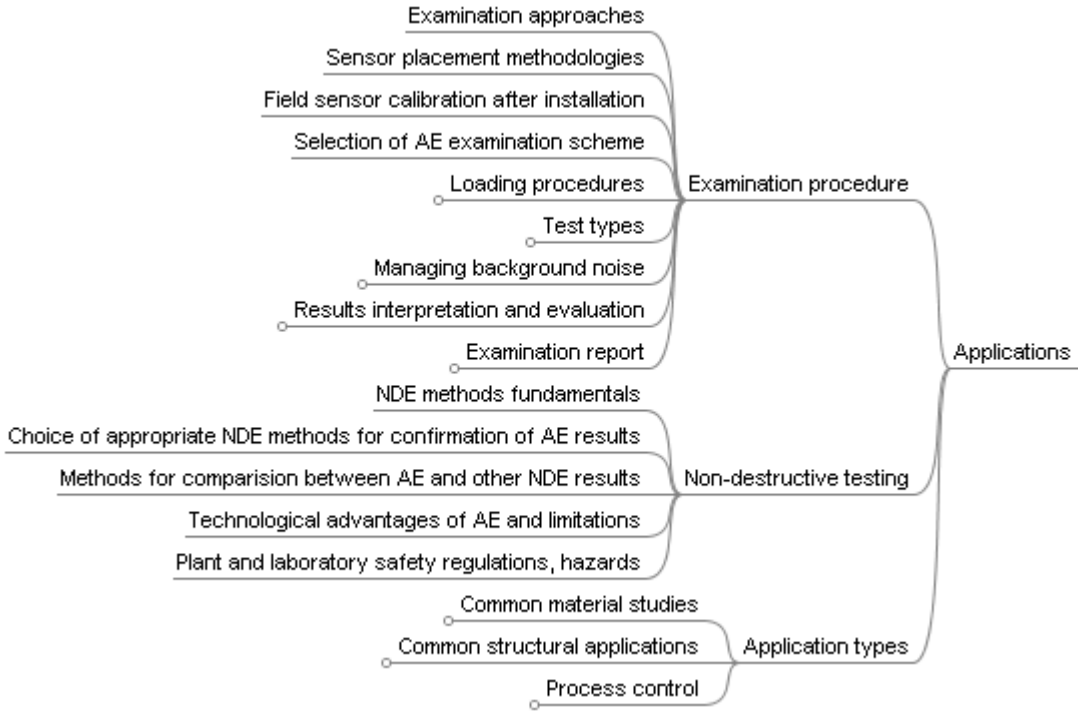

Figure 5. Topics of the applications subject.

Methods of data analysis

This subject describes different methods that are used for analysis of AE data (Figure 6).

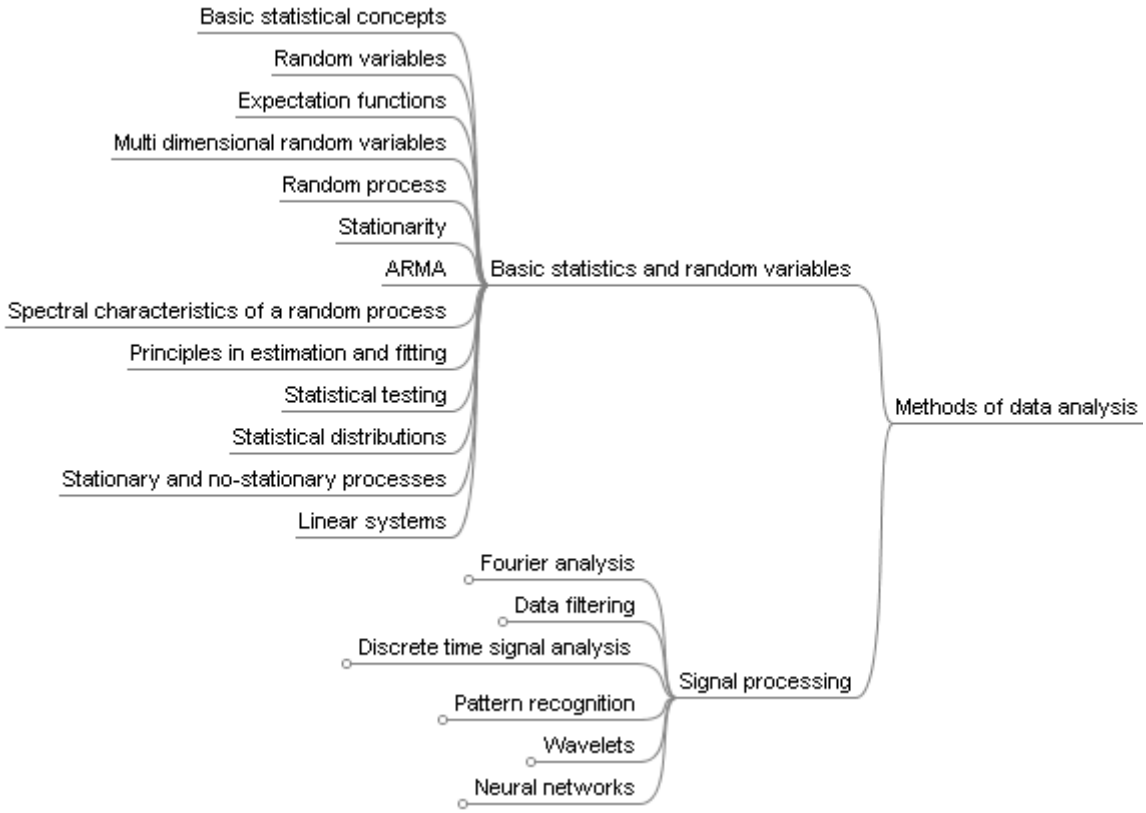

Figure 6. Topics of methods of data analysis subject.

More detailed topical outline of AE science can be found in [4].

PROGRAM OUTLINE

For assembly of the education program it is necessary to translate the above defined subject structure of AE science to a list of corresponding academic courses and training classes. Below is proposed an example of such program (Table 1). The program is appropriate for students studying for Master of Science degree in mechanical or material engineering. The program consists of 494 study hours dedicated to the core AE education and is appropriate for one academic year. Other academic mandatory or non-mandatory courses usually given in the frame of Master of Science degree or courses from the Bachelor degree necessary for studies in the developed program, like introduction to electronics, metrology, technical writing are not described in this work. In addition to the courses and practical classes, individuals have to participate in two AE seminars. At the end of the program students submit final project work or thesis on one of the research subjects related to AE. The thesis or final project has to be an original work of research, design, or development.

Table 1. Acoustic emission education program outline.

Course	Name of course	Subjects covered	Recommended literature	Duration
1	Fundamentals of AE	AE phenomena, types of AE, sources of AE, wave propagation theory, AE effects and models and AE knowledge base	[1], [5], [6], [23]	Semester, 3 hour lectures
2	AE technology, apparatus and applications	AE technology, sensors, equipment, applications, inspection procedures	[1], [5], [7]	Semester, 3 hour lectures
3	Materials I	Nature of materials, mechanical fundamentals, phase diagrams and phase transformations, physical metallurgy, non-metal materials	[8]-[11], [21], [23]	Semester, 3 hour lectures
4	Materials II	Manufacturing and processing, testing methods, failure mechanisms, corrosion	[12]-[22], [24]	Semester, 3 hour lectures
5	Fracture mechanics	Linear elastic and elastic-plastic fracture mechanics, parameters of fracture mechanics, fracture mechanisms, dynamic fracture mechanics, flaw assessment diagrams, remaining life time evaluation, computational fracture mechanics	[24], [25]	Semester, 3 hour lectures
6	Methods of AE data analysis I	Statistics and random variables	[26], [27]	Semester, 3 hour lectures
7	Methods of AE data analysis II	Advanced signal processing	[28]- [34]	Semester, 3 hour lectures
8	AE training class	Sensors, equipment operation, signal processing and location	-	Semester, 4 hour lectures
9	AE laboratory	Laboratory material testing and characterization by AE.	-	Semester, 4 hour lectures
10	Non-destructive testing	NDT methods, typical applications, confirmation of AE results, certification bodies and programs, safety at site, hazards	[2], [3], [35], [36]	Semester, 3 hour lectures
11	AE seminar I	Presentation and discussion of different AE scientific subjects	-	Semester, 3 hour lectures
12	AE seminar II	Presentation and discussion of different AE scientific subjects	-	Semester, 3 hour lectures

CONCLUSIONS

In this work, the authors presented a recommended program for academic education of AE specialists. This program consists of theoretical and practical studies that intend to develop a necessary knowledge and skills for performing effective AE academic research and diagnostic work.

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