Non Destructive Method for Detection Wood-destroying Insects

P. Fiala[1], M. Friedl[1], M. Cap[1], P. Konas[1], P. Smira[2], and A. Naswettrova[2]

[1]Department of Theoretical and Experimental Electrical Engineering
Brno University of Technology, Technicka 3082/12, Brno 616 00, Czech Republic
[2]Thermo Sanace s.r.o., Chamradova 475/23, Ostrava, Kuncicky 718 00, Czech Republic

Abstract— The problem of finding a suitable diagnostic procedure for the examination of structural elements has been closely analyzed in recent years. In this connection, the main material of interest is wood as a sort of heterogeneous matter, and the diagnostic procedure is directed towards enabling industrial application in the future. A new diagnostic method based on X-ray imaging and acoustic electromagnetic wave; the X-ray technique utilizes the reduction of imaging information into 2D planar projection and acoustic recording system allows to find out activity of the wood-destroying pests. After researching activities and localization of wood-destroying pests, there are two methods for its disposal-thermal sanitation and microwave system.

X-ray method is known as nondestructive diagnostic methods in the medical or veterinary practice. This X-ray mobile system was designed for evaluate of the wood quality and presence of wood-boring insects and wood-destroying fungi. Special software are single parts of the X-ray system and enable automatic/semi-automatic diagnostic of the level of damage wood and localization of wood-destroying pests.

Field X-ray monitoring of vital activity of wood-destroying insects is very robust and ineffective in comparison with the acoustic method, which seems like a much better solution. Therefore was designed acoustic system for the initial detection of wood-destroying insects in building construction.

1. INTRODUCTION

Currently, the protection of structural elements made of wood against decay fungi and wood-destroying insects is widely realized through the thermal treatment technique, which has been known and used in Germany since 1930. The principle of this method consists in heating the related wooden structures, by means of hot air whose temperature does not exceed 120°C, for a period of 4–10 hours. Heat is accumulated inside wooden components of the structure under treatment, and the temperature of these components may reach as high as 60°C within the cross-section, Fig. 1. At the temperature of 55°C, all viable forms (including the ova, worm, nymph, and beetle) of wood-destroying insects perish; this temperature is the boundary value for the coagulation of proteins that nurture wood-destroying insects such as old-house borer (*Hylotrupes bajulus* L.), common house borer (*Anobium punctatum*), the death watch beetle (*Xestobium rufovillosum*), or the powder post beetle (*Lyctus brunneus*).

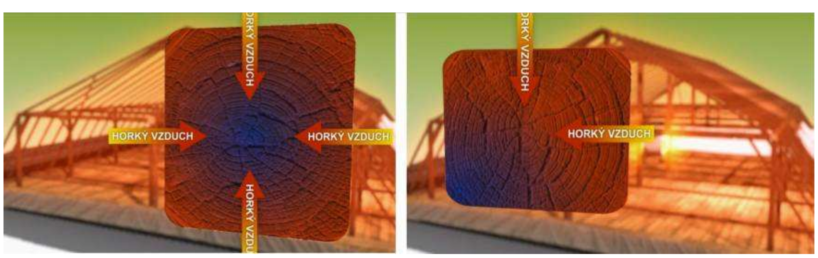


Figure 1: Heat propagation and detection in a non-homogeneous material: wood.

A necessary precondition for any sensible application of the method (Fig. 2) consists in diagnostics performed on damaged portions of structural elements. The diagnostics can be realized by means of non-destructive techniques or, alternatively, through destructive methods resulting in partial disruption of the examined element. This contribution contains the proposal and analysis of a mobile non-destructive diagnostic method (X-Ray monitoring and acoustic system) suitable for use with a damaged or disrupted structural element (Fig. 3). In connection with non-destructive diagnostics, the thermal treatment method constitutes a well-suited approach to be applied in artifacts and buildings of great historic value [1].

Figure 2: The removal and treatment of wood invaded by wood-destroying insects and fungi.

Figure 3: Examples of wood invaded by decay-fungi and wood-destroying insects.

The group of basic treatment methods includes the liquidation of insect foetus, fungus, or rot through the use of hot air or chemical preparations. In all application cases, these techniques are further modified or combined, and the extent of their use is usually determined from the diagnostic results.

2. NON-DESTRUCTIVE DIAGNOSTIC METHODS

The group of non-destructive methods classifying the rate and extent of damage or inhomogeneity in wood includes various techniques that utilize, as a source of the active system, an electromagnetic wave with a wavelength shorter than 3 mm. Thus, wood treatment processes may involve the use of antenna systems applied in the diagnostics of breast carcinoma [2] or utilization of the X-ray diagnostic method known in the fields of human medicine. With this technique, however, there occurs certain difficulty related to the evaluation of damage to the material volume. In spite of the fact, a cycle of tests using damaged material samples (Fig. 3) has led to an alternative approach; this solution is based on the evaluation of the obtained shot image through a transparent X-ray method having a high rate of image resolution. Field X-ray monitoring of vital activity of wood-destroying insects is but relatively robust and ineffective in comparison with the acoustic method, which seems like a much better solution. Therefore was designed acoustic system for the initial detection of wood-destroying insects in building construction.

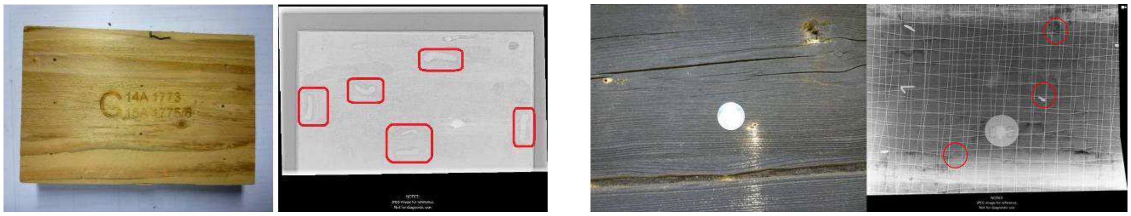
2.1. X-ray Diagnostic Method

The X-ray method is well-known as a nondestructive diagnostic method used in the medical or veterinary practice. The mobile system shown in Fig. 4 was designed at the DTEEE to evaluate wood quality and detect the presence of wood-boring insects and wood-destroying fungi. The designed diagnostic system is mobile and meets the requirements for accuracy of image resolution evaluation.

Figure 4: X-ray diagnostic system for monitoring building elements.

This system can monitor and evaluate the condition of wooden elements. It is possible to evaluate the level of damage, as shown in Fig. 5 the condition and the presence of Old-house borer

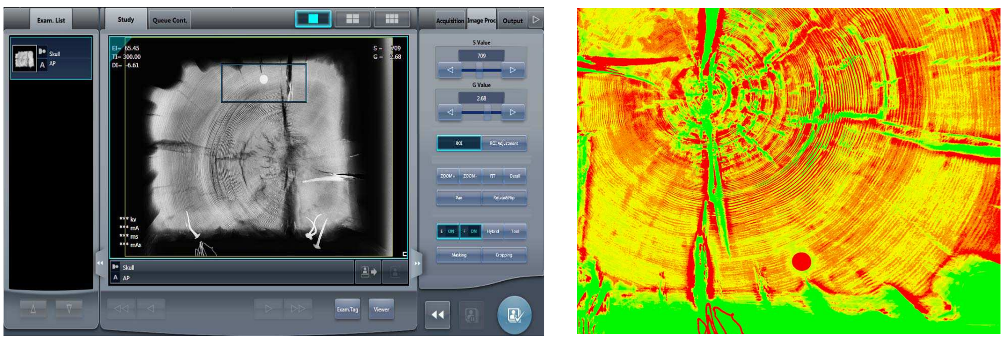
(*Hylotrupes bajulus* L.), a wood-destroying insect. The wood-destroying insect localization has been tested on laboratory samples in a defined manner which were attacked by germs of *Hylotrupes bajulus* L..



(a) (b)

Figure 5: Attacked wooden elements (the larva is marked). (a) Laboratory sample. (b) Building element combined with plaster and metal mesh; Measured on 1 June 2012, Mlýn, Kozlovice, Czech Republic.

A vital part the X-ray system consists in a special type of software, which enables automatic or semi-automatic diagnostics of the level of damage caused by the insects (Fig. 6). The software also facilitates the localization of wood-destroying pests [4–9].



(a) (b)

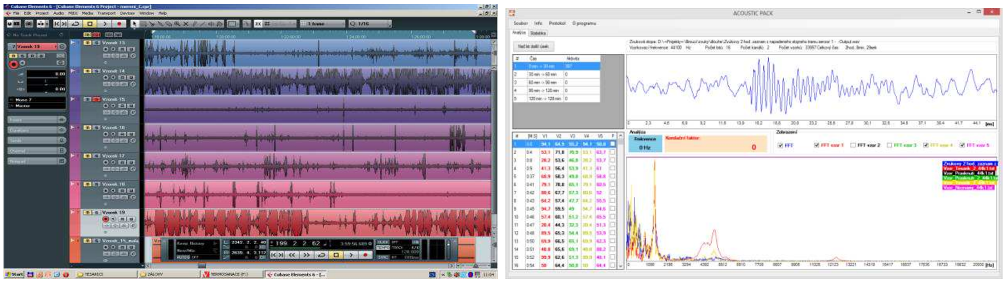
Figure 6: Special software for processing wood-destroying material. (a) X-ray image of the real sample. (b) Demonstration of the wood damage calculation software.

2.2. Acoustic Diagnostic Method

Wood-destroying insect activity detection is possible due to the sound that issued larvae especially during the creation of feeding damage. The UTEE was developed acoustic device — ACOUSTIC PACK (Fig. 7(a)) for the detection of wood-destroying pests in building elements and verification laboratory and terrain measurements. The acoustic system enables us to record up to 8 audio tracks in real time. Importantly, the system also facilitates the subsequent semi-automatic (automatic) analysis of the tracks and ensures the evaluation of the state of the sample (Fig. 8). The audio signals are recorded by individual sensors (Fig. 7(b)), in which a low-noise preamplifier is integrated [10].

(a) (b)

Figure 7: The realized acoustic diagnostic system. (a) Terrain workplace. (b) Detail of the acoustic sensor.



(a) (b)

Figure 8: (a) Special software for recording of the acoustic signals. (b) Designed statistic software for processing and evaluation acoustic data.

The amplified signal is then processed by an A/D converter which sends the data to a PC USB interface; after that, the above-mentioned analysis of the level of damage to the sample is performed. The recording can be continuously run on all eight channels for several days, the resulting state of the sample using the software and displayed graphically. For these purposes special software (Fig. 8(b)) has been programmed that allows you to statistically process the data obtained and protocol indicating the level of attack element of building wood-destroying pest is its output. The system also allows independent on-line listening all the individual audio channels using two headphone outputs. This is advantageous for fast detection and location of the wood-destroying pest, consequently on the basis of this listening is possible strategically locate sensors and start recording for more detailed analysis wood-destroying pest attack.

3. CONCLUSION

We designed and tested new X-ray diagnostic methods (Fig. 4) for 2-D imaging. The parameters were set in such a manner as to enable the imaging of shot sections showing the rate of damage to the heterogeneous structure building. Because this X-ray monitoring of the vital activity of wood-destroying insects is very robust and ineffective, the acoustic method (Fig. 7) was designed. This method allows us to record up to 8 audio tracks in real time; these tracks can be subsequently analyzed on a semi-automatic (automatic) basis, and the evaluation of the state of the sample can be performed. Diagnostic tests of quality (damage) of wooden bearing and structural elements were carried out on real building elements.

Currently, the protection of structural elements made of wood against decay fungi and wood-destroying insects is widely realized through the mainly thermal treatment technique described in the text above. The thermosanitation is using based on the diagnosis rate of infection structures for disposal of wood-destroying pests. These approaches are thermal sanitation (Fig. 1, Fig. 2), which consists in heating the related wooden structures by means of hot air (below 120°C).

ACKNOWLEDGMENT

The research described in the paper was financially supported by the project of the BUT Grant Agency FEKT-S-14-2545/2014, project from Education for Competitiveness Operative Programme CZ.1.07.2.3.00.20.0175 (Electro-researcher) and Thermosanace company Czech Republic. This paper also benefited from the use of the Insight Segmentation and Registration Toolkit (ITK), and pen source software developed as an initiative of the U.S. National Library of Medicine.

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