Tracing thermal treatment in wood using RFID

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Abstract

In order to detect previous thermal handling and treatment in sawn wood and wood packaging materials, radio frequency technology can be used. Wood pieces in which thermal sensor were embedded, were cured in 56^{o} C temperature for 30 minutes and then were laid for a period in external conditions. Thermal treatment process and any other information saved in the implanted microchip was possible to be recalled, using radiofrequency technology. Respectively, wood specimens with embedded temperature sensors were cured simulating a wood drying program for one week period. All information regarding the course of temperature was possible to be regained using radiofrequency technology. The specific technology seems suitable to contribute in tracing thermal treatment that has been applied in sawn timber and wood packaging materials.

1 Introduction

In wood conversion process the application of high temperatures is necessary, a lot of times. Thus, in a lot of procedures such as wood drying, unreeling, decorative veneers production, wood bending, wood covering using thermoplastic glues, etc. temperatures much higher than those of the environment are applied. These temperatures are associated either to physical properties (e.g. wood moisture content drop, advancing of wood elasticity) or to chemical procedures (e.g. glue curing).

As wood is a thermal insulating material, heat transmission delays and in wood core can’t always be obtained the same temperatures, compared to those of the surface. So, the main goal for which wood is heated maybe not be achieved and for this reason temperature monitoring in solid wood core or in wood panels core is many times imposed, not only for laboratory processes but also for ascertaining industrial processes. The particular question (warming up to specific temperatures) is quite crucial during thermal treatment of wood that is intended to be used for wood packaging material or during thermal treatment of ready wood packaging material. The spread of the nematode *Bursaphelenchus xylophilus* in conifer forests has imposed internationally urgent measures to be taken, for the sterilization of lumber. In this case temperatures over 56^{o} C are needed in the core of wooden pieces with the larger cross sections, for a period at least 30’ (FAO, 2002). In most of the cases, lumber that has been kiln dried is assumed that covers the requirements of FAO’s International Standard ISPM 15 but this depends on drying method, as there are drying methods where lower temperatures are applied (e.g. dehumidification). It depends also on the initial

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moisture content of wood, as over FSP wood behaves like a wet-bulb thermometer, and it results in showing temperatures that do not correspond to reality. As a more precise method, temperature measuring in wood core is assumed (Welling and Lambertz, 2009). The procedure should be recorded and data should be stored, so in case of compliant it can be investigated whether the specific batch has been cured in the proper way, according to ISPM 15. This is legislated in many countries and so there exists traceability, in order to examine whether the procedure has been carried out properly in a batch. Nevertheless, some questions can still occur:

- What happens when there are not any data stored?
- What happens when there aren't mentioned (next to FAO stamp) the batch number or the date, when batch was cured?
- How could be sure that the wood packaging material examined is really the same with that who was cured?
- How can ensure that temperature sensors work properly?

In many cases, as the above mentioned, no safe conclusions could be derived, because some "traces" have been lost and the chain of traceability is broken. So, it is new advances in electronics that might give us some solutions.

In the last years you can hear "RFID" as word more and more often and most of us believe that it is really a new technology. The truth is that the RFID systems with low frequency are existing from the decade of '70. The reason that this technology did not manage to expand all these years was the high cost of the microprocessors construction and the cost of the reading equipment. Another reason was the lack of common software, in order all the readers to be able to recognize all the microprocessors. RFID technology was developed over several decades, as reviewed in the works of Landt (2001), Lahiri (2005), and Dew (2006). Ngai *et al.* (2008a, b) presented a literature review of 85 academic journal papers that were published on RFID between 1995 and 2005, organized into four main categories: technological issues, applications areas, policy and security issues and miscellaneous. Since then, several other academic studies have been written about the benefits (and costs) of adopting RFID. Doerr *et al.* (2006), Niederman *et al.* (2007), De Kok *et al.* (2008), Rekik *et al.* (2008), Szmerekovsky & Zhang (2008), Veeramani *et al.* (2008) and Kim *et al.* (2008) studied the use of RFID to improve supply chain and inventory operations

All the above mentioned now are changing in RFID technology and all the producers are looking in a more promising, reliable and lasting more than the barcode system which very often presents problems, when barcodes are not in front of the scanner or when they are scratched, etc. RFID tags carry a larger set of IDs and more information than barcodes. RFID readers can identify RFID tags from a distance, without requiring a line of sight. Furthermore, RFID application systems can distinguish among many different RFID tags in the same area, without human help. Therefore, RFID is becoming a mainstream technology.

Cost is the primary reason for the popularity of this technology got lately. To compete with the cheapest barcode technology, electronic identification technology must be equally inexpensive or add adequate added value, to improve its applications.

1.1 What is the RFID?

Radio Frequency IDentification (RFID) represents a significant change in information tracking applications. RFID can be used to trace objects and assets worldwide. The RFID are using radiowaves and they allow automatic recognition of items that are carrying RFID tags. They can be tracked automatically from stable or portable readers and without any need to be scanned separately. For information applications, industries can reduce the investment in management and improve the high-quality services by attaching smart RFID tags to objects.

1.2 Description of RFID

The basic system of an RFID is based in three parts:

- One or more antennas (RFID antennas).
- One or more readers (RFID readers)
- One or more tags (LF - HF – UHF RFID tags)

In Figure 1 we can see a basic RFID system.

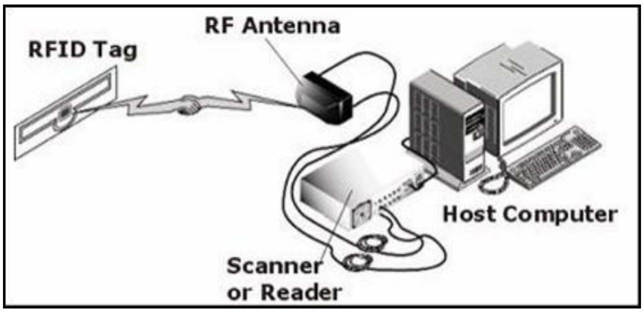

Figure 1. The basic elements of an RFID system

The antenna transmits radio signals in order to activate the tag and also can read or write data on it. The antennas transmit the signals for the communication between the tag and the transmitter – receiver, which controls the communication of the data also. Usually the antenna is packed together with the transmitter and receiver in order to become a reader which can be portable or not. An RFID Reader obtains object information from its RFID tags. The Object Naming Service (ONS), a protocol resembling Domain Name Server (DNS) concept, has been proposed to enable Internet users to access the object information from RFID Readers.

The reader transmits radio waves in a distance between 3 cm up to 30 m or more, depending on the output power and the radiofrequency.

1.3 Characteristics

Tags can be separated into categories, as:

Active tags: The active tags have a transmitter and their own power source (usually a battery), which is used for the microprocessor and for the transmission of the signal to the reader. Passive tags: The passive tags do not have any power supply and they are taking the necessary energy from the reader which transmits electromagnetic waves, which in turn produce a field in the tags antenna. There are also semi active tags (or *semi passive*), which use a battery for the microprocessor but they need energy from the transmitter for the communication. The active and semi active tags are used for high value items and the others for the low cost products.
There are also tag categories only for reading ("read-only") and for reading but also capable for changing the data ("read-write"). In the second case we can add information or we can write on the existing data when the tag is in the radius of the reader. Usually these tags have a serial number that we cannot change or we can also lock some data, in order not to be removed. The "read-only" tags are providing us with information that we put during the construction and we cannot change them.

1.4 Frequency zones of RFID

Several different types of RFID tags in different frequencies can be found in the market. The different zones of frequencies are the following:

Low frequency zone (LF) in 100-500 KHz, with low speed of reading.
High frequency zone (HF) in 13.56 MHz, with medium distance and low speed of reading.
Ultra high frequency (UHF) from 850 to 950 MHz and from 2.4 to 2.5 GHz, with big distance and high speed of reading.

For wood the most suitable frequencies are LF and UHF. Each country has different zones of frequencies for RFID uses.

1.5 The Electronic Product Code (EPC)

The electronic product code is a number that is used together with the RFID technology to improve the management of the supply chain and to eliminate costs. This code provides us with detailed information about the product in high speed. This code is a unique number which is similar to the numbers for barcodes (Figure 2).

This number contains:

a. Header with 8-bits and gives the length of the UPC
b. EPC manager and gives the producer of the product
c. Object Class and gives the certain type of the item with the same way as the Stock Keeping Unit (SKU)
d. Serial number and gives the unique number of the certain item.

Figure 2. The EPC (Electronic Product Code)

2 Applications of RFID

RFID tags can carry from simple information, such as the details of the owner of a pet or the cleaning information of a cloth to much more complicate information, like the year of the production, the country and the type of grapes that were used for a wine production or even the details of the assembly of a car (Kim *et al*. 2008). The quantity of the information that usually a tag can carry does not exceed the 2 Kbytes. We can say that RFID technology can be used in the package of a product, in libraries, in credit cards, in an ID, in passports or driving licences etc. It was used successfully on the tickets of big athletic events (Philips *et al.* 2005). But most of all it can be used for traceability reasons. *I.e.*, the following simple report (printout) was taken from one of our experiments,

Tag ID	Condition
6600929	Exceeded limit: 9/12/2006 2:01
6600930	Exceeded limit : 9/12/2006 4:46
6600931	Exceeded limit : 9/11/2006 17:31
6600933	Exceeded limit : 9/12/2006 3:31
6600936	Exceeded limit : 9/12/2006 6:01
6600937	Exceeded limit : 9/12/2006 10:31
6600941	Exceeded limit : 9/11/2006 17:31
6600942	Exceeded limit : 9/12/2006 5:01
6600945	Exceeded limit : 9/12/2006 11:46
6600946	Exceeded limit : 9/12/2006 6:01
6600950	Exceeded limit : 9/12/2006 7:31

Figure 3. Printout from an RFID reader

when some RFIDs were embedded inside some wooden pieces placed in a heated oven in lab (they simulated wooden pallets in a heating chamber or wooden planks in a dry kiln) and were giving information about the time when temperature was exceeding a preset limit (Figure 3). As are shown in Internet, some commercial applications are already in use (www.confidex.fi, www.iris-rfid.com) in wooden pallets circulation or in other wood products as logs, dealing mainly with logistics and supply chain. But there are still many applications that could be in use, concerning wood conversion processes. *I.e.*, there is always a question where the coldest places are in a drying kiln or in a heat treatment chamber, as chamber’s loading is different from batch to batch. The use of some RFIDs could answer immediately the question, the information could be compared to that given by the chamber’s software and also can be stored and accompany the wood packaging material for its whole life (Fig. 4).

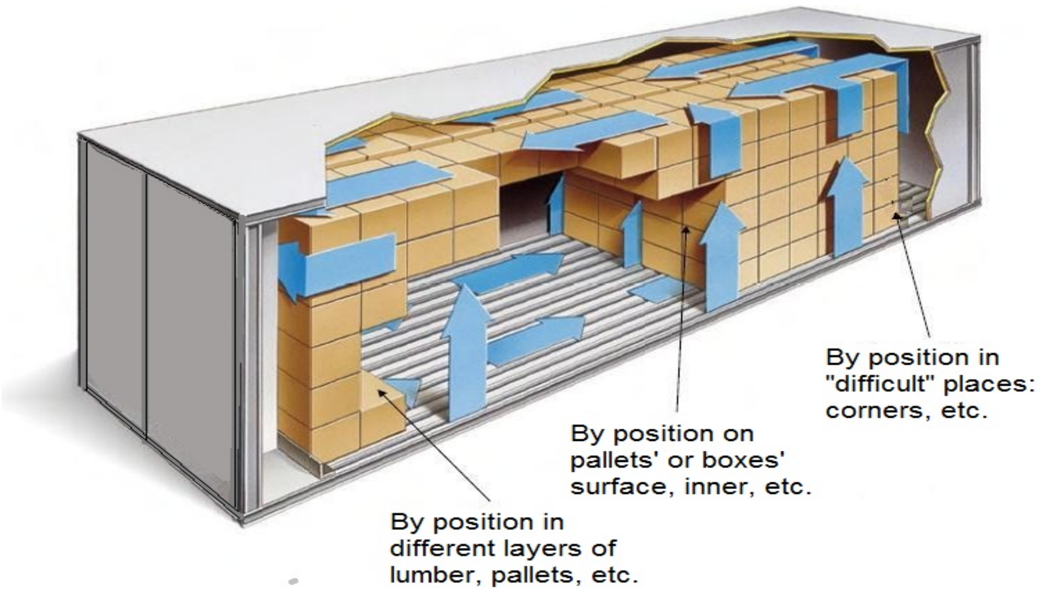

Figure 4. RFIDs can be placed anywhere in a dry kiln or heat-treatment chamber, in order to record temperatures.

3 Conclusions

Inspecting some pallets there might be always the question: is this wooden packaging material thermal treated in the right way? In order to detect previous thermal handling and treatment in sawn wood and wood packaging materials, radio frequency technology can be used. Thermal treatment process and any other information can be saved in an implanted microchip and can be recalled, by using radiofrequency technology. The specific RFID technology seems suitable to contribute in tracing thermal treatment that has been applied in sawn timber and wood packaging materials. In many cases, like bar code or ISPM stamp no safe conclusions could be derived, because some “traces” have been lost or not truly marked and the chain of traceability has been broken. So, it is new advances in RFID technology that might give us solutions.

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