Internal Properties Assessment in Agarwood Trees Using Ultrasonic Velocity Measurement

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Abstract

This paper presents the application of ultrasonic velocity in agarwood trees (Aquilaria crassna) with the purpose of evaluating the relationship of the ultrasonic velocity to the variations of internal properties of trees. In this study, three circular cross-sectional discs from the freshly cut tree were selected as samples. First sample with a big hole (decay) in the middle, second sample with internal resinous and the last one is the sample with no defects. The through transmission ultrasonic testing method was carried out using Tico ultrasonic pulse velocity tester which is from Switzerland. Two-dimensional image of internal properties evaluation by an ultrasonic investigation was obtained using Matlab. The results showed that the ultrasonic wave cannot pass through the internal decay or resinous so that the wave went round it and thus ultrasonic wave velocity significantly decreased by increasing the hole or resinous. The difference in color of the image generated by Matlab software based on variation of ultrasonic velocity between the internal decay area and its surrounding area was obvious. Therefore, the properties of internal properties of the tree could be detected by ultrasonic line imaging technique.

Introduction

Non-destructive testing (NDT) with ultrasonic has been widely used for decades and it has become a classical test method for detection of flaws in different materials. Today, it is expected that ultrasonic testing (UT), supported with great advance in instrument technology could give the most accurate result in each inspection. Ultrasonic testing has been used for application in variations of industries such as oil and gas, construction, manufacturing, forestry and more. In this study, the application of ultrasonic testing in forestry is given priority with the main focus is on the evaluation of properties of tropical agarwood (Aquilaria) using ultrasonic pulse velocity (UPV) line imaging technique which is the image is to be generated by matlab software. Besides, this study also evaluates the influence of internal decay in Aquilaria tree on ultrasonic pulse velocity.

Agarwood is a resinous that forms inside the tree called Aquilaria when the tree infected by bacteria or fungi. The tree will spread fragrance oil to protect the infected parts and eventually the oil is getting harder and transformed into resinous (gaharu). With this nondestructive testing method, quality assessment, identification and detection of agarwood (gaharu) and internal decay can be done without destruction of the integrity of the tree. Due to increasing demand, agarwood has become very rare in the wild [1, 2, 3, 4] and many species of Aquilaria and Gyrinops are now threatened with extinction due to illegal logging and confined to well-protected areas only [5]. Therefore it is necessary to have an effective, easy-to-use field portable instrument or technique for detecting resinous in standing trees without destruction the integrity of trees. For good forest management, it is important to detect deterioration in tree in order to identify hazardous tree, to prevent the spread of decay and to improve stand conditions. However, there is no external indicator to detect the defects in trees without destruction the condition of the trees.

The objective of this study is to analyze the relationship between ultrasonic pulse velocity and resinous (gaharu) inside the agarwood tree and to evaluate the influence of internal decay in agarwood trees on ultrasonic pulse velocity.

Materials and Methods

In this study, three circular cross-sectional discs from the freshly cut agarwood tree were selected as samples. The samples were prepared from agarwood tree (Aquilaria) and in order to study the relationship between internal decay and ultrasonic pulse velocity. The first sample was a sample with a big hole at the centre of the sample that exists naturally. The diameter of the sample is 23.8 cm (Figure 2). The second sample was a sample with resinous in the centre (diameter $\approx$ 20.05 cm) was selected with the purpose to evaluate the relationship between resinous and ultrasonic pulse velocity (Figure 3). The third sample from agarwood tree with no defect (diameter $\approx$ 14.00 cm) was selected in order to study the difference of the ultrasonic pulse velocity in decayed tree and perfect tree (Figure 4).

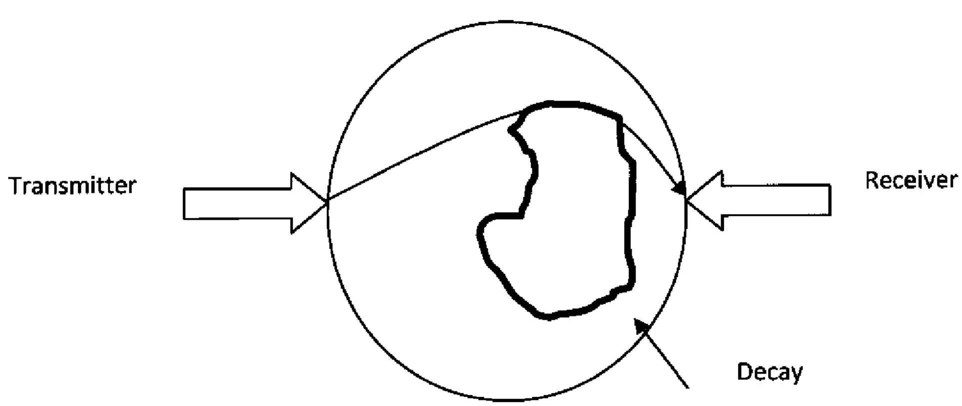


Figure 1: Travelling path of ultrasonic wave in the sample with internal decay

Figure 2: Diagram of sample with internal hole

Figure 3: Diagram of sample with resinous in the middle

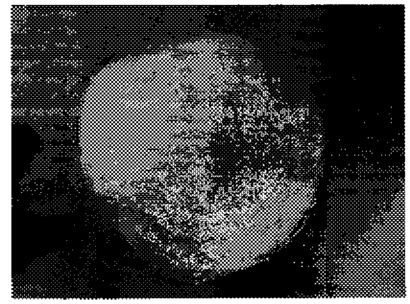


Figure 4: Diagram of sample with no defects

All ultrasonic measurement for this study have been made using experimental setup as illustrated in Figure 5.

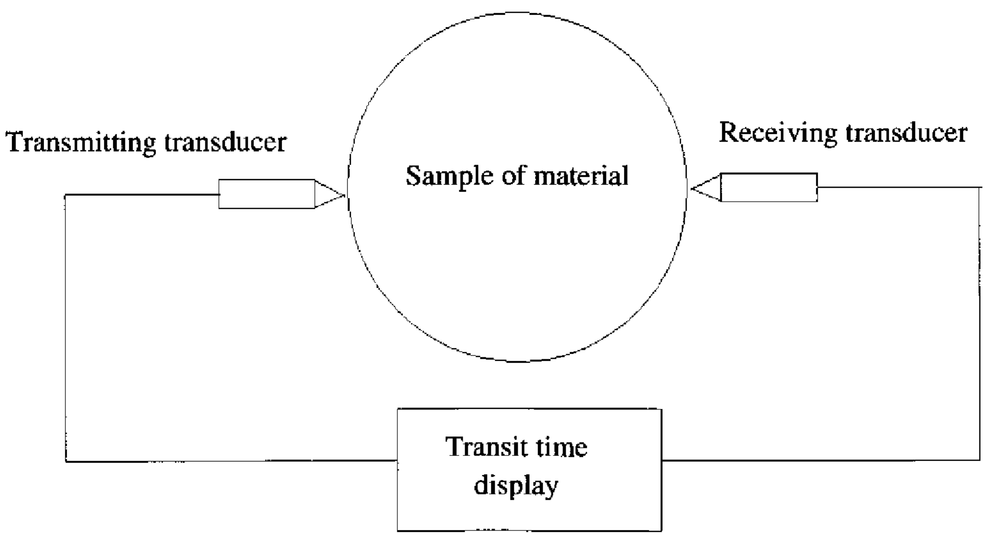
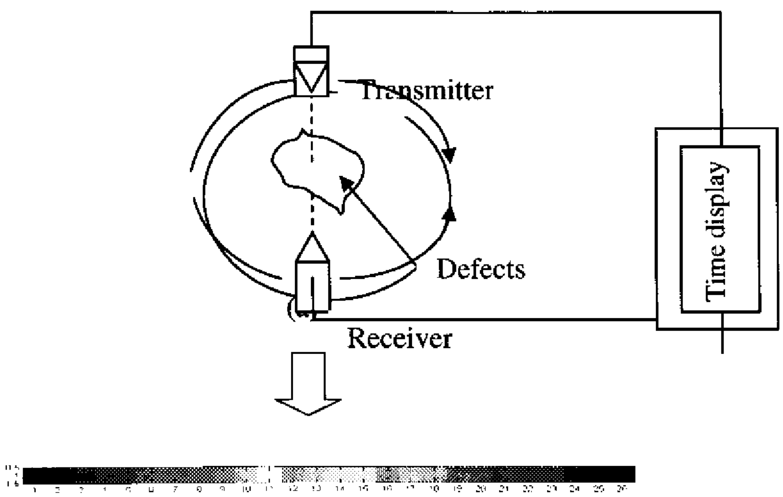


Figure 5: Schematic diagram of ultrasonic pulse velocity testing circuit.

In order to study the relationship of shapes and size of defects and resinous on ultrasonic pulse velocity, the steps in figure 6 below is followed. The inspection on tree has been done from end to end with the scale 1 cm for each measurement. All the data obtained is in the form of transit time from transmitter to receiver. From the transit time, the velocities of ultrasonic pulse were then calculated. Two-dimensional image of defect evaluation were made by the ultrasonic measurement and finally the image was generated by using Matlab software.



(b)

Figure 6

Results and Discussion

As shown in Figure 6, in order to evaluate the defects, the ultrasonic velocity was converted to the image using the Matlab software. The color of the image gradually changed from bright brown to dark brown and black as the ultrasonic wave travel inside the sample. The dark brown and black color shows a position of propagation of ultrasonic wave with the minimum velocity. The image shows that from point 2 to 20, the color has changed to dark brown and black and this is due to the internal decay occurred in the sample. From the image analysis, it can be assumed that there is a big internal decay in the sample.

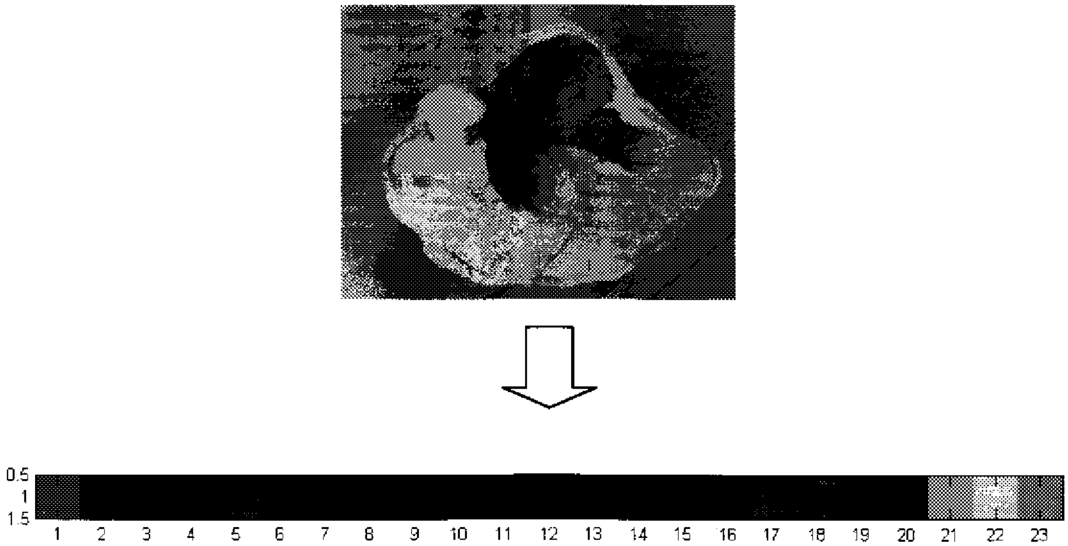


Figure 7: Two-dimensional line imaging of internal decay evaluation by ultrasonic testing

Figure 8 shows the data from the inspection that was converted to the image using the Matlab software. The image shows that between points 5 to 8, the color has changed to dark brown and black and this is due to the internal resinous occurred in the sample. From the image analysis, it can be assumed that there is an internal resinous in the sample.

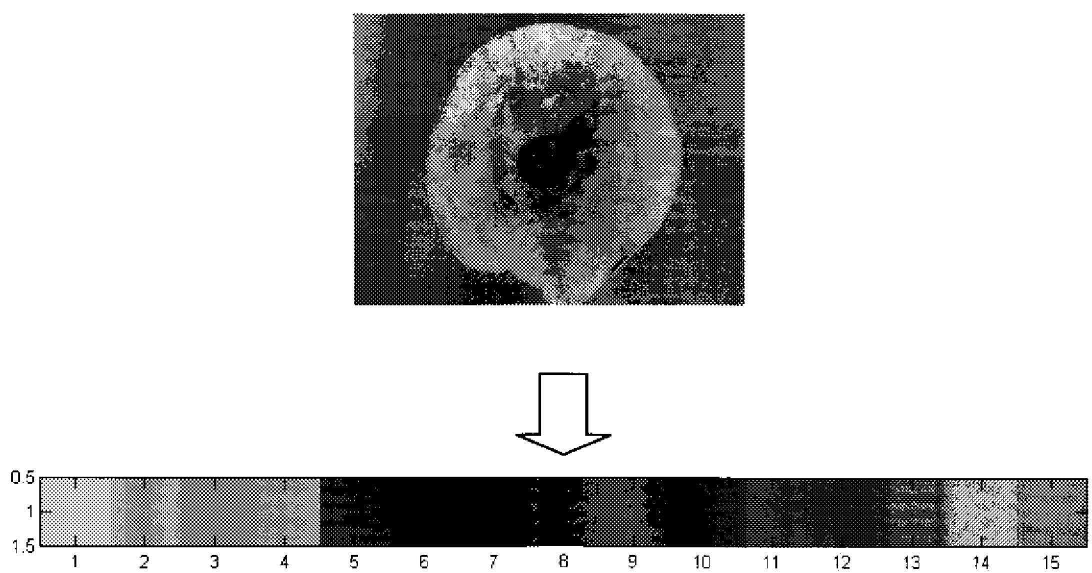


Figure 8: Two-dimensional line imaging of internal resinous evaluation by ultrasonic testing

Figure 9 shows the data from the inspection that was converted to the image using the Matlab software. Previous research has shown that ultrasonic velocity in tangential direction is the lowest and in radial direction is the highest [6]. However, the image shows that ultrasonic velocity at points 1 and 2 does not appear to be the same with points 10 and 11. This is probably due to error in reading measurement.

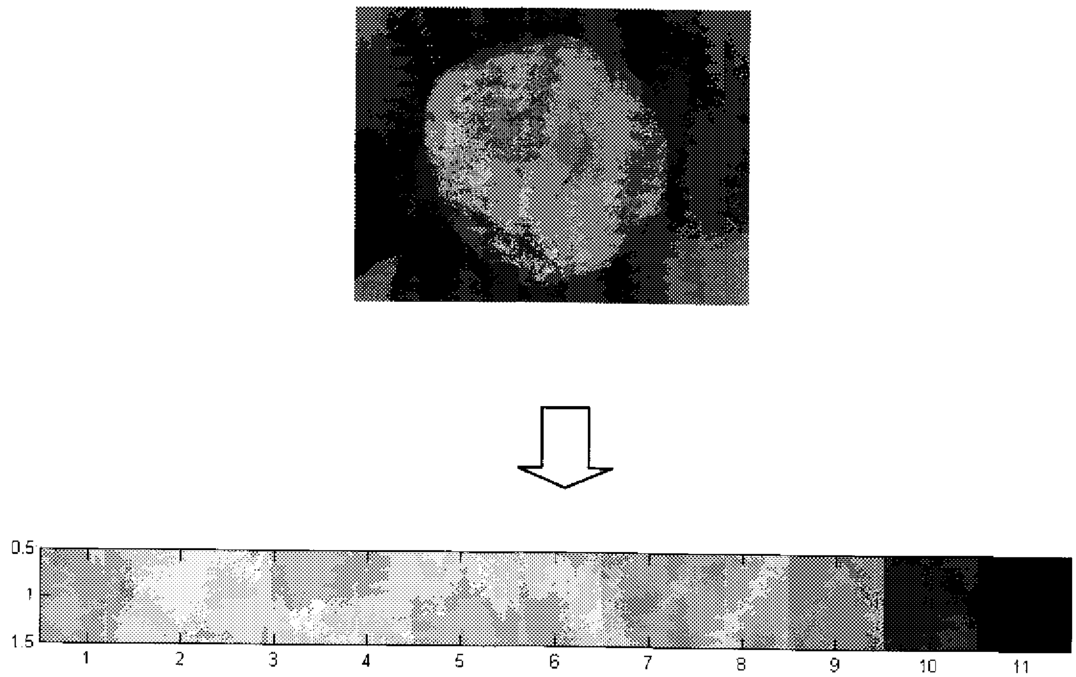


Figure 9: Two-dimensional line imaging of healthy sample evaluation by ultrasonic testing

Conclusion

The results of this study showed that the ultrasonic wave cannot pass through the internal decay or resinous so that the wave went round it and thus ultrasonic wave velocity significantly decreased by increasing the hole or resinous. The difference in color of the image generated by Matlab software based on variation of ultrasonic velocity between the internal decay area and its surrounding area was obvious. Therefore, the properties of internal properties of the tree could be detected by ultrasonic line imaging technique.

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