ULTRASONIC PULSE COMPRESSION TESTING ON AGARWOOD SAMPLE

PENGUJIAN TERHADAP SAMPEL AGARWOOD MENGGUNAKAN ULTRASONIK NADI MAMPATAN

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Abstract

Methods based on propagation of stress wave phenomena indicate particularly useful in diagnosis of non-metallic materials. The aim of this research is to demonstrate that ultrasonic measurement can produce satisfactory results in predicting certain mechanical properties of standing Aquilaria malaccensis tree. The mechanical information is very important to diagnose the condition inside the trunk. The experiment has been conducted on agarwood samples using a pulse compression ultrasonic system. The apparatus equipped with exponential horn 54 kHz piezoelectric normal probe. Through transmission method of longitudinal ultrasonic wave has been used throughout this experiment to measure velocity of ultrasonic signal through the sample. The result showed that the ultrasonic technique can be used in diagnosing of wood-based samples.

Abstrak

Kaedah berdasarkan penyebaran fenomena gelombang tegangan menunjukkan amat berguna dalam diagnosis bahan bukan logam. Tujuan penyelidikan ini adalah untuk menunjukkan bahawa pengukuran ultrasonik dapat menghasilkan keputusan yang memuaskan dalam meramalkan sifat-sifat mekanik tertentu dari pokok Aquilaria malaccensis. Maklumat mekanikal yang diperolehi amat berguna untuk diagnosis keadaan di dalam batang pokok. Eksperimen telah dijalankan pada sampel agarwood menggunakan sistem ultrasonik nadi mampatan. Alat ini dilengkapi dengan piezoelektrik normal probe yang menghasilkan frekuensi eksponensial tanduk sehingga 54 kHz. Kaedah melalui-penghantara daripada gelombang membujur telah digunakan sepanjang eksperimen ini untuk mengukur halaju isyarat ultrasonik yang melalui sampel. Hasilnya menunjukkan bahawa teknik ultrasonik boleh digunakan dalam mendiagnosis sampel berasaskan kayu.

INTRODUCTION

Agarwood, eaglewood, gaharu, aloeswood, kalamabak - these are just a few of the names for the resinous, fragrant and highly valuable heartwood produced by Aquilaria malaccensis and other species of the Indomalesian tree genus Aquilaria. The gaharu is produced by ecological interaction between the host tree and the wound and/or the fungi. Aquilaria malaccensisis are widely distributed in South and South-East Asia. Based on available trade data, in international, Indonesia and Malaysia appear to be the main sources of gaharu (from all species) with export over 700 tans in 1997 (Van Beek *et al.*, 1999). The international trade in gaharu involves wood, wood chips, powder, oil, and, although not identified in available trade data, almost certainly finished products such as perfumes, incense and medicines. Gaharu chips and segments may sell for several hundred to several thousand US dollars per kilogramme. The price of oil distilled from gaharu is generally between five and ten thousand US dollars per kilogramme, but can be significantly more for gaharu oil of exceptionally high quality. Unfortunately, the demand for gaharu currently far exceeds the available supply, which is naturally restricted owing to the nature of its formation - gaharu is only found in a small percentage of Aquilaria trees of those species known to produce it.

Due to its huge economic potential, the Malaysia government has developed several programs in recent years for the establishment of Aquilaria plantation to supply to the market needs (Barden *et al.*, 2000). Gaharu production is triggered by the inoculation technique where after five years of age the tree is injected with spores. This inoculation process is carried for a period of one to two years before the gaharu is produced by the tree and harvested. Gaharu is harvested by felling and then splitting trees open. External signs of the presence of gaharu are not always obvious. As a result, Aquilaria trees are often cut down indiscriminately on the search for those containing gaharu. By this method, many Aquilaria trees without gaharu may be wasted. The negative impacts of such declines will be felt not only in terms of biodiversity loss, but also in terms of the reduced availability of what is clearly a highly valued and valuable forest resource.

Ultrasonic velocity measurement is a popular method for detecting internal decay of standing tree (Najafi *et al.*, 2009). Meanwhile, ultrasonic tomography is an advance ultrasonic technique that's becoming more popular recently in presenting ultrasonic measurement data. Tomography refers to the cross-sample imaging of an object from either transmission or reflection data collected by illuminating the object from many different directions. Ultrasonic tomography allows the user to reconstruct the distribution of the velocity of ultrasonic propagation within the investigated sample. Since the velocity is related to density and dynamic of elasticity modulus, increasing velocity due to resin growth in the trunk hopefully can be detected and measured using this technique. The ultrasonic tomography has been used as a suitable technique for fungal degradation in tree (Bucur, 2005). Furthermore, ultrasonic velocity has been demonstrated to be very sensitive in the early stage of the wood degradation as demonstrated by Wilcox (Wilcox, V).

In this study, we came up with an idea to develop Ultrasonic based line imaging measurement of gaharu volumes in Aquilaria using Matlab. The system is expected to be able to estimate the quantity of generated gaharu by giving out the cross sample image of the Aquilaria tree without destroying its quality.

MATERIALS AND METHODS

Two agarwood samples with different conditions were tested throughout this experiment, namely sample 1 and sample 2. Sample 1 is an agarwood sample to internal decay, whereas Sample 2 is a good agarwood without decay. Ultrasonic measurements have been conducted on both samples using through transmission technique with exponential horn type 54 kHz piezoelectric transducers. 15 point measurement was made for each sample where transit time for each point was recorded. The data in transit time were then converted into velocity values and presented line mag as in Figure 3. Finally results for both samples were fitted with the image of the samples to correlate with the internal condition of the samples.

RESULTS AND DISCUSSION

The result of ultrasonic measurement was presented in line image that has been generated using Matlab. Figure 1 shows the ultrasonic pulse velocity result of the sample 1 measurement. From the image, it shows that there are changes along the ultrasonic pulse velocity testing in which the central part of the trunk produced lower velocity readings as compared to the outer part. When the tree was cut down, experiment data and the sample comparison shows an interesting relationship. It was discovered that the central part of the trunk at the sample 1 has decayed as shows in Figure 2. There is a thin resinous layer of gaharu has existed in between the decay and solid part of the trunk. Figure 3 shows the fitting image of Matlab result and slice image of sample 1. It is clearly seen that there are correlated between ultrasonic measurement and physical condition of the sample.

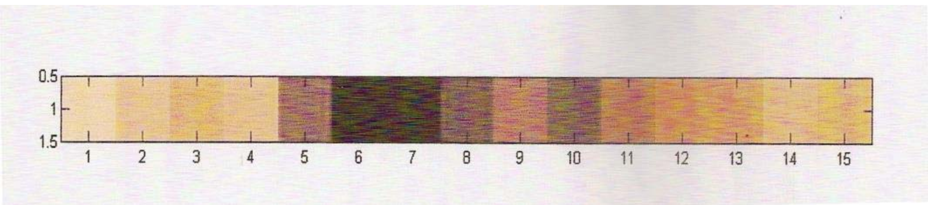

Figure 1. Line image generated using Matlab

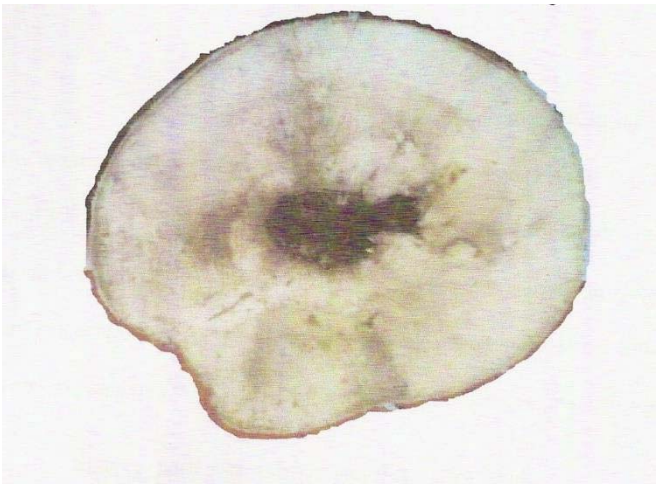

Figure 2. Cross sample of the sample 1

The result shows that the ultrasonic velocity was minimized at the point where the internal decay occurs while at the points near to the edge showed a higher ultrasonic velocity. The variation of ultrasonic velocity depends on the internal properties of the sample. Any disturbance in the tested sample such void, decayed part or resinous has resulted in producing lower velocity of ultrasonic signal. When there is a void or internal decay, ultrasonic wave travelled in lower velocity or avoided to pass through the area and it is forced to go around the hole and travel a longer distance. Eventually, the transit time of ultrasonic wave increase and the velocity will consequently decrease. The ultrasonic velocity minimum at the point where the internal resinous occur. When there is internal resinous, ultrasonic wave cannot transmit in the resinous and it is forced to go around the resinous and travel a longer distance (Dzebenski, *et al.* 2007). As the ultrasonic wave hit the resinous, the transit time of ultrasonic wave increase and the velocity will consequently decrease.

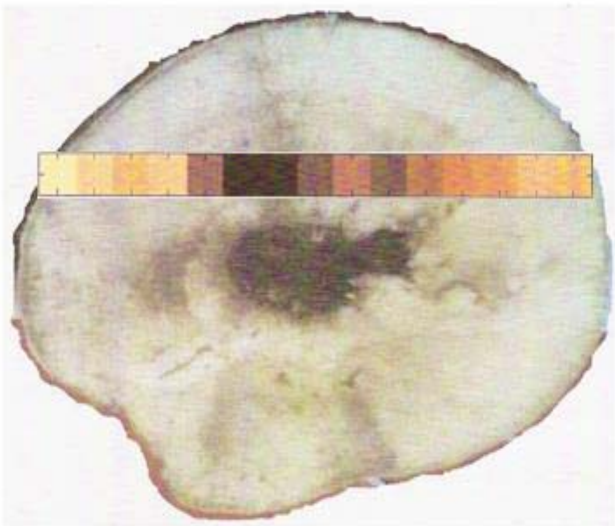

Figure 3. Fitting of Matlab result and Sample 1

Meanwhile, the measurement of sample 2 showed that variations of ultrasonic velocity are slightly different as compared to the result of sample 1. The result shows that ultrasonic pulse velocity is almost consistent for all points. Figure 4 shows the comparison of Matlab result and the slice image of sample 2. It is discovered that sample 2 has no defect and this condition is correlated with the ultrasonic measurement.

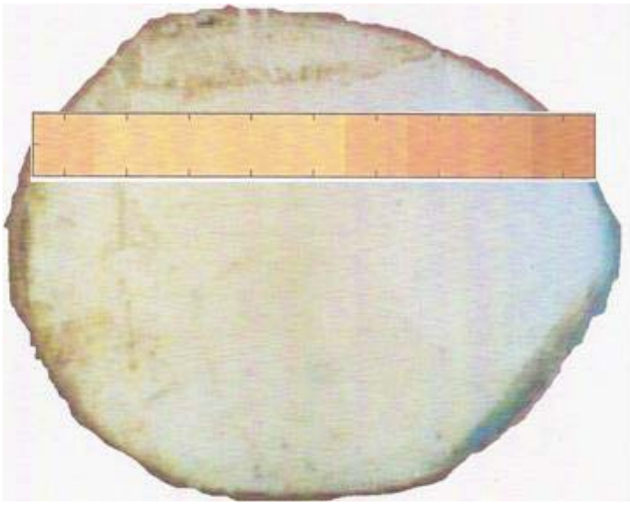

Figure 4. Fitting of Matlab result and sample 2

CONCLUSION

The results of this study showed that the internal decay that can lead to producing of gaharu resin can be correlated with the propagation of ultrasonic wave. The decay part of the tree had resulted in producing lower ultrasonic velocity. The difference in colour of the image generated by the Matlab software based on variation of ultrasonic velocity between the internal decay area and its surrounding area was obvious. Therefore, the internal properties of Aquilaria tree could be detected by ultrasonic line imaging technique.

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