Application Low Cost Air Drying Model in Indonesian Traditional Shipbuilding

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Paper History

Received: 9-July-2014
Accepted: 19-July-2014

ABSTRACT

Indonesian traditional ship is a product of an indigenous technology developed long before the advent of western culture along the Coast of Sulawesi Island. The ships are built traditionally in both method and equipment without any sketches or calculations. Advancement in science and technology, and abundant information available on the World Wide Web has caused unprecedented changes in many areas of human Endeavour. However, Indonesian traditional ship builders have not taken full advantage of available technology and information particularly in the preparation of lumber which remains one of the critical and most unpredictable stages in construction. This study addressed the issue of delays which is always one of the critical issues confronting the construction of traditional ship in Kepulauan Riau. A low cost air drying model was proposed. The model was tested by comparing the air drying time of lumber in two specific conditions. Four different samples of lumber were used to test the efficiency of both the air drying model and the natural air drying technique. In conclusion, the proposed model having applied and compared with the traditional method clearly show a better method.

KEY WORDS: *Lumber Drying Process; Traditional Ship Production; Kepulauan Riau-Indonesia.*

NOMENCLATURE

EMC Equilibrium Moisture Content

1.0 INTRODUCTION

Indonesian traditional ship is a product of an indigenous technology developed long before the advent of western culture along the Coast of Sulawesi Island. The ships are built traditionally in both method and equipment without any sketches or calculations. The building expertise is passed down from generation to generation, a knowledge that is further honed through daily practice with the help of each builder's instincts and natural gift. Still built by hand in the traditional manner, these majestic sailing ships are a living spirit from the golden age of sail, which ended in the West in the early twentieth century, but still thrives in the waters of Indonesia.

The beauty and efficiency is not a product of technical science, they are a product of the spiritual nature of these people and their culture. They are at one with their environment and they follow a path of least resistance in their lives and in their work. This philosophy contributes to the beauty and efficiency of their ship designs, and it comes from a basic and simple understanding of the world in which they live. This philosophy based nature and balance allowed the peoples of the Indonesian islands to produce solutions to practical challenges long before the societies of Europe were able to.

In as much as one would like to appreciate the people and their philosophy, it is also good to mention that a mix of local craft and beliefs plus modern and scientific ways of doing things will go a long way in transforming the practice of ship building in Indonesia. Advancement in science and technology, and abundant information available on the World Wide Web has caused unprecedented changes in many areas of human endeavour. However, Indonesian traditional ship builders have not taken full advantage of available technology and information particularly in the preparation of lumber which remains one of the critical and most unpredictable stages in construction. They have failed to explore outside the ancient method of wood preparation other possible ways of making lumber ready for use in shipyards. Nofrizal et al, 2012 has raised the drying lumber issue in traditional shipbuilding in Kepulauan Riau, Indonesia as shown in Figure.1.

Figure.1: Drying lumber issue in traditional ship production in Kepulauan Riau, Indonesia.

It is in the light of the above statement that this study will like to identify from literature different ways of preparing lumber for use in traditional shipyards and proposed a low cost model that may help in impacting the practice of traditional ship building in Indonesia positively.

2.0 LITERATURE REVIEW

The demand for traditional wooden ship in Indonesia is on the increase, this is evident from the high patronage especially among local fishermen. The ship building industry in Indonesia has survived many centuries ably supported by the activities of locally trained builders. Many of the builders acquired the required skill through biological descent or through apprenticeship schemes. Hence, it a common phenomenon to find men with minimal educational ability, narrow world view and limited exposure to the outside world in ship building industry **(**Risandi et al, 2012**)**.

Wood remains the major material and the role of wood in the traditional shipbuilding in Indonesia cannot be overemphasized. When wood is fallen down and sawn into various shapes and sizes, the sawn lumbers are usually allowed to dry before they are used in the construction of ship. However, the drying process is not usually controlled. The drying process most times takes place in open air and as such is exposed to elements of weather which makes the drying process and the drying time highly unpredictable.

Literature reviewed revealed that several studies have identified some of the specific issues central to traditional ship construction in Indonesia. Production issue of traditional shipbuilding in Kepulauan Riau, Indonesia was studied by Nofrizal et.al (2012). His research is proposed to collect data for ship production process and redraw the work flow required to pass through in order to construct the a traditional wooden ship and also identify the major problems exists in the process. Mufti et al, 2012, lamented the lack of blue print or formal sketches as well as calculations on performance during the design stage. The study stated that the traditional ship designs are derived from the replication of an existing ship that is serving its purpose well or from informal conversation between the ship builders and the client.

In another study, E. Prayetno et al, 2012, dwelt on quality control issues in traditional shipbuilding as shown in Figure.2. The study mentioned that there is no standard quality control measure in the choice of materials. The master builders depend heavily on their senses specifically visual assessment and on the job experience acquired over the years. There is no scientific approach to quality control.

Figure.2: Quality issues in traditional ship production.

Moreover, A. Deah et al 2012, addressed safety issue from the perspectives of occupational safety and policies. The study observed that at the construction stage most of the builders failed to take necessary precautions to arrest issues that can expose workers to fatal injuries and jeopardize their health. For instance workers are not provided the required safety wares that such as helmet, boot, hand gloves that can protect them from against injuries. Furthermore, the study highlighted non compliance to specified safety regulations at the point of ship building as laid down by government appointed regulatory agencies.

It is important to mention that some other studies have identified delivery as one of the critical issues in traditional ship building process. Surhan et al 2012, mentioned that traditional shipbuilding process follows a certain unique procedure, a procedure which been handed down from one generation to another generation. The study posited that the unique procedure adopted by the builders was often fraught with flaws. These observed flaws make it almost impossible to give a definite start or completion date for a given project.

One of the major flaws cited by Surhan et al 2012, centred on the refusal of the builders to take advantage of available knowledge in modern day science and technology. The preparation and processing of wood for construction till date still take place in open air. Consequently, wood air drying time remains dependent on prevailing weather conditions. Hence, it is difficult to estimate or project the time required to air dry a given quantity of wood needed to build a specific ship size.

Modern technology nowadays however, does allow wood drying to be carried out in diverse ways instead of just drying outside under the sun. This makes room for better and consistent results as the process can be partly or fully controlled. Not only that, it can also help in the projection of air wood drying time and also encourage the application of scheduling tools at the construction stage. Application of scheduling tools in return may be an advantage in the optimization of the overall ship production process.

The focus of this study is to discuss and address lumber air drying time, and also develop a model that can be used in air drying time calculation. The ultimate goal is to propose a low cost air drying model which may be used to predict the time required to prepare a specific needed quantity of lumber for a given size of ship. This study believes that the proposed model with the ability to predict time for air drying of lumber will eliminate non standardization of time which has been a familial and perennial problem and hence the optimization of the overall production process through the application of scheduling tools.

3.0 LOW COST LUMBER DRYING MODEL

Lumber used in shipbuilding must be seasoned, which means that the moisture from the green wood has to be removed in order to improve its serviceability. Air drying and kiln drying are the two methods used for lumber seasoning, and generally speaking, the air dried process is the best for shipbuilding woods. Most of the lumber available in advanced countries in the west is kiln dried but air drying method is still very rife in Indonesia which is equally acceptable if done properly. Lumber drying process has to be done with great care. If the process is either rushed (leaving too much moisture in the wood), or the lumber is "cooked" too long or at too high a temperature, (thereby removing too much of the moisture and making the wood brittle), the lumber will not be suitable for ship building.

For most ship building lumber, the ideal moisture content ratio to lumber weight after drying (regardless of the process) is approximately 15%, with a range of from 12% to 16% being acceptable (W. Simpson, 2004). When the wood is seasoned, it shrinks to some degree, and if during drying, too much moisture is removed, the wood will later absorb moisture and swell excessively once in use in the ship. On the other hand, if the wood is "green" or contains too much moisture after seasoning, the wood will tend to shrink and split while the ship is being built.

The moisture content of wood below the fiber saturation point is a function of both relative humidity and temperature of surrounding air. The EMC is the moisture content at which the wood is neither gaining nor losing moisture; this however, is a dynamic equilibrium and changes with relative humidity and temperature.

The Hailwood-Horrobin equation for two hydrates is often used to approximate the relationship between EMC, temperature (T), and relative humidity (h) (R. Baronas, 2001):

$$M_{eq} = \frac{1800}{W}\left[\frac{kh}{1-kh} + \frac{k_1kh+2k_1k_2k^2h^2}{1+k_1kh+k_1k_2k^2h^2}\right] \quad (1)$$

where;

$$W = 330 + 0.452T + 0.00415T^2$$

$$k = 0.791 + 4.63x10^{-4}T - 8.44x10^{-7}T^2$$

$$k_1 = 6.34 + 7.75x10^{-4}T - 9.35x10^{-5}T^2$$

$$k_2 = 1.09 + 2.84x10^{-4}T - 9.04x10^{-5}T^2$$

If the wood is placed in an environment at a particular temperature and relative humidity, its moisture content will generally begin to change in time, until it is finally in equilibrium with its surroundings, and the moisture content no longer changes in time. This moisture content is the EMC of the wood for that temperature and relative humidity.

The moisture content of wood is calculated by the following formula::

$$MC = \frac{m_g - m_{od}}{m_{od}} \quad (2)$$

where, m_g is the green mass of the wood, m_{od} is its oven-dry mass. The equation can also be expressed as a fraction of the mass of the water and the mass of the oven-dry wood rather than a percentage. For example, 0.59 kg/kg (oven dry basis) expresses the same moisture content as 59% (oven dry basis).

3.1 Construction of the Air Drying Model

The model was constructing by using an aluminum rectangular frame with 69 cm of length, 65 cm of with and 42 cm of height and a polythene sheet as shown in Figure.3. The polythene sheet was spread over the frame and held firmly to the frame by tape and screws. The purpose of the polythene is to serve as shed for some of the samples.

Figure.3: Constructing the Air Drying model.

Using the model, experiment was conducted for 7 days with detail as follows:

Day 1

- The low cost air drying model was constructed using a rectangular frame and a polythene sheet.
- The length of each of the Samples A, B, C, D, 1 and 2 of lumber pieces were recorded
- The initial weights of the samples were also recorded.
- The samples A, B, C, D, 1 and 2 were immersed in water
- The samples A, B, C, D, 1 and 2 were removed from water for about two and a half hours. The weights of the samples were recorded again.
- Samples A, B and 1 were placed inside the model.

- Samples C, D and 2 were placed outside the model in the open air (that is they were exposed to elements of weather condition).
- The following parameters time, temperature and relative humidity were recorded.
- The samples were kept outside for another ten hours and the changes in weight (that is loss in moisture content) were recorded.

Day 2- Day 7

- The samples were kept outside in two different specific conditions and their weights, time, temperature and relative humidity were steadily recorded at time interval of two hours for a given period of one week.
- Condition 1: samples A, B and 1 were spread out inside the model protected from elements of weather with a clear transparent polythene sheet.
- Condition 2: samples C, D and 2 were spread out in the open air unprotected from elements of weather.
- The data obtained were tabulated accordingly.

3.2 Immersion of Samples in Water and Sample Arrangement

The samples were immersed in water after taking their initial weights in order to confirm how dry or wet they were. They were immersed for a period of two and half hours. Their weights were also recorded and this is illustrated in figure.4 below.

Figure.4: Samples immersed in water

After immersion, the samples were laid apart in upright position in order to allow for direct effect of weather condition as shown in the Figure.5, Figure.6 and Figure.7.

The data were collected at different time interval. Day 1 data was collected at time intervals of two hours. This is only to find the patent of dryness of lumber. The time interval for day two and three is four hours and day four and above is six hours.

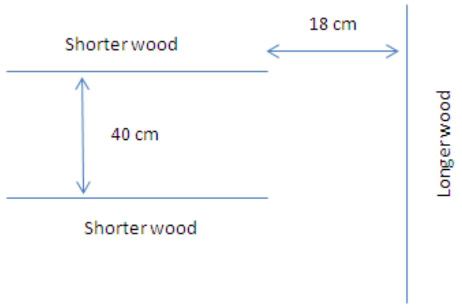

Figure.5: Samples arrangement.

Figure.6: Arrangement of the samples

Figure.7: Experiment under rain showers

3.0 REQUIRED DRYING TIME OF LUMBER

To determine the number of days required to dry lumber, this study applied EMC equation to determine the dryness of the lumber. In general, the moisture content of lumber below the fiber saturation point is a function of both relative humidity and temperature of surrounding air. The EMC is the moisture content at which the wood is neither gaining nor losing moisture; this however, is a dynamic equilibrium and changes with relative humidity and temperature.

Let assume that *m* is the mass of the lumber (with moisture) and m_{od} is the oven-dry mass of lumber (i.e. no moisture). If the lumber is placed in an environment at a particular temperature and relative humidity, its moisture content will generally begin to change in time, until it is finally in equilibrium with its surroundings. At that point, the moisture content no longer changes. This moisture content is the EMC of the lumber for that temperature and relative humidity. To estimate the EMC, Hailwood-Horrobin equation for two hydrates is often used to approximate the relationship between EMC, temperature (*T*), and relative humidity (*h*). The example below shows the application the Hailwood-Horrobin equation to calculate the EMC of sample A and sample C. The initial data obtained during the experiment for sample A is highlighted in the Table.1 below:

Table.1: The initial data for sample A after immersion.

Particular	Recorded Data
Initial Weight, m (Weight remove from water)	0.972 kg
Average Temperature, T	30.85 ^{0}C (87.53 F)
Fractional, H (Average Humidity)	83.16% (0.8)

From the calculation above, the drying weight for the sample A (inside the model) and sample C (outside the model) is 0.841 kg and 0.742 kg respectively. In the calculation, the Moisture Content is 15 percent (My Life: Kayu). By plotting the graph of sample A and sample C using the data from the experiment against recorded time. The total time required for the lumber to air dry from fully wet condition can be determined. The Comparison between the required times to air dry the samples (A and C) with both the proposed technique and traditional technique is showed in the figure.8.

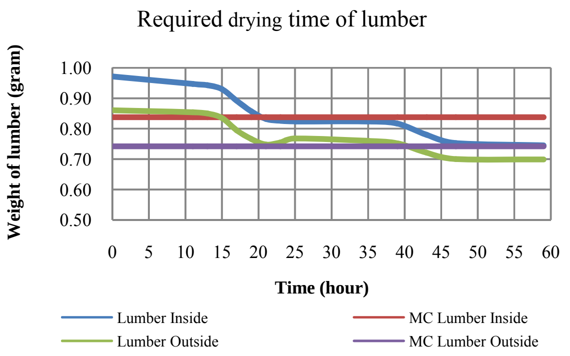

Figure.8: The air drying time of lumber in two specific conditions i.e drying time between proposed technique and traditional lumber drying technique.

According to figure 8, it is evident that the proposed technique proves to be more successful, drying the lumber in less than one day (20 hour). While the traditional method shows delay that is it takes almost two day (40 hour). The delay caused by the traditional technique as observed from the graph is because of rainfall the second day after the drying process started.

According to the rainfall data from Department of Irrigation and Drainage Malaysia, the amount of cumulative rainfall in Johor Bahru area on initial data collection day which is 7th July 2013 is as high as 10mm. The cumulative rainfall data provided by the Department of Irrigation and Drainage Malaysia is shown in figure.9.

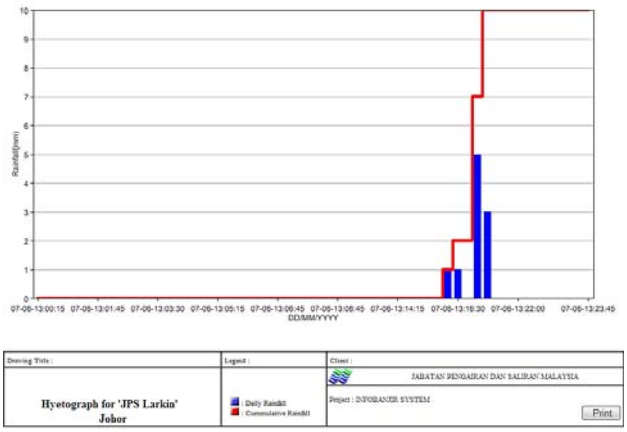

Figure.9: The cumulative rainfall for the month of June, 2013 by Department of Irrigation and Drainage Malaysia.

By comparing the cumulative rainfall data to the amount of the drying time, it can be assumed that for every 10 mm of rainfall, the air drying time of the lumber is elongated using traditional drying method. In other words, if there no rainfall the following day, the lumber air drying time by traditional technique can also be predicted to dry in one day.

3.1 Comparison between the Use of the Proposed Model and Traditional Method

From the experiment conducted, the lumber placed outside the model is exposed to rainfall therefore becomes wet when it rained and also difficult to work on because of the wet surface as shown in Figure.10. The wet surface would invariable translate to delay in the overall production process because it required more time to dry.

Figure 10: Effect of rainfall on drying of lumber using the proposed technique and traditional technique.

3.2 Effect of Air Drying on the Size of the Lumber

Also from the experiment, it is deduced that there was no noticeable change in the size of the lumber. Figure.11 shows the graph of the air drying time for different sizes of lumber. The result shows that the changes are negligible.

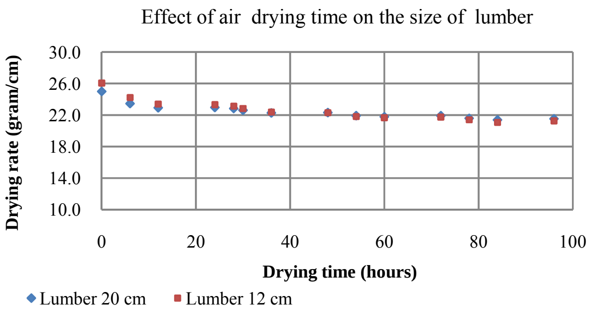

Figure.11: Effect of air dry time on the size lumber using the proposed technique.

5.0 CONCLUSION

The following conclusion is to answer the objective of the present study.

- The low cost lumber drying model is proposed in the present study.
- The low cost model was constructed using a rectangular frame and a polyethylene sheet.
- Experiment was conducted to determine required drying time of lumber using the proposed drying model and current technique which is applied by traditional shipyard in Kepulaun Riau, Indonesia.
- In the experiment, length of lumbers are as follows 31 cm, 20 cm and 12 cm. Width and thickness are the same in which 20 cm of width and 2 cm of thickness.
- The interval time is record
- The analysis of experimental results show that required drying time using the proposed model is shorter than the current technique.

ACKNOWLEDGEMENTS

The authors would like to convey a great appreciation to Universiti Teknologi Malaysia and Ocean and Aerospace Research Institute, Indonesia for supporting this research.

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