The Barn Raiser

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The Importance of a Mill Appraisal: *Understanding and Accepting the Financial Implications of a Volatile, Uncertain Marketplace*

By: Jordan McInvale

With the current economic uncertainty in the American housing market comes increased exposure to various market risks for many wood-products companies. Most mill managers understand the standard market risks of mill operations such as lower product prices, increases and decreases in domestic and international competition, supply and demand volatility of both raw materials and finished products within the industry, etcetera. However, the same managers may not realize or may fail to fully protect their mills from other serious financial risks such as: inflation pressures, short-term financial difficulties, and unforeseen damage to mill property. MS Appraisal Services, LLC, a subsidiary of Mid-South Engineering Company offers mill appraisals which in many cases can mitigate many of these risks while providing mill management with the knowledge and information needed to make prudent financial decisions. The purpose of this article is to briefly describe our appraisal process and explain how our appraisal process helps wood-products companies significantly lower and manage many financial risks faced in today's uncertain marketplace.

Our mill appraisal process usually starts with a phone call and an arranged site visit. This site visit includes interviews of mill managers and personnel and the gathering of site specific data such as: pictures of the facility, sketches for dimensioning of plant equipment and structures, and professional observations and insights about the general working condition of all mill assets.

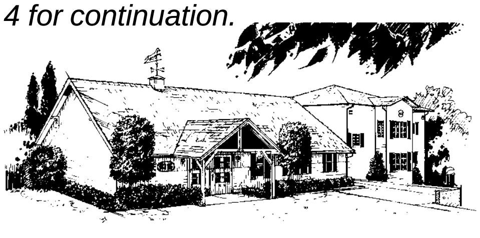
Next we use the information obtained from the site visit, engineering drawings gathered from the client, and dimensioned sketches made at the plant to develop a complete listing of all mill assets so a complete replacement cost estimate of the entire facility can be constructed. This cost estimate, in conjunction with an economic analysis of financial information provided by the client, is used to develop a cash basis value of the mill.

The mill appraisal product can be used in many ways. The appraisal can be used to determine the need for updated insurance values for the mill—effectively lowering the risk of financial loss due to a catastrophic event such as a hurricane or fire. This is particularly important if the current insurance policies on the facility do not account for the recent replacement cost of equipment—significant costs which have dramatically increased over the past five years because of rapid inflation in base metal prices for copper, steel and other costs.

In addition to updating insurance, the appraisal can be used for financial planning purposes such as securing debt financing in the form of a short-term loan or an emergency revolving line of credit. This is important for many wood products companies facing financial difficulties who require emergency debt financing for maintaining mill operations. The unfortunate reality is that some mill operations may become financially insolvent in the upcoming months because of liquidity problems related to the mill's ability to borrow sufficient funds to finance day-to-day operations. Some of these companies could have been saved from bankruptcy, except that the emergency financing was not in-place fast enough to keep the company financially solvent.

It is our experience that some banks have been less likely to foreclose on bankrupt mills if the bank had sufficient understanding of the cost structure and the depreciated cost of the equipment.

See Page 4 for continuation.



"The Barn" built in the 1930's to house Welsh ponies, serves as Mid-South's offices.

Heating Characteristics: Roundwood

By: Jason Garner

Thermal Conduction Coefficient (k):

Steel:	360 BTU-in/hr-ft^2-°F
Aluminum:	1,460 BTU-in/hr-ft^2-°F
Cobalt:	480 BTU-in/hr-ft^2-°F
Roundwood:	VARIES

Specific Heat Capacity (Cp):

Steel:	0.116 BTU/lb-°F
Aluminum:	0.215 BTU/lb-°F
Cobalt:	0.105 BTU/lb-°F
Roundwood:	VARIES

In designing a thermal system to be used for heating roundwood, the thermal conduction coefficient and the specific heat capacity scenarios presented above become apparent when defining known and unknown conditions/parameters in the heating process. The required design conditions/parameters for the thermal system calculations related to, for example, steel, aluminum or cobalt would be quite trivial, because of the uniformity of the material regardless of its origination location and the wide availability of published values. Wood's physical, and therefore thermal, characteristics, being a living organism, vary from location to location, and this "location to location" is not state to state, it is more closely from here to fifty (50) feet away, for example. The amount of sunlight, water, the soil conditions, exposure to wind/weather conditions, genetics, etc. are all examples of conditions that affect the physical characteristics of the wood. It is near impossible to account for <u>all</u> of these conditions when making calculations, so an understanding of general heat transfer principles, a broad understanding of existing research on heat transfer related specifically to wood and access to applicable experimental data or facilities to perform experiments on the wood that will be heated are required to make the educated assumptions necessary for an effective design. A process for calculating the heat energy required to raise the core temperature coupled with conclusions reached regarding existing research versus experiments, which Mid-South participated in, will be discussed in this article. The example provided is specific to "Southern Yellow Pine".

Step 1: Understand General Wood Heat Transfer Characteristics

Before any calculations are made, heating parameters and design conditions must be collected and, most importantly, understood. A few of the key wood heating characteristics are outlined in this paragraph. The rate of heat transfer in the longitudinal direction can be as high as 2 ½ times to 3 times that of the heat transfer in the radial directions, so special attention must be paid to the ratio of diameter to length of the wood piece being heated. For example, this effect on small diameter logs, less than 8", which are eight feet six inches (8'-6") long can be neglected in the heating calculations. Green wood (Moisture Content > 30%) transfers heat better than dry wood (Moisture Content < 30%). This is due to the fact that the voids between cells, latewood and earlywood, are filled with water which presents a more homogeneous heat transfer medium. The voids between cells in dry wood are occupied, primarily, by air which is an insulator not a conductor of heat energy, so this negatively affects the heat transfer rate. The wood porosity and cell orientation/structure, which vary from tree to tree, also affect the heat transfer rate.

Step 2: Calculate Wood Heat Energy Requirement

Knowledge and understanding of the above mentioned items play a critical role in the successful design of a roundwood heating system. A preliminary set of example calculations, pertaining to Southern Yellow Pine, will be covered in the next section. This sample calculation represents the next step in designing a roundwood heating system.

Example Calculations:

How to approximate the heat energy required to raise the core temperature of the given amount of wood from its initial condition to its final condition:

Equation to be used: $Q=m_{wood}*Cp*\Delta T$

Where: *Q=Heat Energy Required (BTU); m_{wood}=Total Mass of Given Amount of Wood (lb); C_p=Specific Heat Capacity (BTU/lb-°F); ΔT=Final Temp. Minus Initial Temp. (°F)*

<u>Mass Calculation:</u>

Determining the mass of the wood requires some assumptions about the average diameter, length and density of the wood. For this example the following assumptions will be made:

Parameters/Assumptions:

$Length_{avg}$ = 8'-6"

$Diameter_{avg}$ = 8 inches

$Density_{avg}$ = 62 lb/ft^3 *(Densities vary from location to location as well as from season to season as moisture contents change, so take into consideration the worst case heating scenario for a more conservative design)*

$Number_{logs}$ = 100

Mass equation:

$$M_{wood}=\pi/4*(Diameter_{avg}/12in/ft)^2*Length_{avg}*Density_{avg}*Number_{logs}$$

Mass calculation:

$$m_{wood} = \pi/4*(8\ in/12\ in/ft)^2*8.5\ ft*62\ lb/ft^3*100\ logs$$

$$\underline{m_{wood} \approx 18{,}396\ lb}$$

<u>Specific heat capacity (C_p) approximation:</u>

The specific heat, as mentioned above, depends on two variables: (1) moisture content of the wood and (2) specific heat of the wood fiber itself. Determining moisture content is an elementary task, and will be summarized below, but combing through research papers and published values for the specific heat of wood is time consuming and have significant variations. The specific heat value for wood fiber that I have used in the example below represents a collaboration of values used in heating calculations performed by Mid-South Engineering Company, and others, over time.

$C_{p\_fiber} = 0.35$ BTU/lb-°F

$C_{p\_water} = 1.00$ BTU/lb-°F

C_{p_wood} = *Weighted composite of C_{p_fiber} and C_{p_water}*

The moisture content of the wood will be needed to establish the weighting basis. The moisture content calculations presented below are on a dry basis, or the denominator in the moisture content fraction is the “oven-dry” or fiber weight.

1 ft^3 *of wood and 100% moisture content will be assumed for moisture content calculations, so at 62* lb/ft^3 *(from above) this yields 62 lb of wood.*

Moisture Content Dry Basis ($M.C._{DB}$) *= (Green Sample Weight – Oven Dry Sample Weight) / (Oven Dry Sample Weight)*

With some algebra, the $M.C._{DB}$ *equation from above is rearranged to solve for the Oven Dry Sample Weight, or fiber weight, variable. This yields the following equation:*

Fiber weight = (Green Sample Weight) / (1 + $M.C._{DB}$*), which yields*
Fiber weight = 62 lb / (1 + 1) = 31 lb

So by this calculation, it is known that half of the weight is wood fiber and half of the weight is water, which yields the following weighted specific heat equation:
$C_p = ½ * C_{p\_fiber} + ½ * C_{p\_water} = ½ * 0.35$ *BTU/lb-°F +* $½ *$ *1.00 BTU/lb-°F*
So $C_p = 0.675$ *BTU/lb-°F*

ΔT:
As mentioned above, ΔT is the required temperature change, or specifically to this example, the core temperature change. The temperatures assumed for this example are as follows:
Starting Temperature (T_i) *= 40°F*
Final Temperature (T_f) *= 180°F*
$\Delta T = T_f - T_i = 180°F - 40°F = 140°F$

Heat energy requirement (Q) calculation:
$Q = m_{wood} * C_p * \Delta T$
$m_{wood} \approx 18{,}396$ *lb*
$C_p = 0.675$ *BTU/lb-°F*
$\Delta T = 140°F$
So **Q** *= 18,396 lb * 0.675 BTU/lb-°F * 140°F* ***= 1,738,400 BTU***

So the minimum amount of energy required to raise 18,396 lb of wood at 100% moisture content from 40°F to 180°F is 1,738,400 BTU. The heat energy required is the starting point for the design calculations for the rest of the thermal system and does not account for system inefficiencies, such as evaporative losses, insulation R-values, heat exchanger efficiencies and, most importantly, the time required to reach desired core temperature.

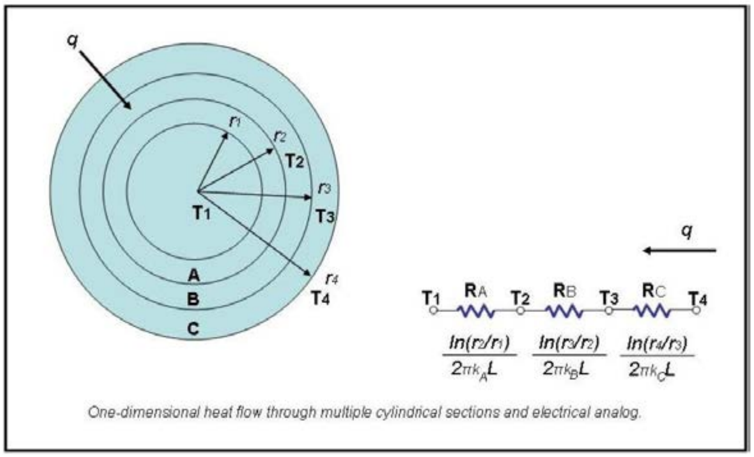
What is the next step?

The heat energy required to raise the wood core to the desired temperature is now known, but how long will it take to reach this temperature, or, in other words, what is the process dwell time? How does one determine the answers to these questions so that an optimal design formulation can be executed? Heat Transfer book; Mechanical Engineer’s Handbook; research papers; experimentation; or experience? Conclusions made specifically to juvenile roundwood are detailed below.

Step 3: Determine Accurate System Dwell Time

Heat Transfer Book/Mechanical Engineer’s Handbook:

The principles of heat transfer work very well for homogeneous materials, or at least a system of layers of different homogeneous materials. The radial heat transfer in roundwood is modeled as a system of round layers, representing earlywood and latewood, but these layers are anything but homogeneous. The layers’, or rings’, cell structures and orientation vary from layer to layer as conditions change from year to year. This in turn affects the heat transfer characteristics, i.e. the thermal conductivity coefficient, of each individual layer, so when assigning parameters and making assumptions related to heat transfer modeling a grossly wrong assumption of the heat transfer coefficient will be made by assigning a single thermal conductivity value to all layers or alternating layers, latewood and earlywood. As an example, by performing a transient error function analysis to the block heating scenario described above an actual error of 300% from the actual experimental results was obtained. In this analysis a single heat transfer coefficient was assumed and proved to be an incorrect and inaccurate assumption. As another example, a complete thermal resistance analysis was modeled by calculating the thermal resistance of every layer, as generally depicted in Figure 1 below, of the roundwood, i.e. the earlywood and latewood, and a thermal conductivity coefficient was assigned for earlywood and a thermal conductivity was assigned for latewood.



One-dimensional heat flow through multiple cylindrical sections and electrical analog.

Figure 1. Thermal Resistance Heat Transfer Method Considered

This analysis proved to be flawed in two areas: (1) as mentioned above, there is no one thermal conductivity coefficient for earlywood or for latewood, the thermal conductivity varies from layer to layer and (2) it was assumed that the layers were at uniform distance from one another, or have equal spacing, and this is not true, but there is no computational method for modeling the shape and spacing of rings from tree to tree due to the quantity of variables involved.

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Heating Characteristics: Roundwood

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Research Papers:

Research papers provide a multitude of relative, useful information related to the heating characteristics of roundwood, but it must be understood that reading through this research to pick out the pieces of information needed for a specific design scenario can be time consuming. The average wood diameter delivered to any wood processing facility has been decreasing over time, generally speaking, so as a result the time curves in the published research papers have become obsolete to many operators. So in summary, related to research papers, practical information can be pulled from these papers on the general heating characteristics of wood, but in graphical and data form, it generally does not apply to many of today's wood products facilities.

Case Study: A set of curves representing the core temperature versus time in respect to diameter were extrapolated for smaller diameter wood, but this curve extrapolation gave heating times that were 75% - 150% greater than the actual heating times.

Experimental Results:

Southern Yellow Pine juvenile roundwood heating experiments were performed and yielded repeatable results. These results have proved that the mathematical models can be rebuilt to back calculate the average thermal conduction coefficient (k). With this understanding of the heat transfer characteristics of juvenile roundwood Southern Yellow Pine, the 300% dwell time error obtained by straight mathematical methods can nearly be eliminated.

Conclusion:

Due to the complex physical characteristics variance of wood, from tree to tree and species to species, a broad engineering approach that combines all of the resources described in this article are necessary for the successful and accurate design of a new wood heating system. The concepts covered in this article involve only the front end of a roundwood heating system design, now it is time for Step 4: detail engineer the system to deliver the heat at the rate calculated in Steps 1-3.

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The Importance of a Mill Appraisal

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After all, generating 10 cents on the dollar for liquidated equipment is usually less economically viable than allowing the bank's debt to remain outstanding until the wood-products market turns around—providing the mill with an opportunity to repay the debt in full.

Our appraisal services also provide other financial advantages. Our appraisals allow companies to analyze potential financial decisions regarding the mill from both a cost perspective and an accrual accounting perspective—giving the client a better understanding of the cost structure of their business. This is vital for American wood products companies that are facing increased domestic and international competition and need to understand the nuances of their cost structure in order to remain competitive in growing global economy.

Our unique expertise in the wood products industry and detailed understanding of mill processes provides MS Appraisal Services with a unique competitive advantage over other appraisal firms. Our extensive knowledge base in the wood products industry allows us to determine a realistic and proper replacement cost estimate of the facility based on the most optimal equipment processes available at the time of appraisal. This approach provides our clients with the peace-of-mind that our appraisal will represent market reality and not drastically over-estimate or under-estimate the true value of the mill.

In the current economic environment, appraisal services are worth considering. A small investment in a mill appraisal can provide a substantial return on investment both in real terms and in the mitigation of financial risk by updating insurance costs, providing cost basis financial information, and aiding financial planning. If you feel that an appraisal can be very beneficial to your organization or if you have questions about the appraisal process; please give us a call.

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