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Simplified Quality Control in Lumber Manufacturing

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One of the major objectives of saw milling is maximizing the value of lumber products. A quality control program can significantly increase the output from overall lumber manufacturing. Quality control activities should be carried throughout lumber evaluation, storage and shipping. This fact sheet reviews basic quality control concepts and their influence on both lumber manufacturing and improved product quality.

Lumber Recovery Factor (LRF):

LRF, which is the board feet lumber production per cubic feet of actual log volume, is a measure of mill productivity. It is determined based on the following equation:

$$\text{LRF for a certain period} = \frac{A+B+C}{X+Y+Z}\ \text{bdft/ft}^3$$

where: A: Lumber inventory at the beginning of the period (bdft).
B: Lumber shipment during period (bdft).
C: Lumber inventory at the end of period (bdft).
X: Log inventory at the beginning of period (ft^3).
Y: Log shipment into the mill (ft^3).
Z: Log inventory at the end of period (ft^3).

LRF can also be expressed in terms of thousand board feet/cunits or cubic meters of lumber/cubic meters of logs. One board foot is defined as an unfinished board with 1-inch thickness, 12-inch length, 12-inch width (144 in^3.) and commonly indicated as MBF for 1,000 board foot. Calculating of overall LRF is illustrated in the example below:

Target size: 2 in. by 6 in. and 2 in. by 8 in.
Kerf: 0.25 in.
Log length: 10 ft.
Log diameter (small mend): 7 in.
Log volume: 3.0 (ft^3).
Board feet content: 15
LRF = 15 ÷ 3 = 5.0 bdft/ft^3

LRF can also be expressed as MBF/cunit (1 cunit is 100 ft^3 or 2.83 m^3 of solid wood) or cubic meters of lumber/cubic meters of logs. LRF in this example is 5.0 bdft/ft^3, 0.5 MBF/cunit, or 0.5 x 0.823 = 0.416 cubic meter of lumber/cubic meters of logs. (1 MBF/cunit = 0.832 cubic meters of logs/cubic meters of lumber).

A roughmill is a machine center where sawn lumber is converted into smaller pieces to be used for value-added products such as furniture manufacture. The yield from a roughmill can be determined based on the ratio between volume of green rough lumber and volume of dry rough lumber. This ratio is expressed as a percentage. The reason the volume of dry lumber is included into the yield calculation is to account for the shrinkage of wood due to moisture content reduction. For example, an average voumetric shrinkage of wood is about 8 percent during drying. If 10 million bdft of green lumber enters into the mill, actual raw material input will be around 9.2 million bdft as a result of volumetric shrinkage.

One of the major objectives of a quality control program in lumber manufacturing is to maximize LRF and the yield in roughmill, while producing a minimum amount of waste. Having a higher LRF and roughmill yield not only increases profit of the overall production but also reduces waste. Having a higher LRF and roughmill yield not only increases profit of the overall production but also reduces waste. Different log scales such as Doyle, Scribner, or International rules can be used to determine how much lumber can be sawn out of the log to be used for expected LRF. Average values of regional LRF range from 5 to 8 bdft/ft^3. The difference between the greater volume actually sawn over the lesser estimated log scale volume is called overrun and it is the ultimate goal of many lumber manufacturers.

Both LRF and roughmill yield are significantly influenced by raw material characteristics, defects, best opening face, sawing pattern, mill size, management objectives, market demand, equipment age, number of trained operators and target lumber thickness. Therefore, both LRF and roughmill yield play a very important role in determining the input/output ratio throughout the production. An ideal quality control program in lumber manufacturing should be designed with consideration of these two parameters, which are continuously monitored. Also overall quality standards in lumber manufacturing should be based on a sound quality control program within the perspective of the following concepts:

1. Standards should be set realistically based on the production line capacity and current technology used in the manufacturing process.
2. Quality performance should be constantly evaluated.
3. Any delay or postponement in a quality control program should not be tolerated.

4. Management and labor force should actively be involved with establishing and monitoring standards and quality control programs. Constant interaction between managerial and labor positions should take place.
5. Statistics and probability theory should be combined by employing computer technology.

An Application of Quality Control Chart in Lumber Manufacturing

Good quality usually requires consistent production of the same item. However, almost any manufacturing environment is dynamic due to raw material characteristics and production variables. Therefore, it is important to determine quality level of a process using statistical methods. Application of quality control charts is one of the most commonly used methods to evaluate different processes in many production lines, including lumber processing. Three main terms are related to quality control charts: control limits, upper and lower control limits and possible cause of variation.

Control limits can provide criteria for any process based on the amount of variation from one sample to the other. The upper and lower control limits can be developed statistically and reflect how a process is working. Generally any measurements above and below control limits are not desired. Finally, information gathered from the quality control chart can be used to identify possible causes of the variation of a product or process. A typical quality control chart is illustrated in Figure 1. These charts are developed based on data collected at a certain point within the production line.

Determining board target thickness in lumber manufacturing is a typical application of quality control charts.
Consistent control of lumber thickness is very important from both manufacturing and customer points of view. Some of the benefits of uniform board thickness include reduction of drying time, waste reduction, increased during capacity, ease of handling and increased efficiency of matching.

Dried and planed board size is mainly a function of planer allowance, sawing variation and shrinkage of the species. Rough green target thickness should also be calculated based on above factors to have a desired board thickness. Rough green target thickness of a board (T) can be estimated by

$$T = \frac{F+P}{1-(S/100)} + (Z \times V)$$

where F is final thickness, P is planer allowance, S is shrinkage in percent, V is sawing variation and Z is undersize factor, which is 1.65 with 5 percent of the lumber sawn. In general, lumber may vary in thickness due to sawing variation. If the log is not moved in a straight line through the sawing system, lumber thickness will vary, which is called sawing variation. Saw thickness and its design are also responsible parameters for sawing variation. Figure 2 shows a schematic of these variables to obtain the final board thickness.

For example, if the board thickness is 1.85 inches and sawing variation is 0.038 in.: 1.85 - (1.85 x 0.038) = 1.77 inches and 1.77 inches will be the threshold thickness value during the sawing.

Rough green target thickness of three sawmills (A, B and C) with the same parameters except sawing variation are compared to each other in the following example:

White oak lumber with a 1.77-inch final thickness and 4 percent shrinkage will be sawn on a bandsaw with planer allowance of 0.075 in. If mills A, B and C have sawing variations of 0.030 in., 0.055 in. and 0.066 in., respectively, target thickness of the boards manufactured by three mills can be estimated as below:

Boards in mill A should be sawn to a 1.97-inch thickness to have a 1.77-inch final thickness after they are dried and planed. The only difference among the three mills is sawing variation; mill A had the lowest target thickness needed, while mill C had the highest target thickness. Thicker boards cut in mill C will increase cost of the final product. In general, reducing

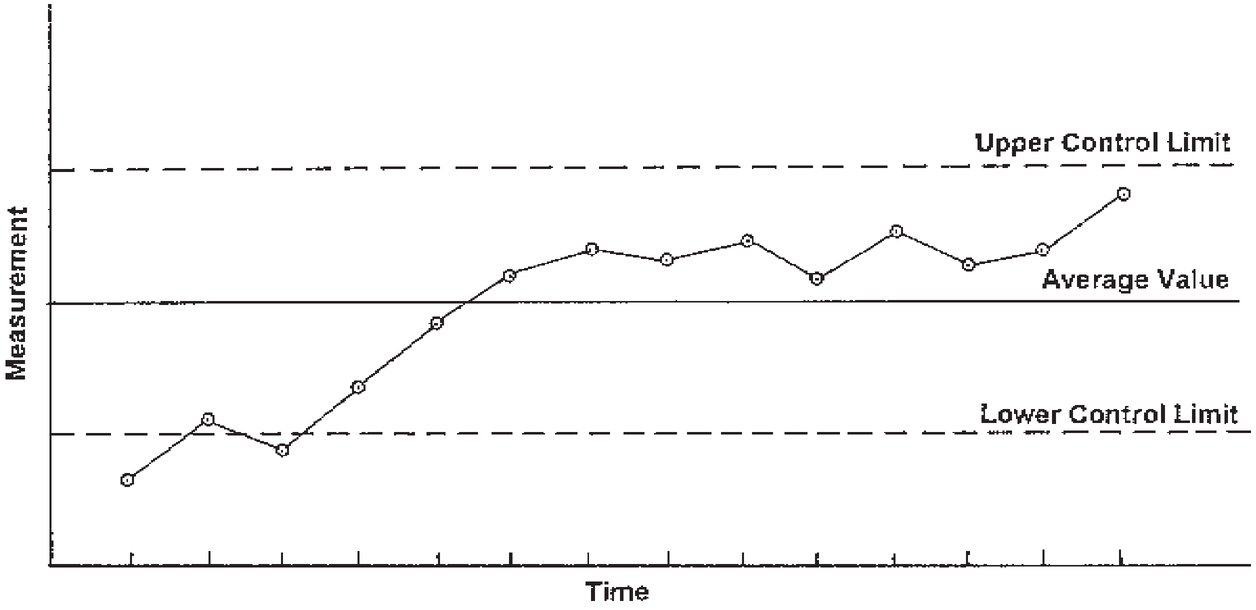

Figure 1. A typical quality control chart.

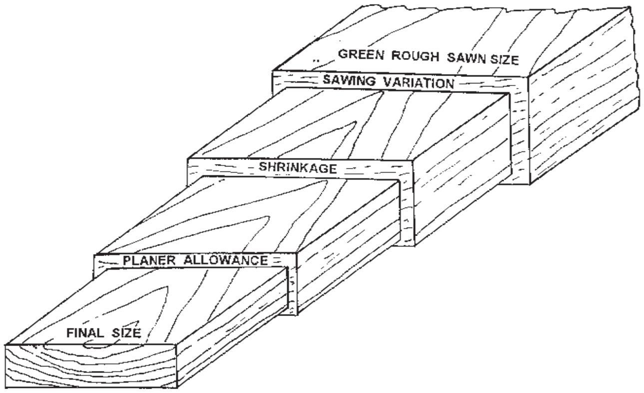

Figure 2. Allowances from green rough sawn size to the final size of a board.
Adapted from A. Jappinen and S. Offen. 1995. *Timber Size in Control Sawmills*. Bulletin 189. New Zealand Forest Research Institute.

$$T_A = \frac{1.77+0.075}{1-(4/100)} + (1.65 \times 0.030) = 1.97 \text{ in.}$$

$$T_A = \frac{1.77+0.075}{1-(4/100)} + (1.65 \times 0.055) = 2.01 \text{ in.}$$

$$T_A = \frac{1.77+0.075}{1-(4/100)} + (1.65 \times 0.066) = 2.03 \text{ in.}$$

target thickness by 0.1 will result in an increase of 8 percent or more lumber for 1.24-inch thick lumber. Quality control charts can easily be employed to have a uniform thickness control in such applications. Initially about 50 boards should be taken from the machine center. Thickness measurements should be carried out using a dial or digital caliper at the accuracy of 0.01-inch along each edge and opposite each other to monitor both thickness and edge-to-edge wedging as illustrated in Figure 3.

Standard deviation values within the board and between the boards are calculated. Once overall standard deviation value for each sample batch is calculated, quality control charts can be developed based on the average measurement (x) calculated by UCL and LCL limits values. UCL and LCL can be determined using $x \pm 3SD_{TOTAL}\sqrt{n}$. Data gathered from each batch of lumber can be plotted on the chart to evaluate overall performance of the thickness control.

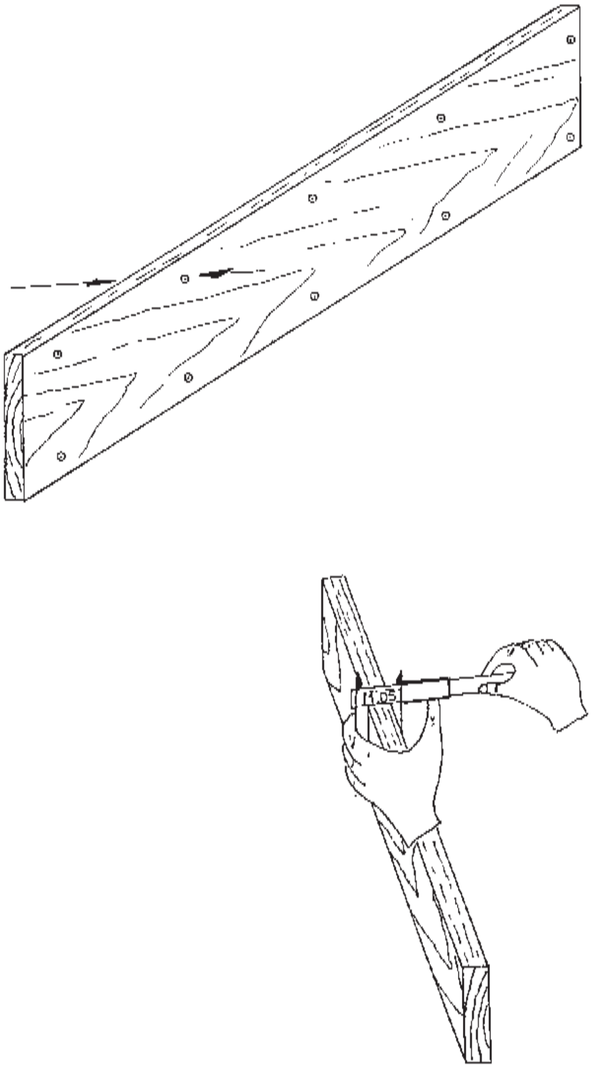

Figure 3. Thickness measurement of the board.

In conclusion, the information obtained from quality control charts can be used to monitor overall production to have target board size. Data can be analyzed to determine sawing variation. If values are inconsistent, possible reasons such as inadequate maintenance work, improper sharpening of saw blade, improper feed speed, and operator error should be taken into consideration. Once the reasons are discovered, necessary modifications to the process should be done for better product quality, higher yields and increased profit.

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