FORMEC 2019 – Exceeding the Vision: Forest Mechanisation of the Future
6-9 October, 2019 - Sopron, Hungary

ANALYSIS OF PROCESSING HEAD MEASUREMENTS IN MERCHANDIZING SOUTHERN YELLOW PINE

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Abstract: *Today's timber market in the Southeast US demands a specific size log; thus, the harvested trees need to be processed on the landing. In addition, merchandizing harvested trees is more profitable for the loggers as they are able process the timber to its highest economic value. The utilization of a processing head in the logging industry is encouraged due to the presence of technology advancement on the machine that allows the loggers to merchandize and top the logs by specifying the desired measurements into the processing head's computer program. The result from this study shows that, regardless of the amount of experience owned by the operator and whether a calibration was conducted on the machine, the measurements given by the processing head is not accurate. Continuing research to understand the extent of experience and calibration in the utilization of processing head in the Southeast US are encouraged.*

Keywords: processing head, merchandizing, accuracy, Southeast US

1. Introduction

The growing presence of sawmill across the Southeast US has provided a new challenge as well as the opportunity for the loggers around the area. The requirement to transport the specific size of logs to these mills is strictly enforced. Therefore, the loggers need to process the harvested trees on the landing before they are loaded to the truck. On the other hand, the loggers' ability to merchandize the stems is providing them the opportunity to gain a higher income compared to selling the harvested woods as tree length.

The practice of merchandizing is commonly conducted by the loggers using a pull-through delimber and a slasher saw that are attached to a knuckleboom loader. The knuckleboom operator delimbs and tops the harvested trees using the delimber and merchandizes them by utilizing the slasher saw. These processes rely on the operator's subjectivity in estimating the top diameter; hence, the result of topping and merchandizing are susceptible to measurement errors.

To avoid this subjectivity, the utilization of a processing head in the logging industry is encouraged due to the technology advancement on the machine. This technology allows the loggers to merchandize and top the logs by specifying the desired measurements into the processing head's computer program. Therefore, the incorporation of a processing head in logging operations is expected to provide the exact measurements of the logs. However, with such an effective measurement, its accuracy needs confirmation.

The ability to produce logs into accurate dimensions as desired using a processing head would likely to depend on the operator. An adequate amount of experience in operating a machine provides the operator with the skill to run the operation in the most efficient way, which results in maximum production. Kärhä et. al (2013) reported that an experienced operator performed 40% higher productivity compared to an inexperienced operator. Despite higher production, the experience would also likely to affect the accuracy of processed logs. As the machine savvy operator is familiar with the computer system and panel control that are installed on the head processing head, a higher accuracy on the processed logs is expected. Purfürst (2010) examined 32 operators to understand their learning curves. Forestry machine operators showed a

slow performance level as they start operating the machine and doubled the performance in their third year. It is identified that the operator's learning curve reaches a constant performance after nine months (Purfürst, 2010).

In addition to experience, the calibration is an important element in producing the desired log dimensions. Even though a processing head is designed to handle a heavy object (trees) in the field, the machine's accuracy could be compromised after a certain amount of usage. Therefore, it is important to keep the machine calibrated to ensure that the products are measured correctly. As reported by Nieuwenhuis and Dooley (2013), conducting harvester calibration regularly could reduce the difference between harvester measurements and manual measurements which resulted in the higher accuracy in the length measurement. Additionally, when a harvester is regularly calibrated, the accuracy on the volume of timber produced can be increased by 6% (Dooley et al, 2006).

This research aimed to evaluate the accuracy of a processing head in merchandizing logs. Statistical analysis is conducted to determine the significance of the difference between processing head and post measurement.

2. Material and Methods

The study sites were located in several operations in the Southeast US where the market for cut-to-length logs exists. The observed machines include the processing head manufactured by Waratah and Tigercat. In this study, the logs are processed based on the specifications that were determined by the mills. For every operation, the data collection was divided into 4 sets where each set contains 25 logs. In addition, several aspects of operating the machine are observed while collecting the data, such as the calibration conducted by the operator and the activity performed by the operator while processing the stems.

To confirm the measurement accuracy, two types of measurement were gathered in this study. The processor's measurements were obtained by recording the processor's monitor inside the cab, while the post measurements were obtained by manually measuring the processed logs. The logs were numbered directly after they were cut by the machine, to keep them in order in the post measurement. The processing head measurements were obtained after the recordings were reviewed. Meanwhile, post measurements were collected by measuring the length and diameter using a caliper and tape. The measurements collected in this research include the butt diameter, top diameter, and length of the logs. At the post-measurement, the diameter was measured as the inside-bark diameter.

Measurement difference was calculated as the difference of processing head measurement with post measurement.

$$Measurement\ difference = Processor\ head\ measurement - Post\ measurement$$

An analysis of variance was run to assess the significance of measurements difference between processing head and manual measurements on three logging operations. This analysis was analyze using R software for every data collected (butt diameter, top diameter, and length).

3. Result and Discussion

3.1. Data Distribution

3.1.1. Butt Diameter

The data distribution of butt diameter from logger A and logger B show a normal distribution, while the data from logger C is right-skewed (Figure 1). Logger C also shows high variability in the measurement differences. It ranges from -6.6 to 1.1 inches. Meanwhile, logger A and B depict a narrower data range (-0.7 to 3.5 and -1.1 to 3.5 respectively). Diameter distribution is highly concentrated from 0 to 2 inches differences for logger A, while the other loggers intensify between -0.5 to 1 cm in their measurement differences. Unlike the first two loggers, logger C shows a high number of underestimation of butt diameter measurements. The processing head recorded a smaller diameter than the actual butt diameter.

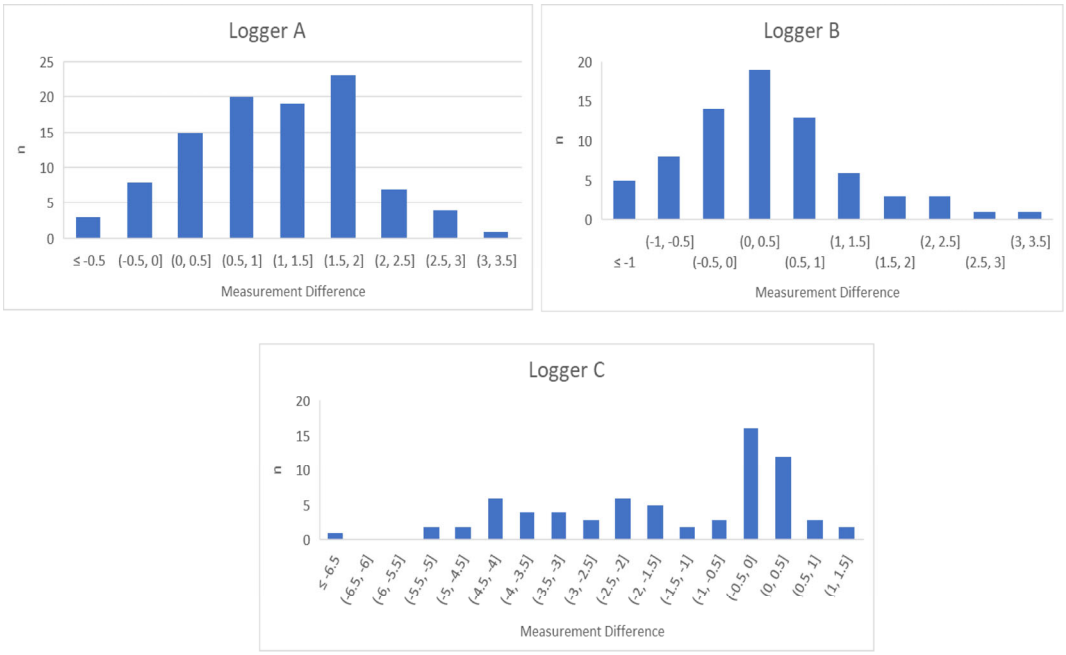

Figure 1. Butt Measurement Differences Distribution

3.1.2. Top Diameter

Data distribution for top diameter for all loggers is showing a normal distribution (Figure 2). The top diameter measurement differences concentrated from 0.5 to 2 inches for Logger A and -0.5 to 1 inches for logger B and logger C. The histogram shows underestimation was rarely performed by Logger A, whereas logger B and logger C are showing a higher number of samples that are underestimated.

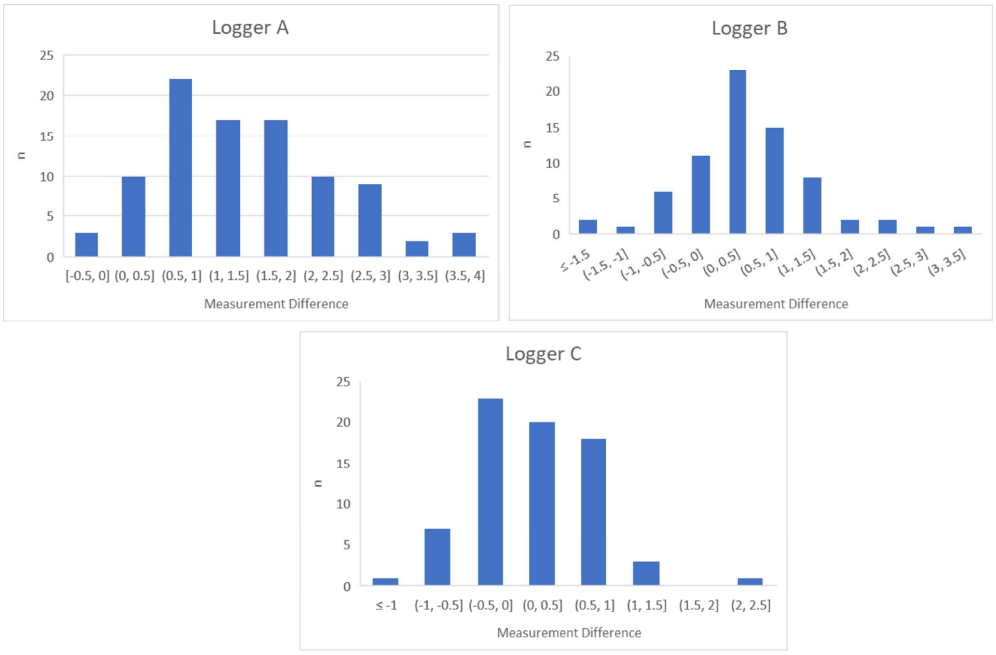

Figure 2. Top Measurement Differences Distribution

3.1.3. Length

As shown in Figure 3, the distribution data of length measurement differences are normally distributed for all loggers. The data from logger A indicates that mainly processing head gave a higher value than the actual measurement. A similar observation is seen on the data from logger B, although underestimation by the machine up to 0.6 feet was also observed. The highest length underestimation is observed from logger C, where the processing head is measuring logs shorter than the actual length by 0.8 feet.

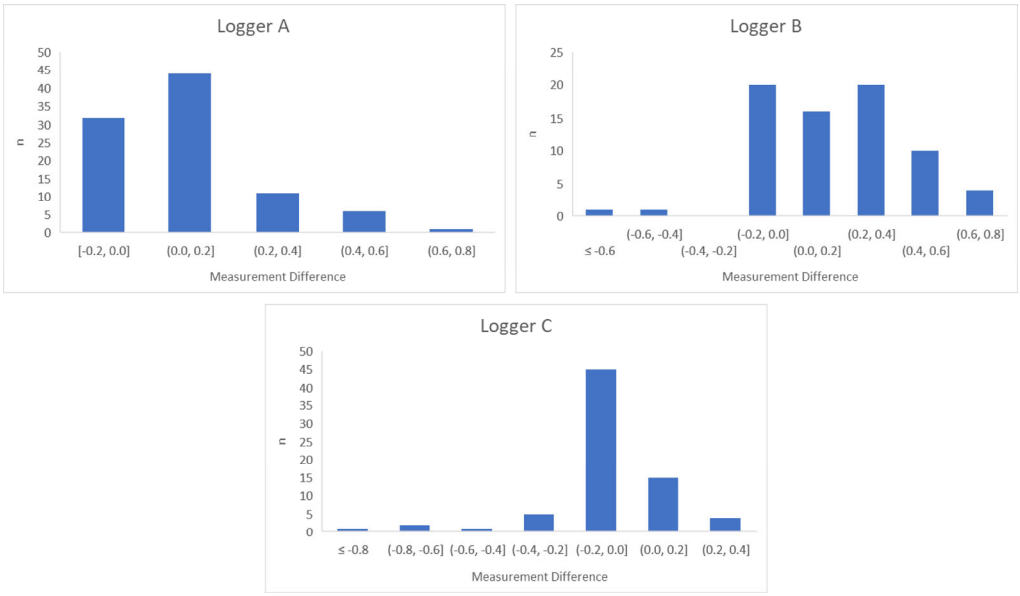

Figure 1. Length Measurement Differences Distribution

3.2. Measurement Differences Analysis

Table 1 shows that for logger A and B, the value given by processing head is higher compared to the manual measurement for all log dimensions. Meanwhile, the result of logger C is inconsistent. At this operation, butt diameter and length measurement differences show that the processing head measurement is giving lower values, whereas top diameter shows a similar correlation to measurement differences from logger A and B. As shown in the data distribution, logger C has a wide data range in the butt diameter and length measurement differences. It is also noted that for this logger, the processing head gave a smaller number in comparison to the post measurements. This results in negative measurement differences for the two log dimensions.

Table 1. Summary Data of Measurement Differences

Logger	Measurement Difference					
	Butt Diameter (in)		Top Diameter (in)		Length (ft)	
	Mean	SD	Mean	SD	Mean	SD
A	1.130	0.863	1.492	0.956	0.103	0.956
B	0.408	0.924	0.467	0.857	0.179	0.857
C	-1.525	1.895	0.222	0.571	-0.084	0.571

At the data collection, it was noticed that when a slash was not required (the stem is free from any defect), operator C did not run the machine to return to the stem's butt as he processed the trees. This resulted in a smaller butt diameter observed from the processing head as the measured diameter was away from the actual butt. The same situation observed for the length. Due to the inappropriate starting measurement, the processing head provided a lower number than the actual length.

Compared to the other two loggers, the diameter differences at operation A is the highest (1.13 and 1.492 inches). However, as the manually measured diameter was inside-of-bark, it is expected that the diameter measured by the processing head is 1 inch higher than manual measurement. Therefore, the diameter measurement differences from logger A, both for butt and top, was observed as the most accurate. In addition, logger A also provides the most accurate length measurement (0.103 feet length differences) compared to all loggers studied in this research.

The measurement difference between processing head and manual measurement could be caused by several reasons. The effect of operators' experience suggests a considerable impact in this study. Prior to conducting the data collection, an interview to understand the length of experience owned by each operator was conducted. The most experienced operator is from operation B with a total of experience for 16 years in running processing head, while operator A has 2 years of experience and operator C has only run the machine for approximately 100 hours. This insufficient experience caused different correlation of measurement differences in butt, length and top diameter. The measurement from this operation tends to underestimate the butt diameter and length yet overestimate the top diameter. The result from this study shows that experience of the operator plays an important role in producing logs with an accurate measurement. To obtain a more accurate measurement, it is recommended for the operator to run the machine from the butt of the harvested trees even though a cut from the butt is not needed.

Another factor that influence accuracy is the calibration. At the data collection, it was observed that from all operations, Logger A is the only operator who calibrated the machine. The calibration was conducted by the operator as the post-measurement data collection of the first set was performed. This calibration may contribute to the accuracy gained at this operation.

In spite of the aspects from the object studied, some measurement differences could also have resulted from the post-measurement error after the logs were processed. As an effort not to impede the operations, some processed logs were found to be overlapped on top of each other. Therefore, it resulted in difficult accessibility to manually measure the log dimensions.

Despite all the explained factors, the analysis of variance shows that processing head measurement is significantly different from post-measurement for all log dimensions in all locations studied (α=0.95). This implies that, regardless of the amount of experience owned by the operator and whether a calibration was conducted on the machine, the measurement by the processing head is not accurate. Therefore, continuing research is encouraged in order to understand the extent of experience and calibration in the utilization of processing head to merchandize southern yellow pine in the Southeast US.

4.Acknowledgements

We would like to acknowledge Auburn University, Fulbright, and United States Forest Service for supporting this research. We also appreciate all the loggers for their willingness to be involved in this study.

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