A Study on the Wearing Process of Stellite-Tipped and Swage-Set Saws During Sawing with a Bandsaw

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DOI: https://doi.org/10.51244/IJRSI.2025.120600117

Received: 23 May 2025; Accepted: 10 June 2025; Published: 15 July 2025

ABSTRACT

The application of modern industrial and management techniques to improve sawmill conversion efficiency is very necessary to control deforestation. Throughout the sawmill industry there is an apparent desire for the most effective utilization of wood resources. Mill efficiency can be improved by using suitable tipping materials. Stellite-tipped and swage-set saws are the most common types of saws that are used in the wood industry especially in the developing countries. This study was conducted in order to determine the wearing process of stellite-tipped and swage-set saws when they are in operation. This is required by operators to enable them develop a schedule upon which saw doctoring operations would be based. The stellite-tipped and swage-set saws were used to process three different species of wood, that is, low, medium and high densities, and the time taken for their kerf widths to wear to an undesirable level was investigated. Equations are presented showing the relationship between actual sawing time and saw kerf width or kerf losses during sawing. The relationship between actual sawing time and the standard deviation of the lumber thickness is also presented. From this relationship, the optimum kerf width for minimum standard deviation of the lumber thickness can be determined for the three wood species.

Keywords: Stellite-tipped saw, swage-set saws, cutting performance, bandsaw, wood species

INTRODUCTION

Wood resources worldwide are declining fast giving rise to escalating log prices [1]. Thus sawmill managers are becoming very conscious of the application of modern industrial and management techniques to improve log conversion efficiency. Throughout the sawmill industry there is an apparent desire for the most effective utilization of wood resources. Productivity is related to the type of saws used in the mills. The rate and the extent to which the saws wear greatly affect the productivity of sawmill.

Worn saws have a major impact on key operational parameters such as downtime, material loss, and production costs [2]. As saw blades deteriorate, they require more regular maintenance and replacement, resulting in increasing operating downtime. Optimal sawmill needs to replace blades after 500logs, however with rapid wear rates, replacements may be required every 250-300 logs. Each replacement entails 30-60 minutes of machine downtime causing productivity loss. Worn saws reduce wood quality and increase kerf width, resulting in 20% greater material waste (4.0 mm to 4.8 mm) [3]. This is 20 meters of lost useful timber per 1,000 logs. Increased wear has a direct impact on cost per log. A sawmill with well-maintained blades may pay less per log, taking into account blade and sharpening expenses. However, when blades wear too fast, the cost-per-log might increase by 60.0% due to the increasing frequency of blade replacements and maintenance. This cost difference adds up over the course of processing 3,000 logs [3].

The principal properties required of modern cutting tool materials for a high production rate and high precision machining include good wear resistance, toughness, and chemical stability at high temperature, and sufficiently high flow strength. Several reports have been published on advances in saw tipping materials for optimum cutting performance and improve service life [4] [5] [6] [7] [8] [9]

Stellite-tipped saws and swage-set saws are the most common types of saws used for wood processing in most part of the developing country. Stellite-tipped saw is usually used on abrasive species containing silica. However, due to its high cost, stellite tipping which increase the cutting-edge life of saws are not common in most mills. Swage-set saws on the other hand, are less expensive. It is known that less than 28% of sawmills in Ghana use stellite-tipped saw blade because they find Swage-set saws more affordable [10].

Saw wearing depends on the condition of the wood species being processed. It also depends on the timber species to be sawn, that is, low, medium or high densities. Many sawmills are not endowed with state-of-the-art laboratory equipment for measuring the wear of cutting edge. Therefore, the saw kerf or side-clearance that reduces or increases friction during sawing is the main parameter that can be measured to assist us in studying the wearing process of saws in our situation. With time, saws in operation reduce in saw kerf or side-clearance.

Most of the mills do not have any documented information on the wearing process of their saws. Sawmill operators grind till rough surfaces and other defects are discovered before the saws are removed for re-swaging, stellite-tipping or sharpening. Productivity and quality in this way are affected. This leads to rejection of lumber by aggrieved customers. Unlike ordinary saws, stellite-tipped saws wear slowly and therefore many logs can be converted before they are changed. As time is money, the number of times the saw would be changed is reduced. Again, lumber produced from stellite-tipped saws usually have smooth surfaces. On the other hand, saws that wear faster in operation have on overall declining effect on productivity. When saws wear, they introduce defects into the lumber. Due to their faster rate in wearing, they are changed frequently and this increases the down time losses. In this paper, Equations are presented showing the relationship between actual sawing time and saw kerf width or kerf losses when processing three wood species of different densities. The relationship between actual sawing time and the standard deviation of the lumber thickness is also presented.

MATERIAL AND METHODS

The bandsaw used for the study has a wheel diameter of 1328 mm, a rated motor power of 110hp and spindle speed of 1440 revolutions per minute (rpm). Three wood species of low medium and high densities were selected for the study. The species are: Triplochiton scleroxylon of density 369kg/m^3, Khaya ivorensis of density 540kg/m^3 and Piptadeniastrum africanum of density 690kg/m^3. The species were then classified into low, medium and high density species according to their density. Three stellite-tip and three swage-set saws of the same dimensions reported in a previous study by Okai [11] were used for the study.

The moisture content of the species in the green state varied from 60% to 70%. Each of the species was prepared into cants of depth 400mm and sawn into boards of nominal thickness of 40mm at an average feed speed of 10m/min. Measurement of kerf width and side clearance of all the 209 teeth of each saw was performed and repeated three times using a vernier caliper and a dial gauge. The kerf width and side clearance of the saw teeth were measured when the band saw teeth were freshly sharpened and fixed on the pulleys. Measurement of kerf width and side clearance was taken for every 10 minutes of cutting time on six occasions. Note that 10 minutes is the actual cutting time and it excludes idling time or no-load running. After each cutting condition, 5 boards were randomly sampled and the thickness of the boards measured at ten locations on each board along the top and bottom edges of the boards for subsequent analysis on lumber thickness variation.

RESULTS AND DISCUSSION

Kerf width and Kerf losses during sawing

Saw teeth are set to the required dimensions to enhance the saws performance while in operation. The setting of the saw teeth depends on the timber specie to be sawn. In other words, the width of the saw kerf is set to suit the type of timber species to be sawn. Kerf width of saws to be used on low-density species is bigger than that of medium-density and subsequently high-density species. This can be explained by the spongy nature of the low-density species. It requires a larger side clearance to prevent friction between the saw blade and the log while cutting. Figure 1 shows the relationship between the actual sawing time and the kerf width or the kerf loss during sawing with a stellite-tipped saw. It can be seen that as the sawing time increases, the kerf width decreases and the kerf losses increases. It also can be seen that the biggest saw kerf at the beginning of sawing is associated with the low-density species followed by the medium-density species and the high-density species in that order.

Due to the rising cost of stellite tipping, some sawyers have developed the techniques of preparing the same stellite-tipped saw to process low density, medium density and high density species. The crux of the matter is

INTERNATIONAL JOURNAL OF RESEARCH AND SCIENTIFIC INNOVATION (IJRSI)
ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VI June 2025

that the bigger saw kerf is first used to process a low density species which required a bigger kerf. As the kerf width reduces the saw is then used to process a medium density species or a high density species depending on the kerf width. This process saves time because frequent tipping of the saws is prevented. In this paper, the wearing of the saws can be related to the kerf loss. It can be seen in fig. 1 that the kerf loss increases with density or the type of species. Thus the high density species wear the saw faster than medium or low density species. Similar results can be seen in Fig. 2 which shows the relationship between the actual sawing time and the kerf width or the kerf loss during sawing with a swage-set saw. The kerf width decreases with increasing time while the kerf loss increases with increasing time or increasing density

Wearing of Saw Teeth

Continuous grinding results in the wearing of the saw kerf. Growth stresses, defects, mineral streaks and nature of the wood all contribute to the wearing process. Species that have high density wear saw kerf extensively as compared to the low density species. This is because the fibres in high-density species are tougher and well bounded and are not spongy like the low-density species. The saw blade thickness and the kerf width are never the same. The kerf is created to introduce a side clearance between the work piece and the saw blade. Therefore, the kerf should not be reduced to the thickness of the saw blade. Wearing is more pronounced in high-density species no matter the type of saw used. Actually, this is an expected trend, but our interest lies in the rate at which the saws wear when in operation. This is needed to provide saw operators with a guide upon which saw doctoring (sharpening, stellite tipping, re-swaging) will be based.

Wearing trend determined by gradients of an equation

Table 1 shows a summary of the relationship between sawing time t and saw kerf width y_w or kerf loos y_{loss}. The equations presented in Table 1 can be used to predict the kerf losses when sawing with a stellite-tipped saw or swage-set saw. From these equations, the time taken for saws to wear to an undesired kerf width when processing Triplochiton scleroxylon, Khaya ivorensis and Piptadeniastrum africanum can be calculated. The result presented in Table 1 indicate that there is strong correlation between the sawing time and kerf losses.

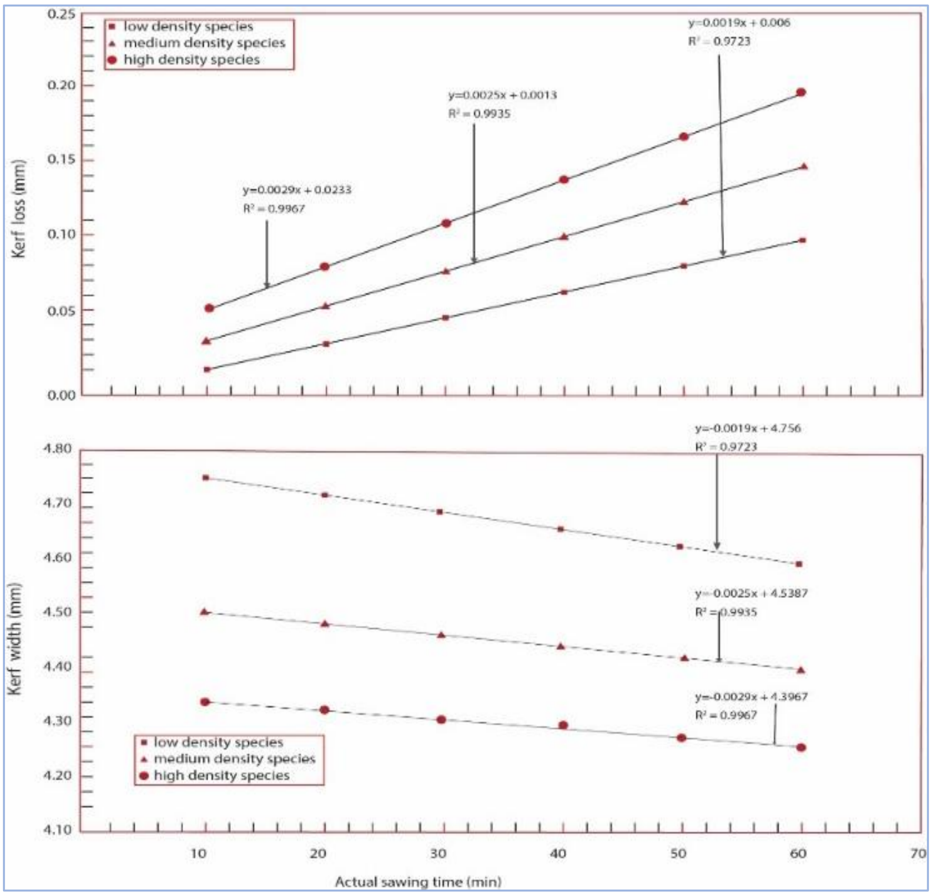

Fig. 1. Relationships between actual sawing time and kerf width or kerf loss during sawing with a stellite-tipped saw.

Modeling of saw replacement time

For efficient wood processing, it is required that saws should be replaced when found to be dulled. Some sawyers are of the opinion that saws should be replaced when they are in service for every 2 hours regardless of the state of the saw. This assertion is not properly supported by literature even though some sawyers adopt it. In this section a model based on the experimental results presented in Table 1 can be formulated to predict that actual time required to replace a saw blade. From the standard deviation of the lumber thickness of boards sampled, as shown Fig. 3 we can determine when a saw becomes dull and needs to be replaced. From Fig. 3, we can see that the minimum standard deviation of boards sampled from low density species is least followed by the medium density species and the high density species in that order. The general trend is that as sawing progresses the standard deviation of the lumber thickness decreases and attains a minimum value of 0.01 mm, 0.032 mm, and 0.046 mm for the low, medium and high density species respectively. Thereafter, there is an increase in standard deviation of the lumber thickness with increasing sawing time.

In a previous report, it was established that too big a side clearance or too small a side clearance could lead to instability in saw blades [11]. The decrease in standard deviation with increasing sawing time suggests that the saw is adjusting itself gradually to the optimum side clearance of kerf width. When the kerf width is too big, there is sawdust spillage between the saw and the cut surface resulting in saw instability. As the kerf width reduces the sawdust spillage reduces and saw stability improves. As sawing progresses, the reduction in kerf width or side clearance with increasing sawing time begins to have adverse effect on the sawing performance of the saw. It was explained in section 3.2 of this report that due to the spongy nature of low density species, bigger side clearance or kerf width is required for saw stability. The increase in lumber thickness standard deviation with increasing sawing time is due to the decrease in saw kerf resulting in friction between the saw and cut surface. The heat generated leads to saw instability.

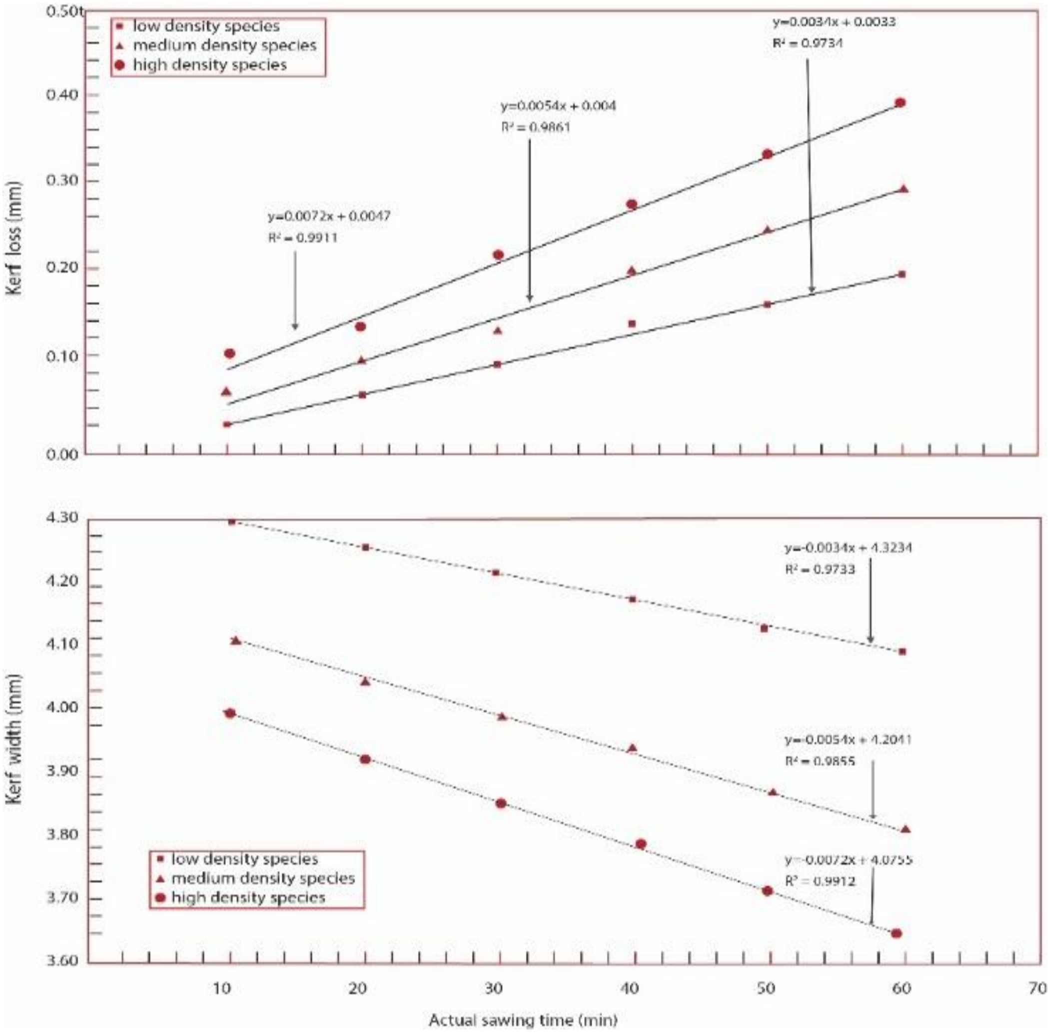

Fig. 2. Relationship between actual sawing time and kerf width or kerf loss during sawing with a swage-set saw.

Another factor that cannot be ruled out completely is saw dullness leading to saw instability. This is the basis of the present study. How can we determine when to replace a saw without necessary examining the cut surface? Figure 3 tells us that when processing the wood species under consideration saw instability begins to occur after sawing for 50 minutes, 40 minutes and 30 minutes for the low density, medium density and high density species respectively. The signal is then sent to the sawyer that saw instability has occurred.

From Fig. 3, when sawing the high density species after arriving at the minimum standard deviation one can saw for additional 25 minutes to achieve the same level of standard deviation at time 10 minutes or the same level of standard deviation will be achieved at the actual sawing time 55 minutes. For medium density species, one has to saw for additional 10 minutes to achieve the same level of standard deviation. It is clear from Fig. 3 that more than 10 minutes is required to achieve the same level of standard deviation for the low density species.

If a time study is conducted in conjunction with the data presented from Fig. 1 to 2, and Table 1, one can determine when to replace the saw. Parameters to consider for the time study include: (i) fixing of saw on the pulley, (ii) carriage movement, that is, time for the return stroke of the carriage, (iii) mechanical stoppages, (iv) machine operator's movement, (v) log handling by the log turner.

Table 1. Relationship between sawing time t and saw kerf width y_w or kerf loss y_{loss}

Stellite-tipped					
species	Density kg/m^3	Equation for kerf width, y_w		Equation for kerf loss, y_{loss}	
T. scleroxylon	360	$y_w = -0.0019t + 4.756$	$R^2 = 0.97$	$y_{loss} = 0.0019t - 0.006$	$R^2 = 0.97$
K. ivorensis	540	$y_w = -0.0025t + 4.539$	$R^2 = 0.99$	$y_{loss} = 0.0025t + 0.001$	$R^2 = 0.99$
P. africanum	690	$y_w = -0.0029t + 4.397$	$R^2 = 0.99$	$y_{loss} = 0.0029t + 0.023$	$R^2 = 0.99$
Swage-set					
species	Density kg/m^3	Equation for kerf width, y_w		Equation for kerf loss, y_{loss}	
T. scleroxylon	360	$y_w = -0.0034t + 4.323$	$R^2 = 0.97$	$y_{loss} = 0.0034t - 0.003$	$R^2 = 0.97$
K. ivorensis	540	$y_w = -0.0054t + 4.204$	$R^2 = 0.99$	$y_{loss} = 0.0054t - 0.004$	$R^2 = 0.99$
P. africanum	690	$y_w = -0.0072t + 4.076$	$R^2 = 0.99$	$y_{loss} = 0.0072t - 0.005$	$R^2 = 0.99$

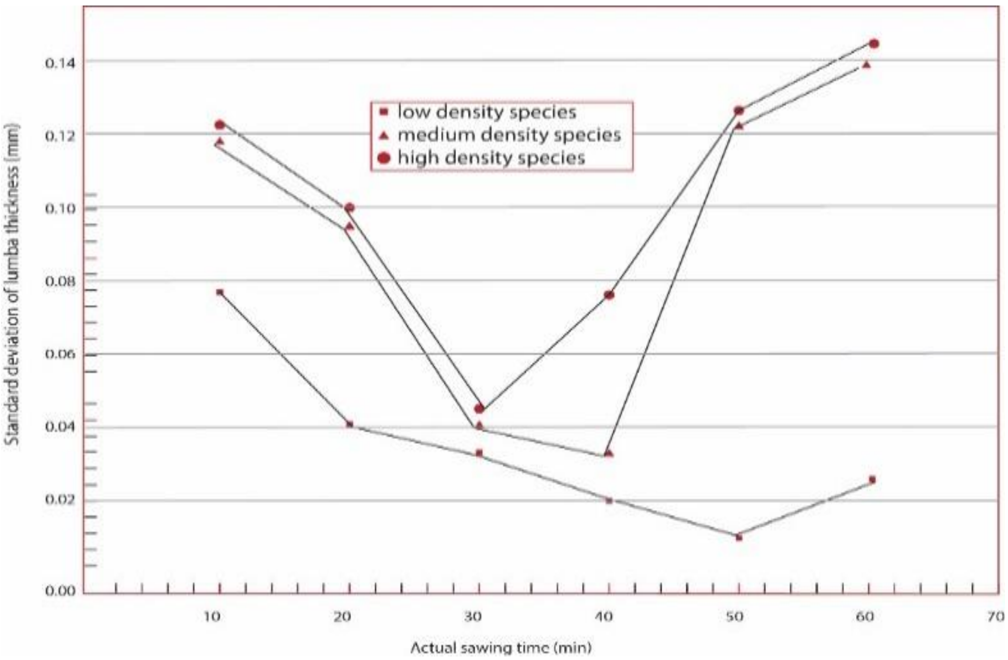

Fig. 3 Relationship between actual sawing time and standard deviation of lumber thickness during sawing with a stellite-tipped saw

CONCLUSIONS

This study was conducted in order to determine the wearing process of stellite-tipped and swage-set saws when they are in operations. Equations are presented showing the relationship between actual sawing time and saw kerf width or kerf losses during sawing. The relationship between actual sawing time and the standard deviation of the lumber thickness is also presented. From this relationship, the optimum kerf width for maximum efficiency can be determined for the three wood species.

ACKNOWLEDGMENT

We acknowledge the support received from LLL Company Limited in executing this study.

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