UNIVERSITI PUTRA MALAYSIA

INCREASING SAWNTIMBER RECOVERY BY TARGET SIZE REDUCTION

LIEW SUNG FATT

Approval Sheet

Name of Candidate : LIEW SUNG FATT

Title of Project : Increasing Sawntimber Recovery By Target Size Reduction.

Approved by:

ISMAIL HASHIM
(Examiner)

DORAISINGAM MANIKAM
(Examiner)

Dr. RAZALI ABDUL KADER
Associate Professor,
Head of Department,
Department of Forest Products,
Faculty of Forestry.
(Coordinator of Programme,
M.S. Wood Industries Technology)

Dr. KAMIS AWANG
Associate Professor,
Dean,
Faculty of Forestry.

Date of Examination: November, 1990

INCREASING SAWNTIMBER RECOVERY

BY TARGET SIZE REDUCTION

BY

LIEW SUNG FATT

This report is submitted in partial fulfilment
of the requirement for the degree of Master of Science
(Wood Industries Technology) in the Faculty of Forestry
Universiti Pertanian Malaysia

November, 1990

ACKNOWLEDGEMENT

The author wishes to express his sincere gratitude and appreciation to his supervisors, Mr. Ismail Hashim and Mr. Doraisingam Manikam for their constructive criticisms, guidance, reading through and providing suggestions for this project.

A record of appreciation also goes to Dr. Razali Abdul Kader and Dr. Kamis Awang for their kind endorsement which enable the author to attain another milestone of education.

The author also wishes to record his special thanks to:

- ASEAN Timber Technology Centre for the Scholarship
- Malaysian Timber Industry Board for giving the previlege of having the Scholarship
- Kim Chin Hoe Sawmill for permission to conduct the project

Last, but not least, the author expresses his most sincere appreciation to his wife for her encouragement throughout the study, and for assisting in the completion of this report.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF SYMBOLS

d_2	-	Central line factor for control charts for the number of measurements per board or the number of boards per subgroup.
D_3, D_4	-	Factors for upper and lower control limits respectively for range-charts for the given number of measurements per board in Rw-charts or the given number of boards per subgroup in Rb-charts.
F	-	Net finished thickness.
LCL	-	Lower control limit of control charts.
n	-	Number of boards per subgroup.
P	-	Planing allowance.
R_B	-	Between-board range in subgroup.
$\bar{R}_B$	-	Overall average of between-board ranges of a series of subgroups.
R_T	-	Total range.
R_w	-	Within-board range.
$\bar{R}_w$	-	Average of within-board ranges in a subgroup.
$\bar{\bar{R}}_w$	-	Overall average of within-board ranges of a series of subgroup.
S_B	-	Estimated standard deviation between-board variation.
Sh	-	Shrinkage allowance.
S_T	-	Sawing variation.
S_W	-	Estimated standard deviation within-board variation.
$\bar{S}_W$	-	Average of within-board variation.
T	-	Target thickness.
UCL	-	Upper control limit.
$\bar{X}$	-	Average thickness of a board.
$\bar{\bar{X}}$	-	Average thickness of boards in a subgroup.
$\bar{\bar{\bar{X}}}$	-	Overall average of board thicknesses for a series of subgroup.
Z	-	Undersize allowance factor.

ABSTRACT

Sawing timber with excessive oversize, undersize or poor sawing accuracy can result in a decreased sawntimber recovery. As timber gets scarcer and more expensive, there is a need for sawmillers to improve sawntimber recovery to enable them to remain in business. Statistical Lumber Size Control (SLSC) has wide recognition as a useful technique in increasing sawntimber recovery. The objectives of this study are; to apply the technique to monitor sawing accuracy and to appraise the economic benefit of Target Size Reduction (TSR). The study was done in three stages. Stage One involved the measurement of 100 boards (25 subgroups of 4 boards per subgroup) to establish the green target size and the existing recovery rate. In Stage Two, $\bar{X}$-R Control Charts were drawn and used to monitor the sawing accuracy. The last stage assessed the net revenue improvement based on the TSR. The result showed that a 2% increase in recovery rate based on the nominal thickness of 7/8" (22.22mm) can increase the estimated net revenue by $293,912.00 for the first year of implementing a SLSC programme in a sawmill. The technique and $\bar{X}$-R Control Charts are effective tools in improving the sawn timber recovery. However, in order to obtain a higher recovery improvement, it is necessary to improve the dimensioning device and the fence setting mechanism at the resaw machine.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

The sawmilling industry in Peninsular Malaysia is at its cross-road. Never before a sawmiller is faced with such a drastic decision as to remain in business or close down. According to a report there were 678 sawmills registered in Peninsula Malaysia in 1984. Out of these total only 595 (87.8%) were in operation (FDPM, 1984). In 1988, only 589 were in operation, i.e. about 13% had closed down within four years (FDPM, 1988).

The shrinkage process of the Malaysian sawmills is typical of what the North American sawmillers had experienced; a transition from the supply of logs which were big, straight and sound to logs which are small, irregularly shaped and with bigger hollows, and to small diameter plantation logs. Simultaneously, irregular supply of log persists. As a result of these, the prices of logs continue to fluctuate with an increasing trend.

According to Lim (1990), raw logs for conversion into export-grade sawntimber can cost as much as 85% to 90% of the total production cost. Besides, there is indication that due to the decreasing supply of good quality logs couple with a general lack of improvement in production method over time, the sawntimber recovery has actually deteriorated. Yap (1990 b) suggested that the average recovery ranges from 48% to 52%. As compared to the late 1970's, the average sawmtimber recovery for most sawmills in Selangor and Federal Territory was found to range from 53% to 61% (Ling, 1981).

The sawmill management system practised by Malaysian sawmillers is somewhat unique. The typical contractual arrangement at headrig, resaw, and saw doctoring where these units work independently of each other within a sawmill has been used since a long time ago. The industrious `gang of four' of a resaw unit is able to produce about 15 m^3 of sawntimber per 8-hr shift. For a typical 4-resaws lay-out sawmill, the annual sawntimber production is about 15,000 m^3 (Schrewe, 1986).

1.2 Statement of Problem

In terms of sawntimber sizes, excessive oversize and undersize are problems commonly faced by Malaysian sawmillers. In separate studies done by Lau (1985), Suria et al. (1986), and Rokhaime et al. (1988) they found that most local sawmillers have been sawing with excessive oversize allowance and poor sawing accuracy. These problems not only resulted in a huge loss of wood fibre in terms of excessive oversized lumber turned into wood shavings, planer waste, sander dust; it also resulted in sawntimber with poor dimensional accuracy which resulted in lower quality sawntimber or rejects due to undersize.

1.3 Justification

It is fast becoming a norm for Malaysian sawmillers that big diameter, good straight and sound logs are getting scarcer and expensive. Gone are the days of cheap and plentiful timber. For most sawmills this evolving situation of forest resources means a decreased productivity and ever-shrinking profit margin. For others, the question is how to remain economically viable and not ceased operation. Recently, many renovative and innovative technologies have emerged to assist those sawmillers who are in the danger of ceasing operation. Among the technologies are: log scanning devices, computer optimised bucking, automated positioning headrig carriages, computer program for optimum breakdown pattern, automatic bandsaw blade monitoring and feed-speed control, optimizing edger/trimmer, optical scanning grader, bar-code lumber inventorying, etc.. It is claimed that these technologies have helped to improve lumber recovery ranging from 3% to 30% (Carino, 1986; Griffin, 1988; Hattori and Shigemasa, 1988; Wang and Giles, 1989). However, these technologies are either capital intensive or technically complicated to operate and require high maintenance cost. Furthermore, not all of these high-tech are appropriate to the local sawmillers.

Therefore, there is a need to adapt and adopt alternative technique which require low capital investment, low technical complexity and easy to maintain yet could also improve sawntimber recovery. One such technique is the Statistical Lumber Size Control (SLSC) technique which also employs control charts to monitor sawing accuracy.

Unfortunately, most local sawmillers pay very little attention to size control, let alone SLSC technique. The usual practice in the sawmills is by occasional spot-checking of thick and thin boards using a ruler. This method is not accurate and does not give sufficient data to trouble-shoot those "assignable factors" which cause size variation and poor sawing accuracy. To-date, there has been no report on the use of SLSC technique in Malaysian sawmills.

SLSC is a useful technique for assessing the performance of a sawing machine centre where dimension accuracy is of great importance. The technique helps to distinguish between correctable factors and chance factors that contribute to sawing variation. Dimensional variation of sawntimber produced from a machine centre when not in control can lead to lost of recovery. When variation is kept to a minimum level, a reduction in target size can result in an increase in sawntimber recovery. UDDEHOLM (undated) reported that a decrease in target size of 0.031" (1/32") could increase lumber yield from 1% to 3%.

Through the use of SLSC to monitor sawntimber sizes, variation in sizes can be spotted more easily, rapidly and precisely. Hence, any faults of the machine and operator can be trouble-shooted more accurately. Usually by simple machine adjustment or "tightening up" the sawmills with minimum or no capital spending an increase in revenue could be accomplished (Whitehead, 1978). In fact, the quality improvement accomplished (in this case quality in terms of sawntimber sizes) is free (Crosby, 1979).

1.4 Objectives

This project is intended as an attempt to apply a Statistical Lumber Size Control technique in a sawmill to improve sawntimber recovery. The objectives of this project are;

(a) to apply Statistical Lumber Size Control (SLSC) technique to monitor sawing accuracy at a resaw;

(b) to appraise the economic benefits of Target Size Reduction (TSR).

It is often said that by borrowing technologies from the developed countries provides advantage to latecomers to a development process. For example, it is widely recognised that the phenomenal achievements in the economic development of Japan have been made possible by the acquisition of technical knowledge from the West and successful adaptation and utilization of it in the domestic scene. Therefore, to adopt and adapt the use of SLSC technique seems very appropriate to the local sawmill industry.

1.5 Scope of Study

There are many factors that can influence sawing accuracy. In general, these factors can be categorised as assignable factors and chance factors. Sawing variation (with-in board and between board) caused by assignable factors such as saw conditions, alignment etc. can be corrected. However, those variation caused by chance factors such as striking a concealed knot are not readily rectifiable. This study focuses only on assignable factors.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Sawmill Improvement Program (SIP)

Serious desire to `tighten up' sawmill operations to get more out of the wood harvested was started in the early 1970's. In 1971, the Forest Product Laboratory (FPL) researchers at Madison, Wisconsin, USA, recognised the potential of improved lumber recovery using the Best Opening Face (BOF) approach. Hallock and Lewis (1971) found that by using BOF can increase lumber yield by up to 100% with 20% to 30% being quite common. Later in July 1973, the Sawmill Improvement Programme (SIP) was launched. Basically, SIP was a cooperative effort between State and Private Forestry Branch of US Department of Agriculture to help the softwood sawmill industry get more lumber out of the timber that was being cut (Yerkes, 1973). It was reported that with help of SIP software programmes, some sawmill operators in the United States were able to convert 70% or more of the log into dressed lumber (Risbrudt and Kaiser, 1982; Suleski, 1985; Carino, 1986; Stewart, 1987).

2.2 Lumber Size Control

Part of the SIP emphasized the element of lumber size control in relation to Lumber Recovery Factor (L.R.F.). Yerkes (1973) reported that an excessive planing allowance of 3/32" (2.381mm) of wood off the 4" x 4" (101.6mm x 101.6mm) lumber can reduce L.R.F. by 0.45 point. An extra of 1/8" (3.175mm) in sawing variation on a 4" x 4" (101.6mm x 101.6mm) lumber worth is 0.6 L.R.F. point. While an excessive oversizing of 5/32" (3.969mm) on 4" x 4" (101.6mm x 101.6mm) lumber can decrease recovery by 0.75 L.R.F. point.

Lumber size control has gained a wide recognition as an effective too in improving the quality and productivity of lumber manufacturing (Hallock, 1978; Williston, 1981; Brown, 1982; Wray, 1988; Higgs, 1989; APFIDG, 1990; UDDEHOLM, undated). According to APFIDG (1990) lumber size control is an already well established example of statistical quality control applied to the sawmill manufacturing process. The purpose of statistical quality control as applied to lumber size control is to gain a realistic understanding of the performance of the saws, machines and operators such that optimum target size is continuously achieved.

2.2.1 **Definition and Scope of Lumber Size Control**

There is no single phrase definition for lumber size control. However, it was broadly catagorised as the goal of minimising the sum of three items; namely kerf loss, sawing variation (standard deviation) and surface roughness (Bennett, 1974). The principle is that lumber is not just a board but a precision machined product. It requires careful control so as to produce lumber with close size tolerances. Lumber size control has the role of controlling the process and by analysis to continuously improve the product (Wray, 1988).

2.2.2 **Approach of Lumber Size Control**

Lumber size control is basically based on statistical process control (SPC) techniques. SPC itself is not new (Owen, 1989), but its usage in sawmill is rather recent (Brown, 1982). In general, there are two approaches to lumber size control; namely manual analysis of dimensional data using manual statistical calculation (Brown, 1982; UDDEHOLM, undated) and computer-based programs. There are a number of computer packages on lumber size control available in the market (Anon, 1988; FPL, 1989; FRI, 1989; COFI, undated).

2.2.2.1 **Manual Calculation**

Warren (1973) showed in detail how to calculate target thickness for green lumber. Since then, most of the manual calculation methods have been based on Warren's approach. For instance, Brown (1979) calculated the within-board thickness variation, between-board thickness variation, and total thickness variation using simple statistical formulas of standard deviation. The mathematics involved is simple, making the calculation more acceptable to sawmill personnel (Brown, 1982).

2.2.2.2 **Computer Approach**

Lumber size control programs in computer software diskettes and manual with step-by-step instruction were made available only recently. Examples of such packages are CETEC Engineering's Recovery I (Anon, 1988); Lumber Product Size Analysis Routine (FPL, 1989); TSIZE Program (FRI, 1989) and SICON Lumber Size

Control Program by COFI (undated).

2.3 Lumber Sizing

It is well documented that the smaller a mill's target size, the greater its product recovery (Higgs, 1989). Besides factors such as mill type and condition, processing decision and log characteristics, product size also affects Lumber Recovery Factor (L.R.F). According to Yerkes (1973) if a mill produces 3/4" (19.05mm) lumber and sells it for 1" (25.4mm) lumber, it is going to have a higher L.R.F. than one that saws 1" (25.4mm) lumber and sells 1" (25.4mm) lumber. The smallest size of lumber that the operator saves is another way that the product size can influence lumber recovery.

2.3.1 Target Size Reduction

Williston (1981) says that the first, and probably the most important, inexpensive opportunity to increase L.R.F. is through target size reduction (TSR). It is known that a decrease in either kerf or target size of 1/32" (0.794mm) will result in an increase in lumber yield of from 1 to 3% depending on the product line being manufactured. One mill, for example, reduced its target size by 2mm overall and gained a 2% increase in recovery (FRI, 1989). However, to achieve target size reduction, adequate control of sawing accuracy and reduction of sawing variation are vital. To achieve this, statistical quality control technique such as control chart has been widely suggested (Whitehead, 1978; Brown, 1979; FPL, 1989; APFIDG, 1990).

2.3.2 Control Charts

Control charts are statistical tools used to analyse and understand process variables, to determine a process's capability to perform with respect to those variables and to monitor the effect of those variables on the difference between customer needs and process performance. According to Chase and Aquilano (1989) there are four main issues to address in creating a control chart; namely the size of the samples, the number of samples, frequency of samples, and the control limits. A search through the literature reveals that there is no generally agreeable way to define each factor in lumber size control. For example, the size of samples varies from as few as one (Bethel et al., 1950) to as many as five (Brice, 1962). On the other hand, FPL's (1989) Lumber Product Size Analysis Routine computer package suggested the sample size of two consecutively pieces. However, there is a common trend of using total samples size of 100 boards in 25 groups of 4 boards per group (Brown, 1979).

Basically, there are two types of control charts, the attribute control charts and variable control charts. Variable charts have wider application in lumber size control. It can be differentiated into $\bar{X}$-R Control Charts, and $\bar{X}$-s Control Charts.

2.3.2.1 $\bar{X}$-R Control Charts

The most commonly suggested control charts for lumber size control is the X-R Control Charts (Bethel et al., 1950; Burnet, 1957; Brice, 1962; Jackson et al., 1965; Whitehead, 1978; Brown, 1979; Peterson, 1979; FPL, 1989; APFIDG, 1990). These charts are generally based on Average ($\bar{X}$), Range-within (R_W), and Range-between (R_B).

In quality control analysis, control charts based on range values are more preferred compared to standard deviation (Duncun, 1974; Gitlow et al., 1989). It is especially so when one uses a small subgroup, usually with a size of less than 10. When the subgroup size exceeds 10, control charts based on standard deviation, i.e. $\bar{X}$-s Control Charts should be used (Besterfield, 1979).

2.3.2.2 $\bar{X}$-s Control Charts

The use of $\bar{X}$-s Control Charts in lumber size control is less extensive compared to $\bar{X}$-R Control Charts. A search through the literature shows that only a few authors suggested its application in lumber size control (Bennett, 1974; FPL, 1989). $\bar{X}$-s charts are quite similar to $\bar{X}$-R charts. Both provide the same sort of information. But, the $\bar{X}$-s charts are used when subgroups consist of 10 or more observations (Gitlow et al., 1989).

2.3.2.3 Interpretation of Control Charts

There are several rules governing the correct approaches to the interpretation and analysis of control chart. For example, Gitlow et al. (1989) suggest that control chart should be analysed from right to left starting with the most recent sample points and working backwards. In general, there are about five rules or trends that can suggest whether if a process is stable and under statistical control (Grant and Leavenworth, 1985; Karatsu and Ikeda, 1987; Messina, 1987; Owen, 1989). However, in lumber size control the interpretation and analysis of control charts only pay attention only to the value lying outside the control limits. UDDEHOLM (undated) suggested that only if the process goes out of control and points occur outside the control limits, then the charts indicating standard deviation or range within or between boards can provide clues as to where the fault can be located.

2.3.3 Sources of Sawing Variation

Sawing variation can be attributed to two sources. Duncun (1974) and Grant and Leavenworth (1985) categorised the sources into assignable causes and chance causes.

2.3.3.1 Assignable Sources

The assignable causes of both within-board and between-board variations in lumber manufacturing has been written elsewhere (Bramhall and McIntyre, 1973; Warren, 1973; Brown, 1979; Williston, 1981; Wray, 1988). Basically, variation within-board means that something is moving while the saw is cutting, while variation between-board means that something is moving or inaccurate in the positioning to cut different boards of that same target size (Wray, 1988).

2.3.3.2 **Chance Sources**

Chance sources which cause variation in lumber manufacturng is seldom documented. According to Grant and Leavenworth (1985) chance variation causes are complex. It is beyond control because the effect of each is slight and it is difficult to trace which part of the total variation is due to a single source. Gitlow *et al*. (1989) say that variations created by chance source lie outside the manufacturing system.

CHAPTER THREE

3.0 METHOD

3.1 Data Collection

3.1.1 Location and Scope

The study was carried out at a sawmill in Klang, Selangor. It was chosen mainly because of the high receptivity of the sawmill management toward this study. The sawmill processes timber species such as Kempas, Meranti(s), Geronggang, Keruing(s), and MLH (Mixed-Light Hardwood) species. However, to facilitate and suit the objectives of the study only Kempas (Koompassia malaccensis) was chosen.

Besides limiting the species of timber, it was necessary to limit the nominal sizes of timber for this study to six common ones [out of a total of 14 nominal sizes cut for Kempas species] (Appendix 1). Only the most common nominal sizes i.e. 7/8" and larger were chosen because other nominal sizes of sawntimber can not ensure adequate total sample size of 100 boards for each nominal size. Besides, it is necessary to limit the nominal size to ensure a more reliable recovery results for comparison purposes.

3.1.2 Stages of Study

The three stages of study carried out is as shown in Figure