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ITTO Project PD 700/13 Rev.2 (I)

Development of Intra-African Trade and Further Processing in Tropical Timber and Timber Products (Phase I Stage I)

A Report on the Implementation of Activity 6.1

"IN-HOUSE TRAINING MATERIALS ON FURTHER PROCESSING
(natural forest timbers and plantation timbers)"

Prepared for the Project
by

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Executed by the International Tropical Timber Organization
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Foreword

The African ITTO producers, with a total forest area of around 252 million hectares or 40 percent of Africa's total forest area in 2005, are the mainstay of logs supply in Africa. Notwithstanding the great logs supply capacity, it is widely acknowledged that further timber processing in the form of secondary and tertiary processing such as the manufacture of molding, flooring, furniture and joinery, the stages that generate most added value to timbers and forests, is only at an embryonic stage in most African ITTO member countries. In fact, many countries do not yet have a well-developed sawnwood primary processing sector, which is the starting point for further processing.

One of the primary reasons for the underdeveloped timber processing is the lack of competent managers, supervisors and operators which has resulted in low efficiency of processing and inferior quality of processed products, two of the most important determinants of competitiveness of the timber industries. Realizing the need to promote capacity in timber processing at different stages, in view of generating larger value added and enhancing competitiveness, the governments and timber industries in ITTO member countries have been for years striving to implement training programs on timber processing with the assistance of ITTO. One of the ITTO assisted projects that deals with such training is PD 700/13 Rev.2 (I) "Development of Intra-African Trade and Further Processing in Tropical Timber and Timber Products" currently under implementation in Cote d'Ivoire, Democratic Republic of Congo and Cameroon.

The training approach that has been piloted by ITTO for capacity building in its member countries is the so called "in-house or in-factory training". The approach, first introduced in Indonesia under ITTO Project PD 286/04 Rev.1 (I) and has since been implemented in eight ITTO member countries, had received strong positive responses from training participants due to the advantages it offers over the conventional training model. The in-house training is a problem solving approach and mill specific in nature; its scope is flexible, based on actual needs to solve managerial and technical problems encountered at the mill hosting the training. One of planned activities of Project PD 700/13 Rev.2 (I) is to undertake in-house training on timber processing involving three member countries hosting the project.

This document presents some materials on timber processing that have been obtained from different sources including the experience and lessons learned from the implementation of in-house training in eight countries across three regions. The main purpose of compiling the materials is to promote understanding on selected themes of timber processing and facilitate discussion between trainers and trainees. Noting that timber processing involves a myriad of procedures and techniques, the materials presented in this document may be less satisfying. In addition, as scope of training varies between host mills in accordance with the problems actually encountered, the materials presented in this document may only partially match the scope of training actually covered at individual mills. Despite its limitations, the document is surely a meaningful contribution to strengthening implementation of in-house training on timber processing in ITTO member countries.

Executive Director

International Tropical Timber Organization

Acknowledgement

I wish to express my sincere appreciation to Mr. Emmanuel Zemeka, Executive Director of the International Tropical Timber Organization, for granting me the opportunity to take part in the implementation of Project PD 700/13 Rev. 2 (I) "Development of Intra-African Trade and Further Processing in Tropical Timber and Timber Products (Phase I Stage 1). The specific task given to me, to compile available training materials on further processing, was truly challenging given the myriad procedures and techniques applicable to timber processing. Selecting the right themes and information to be included in the document within the sanctioned inputs to the task required deep thought and serious contemplation as well.

I also wish to take this opportunity to convey my sincere thanks to Dr. Steven Johnson, Assistant Director of ITTO and Dr. Tetra Yanuariadi, ITTO Projects Manager, both from the Division of Trade and Industry, for making the necessary administrative arrangements that has facilitated the timely and effective completion of the task and to Dr. Hiras Sidabutar for his continued and untiring assistance in the material compilation and textual editing processes.

Best regards,

Sukiman_____
The Consultant

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1. Background Information

1.1. Forest resources of Africa

The forest cover of Africa in 2005 was estimated at 634 million hectares, accounting for 16.1% of the world forest area, distributed unevenly among different sub-regions and countries; Central Africa and Southern Africa accounted for 37% and 27%, respectively, of the total forest area in 2005. The ITTO producers are the mainstay of raw wood material supply in Africa; the estimated forest cover for ITTO producers in 2005 was 252 million hectares, accounting for 40% of total forest area in Africa (Favada, 2009).

Indeed, forests of the ITTO producing countries vary between the countries in terms of area size, forest types and growing stock. For examples, the extent of Cameroon's forest area was estimated at 19.7-27.2 million hectares in 2010 and are rich with *Entandrophragma cylindricum (sapelli)* and *E. utile (sipo)*; the forests of Democratic Republic of the Congo covered an area of around 112 million hectares with *Guibourtia demeusei, E. palustre, Garcinia spp., Grewia spp., Carissa edulis* and *Euphorbia spp*. as the dominant species; while Gabon's forests with an estimated total area of around 21.7 million hectares are rich with *Aucoumea klaineana (azobie), Terminalia superba (limba)* and *Millettia laurentii (wenge)* (ITTO, 2010). These forests, if efficiently and sustainably managed, could provide significant social, economic and environmental benefits to the countries.

1.2. Current status of forest resource utilization

As to date, the African timber industry is mainly characterized by primary processing: sawnwood, peeling and slicing for the production of plywood and veneer and most countries do not yet have a well-developed sawnwood primary processing sector which is the starting point for upstream processing. Most sawmills are supplied mainly with poorer quality logs with a low efficiency rate, which itself is justified by the poor quality of equipment and insufficient skills of machine operators; many timber companies have established sawmills solely to comply with regulations, with no obligation to be cost effective, in the knowledge that greater profit margins can be obtained by exporting logs (ITTO, 2010).

A review of national forest industries shows that status and levels of development vary greatly by country: from those countries with a more established industry such as Ghana and Cote d'Ivoire to those of the Congo Basin countries where timber industries are most recent, except Cameroon where sawnwood production has expanded greatly in recent years and has contributed to the beginnings of secondary and tertiary processing.

Further timber processing in the form of secondary and tertiary processing such as the manufacture of moldings, flooring, furniture and joinery, the stages that generate most added value to timber and the forests, is only at an embryonic stage in most African countries. Prerequisites to promoting further timber processing include sufficiency and continuity of logs; skillful managers, operators and laborers; capital investment for provision of appropriate technologies, and; favorable business environment which is heavily influenced by government policies.

Training of personnel is essential to timber industrial development and should be a priority. However, most African countries have not performed adequate training programs that skillful personnel are scarce to support an efficient wood processing at all stages of process.

2. Proposed Training Approach and Method

2.1. The approach

Most forest rich African countries have established training centers and developed training programs on wood processing yet have proved not able to produce sufficient number of skillful managers, operators and laborers to support promotion of an efficient wood processing. Most training is provided by the industries themselves but limited only to introductory skills on machine operation (ITTO, 2010). Certainly, training on wood processing must cover the entire value adding chains, from breakdown sawing to resawing, to kiln drying, planing and packaging.

The training approach proposed here is in-house or in-factory training format which was initially introduced in Indonesia under the ITTO Project PD 286/04 Rev.1 (I) and had been replicated in eight ITTO member countries including Papua New Guinea, Guyana, Myanmar, Malaysia, Cameroon, Ghana, Guatemala and Mexico. The salient features of the in-house training include:

- The training is organized and implemented under the partnership of ITTO, the governments and forest industries thus it is a sustainable training mode
- It can accommodate a large number of trainees comprising in-house employees of different levels
- It is a capacity building program that focuses on problem detection, trouble shooting and discussion at the mill floor
- Low training cost per employee and highly secured business confidentiality
- In general, the in-house training method appears more effective than the conventional training method as shown in Table 1.

Table 1: In-house training vs conventional training methods

No	Elements	In-house training	Conventional training
1.	Site of training	Host mill	Class room and mill(s)
2.	Origin of participants	Host mill only	Many mills
3.	Number of participants	Flexible, large	Fixed, limited
4.	Educational and occupation background	Flexible	Comparable
5.	Subjects	Flexible, need-based	Fixed
6.	Unit cost of training	Low	Higher
7.	Business confidentiality	Secured	Less secured
8.	Field arrangements	Simple	Less simple

2.2. The methods applied

The training at each of the host mills in individual ITTO member countries will be organized in the following manner:

i. A short meeting between the trainer(s) and mill owner(s), executive(s), manager(s) as well as operator(s) will be held to discuss on scope, purpose as well as expected outcomes of the training and training processes.
ii. After the short meeting, a quick visit to stock piles of end products will be made in order to get a general impression on conduct of processing; appearance of end products provides clues on general level of processing efficiency.
iii. A swift visit will also be paid to wood waste piles; quality and characteristics of wood wastes, e.g. dimension, performances, etc. provide good hints for tracing back those process chains responsible for generating the wastes.
iv. After obtaining clues from performance of the end products and appearance of the wood wastes, the trainers and trainees together will pay visits to the product chains suspected as the origin of defects or source of irregularities in processing. Any suspected process chains will then be carefully examined, their technical problems identified and repairing actions demonstrated.

v. At each of the products chain examined, discussion will be held with the respective manager(s), operator(s) and worker(s) as regards causes of each problem, as well as its adverse impact on efficiency and quality if it remains unrepaired. To facilitate fruitful discussion at a later stage, any irregularities encountered at any process chains will be documented on camera pictures.
vi. Field observation will not be limited to the suspected process chains. Subject to time availability, other chains will also be observed in random or on purpose or at the request of trainees. At any chain, the trainer and trainees will visually examine appearance of the flowing products produced by that chain, indicate any irregularity of process, identify their sources and demonstrate needed overcoming actions.
vii. After finishing observation of the process chains, as needed and as necessary, a typical closing meeting will be held to discuss with all participants on findings, problems encountered, as well as causes and business consequences of the problems. To help clarify the problems discussed at this meeting, the trainer will show, as appropriate, the pictures of irregularities taken at the visited process chains and compare them to the desired ones that are free of technical irregularity. During this final meeting, the trainer also will provide the participants with relevant information on needed resources for troubleshooting in terms of source, price, and technical specifications. In addition, as time permits, the trainer will also demonstrate the intimate link between processing efficiency, product quality, competitiveness and business survival.

Above methods are expected to contribute to increasing awareness and understanding of forest industry owners, executives and managers as well as government training and research institutions on the importance of maintaining wood processing efficiency, improving knowledge, skill and mentality of forest industry operators and validating applicability of the in-house training model for enhancing competitiveness of wood industries in the tropical regions.

3. Training Materials

3.1. Introduction

The in-house/in-factory training mode is site or mill specific, designed as a problem solving approach. As the problems encountered may vary between individual mills, so is coverage of the training. For examples, mill A may face problems on plywood production techniques but is doing fine with kiln drying; consequently, the training will exclude kiln drying from its work program. In contrast, mill B may not have problems on sawing techniques but on kiln drying techniques; accordingly, the training will include kiln drying techniques in its agenda.

A woodworking industry employs considerable number of processing techniques. This document does not attempt to provide information on all those techniques. Instead, the information presented here concerns only with major elements of wood processing, especially in the primary and secondary stages. The main purposes are to provide background information on major elements of wood processing in order to facilitate a two-way discussion between training participants and the trainer.

The training materials presented in the sections that follow include: log handling at logyards, breakdown sawing and resawing, several elements of plywood making, kiln drying techniques, selected elements of further processing, major elements of sawdoctoring and mill management.

3.2. Log handling at logyards

Logs raw material for processing mills are temporarily harbored at logyards; duration of this harboring depends upon the speed of incoming supply and the rate of consumption by the mill which may take weeks or months. Many mills do not adequately treat the logs during their stay at the logyards and have resulted in direct and indirect loss to owning mills. The most common weaknesses in logs treatment at logyards include:

- Logs are piled directly in contact with earth causing the logs become dirty and more easily deteriorating
- Logs are stacked without cover or shading, resulting in cracks and splits
- Cracked logs are not attended using S-hook, causing the cracks freely propagating
- Lack of fumigation to prevent pest and disease from attacking
- Improper log trimming in terms of angle and length of cut has resulted in unnecessary wood waste


(1)


(2)

Photos 1-2 (by Kim): logs piled directly on earth (1), unattended cracked log (2)

The above listed weaknesses can directly decrease logs quality and increase wood waste while indirectly, they may shorten life time of saw blades if dirty logs are not cleaned before sawing and increase unit cost of production due to increased waste and damaged tools. Therefore, the weaknesses have to be removed to the extent possible through application of appropriate simple techniques as follows:

- Pile logs at distance with earth by stacking the logs on top of durable stickers
- Cover logs with canvas and water spray frequently to minimize cracking
- Use plastic S-hook to prevent crack propagation
- Fumigate the logs using environmental friendly substance to minimize damages by pest and disease
- Clean the logs from dirt and bark before sawing
- Trim the logs in a full upgright angle at desired length

3.3. Sawmill

3.3.1. Common defects of sawnwood

Defects of sawnwood are mostly caused by improper setting of machines, inappropriate sawing technique, use of unsuitable tool and device, and weak human capacity. The most common defects include:

i. Snapping in planing process or bends on the panel caused by imbalanced feeding pressure and speed, improper position of cylinder roller, the panel being forcibly or intermittently put into the machine
ii. Press-mark on planed panel due to a too strong pressure imposed on the iron roller
iii. Cutter mark on panel caused by imbalanced feeding speed and machine speed or by fewer number of knife blades than required
iv. Fuzzy defects due to less sharp knives, incomplete cutting during cross-cutting or ripping process
v. Burned mark occurs when knives are sandwiched between two panels during the cross-cutting or ripping process

vi. Discoloration of kiln-dried materials due to inappropriate drying process or improper treatment of lumber, e.g. a too high moisture content
vii. Uneven thickness of a panel caused by improper machine setting at different process chains
viii. Snake-like defect in finger jointing or laminating process due to incompatible tongue and groove
ix. Air bubble or dusty air in painting/coating process caused by the presence of oil spots on the panel or too high moisture content
x. Sanding-mark in sanding process due to uneven pressure or the panel not evenly in contact with sanding paper


(3)


(4)

Photos 3-4 (by Kim): sanding marks caused by dirty sand paper

Any defect degrades quality and so is its selling price. A defective product may be repaired at costs: reduced wood recovery and increased production cost. Obviously, any defect is a loss to the firm thus must be prevented from occurring.


(5)


(6)

Photos 5-6 (by Kim): press mark (5) and snapping (6)

3.3.2. Log carriage

The most common weaknesses observed in many mills in different countries and regions include:

- Carriage wheels are not equipped with saw dust scraper thereby hinder smooth movement of the carrier and reduce sawing precision
- Carriage rails are not built on a strong foundation, dirty and not entirely level causing the carrier moves unsteadily which in turns adversely affect sawing quality
- Log-skid bed is not positioned at the right angle to the knee while fork head is not perpendicular to the band saw giving rise to undesired angled sawing
- Log carriage is seldom equipped with mirror to help the operator observe the position of a log to saw while use of laser ray to guide sawing is not common



(7) (8) (9)

Photos 7-9 (by Kim): damaged rail (7), wheel without scraper (8), unattended log carriage (9)

The above mentioned weaknesses have to be removed to the extent possible if an efficient sawing operation is to be realized. The trainer and trainees will, together, identify the weaknesses and discuss on how they affect efficiency and quality of sawing operation. Technically, removal of the weaknesses is not difficult to do. The trainer will elucidate and demonstrate on the appropriate problem solving techniques.

3.3.3. Breakdown and phony sawing

These tasks can be accomplished using either band saw or circular saw depending on the dimension of stock to saw and availability of machine. When a band saw is used, the most common weaknesses observed during the previous training sessions are:

- Weak, unsteady foundation of machine which causes the machine to shake and vibrate, resulting in defective sawnwood
- Improper greasing of bearing in terms of frequency of greasing and quality of grease causing disturbance on the rotation wheels and in turn irregular dimension of sawnwood
- Inappropriate use of coolant causing the band saw over heating
- Improper setting of band saw rendering sawing operation inefficient and the sawnwood produced defective

Above mentioned problems have to be resolved by employing appropriate problem solving techniques to be elucidated and demonstrated by the trainer on the following line:

- Band saw machine must be installed on a solid foundation, strong and steady construction to avoid shaking and vibrating of the machine while in operation
- The bearing system must be regularly greased using the right quality of grease that can bear temperature up to 280^{o}C or above
- For band saw cooling, use a mixture of water and detergent in proportion of 5 liters and 5 grams, respectively, if the band saw is used to saw hardwood species; use mixture of water (20 liters), solar (0.25 liter) and detergent (5 grams) for sawing softwood species
- It is important to install bandsaw blades carefully and keep them in adjustment if the full life of the blade is to be secured. More importantly, properly installed band saw blade ensures sawing precision and quality. The steps for mounting band saw blades are (Wagner, 1978):
  - ✓ Disconnect the electrical power and open the wheel guard doors
  - ✓ As necessary, pull the table alignment pin and remove the throat plate
  - ✓ Loosen the upper and lower guide assemblies and push them back out of line with the wheels
  - ✓ Uncoil the blade and place it on the wheels with the teeth to the front and pointing down over the blade
  - ✓ Raise the top wheel to apply tension (most machines have a scale to show the correct tension for various blade widths)

- ✓ Roll the machine by hand and adjust the top wheel with the tilting mechanism until the blade tracks smoothly near the center of the tires
- ✓ Move the saw guides forward until the front edges of the jaws are even or slightly back of the tooth gullets; the blade should move evenly between them with about 0.25 inch clearance on each side. Lock the guide assemblies in position
- ✓ Move the blade support wheel forwards on each guide assembly until it is 1/64 in. away from the back edge of the blade; lock them in place
- ✓ Again, roll the machine by hand and check all adjustments and clearances; replace the throat plate and pin and close the wheel guard doors
- ✓ Connect the power, turn on the machine and sawing work is now ready to start


(10)

(11)

Photos 10-11 (by ISWA): bandsaw not perpendicular to stopper and fork (10), bandsaw not perpendicular to sawing table (11)

In using band saws for sawing, safety of the operators and workers must be secured. The following safety need to be observed (Wagner, 1978):

- Wheel guard doors must be closed and the blade properly adjusted before turning on the machine
- Adjust the upper guide assembly so it is ¼ inch above the work
- Allow the saw to reach full speed before starting to feed the work
- The stock must be held flat on the table, round stock must be mounted securely in a steel jaw
- Feed the saw only as fast as the teeth will remove the wood easily


(12)


(13)

Photos 12-13 (by ISWA): use of damaged scraper (12), unleveled saw table roller (13)

- Maintain a 2 in. margin safety, meaning that the hands should always be at least two inches away from the blade when the saw is running
- Plan saw cuts to avoid backing out of curves

- Stop the machine before backing out of a long curved cut
- Turn off the machine at once if a clicking noise occurs
- Turn off the machine as soon as the work is finished

3.3.4. Resawing

Stock can be resawed on the band saw to produce two or more thinner pieces. A simple guide should be used to control the thickness and help hold the stock on edge. Use a sharp blade at least ½ inch wide. Band saw blades are thinner than circular saw blades and thus reduce the amount of waste in a resawing operation. On wide boards however, it is often helpful to first make circular saw cuts in from each edge and then finish the operation on the band saw. Band saws can be equipped with a resawing fixture or attachment, consisting of a special fence and pressure rolls that guide and hold the work so that accurate cuts can be produced.

Resawing can also be accomplished using a circular saw where a stock is cut on edge into two thinner pieces. If the width of the stock does not exceed the maximum height that the blade can be raised, the operation can be completed in one cut. For wider boards, set the saw to cut a little above the center line and make two cuts. Keep the same face of the stock against the fence for both cuts. Use of a feather board increases the accuracy and safety of resawing operation; wide boards can first be cut on the table saw and then the center section cut apart on the band saw.

As described above, resawing can be done using either a band saw, a circular saw or combination, depending upon the size of the stock to saw and availability of machine. In essence, resawing consists of two types of operations: ripping and cross-cutting. The former operation is designed to cut along the length of the grain or with the grain, as used in cutting boards to width while the latter operation involves cutting across the grain of the wood or at an angle to the grain.

(14)
Photo 14 (by Kim): un-squared cut due to
improper positioning of sawblade, table and stopper

3.3.5. Cutting plywood

Special attention must be given to cross-cutting plywood because the pieces are usually wider and there is a tendency for fine hardwood veneers to splinter along the surface. Ripping usually creates no extra problems. For a fine finish, use a special plywood or hollow ground blade.

Since plywood has a finished (sanded) surface and is expensive, especially in hardwood, it must be cut out carefully. Since cutting will almost be to finished size, it is a good practice to use a double line layout. The width of the cutting space will vary with the kind of plywood, type of saw and the method that will be used to smooth the edge. Using a 10 point or finer cross-cut saw is recommended. Work carefully and try to avoid excessive splintering on the underside; always be sure that the panel is well supported and try to prevent any damage to the surface.

The combination blade may work better if it is raised higher than ¼ in. above the surface of the stock. Larger pieces of plywood are difficult to handle on the table saw; for these cuts, a handsaw or a portable circular saw or sabre saw should be used.

The portable sabre saw is a good tool to use for cutting plywood. It cuts on the up-stroke and this will tend to splinter the top surface.

3.3.6. Common problems on sawmilling

The most commonly found problems in sawmilling that cause different defects of sawnwood as listed in the previous section include:

- Shaky foundation of sawing machines
- Improper setting of machines, notably breakdown saw
- Inadequate setting of log carriage
- Lack of maintenance of machines
- Inappropriate cooling treatment for saw blades
- Malfunctioned sawdust scrapers
- Employment of inexperienced operators


(15)


(16)

Photos 15-16 (by ISWA): use of unsuitable type of grease

The trainer should attempt to elucidate the cause-effect of the problems and demonstrate appropriate procedures and techniques for overcoming or avoiding the problems.


(17)


(18)

Photos 17-18 (by ISWA): improper cooling of bandsaw (17), use of damaged gauge (18)

3.4. Kiln-drying

3.4.1. Purposes of wood drying (Hiziroglu, …)

- Wood is a hygroscopic material which gains moisture content as a result of changes in humidity; hygroscopicity is one of the most distinctive properties of wood
- Because the dimensions wood products change with fluctuation in relative humidity, kiln drying becomes one of the most important processes for the efficient use of wood products; proper machining, gluing and finishing of wood are not possible until moisture content is reduced to an appropriate amount
- Other advantages of drying include weight reduction, increased strength properties and more resistance to biological deterioration due to fungi and insects
- Therefore, lumber should be dried before use for any applications in further manufacturing. The kiln process involves the drying of wood in a chamber where air circulation, relative humidity and temperature can be controlled that the moisture content of wood can be reduced to a target point without having any drying defects.

3.4.2. Different drying methods (Nyle Systems, 2012)

i. Air drying
   - Refers to drying that takes place using the natural wind and sun; lumber is stacked on stickers and placed in a manner that allows the prevailing winds to blow through the pile and dry it.
   - Strictly dependent upon weather, which can dry lumber too fast and cause checks and damage, or dry it too slowly, which is expensive.
   - For lumber that is to be used in making finished products that requires a 6 to 8% moisture content, air drying itself can not do the whole job.
   - It is often used as a first step, with the lumber being placed in a kiln for final drying.
   - It poses real problems with damage and degrade; it is often the most expensive way to dry once interest on the money tied up, labor, land cost and degrade loss are included.

ii. Shed drying
   - Lumber is put under a roof or shed to protect it from rain and direct sun that can severely damage wood while air drying.
   - It does not allow much control over factors like humidity, air flow and temperatures.
   - Drying quality is somewhat better than air drying but it extends drying time.

iii. Forced air drying or fan/shed drying
   - It is similar to air drying except fans are used to force air through the lumber rather than relying upon the natural wind.
   - It is faster than air drying or shed drying but the cost of operating the fans is quite high and capital investment is fairly high in proportion to the amount of drying that can be accomplished.

iv. Pre-drying
   - Is used to remove most of the free water from lumber before it is placed in a kiln for final drying.
   - Lumber is stacked in a building where heat and humidity are controlled; the temperature is usually kept around 90^o-100^oF (35^oC) to reach a moisture content of 20-30%, and then placed in a kiln for final drying.
   - It is more costly to run than dry kilns thus usually used only in combination with old, inefficient dry kiln.

v. Kiln drying
This is elaborated in the section to follow.

3.4.3. Types of kiln

The most commonly used kilns are (Nyle Systems, 2012):

i. Conventional kiln
   - uses steam flow into the kiln through pipes and radiates heat into the kiln's atmosphere
   - water content of the wood is converted into vapor by evaporation and discharged from the kiln with the hot air
   - requires large amount of energy thus neither economical nor efficient compared to dehumidification kilns

ii. Dehumidification kiln
   - today, is among the most commonly used kiln type in the wood products industry
   - uses continuous recycling of heat within the kiln rather than the discharging of heat from the kiln as in the case of conventional kilns
   - the majority of water is condensed on the coils of the dehumidifier and removed as liquid rather than being ventilated to the outside of the kiln
   - the air dehumidification kiln reaches a temperature of 95 to 100^{o}F; the hot, moist air is then cooled by passing over cold refrigeration coils; the evaporated moisture condenses into liquid form and is drained as cool water.

The least commonly used kiln type is vacuum kiln as it is 3 to 4 times more expensive than either the conventional or dehumidification kilns because of limited drying capacity in the chamber. However, the main advantage of this system is a very high drying speed.

3.4.4. Kiln scheduling (Hiziroglu, …)

- A kiln schedule is used to determine the temperature and relative humidity needed in the kiln to dry specific wood product at a satisfactory rate without causing objectionable drying defects.
- a typical kiln schedule is a series of temperatures and relative humidities which are applied at various stages of drying as shown in Table 2.

Table 2. Typical drying schedule

Step	MC (%)	Dry bulb (^{o}F)	Wet bulb (^{o}F)	EMC (%)	Relative Humidity (%)
1	Above 50	110	107	19.1	90
2	50-40	110	106	17.6	87
3	40-35	110	104	15.2	81
4	35-30	110	100	12.0	70
5	30-25	120	95	6.5	40
6	25-20	130	90	4.0	22
7	20-15	140	90	2.9	15
8	15 to target	160	110	3.4	21
Equalize and condition as necessary Notes: MC = Moisture Content; EMC = Equilibrium MC					

- in general, the schedule should be developed so that drying stresses do not exceed the strength of the wood at any given temperature and moisture content; schedules vary by species, thickness, grade and intended final use of the material

- a typical hardwood kiln schedule might begin at 110 to 120°F and 70 to 80 percent relative humidity when lumber is green; temperatures might reach up to 170 to 180°F by the time lumber has a moisture content of 10 to 15 percent
- development stages of drying stresses in the kiln shall be elucidated by the trainer which are:

Stage 1: wet lumber having high moisture on the outer and inner portions is stress free; as soon as it dries, the outer portion will go below the fiber saturation point (fsp) which 28 to 30 percent moisture content, before the inner portions reach fsp.

Stage 2:
- As the atmosphere in the kiln is heated and dried, drying occurs faster on the outside and the outer fibers tend to shrink. The interior core of the lumber will be at a moisture content of fsp and will prevent the exterior shell form shrinking. The result will be the development of tensile stresses on the outside and compression stresses on the inside of the lumber.
- If the maximum tension stress is exceeded at the outer fiber, drying defect called "surface check" occurs. If this defect is not handled properly, stress development in the lumber can be severe and lead to "collapse" (internal buckling), a significant drying defect.

Stage 3:
- As drying progresses, the center of the board will lose enough moisture to pass bellow the fsp. As this occurs, it will tend to shrink, but the outer fibers now have a tension set different from the earlier stage of the drying process and will prevent some of the interior shrinking.
- When this happens, the inner portion will become stressed in tension and the outer portion will have compression stress built up; this is called *casehardening* which occurs when the surface layers of the lumber are stretched larger than they should be. Casehardened material will exhibit severe cupping tendencies.


(19)


(20)

Photos 19-20 (by Kim): leaking steam pipe (19) and chamber door (20)

3.4.5. Common problem on kiln-drying

The visit paid to wood processing mills in nine ITTO member countries indicated that the problems as listed below are commonly found in kiln drying process:

- Inappropriate design of chambers raises energy use
- Use of rectangular-shaped chambers does not facilitate a smooth and efficient air flow
- Rough and damaged wall and floor of chambers obstruct air flow
- Heat leaking through chamber door
- Lack of temperature censor calibration
- Improper stacking of timbers inside the chambers
- Inadequate scheduling causes timber defects

The trainer should pay extra attention to above mentioned problems. As applicable and as needed, individual problems should be made clear through discussion and, to the extent possible, demonstration of trouble shooting techniques.



(21) (22) (23)

Photos 21-23 (by Kim): improper stacking of timber inside the chambers

3.5. Plymill

3.5.1. Introduction

- Plywood is constructed by gluing together a number of layers (plies) of wood with the grain direction turned at right angles in each successive layer. An odd number (3, 5, 7, …) of plies are used so that they will be balanced on either side of a center core and so that the grain of the outside layers will run in the same direction
- The outer plies are called faces or face and back; the next layers under these are called cross bands and the other inside layer(s) are called the core. A thin plywood panel made of three layers will consist of just faces and a core
- Quality of a plywood panel depends on the quality of the face veneers and glues while quality of the veneers is strongly influenced by the quality of logs and peeling process

3.5.2. Debarking and logs piling

- Many logs entering the peeling machine are not bark free due mainly to damaged or dull debarker and weak control. As bark makes knives dull faster, it must be completely removed from the logs before entering the peeling machine
- Logs are unusually stacked in direct contact with earth that soil and sands are sticked to many logs. As the dirts may damage the peeling knives, logs must not be piled in direct contact with earth but on top of solid stickers or concrete

3.5.3. Boiling

For high density fancy wood, wood slices, instead of veneers, are produced using slicing machine. To ease slicing, logs or log squares are boiled in a pond. The common weaknesses encountered in the boiling process include:

- Hot water inside the boiling pond is not timely replaced that the water has become too dirty and oily. Boiling logs in dirty and oily water may damage the natural color of wood and prolong boiling time
- The boiling pond is left open air or uncovered and makes the water temperature going down faster
- Many logs are not completely submerged in the water, causing uneven hardness of logs

To ensure that the boiling process could effectively soften the wood, above weaknesses need to be overcome in the following fashion:

- Replace the hot water frequently to avoid sticky water that would prolong boiling time
- Cover the pond with canvas or other material to retain water temperature longer
- Ensure that all logs are completely submerged in the water by using a sinking load

3.5.4. Veneering

Veneering is a process of producing very thin sheets of wood (veneers) by peeling logs using rotary machine. The visits made to the mills in nine ITTO member countries revealed that the following weaknesses are common to many mills:

- Chuck is not placed right at the center that logs do not rotate in a smooth manner causing uneven thickness of veneers
- Incorrect angle of peeling knives
- Improper pressing angle of nosebar
- Speed of peeling machine does not match the density of wood to peel
- Large diameter of peeling residual

The trainer will discuss and elucidate the weaknesses and demonstrate the appropriate techniques for veneering, including:

- How and where to place the chuck
- Why the right angles of knives and nosebar are 89-92^{o} and 20^{o}, respectively
- How to determine peeling machine speed based on wood density
- How to minimize peeling residual


(24)


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(26)

Photos 24-26 (by Kim): use of old-fashioned rotary machine (24), torn veneers due to dull or damaged knives (25), or unmatched speeds of peeling and rolling (26)

3.5.5. Slicing

The previous in-house training indicated that the following problems are common in wood slicing:

- Use of old-fashioned slicing machine
- Inappropriate setting of knife to machine body which produces unequal size and uneven thickness of the slices produced
- Use of dull or damaged knives results in fuzzy slices and irregular dimension
- The pressure applied does not suit wood density

The trainer will discuss on the problems, provide information on recent slicing technology, demonstrate how to properly set knife on machine body, explain the reasons for not using dull or damaged knives and show the way to match pressure with wood density

3.5.6. Veneer drying

The common problems on veneer drying are: uneven temperature, inaccurate gauge of moisture content and dry bearing roller. The trainer will discuss on the overcoming techniques which include: i) the right temperature for veneer drying is between 60 to 80^{o}C depending on wood species, moisture content and thickness of veneers; ii) the need to regularly calibrate moisture content censor or gauge and to grease bearing roller periodically using high temperature grease type.

3.5.7. Veneer pressing

The trainer will discuss on problems relating to veneer pressing and explain or demonstrate the appropriate techniques for removing the problems, which include setting on the right pressing time, i.e. 60 to 90 seconds depending on wood density and thickness of veneers, pressure level, i.e. 10 kg/cm2 and temperature at 100-130^{o}C for UF/MF/RF and 130-170^{o}C for PF glue types, respectively.

3.6. Further processing

3.6.1. Planing

a. Planing machines (Wagner, 1978)
- The jointer and planer, also called a *surfacer*, are power planing machines that smooth the surfaces of lumber, and form faces and edges that are straight and true
- The jointer is the most versatile of the two machines and is a direct counterpart of the hard plane; it will plane surfaces, edges, bevels, chamfers and tapers.
- The planer is a single purpose machine that planes the stock to a uniform thickness

b. Jointer adjustments
- The cutterhead of a jointer holds 3 knives and revolves at a speed of about 4500 rpm; the size of the jointer is determined by the length of these knives and the size determines the maximum width of stock the jointer can handle.
- The outfeed table must be level with the knife edges at their highest point of rotation. This is a critical adjustment: if the table is too high, the stock will be gradually raised out of the cut and a slight taper will be formed; if it is too low, the tail end of the stock will drop as it leaves the infeed table and cause a “bite” in the surface or edge
- The fence guides the stock over the table and knives; when jointing on edge or squaring stock, it should be perpendicular to the table surface; the fence can be tilted to other angles when cutting chamfers or bevels
- To make a cut on the jointer, the infeed table is set below the level of the knives and outfeed table; most jointers have a scale that indicates this distance, which is referred to as the “depth of cut”

c. Planing an edge
- This operation is also called jointing an edge
- Be certain that the fence is square and tight, and that the guard is in position and properly adjusted
- Set the infeed table for the correct depth of cut and turn on the machine; the maximum cut for jointing an edge is 1/8 in. and for a flat surface, 1/16 in.
- Place the stock on the infeed table and press it lightly against the fence; the rate of feed will vary with the kind and size of wood and the depth of cut, but it is seldom slower than 10 fpm
- Narrow pieces of stock that are close to the 12 in., minimum length should be handled with a push of stick

d. Planing a surface
- Turn the stock so that to feed the grain of the wood in the right direction

- If there is some warp in the board, turn the concave (dished in) surface down so the stock will not rock on the table
- Set the depth of cut at about 1/16 in., check the fence and guard, and turn on the machine
- Place the stock on the infeed table and move it into the knives
- Finish the cut by placing a “pusher block” on the end of the board
- To cut boards with twist or wind, apply pressure on the low points and try to keep the board from rocking during the cut.

e. Safety rules for the jointer
   - Before turning on the machine, make adjustments for depth of cut and position of fence
   - The maximum cut for jointing an edge is 1/8 in., and for a flat surface 1/16 in.
   - Stock to be surfaced must be at least 12 in. long and 3/8 in. thick unless a special feather board is used
   - Feed the work so the knives will cut “with the grain” and use only new stock that is free of knots, splits and checks
   - Always keep hands away from the cutterhead, allow at least 4 in. margin of safety
   - Use a push block when planing a flat surface, do not apply pressure directly over the knives with hand
   - Do not plain end grain unless the board is at least 12 in. wide
   - The jointer knives must be sharp; dull knives will vibrate the stock and may cause a kickback.

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Photos 27-29 (by Kim): damaged planing knives (27), wrong position of cutter block (28), dirty machinery and equipment causing defects (29)

3.6.2. Sanding (Hammond, et.al. 1972)

a. Introduction
   - Sanding is the process of using an abrasive to remove material from a surface; the cutting action is derived from the many sharp grains of abrasive material which act as tiny cutting wedges

- Coated abrasives are used for sanding which are natural or manufactured abrading materials adhered to flexible backing

- The abrasives commonly used are:
  <u>Flint quart</u>
  - ✓ a natural mineral generally of yellowish cast
  - ✓ lacks the hardness or durability of other abrasives and the cutting action is short-lived

  <u>Garnet</u>
  - ✓ a natural mineral of reddish brown color
  - ✓ a fairly hard, tough mineral, making it an ideal abrasive for wood-working

  <u>Silicon carbide</u>
  - ✓ is manufactured from silicon (sand) and carbon, fused together in an electric furnace, with steel gray to black color
  - ✓ is extremely hard and sharp, second only to diamond in terms of hardness
  - ✓ it is a brittle material, which limits its usefulness in machine sanding

  <u>Aluminum oxide</u>
  - ✓ is manufactured from bauxite, carbon and iron filings, fused together in an electric furnace, with light brown color
  - ✓ is not quite as hard and the crystals are not as sharp as silicon carbide but it is tough
  - ✓ able to stand up under the most severe working conditions, making it an ideal material for sanding belts

- There are five general classes of backing used abrasives, namely: paper, cloth, fiber, plastics, and a combination of paper and cloth
  - ✓ paper backing is used on almost all hand sanding jobs
  - ✓ the others are used on machine sanders because of their strength, pliability, and the ease with which they conform to curved surfaces
  - ✓ grit cloth, a plastic screen coated with an adhesive and covered with silicon carbide or aluminum oxide is a newer backing material

- Coated abrasives in woodworking are used for hand and machine sanding, removing stock, cleaning and polishing

b. Sanders
- Sanders are power driven abrading tool, rotary or reciprocating
- Three types of sanders are widely known:
  <u>Spindle sander</u>
  - ✓ has a rubber-coated spindle to which is fitted the coated abrasive sleeve
  - ✓ the spindle simultaneously rotates and oscillates up and down
  - ✓ is used to sand concave curves on edge
  - ✓ sleeve diameters range from ¾ in. to 3 in. and lengths from 6 in. to 9 in.

  <u>Belt sander</u>
  - ✓ a cloth-coated abrasive belt revolves on one driver and one idler pulley while passing over a flat table on which stock is placed for sanding
  - ✓ is used to sand flat surfaces; belt widths range from 4 to 8 in. and lengths from 4 to 26 ft.

  <u>Disk sander</u>
  - ✓ a coated abrasive disk is attached to a metal disk which revolves in a clockwise direction
  - ✓ is used to sand straight and convex curves on edge
  - ✓ the diameters of disk range from 8½ to 18 in.

c. Portable sanders
- There are 3 basic types of portable sanding machines, each designed to meet an exact need:

  On the belt sander
  - ✓ a coated abrasive belt is run over a pad guided by an idler and driving drum
  - ✓ is used to do flush or regular sanding
  - ✓ various grit belts are available in width and length to fit a specific make of machine
  - ✓ sizes of belts range from 2 to 4 in. in width and from 21 to 24 in. in length

  On disk sander
  - ✓ a coated abrasive disk rotates on a motor spindle
  - ✓ is used in rough sanding for fast removal of stock and where scratch-free surface is not a requisite
  - ✓ a pad may be fitted over the disk, enabling it to be used in a polishing operation

  On finish sander
  - ✓ a coated abrasive strip fitted over a pressure pad is powered in an orbital or inline oscillating motion
  - ✓ consists of two types: orbital motion sander and inline sander
  - ✓ the orbital motion type is used in finish sanding on flat surfaces by performing rapid hand-sanding operation
  - ✓ the inline sander is ideal for the final sanding of wood surfaces because it leaves no sanding marks as in the case of the orbital sander

d. Expected results of sanding operation
- Surfaces and edges should be sanded smooth
- Finished work should be to the predetermined size and shape, and free of burned marks caused by too great pressure or clogged, worn abrasive
- Surfaces should be free of cross-grain scratches

e. Safety considerations
- Keep your hands away from all moving parts
- Belt sanders should be properly tracked to keep belt on the rolls
- In using the disk sander, sand on the downward rotation
- Do not use torn belts

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Photos 30-31 (by Kim): dirty head roller (30), inappropriate storage of sand papers (31)

3.6.3. Gluing (Wagner, 1976)

a. Introduction

Gluing is an important operation that is performed at various times during the total processing activity. Gluing operations may involve the use of a number of different kinds of adhesive material. The term adhesive is defined as a substance that is capable of holding objects together by surface attachment.

b. Major types of glue:
   i. Polyvinyl Resin Emulsion Glue, or generally called *polyvinyl* or *white glue*
      - is excellent for interior construction
      - it comes ready to use in plastic squeeze bottles and is easily applied
      - it sets up rapidly, does not stain the wood or dull tools
      - it holds wood parts securely
      - it is not waterproof and should not be used in assemblies that will be subjected to high humidity or moisture

   ii. Urea Formaldehyde Resin Glue, usually called *urea resin*
      - is available in a dry powder form which contains a hardening agent or catalyst
      - it is mixed with water to a creamy consistency for use
      - it is moisture resistant, dries to a light brown color and holds wood surfaces securely
      - it hardens through chemical action when water is added and sets at room temperatures in from 4 to 8 hours
      - it is often used for gluing plywood which is bonded in hot presses at 115-126^{o}C for 3 to 5 minutes

   iii. Casein Glue
      - is made from milk curd, hydrated lime and sodium hydroxide
      - it is supplied in powder form and is mixed with cold water for use
      - after mixing, it should be set for approximately 15 minutes before it is applied
      - it is a water resistant glue for interior structural laminating and works well where the moisture content of the wood is high
      - it has good joint filling qualities but stains the wood

   iv. Animal Glue
      - also called *hide glue*, is made from hides, tenons and bones of cattle
      - it was once the glue used most by the woodworking industries until the advent of the synthetic resin glues
      - it is available in liquid form and is packaged in plastic squeeze bottles
      - it holds wood parts securely, easy to handle, but not water proof

c. Preparing wood for gluing
   - wood pieces that are to be assembled with glue should all have the same moisture content
   - the moisture content at the time of gluing should be about equal to that which the glued article will attain when it is placed in service
   - the wood surfaces that will form the glue line should be dry, clean and smooth, and make good contact with each other.

d. Trial assemblies
   - Before applying any kind of glue, one should first place all of the parts together and check the fit, check the squareness of individual parts and also assembled parts.
   - The clearance of interlocking joints must be carefully checked to ensure that they will slip together easily after the glue is applied.
   - All joints and parts should fit together without excessive pressure from clamps
   - When working with assemblies that are large and complicated, there is a need to study and practice the sequence to be followed
   - When working with a fast setting glue it is best to make several sub-assemblies rather than do all of the gluing at one time

- Be certain that all parts are properly identified so that they are not mixed or reversed during the gluing operation
- Use small blocks of wood under the jaws of bar clamps to protect the smooth surfaces of final assemblies

e. Preparing glue
- Polyvinyl, liquid hide and contact cement are ready to use when purchased while many of the other glues will need to be mixed and prepared before using
- When preparing powdered glues, mix just the amount needed for each job because the glues have a working life (pot life) of only a few hours and then must be discarded.
- Stir with a stiff brush or stick until it forms a heavy “gooey” mass, then add a few drops of water at a time until it is reduced to a smooth creamy consistency
- Urea resin glue is mixed in a proportion of eight parts (by measure) of powder to three parts of water
- Casein glue is usually mixed in a proportion of one part of glue to two parts of water


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Photos 32-33 (by Kim): uncontrolled manual gluing consumes excessive glue (32), spreader without scraper causing uneven thickness of glue (33)

f. Making glue spread
- Applying the glue to the wood surface is called spreading
- When the glue is applied to both wood surfaces to be joined, it is called “double spread” and when it is applied to only one surface, it is called “single spread”
- Glue can be spread with a stick, brush, knife, roller, a mechanical spreader or a spay gun


(34) (35)

Photos 34-35 (by Kim): excessive use of glue causing spillovers

- You will need to know the assembly time of the glue you are using which varies between glues. Polyvinyl glues have an assembly time of only about 5 minutes; casein glue has an assembly time of about 20 minutes, etc.

- The assembly time refers to the total time between the spreading of the glue and the application of pressure.
- Always apply the glue carefully so there will be a minimum of squeeze-out; that which appears around the joint should be removed using a sharp stick or wood chisel; then the surface should be wiped thoroughly with a sponge or cloth, moistened with hot water.

3.6.4. Laminating

- Wood laminating is the process of forming parts by attaching two or more layers of wood together with the grain of each ply running in the same direction. Laminated wood is used for curved parts of furniture, baseball bats, boats, structural beams and many other products

- Among the common problems encountered in laminating work are: dirty glue spreader, glue remnant, sawdust or wood slobs; malfunctioning of scraper of glue spreader; uneven thickness of glue, hardener and glue are improperly stored, uncontrolled use glue and inappropriate hardness of glue spreader roller

- The training instructor will elucidate and demonstrate trouble shooting techniques including: i) how to keep glue spreader clean at all times, ii) how to make scraper of glue spreader functioning well, iii) how to control glue thickness, iv) proper way to store glue and hardener, and v) how to identify the right hardness of glue spreader roller.

3.6.5. Wood jointing

Wood jointing is an essential element of woodworking industry. A wood working joint is the place or part in which two separate pieces of wood are joined or united, either rigidly or so as to admit motion. Strength and appearance are the basic qualities of a joint.

Woodworking joints are divided into two basic types: lay-up and assembly type joints. Lay-up joints are those used for building up the dimensions of stock. Assembly types are those used in assembling members which have been cut to specified shape and dimension.

Practically, all joints are held in place by the use of some fastener. Nails, screws, pins, wedges, splines, dowels, corrugated fasteners, mending plates and other forms of hardware, all serve to reinforce or facilitate the purpose of joints. The strength of any given joint depends upon a number of factors, as follows (Hammond, et.al 1972):

i. The degree to which the wood will not twist, cup, bow, swell or shrink
ii. The degree of dryness of the wood and the extent of utilization of factors controlling the swelling and shrinking in making a joint
iii. The degree to which the fibers of a particular type of wood can be compressed as in the use of nails, corrugated fasteners, dowels and splines
iv. The degree of effectiveness of using adhesives with any particular kind of wood
v. The dimensions of the separate members of the joint
vi. Standard of workmanship

Glue is the common adhesive used in wood joints, where the separate members have been fitted; the strength of the joint is determined largely by the accuracy of the fit, the quality of the glue and the observance of sound rules for gluing and clamping.

The basic wood joints are briefly described below:

Butt joint: is produced by butting or bringing together (end, edge, or surface) or one member to the end, edge or surface of another member, secured and reinforced with glue, nails, screws, plates, corner blocks, splines, dowels or other fasteners. It is a common joint, to be used alone where great strength is not a primary consideration.

Miter joint: is a butted joint. The two members of equal width are cut at the same angle (less than 90^o) and are usually fastened together with glue and reinforced with nails, corrugated fasteners, spline or dowels.

Scarf joint: is used for extending length. Two members of equal width and thickness are joined at an acute angle (about 15^o) in order to obtain maximum bearing surface at the joint.

Half lap joint: in the end lap joint, two members of approximately equal thickness and usually of the same width, are joined in a modified type of butt joint to extend length or to change direction. Half the thickness of each member is cut away so that when lapped together, a thickness equal to that of one member is formed, the cross lap joint is an interlocking joint.

Finger, box, or multiple slip joint: is made by cutting notches so that the resulting fingers and sockets alternate and the two sections interlock when joined together.

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Photo 36 (by Kim): incompatible tongue and groove

Dovetail joint: is a modified finger joint where a reversed, wedge-shaped finger fits into a matched socket. The shape of the finger resembles the spread of a dove's tail.

Mortise and tenon joint: is the type of joint where a finger or tenon cut on one member is fitted into a socket or mortise of corresponding dimension in the other member.

Dado rabbet joint: is used in fastening case fronts and backs to ends, such as in cedar chests, top drawer frames to cases, drawer sides and drawer backs.

Dowels: are used to give added strength to a butted joint by providing resistance to cross strain and increasing the gluing service.

Splines: are narrow strips of thin stock. A spline is inserted in a groove or keyway in a butted joint with the short grain at right angles to the joining surfaces thus adds strength to the joint by giving resistance against twist or torsion.

3.7. Sawdoctoring

3.7.1. Introduction

- Sawdoctors play a very important role in the sawmill and to some extent they perform the same type of job as an engineer. They make, repair, maintain and sharpen a wide range of cutting tools and saw blades, and also maintain mechanical parts from a range of production machines

- Sawdoctors may also perform the following tasks:
  - weld tools, saws and cutting edges
  - assemble, calibrate and dismantle instruments
  - repair and service tools and machinery
  - identify and rectify saw performance
  - stock a range of mechanical parts for sawing machinery used in timber processing

- Experience from conducting training on wood processing in nine ITTO member countries revealed several issues as regards sawdoctoring. Firstly, most countries experienced a serious shortage of qualified sawdoctors as evidenced by the generally low efficiency of wood processing and product quality attributable to weak sawdoctoring. Secondly, the responsibilities and skills-set of a sawdoctor are not well understood by mill owners and executives as evidenced by the generally lack of investment in sawdoctoring equipment and facilities. Thirdly, sawdoctoring as a profession has not been fully recognized as a determining factor of efficiency and quality as evident in the lack of accredited qualification programs and weak incentive system for sawdoctors in most countries.

- To facilitate proper understanding on the tasks sawdoctors have to perform, information on selected elements of sawdoctoring is briefly presented in the sections that follow.


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Photos 37-40 (by Kim): unorganized, dirty and messy sawdoctoring rooms

3.7.2. Use and maintenance of circular saws (Hammond, et.al.1972)

- A circular saw is a power driven rotary cutting tool with toothed circular blade that revolves at an arbor speed of approximately 3,450 rpm, cuts on the principle of a continuous set of cutting wedges; it is used to cut stock to length and width and to cut rabbets, grooves, dadoes an tenons.

- In using a circular saw, the following principles need to be observed:
  i. Circular saw blades should be kept sharp and set
     - Sharpening should be done by an experienced person; also jointing, setting and gumming
     - Mechanical parts of some circular saws require periodic greasing; others have sealed bearings
     - If a pin is used to hold arbor or saw blade is in locked position when changing blades, be certain to remove the pin before starting the saw
  ii. Always check alignment of miter gauge and/or fence
  iii. Whenever a saw is left unused for an extended period of time, all machined parts should be coated with a film of oil or paraffin wax
  iv. Sawdust should be blown from motor and machine with blower or bellows


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Photos 41-42 (by Kim): damaged diamond wheel (41) causing damage on circular saw teeth (42)

- Major elements of maintaining circular saws include: sharpening, jointing, filing, teeth setting, gumming, grinding and whetting (Wagner, 1978) which are briefly described below:
  a. Sharpening circular saw blades
     ✓ Sharp saw blades are a pleasure to use; they will produce fine, accurate work with speed and safety
     ✓ Dull blades are dangerous to use because they resist the stock being fed into them and are more likely to cause kickbacks; they tend to heat and this causes pitch and gum to build on the blade which adds more friction and causes more heat to the point where the edge of the blade may snake or warp
     ✓ Blades should be kept bright and clean
       - Small amounts of pitch or rosin can be removed by wiping the blade with a cloth saturated with a special pitch and gum remover, kerosene or mineral spirits
       - The gullets should also be wiped clean
       - A good way to remove a heavy coating of pitch is to soak the blade in warm water then wipe dry and oil lightly
       - Do not scrape the surface of the blade with a metal tool or use a coarse abrasive
       - Rust spots should be polished off with a 600 wet-or-dry paper and oil

- Always clean the saw blade before sharpening it

b. Jointing
- ✓ Jointing is the operation of rounding the blade so that all the teeth will be exactly the same height.
- ✓ Be certain the blade is in the correct position by loosening the arbor nut and retightening with the flange mark and trademark up
- ✓ Clamp an abrasive stone to the miter gauge and raise the blade until it just touches the stone
- ✓ Turn on the machine and move the stone over the blade
- ✓ Stop the saw and examine the blade; tiny "flats" or "brights" should be visible on the points of the teeth, rejoin if necessary
- ✓ If the saw is in poor shape it may be impractical to strike the very short teeth but to allow these to remain until the next time the saw is filed or completely reconditioned
- ✓ The jointing should always be as light as possible so that during the filing operation, just a few strokes of the file will form a new point or edge.

c. Filing
- ✓ Mount the saw in a filing clamp; for rip and rough cut combination blades, select an 8 in. smooth or dead smooth, mill file
- ✓ Set the blade so the teeth are supported close to the saw clamp and file the top bevel of teeth that are set away from you
- ✓ File rip teeth straight across; for combination teeth, drop the file handle about 15 deg.
- ✓ Use light full strokes, forming a bevel with the required clearance; the file will cut smoother and easier if you use a diagonal stroke
- ✓ Watch the jointed flat and stop just as soon as it disappears; filing beyond this point will lower the tooth and it will not do its share of the cutting
- ✓ After you have filed all the teeth set away from you, reverse the blade in the clamp and file the remaining teeth

d. Setting teeth
- ✓ After a number of sharpening, the teeth will require additional set; the amount of set required will vary with the kind of work
- ✓ Generally, blades use on table saws are given 2 gauges of set on each side; blades for portable saws are set 2.5 gauges on each side
- ✓ Too much set is undesirable as it produces a rough cut, creates extra strain on the blade and requires extra power
- ✓ Saws of 14 gauge and lighter can be set with a hand set
  - Only the top 1/8 to 5/32 in. of the tooth should be set
  - Observe the direction of the previous setting and follow the same pattern
  - Check your work by sighting across the flat surface of the blade, toward a major light source
- ✓ Large, heavy gauge saws will require special setting equipment

e. Gumming
- ✓ Is the process of grinding and shaping the saw gullets
- ✓ The edge of a thin abrasive wheel is shaped to the required contour and the saw is held in a special fixture
- ✓ When gumming a blade without special equipment, a reference circle should be made on the blade; lines should be laid out from the front bevel or face of each tooth to serve as a guide during the grinding operation
- ✓ The depth of the gullet should equal about two-fifths of the distance between the points of the teeth

- ✓ The face of the tooth is ground only just enough to clean the surface so that correct spacing can be easily maintained
- ✓ Heavy grinding will produce too much heat and burn the teeth; it is best to grind lightly, skip every other gullet, and go around the blade several times until the required depth is attained

f. Grinding edge tools (Hammond, et.al, 1972)

- ✓ Grinder is a power driven abrading tool for shaping metal. The grinder works on the principle of a large number of cutting wedges revolving at a speed from 400 to 3,600 rpm. The most common type used is dry grinder; but there are also wet and vapor grinders.
- ✓ A grinding wheel is normally worked in six parts, designated by letter and number. Example: B60M5VE where B is type of abrasive (aluminum oxide, silicon carbide, emery, etc); 60 is grain size (coarse (8) to very fine (500)); M is grade (A to Z, soft to hard); 5 is structure (most dense (1) to most open (15)); V is bond (vitrified, rubber, oxychloride, etc) and E is manufacturer number for sales purposes.
- ✓ Grinding is a process of reshaping the cutting edge of a tool; an abrasive wheel or stone is used to give the proper wedge-shaped edge while an oil stone is used to hone to a keen edge.
- ✓ The basic procedures for grinding are:
  - i. Adjust the tool rest slightly below the center of the wheel for straight-on grinding and above center for bevel grinding
  - ii. First, dress the cutting edge square with the sides of the tool by feeding the tool straight onto the grinding wheel; this is also done to remove nicks
  - iii. Work the tool across the face of the wheel with a light pressure which results in a fine cut
  - iv. Adjust the tool rest so that the angle of contact of wheel and tool is about 30^o; to grind the bevel, work the tool across the face of the wheel. Keep the edge being sharpened square with the side of the tool. Apply only enough pressure to make a light cutting action as too much pressure will cause overheating. Frequently dip the tip of the tool in water to cool it.
- ✓ Face grinding produces a slightly hollow bevel that allows for honing several times before regrinding is necessary
- ✓ Safety considerations
  - Eye shields must be in proper position and goggles should be worn
  - Guards and tables should be no more than ¼ in. away from the wheel
  - Tool being ground should be held firmly
  - Clogged and out-of-true wheels should be dressed
  - Badly worn wheels should be replaced; replacement wheels should match with the speed of the machine
  - Avoid jamming tool
  - Always use the face of the wheel
  - Stand to one side of rotation of wheel when starting grinder
- ✓ Expected results
  - The cutting edge should be square
  - The hollow bevel should be ground to a fine edge at about a 30^o angle
  - Sides of the bevel should be of equal length
  - The tool should show no evidence of overheating
- ✓ Common weaknesses observed in grinding
  - Scratchy and craggy surface of grinding stone caused irregular shape and size of gullets as well as unequal height of saw teeth

   - Grindstone wheel installed at erroneous angle brought about unequal height and width of saw teeth, vibration of band saw during operation, imprecision sawing and saw mark defect
- ✓ The main elements for elucidation and demonstration
   - To get familiar with different types of grinder
   - How to maintain grinding stone in good shape (dressing, etc)
   - How to set up and use double sharpener
   - To determine width of saw tooth against the width of the band saw blade
   - To position grindstone wheel in the right angle with the double-side sharpener
   - To properly position illumination lamp in order to facilitate adequate control of double-side sharpener operation


(43) (44)

Photos 43-44 (by Kim): dirty, rusty circular saw causing burn mark (43), overheating causing twisted circular saw (44)

g. Whetting or honing a cutting tool (Hammond, et.al.1972)
- ✓ Honing is the process of sharpening to a fine edge, to remove the wire edge after grinding or to restore a sharp edge. Usually, a combination oilstone is used, which includes a coarse face for rough, rapid cutting and a fine face for dressing a sharp edge.
- ✓ The basic honing procedures include:
   - Select a coarse or fine stone, depending on the condition of the tool edge; a good general purpose stone is the medium grade
   - Secure the oilstone on the bench so that it is level
   - Apply a few drops of thin machine oil to the surface to float away the particles of metal being cut from the tool
   - Hold the tool diagonally across the face width of the stone; the bevel of the tool should form an angle between 30^o to 35^o depending on hardness of the material
   - Move the tool back and forth along the stone with long, straight strokes while holding the tool at a constant angle
   - Use the entire face of the stone and occasionally turn it end-for-end to ensure even wear
   - After the bright edge on single-edge tools has disappeared, place the tool with the surface opposite the bevel flat on the stone, and remove the burr with several sidewise strokes
   - Test for sharpness by drawing the edge lightly across the back of the thumb nail; if it scores a mark on the nail, it is considered sharp
   - Use a leather strap after whetting to produce a keener edge by securing the strap to the oilstone holder cover. Hold the cutting edge flat on the strap and draw the tool away; several strokes will remove any fine wire edge

- ✓ Safety considerations
  - Keep both hands on the tool
  - Care must be taken to avoid cuts when testing the sharpness of the cutting edge
  - Secure the stone to the bench
  - Care must be taken to avoid cuts when sharpening a tool with a slipstone held in the hand
- ✓ Expected results
  - No nicks or burrs should appear on the blade
  - The bevel should be 30^o to 35^o and form the proper cutting angle with the sides of the tool
  - On single-edge tools, the surface opposite the bevel should be flat

3.7.3. Maintenance of bandsaw blades

a. Sawdoctoring facilities (Ho & Gan, 2003)

A sawmill should be equipped with the essential facilities for band saw maintenance like the stretcher roller including leveling bench, automatic sharpening machine and side dresser, welding outfits for joining, crack repair and stellite tipping as well as hand tools such as swage, hammers an gauges. Automatic swaging machine is particularly needed in order to avoid the hardwork of hand swaging.

Bandsaws have two types of teeth: the regular standard rip shaped tooth and the raker tooth used on the saber and skip tooth blades. The former type is an all-hard blade designed as a long lasting saw that may be resharpened for longer usage; it has a rake angle of 8^o to 10^o with round gullets, designed for all types of cutting and alternate set. The latter type generally has a hardened cutting edge and it is designed for both cross cutting and ripping, to be thrown away when the cutting edge finally becomes dull. The large gullet gives extra capacity for the chips, permitting fast cutting (Hammond, et.al.1972).


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Photos 45-46 (by Kim): dressing of damaged sharpener (45), measuring gullet angle using protactor (46)

b. Maintenance of bandsaw blades

Among the essential sawdoctoring works on up-keeping band saw blades that need to be done by experienced professionals include:

i. Straightening (Tesnar, 2013)
  - Involves checking the blade for twists using two methods: firstly, blades are rolled on the floor to see if it has a right or left twist in it; secondly, to hang a blade over a support structure to see existence of twist(s)
  - If the blade shows a twist, it should be marked on the inside and outside of the blade and the back of the saw blade should be straightened because the tooth edge must be shorter than the rest of the blade or the blade must be in a convex form

- To stretch the back of a blade to become convex again, place the straight edge at the back and mark the area to be rolled; roll 15 to 20 mm from the back of the blade and check the blade again; if necessary, roll the blade 15 to 20 mm from the first roll

- To prevent lumps, marks should be made at 45°; when the back of the blade is too long, then the same should be done on the tooth line; small lumps can be filed away

ii. Levelling (Tesner, 2013)

- A lump can be identified as a small tight spot on the saw blade where the metal has expanded owing to overheating and/or friction; if a blade rolls or wobbles to one side with the other side remaining hollow, it may have a lump in it
- Leveling should be done before tensioning to remove lumps and to even out the steel in order to prevent cracking; bigger lumps can be removed with a stretcher-roller while smaller lumps can be treated with a cross face or twist face hammer
- When using the hammer, a piece of leather must be put under the blade to prevent it from stretching too much; do not try to remove the lump with the first hit but hammer the blade two or three times to achieve the best result
- When leveling a blade, the sawdoctor must be careful to not affect the tension in the blade


(47) (48)

Photos 47-48 (by Kim): calibrating grinder using straight edge template (47), broken teeth in need of welding and stelliting (48)

iii. Tensioning (Tesner, 2013)

- Tensioning involves stretching or straining the saw blade to impart stiffness; tension in the blade counteracts expansion, shortens the cutting edge to make it stiff and ensures that the blade runs in a constant position on the wheel. If the wheel is for a 36 gauge and the blade is tensioned for a 32 gauge, the blade will not stay on one place, but runs back to front, making the cutting edge stiffer
- It is important for the sawdoctor to consider the blade specifications (gauge, width and make), the machine the blade is working on (flat wheel or crown, guides or pressure guides and feed speed) and nature of the timber (hard or softwood) before tensioning the blade
- There is no definite rule on the amount of tensioning that should be done; an experienced sawdoctor should be able to estimate when enough tension has been imparted by looking the application in which the saw blade will be used
- Uneven tension over the width of the blade is one of the most common problems faced by sawdoctors; uneven tensioning will cause the blade to move on the wheel creating a wavy cut

iv. Stelliting

- Stelliting involves tipping band saw teeth with and alloy of highly wear-resistant metals, primarily cobalt and chromium, in order to increase the effective cutting time of the blade and to enable the cutting of highly abrasive timber species

- Stelliting procedure can be outlined as follows:
  - ✓ The sawdoctor installing a stellite must be in a sitting position to avoid shaking of the saw blade
  - ✓ Determine the right temperature by scratching a crayon at the tip of saw teeth, then heat it using torch flame (red color) until the crayon scratch is melting which indicates that the temperature has reached 450^{o}C
  - ✓ Soon afterwards, the stellite is installed by welding using blue color flame; the proportion of intensity between the red color flame and blue color flame is approximately 3:1
  - ✓ After the stellite tipping is completed, the saw tooth must undergo grinding and sharpening using grinding stone for the foremost front part of the saw tooth and using double-side sharpener for the edge part of the tooth


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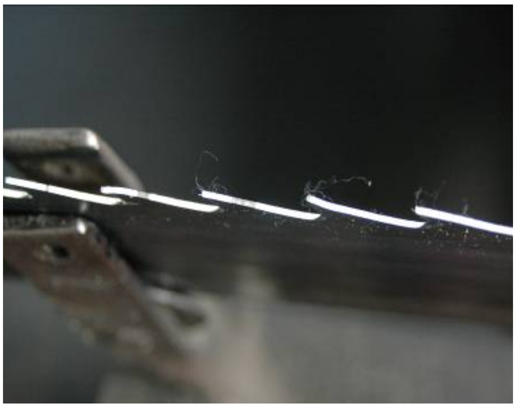
Photos 49-50 (by Kim): incorrect positioning of sawblade in stelliting process

v. Sharpening band saw teeth (Wagner, 1978)
- Band saw blades have many teeth and considerable time is required to set and file them by hand; small shops often prefer to use skip tooth blades with hardened teeth which stay sharp longer than regular blades, can not be filed, and are discarded when they become dull
- Regular blades are filed and set in about the same way as a hand rip saw using a special band saw file that has rounded edges, that keep the bottom of the gullets round, and minimizes checks and cracks in the blade; the same type of file that is used for hand filing, can be mounted in an automatic filing machine to speed up the work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Photos 51-52 (by ISWA): wrong teeth angles and size of gullets

vi. Storing band saw blades (Wagner, 1978)
- Proper storage can prevent band saws from twisting, stretching, elongating, becoming rusty and dirty

- First of all, band saws must be stored in a dry and clean room; to avoid twisting, a band saw must be stored like a belt or ribbon, hung on its center
- To avoid elongation, a band saw must be hung with a weight support as its base
- To effectively avoid rust, lubricate surface of band saws with oil or grease before hanging and hung band saws must not be touching one another
- To ease storing, shipping and handling blades, coiling them is required, which can be accomplished as follows (Wagner, 1978):
  - ✓ With the teeth pointing away from you, grasp the blade in the palms of your hands and step on it with one foot; your index finger, should point down along the back of the blade
  - ✓ Using your index fingers, push the two lower sections away from you and permit the upper loop to swing toward you
  - ✓ Continue the motion with the lower loops swinging toward each other and the upper loop swinging downward and underneath; raise your foot so the blade can turn on edge
  - ✓ Cross the loops and release the blade; it will fall together in three equal loops


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Photos 53-54 (by Kim): improper storage of bandsaw blades

3.7.4. Sharpening of knives

Sharpening of knives involves honing and grinding using abrasive tools. Knives must be kept keen and sharp to do good work; dull knives will vibrate the stock, cause “kickbacks” and increase the hazards of operation. If there are no serious nicks in the edges, the knives can be honed a number of times before grinding is required; to hone the knives, the following procedure can be used (Wagner, 1978):

- Disconnect the electrical power, remove the fence and clean the cutterhead
- Lower the outfeed table until a straight edge resting on it aligns with the knife bevel with about 5^o of clearance
- Drive a wooden wedge between the cutterhead and frame to lock it in position
- Wrap a piece of paper around one end of a silicon carbide oilstone, saturate it with oil, hone the knife edge and stop as soon as a slight wire edge starts to form
- Repeat the operation on the other knives, with the same amount of honing
- Use a fine slip stone and lightly stroke the front of the knife to remove the wire edge while keeping the stone aligned with the surface of the knife
- Clean the machine, readjust the table, fence and guard, inspect all settings carefully and make several trial cuts

 

(55) (56)

Photos 55-56 (by Kim): knife sharpening with coolant (55) and to eliminate burr (56)

- The knives may be jointed lightly before the honing operation, by holding an oilstone on the table and just touching the high point of the rotating edge
- After the knives have been honed a number of times, they will require grinding, best done by a specialist, to insure an accurate bevel (30-35^o included angle) with the edge straight and balanced knives.

3.8. Mill management

3.8.1. General safety (Hammond, et.al.1972)

a. Introduction
- The most important factor in safety is the attitude of the worker himself. Modern tools and machines are designed to be relatively safe; it is the method of using them that causes accidents
- By developing safe working habits and an awareness of good safety practices, accidents may be avoided
- If one analyzes the situation, there are more safe ways to do a job then unsafe ways. Hence don't take chances, become familiar with on operation and follow the correct procedure

b. Personal safety rules
- Clothing: avoid loose clothing; sleeves should be tight; remove ties, rings, watches, etc
- Eye safety: wear safety glasses when doing any cutting or when in proximity to the cutting operation
- Report injuries of any type to instructor immediately
- Never put fasteners or hardware of any description in the mouth
- Avoid throwing tools or any type of material to another person
- Keep working area free of excess waste such as shavings and pieces of wood
- When carrying long stock, secure help to maintain proper control
- Be careful when handling rough stock as splinters are painful
- Lift heavy objects only with judgement; lift with the legs, not with the back

c. Hand-tool safety rules
- Keep finger away from the edges of sharp cutting tools; work away from your body when using sharp cutting tool
- A sharp cutting tool should be secured in a holding device, so that both hands are free to control the tool
- Protect the cutting edge of sharp tools when carrying or storing
- Do not use dull or broken tools

- Be sure that tool handles are in good condition and securely fastened to the body of the tool
- Tools with ragged or mushroomed edges should not be used without prior grinding
- Observe all special safety considerations for each tool or operation

d. Machine safety rules
- Secure instruction in the use of a machine or permission to operate machine
- Make sure that all guards and eye shields are in place
- Cleaning and removing chips should be done only when machine is not running, using a brush, bellows or vacuum
- Check all adjustments to make sure that the machine is in proper operating condition
- Think through all operations carefully before starting the machine
- Do not talk to others when operating the machine
- Generally, there should be only one person at a machine at one time; if a helper is needed, his duties must be clearly explained before beginning the process
- Make sure that operators do not stand directly in line with revolving cutters or stock
- Make adjustments or repairs when machine is inoperative
- If oil is spilled on machine or floor, be sure to remove it completely
- Stand by the machine until it stops
- While machine is running, be alert to sounds which indicate that it is not operating properly
- Be alert for odors which indicate the machine and/or stock is overheating
- Do not touch moving stock or a cutting tool while it is in motion
- Observe all special safety considerations for each machine
- Report all defective electrical outlets and cords
- Examine all stock for physical defects and foreign objects


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Photos 57-58 (by Kim): unsafe circular saw operation (57), circular saw with protector (58)

e. Fire safety rules
- Flammable liquids should be stored in metal containers in a safe place
- Rags used in oil or paint should be destroyed or stored in covered metal containers
- Sawdust, wood shaving and finishing materials are very combustible and should be regularly swept up and removed from the shop

3.8.2. General maintenance

A mill manager should pay extra attention to maintenance and housekeeping in order to create conducive atmosphere in the mill; this is particularly critical for the room where wood finishing processes are to take place. One might leave lumber rocks and tools in disorder and be able to correct them the next day but in the finishing room, paint filled brushes, open containers and spilled materials must be cared for at once or loss and damage will result.

The general directions that need to be followed when performing wood finishing operations are listed below (Wagner, 1978):

- Clean up materials and return them to their proper place as soon as a work has been finished
- Close containers by first wiping out the lip and then sealing the lid tightly
- Keep storage shelves in order with materials in their proper places and labels turned to the front
- Clean brushes carefully and return them to their place of storage
- Rags that contain finishing materials should be discarded by taking them directly to the school incinerator or storing them in a metal container
- Do not touch wet surfaces or spatter them with a finish being used
- Do not use the finishing area for sanding, rubbing or polishing a finish
- The finishing room must be designed for the mixing, application and drying of finishes that its use should be restricted to these activities

In addition to finishing room, it is also important for a mill manager to keep the mill floor and area clean and organized at all times. To this end, the steps below need to be observed:

- Wood products must be stacked neatly and labeled properly
- Wood products must be protected from any damages by applying cover and fumigation
- All the tools and equipment for sawdoctoring must be stored neatly in suitable places
- A comfortable atmosphere for sawdoctoring in terms of space, temperature, cleanliness and lightning must be preserved


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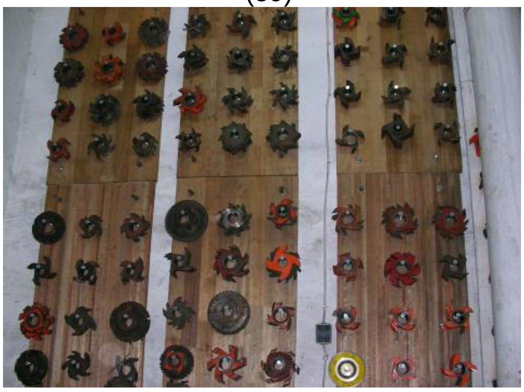
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Photos 59-62 (by Kim): comfortable sawdoctoring room (59), neat storage of band saws (60), and knives (61), placing of tools and equipment well organized (62)

3.8.3. Wood waste utilization

In general, the less efficient a wood processing is, the larger volume of wood waste will be. In fact, the waste, whether its existence is unintended or by technical flow, it is a loss to the company. To minimize loss, it is important for a mill manager to find ways for making use of the waste, for making marketable wood products. For examples, log waste may be used in finger jointing and laminating board, while pieces of wood waste are convertible to frames, sticks and toys using simple technology.

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Photos 63-64 (by Kim): wood wastes can be utilized to reduce loss

A mill manager, therefore, is required to be innovative and creative. To this end, market information needs to be made available to ensure that the waste-based products are marketable. It is also advisable to explore possibility of collaborating with local people in the making of specific such products as sculptures and handicrafts, using traditional craftsmanship, as part of the company's social mission.

3.8.4. Quality control

Product quality is one of the determinants of business competitiveness and a mill manager should pay extra attention to it. Products defects are best to be avoided because once a defect occurs, it is costly to repair. Repairable or not, a defect is certainly a loss to the company.

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Photos 65-66 (by Kim): controlling operations with the aid of gauging devices

To avoid defects from occurring, monitoring of processing operations must be well organized and quality control system put in place. Application of a control card at every machine or value chain is a powerful tool to monitor performance of the machine and its operator. Likewise, frequent visit to individual value chains is useful for early detection of irregular product quality.

 

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Photos 67-68 (by Kim): repairing defective products to reduce waste

3.8.5. Human resource development

It is not always possible to recruit employees having strong educational background or experience in wood processing considering the fact that existing educational and training institutions in many ITTO member countries do not design their curricula to meet such demand. Moreover, vocational schools on wood processing are available only in a few countries.

Conducting training on managerial and technical skills by the forest industries themselves is inevitable if the forest industries would ever be operating efficiently. To this end, any mill needs to develop a realistic mid-term training program and implement it consistently. At the same time, curricula of education and training institutions need to be reviewed and redesigned to produce ready-for-use alumni in forest industry in general, in wood processing in particular. The review and enhancement of the curricula are best to be accomplished by the institutions and forest industries together.

Improving communication between employees, managers and executives of the forest industries is also an important means for building up competitiveness. Conduct of regular meetings to know each other better, to directly discuss on ideas, initiatives and problems deserves serious attention of mill managers. Such a forum is a necessary condition for achieving common goals of any company and for strengthening team work in particular.

 

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Photos 69-70 (by Kim): intolerable attitude and mentality of employees

4. Expected Outcomes of the In-house Training

Upon completion of in-house training at any wood processing mills, participants of such training are expected to have acquired better knowledge and skills, at varying degree, on different elements of wood processing as listed below:

i. The executives and managers would have understood that levels of efficiency of processing and quality of products are generally very much dependent upon the quality of wood raw materials, appropriateness of the technologies employed and competence of the employees involved in the processing

ii. The owners and executives would have recognized the sources of inefficiency of operations as well as inferiority of product quality which could be used as the basis for defining required repairing actions in terms of investment, needed training program and incentive system

iii. Training participants as a whole should have understood that processing efficiency and product quality directly affect costs of production which, in turn, determines level of the company's market competitiveness

iv. Mill managers would have appreciated that inadequate treatment and damages of logs at logyards, directly and indirectly entails loss to the company that their occurrence should be minimized or avoided through application of simple, appropriate techniques

v. The participants would have to realize that primary and further processing are inter-connected that quality of works of primary processing will directly affect quality of works of further processing that the former must be performed with extra care to ensure feeding quality materials to the latter operations

vi. Machine and equipment operators would have enhanced their capacity in proper setting, operating, maintaining and repairing of machines and equipment

vii. Participating technicians that assist managers and operators would have improved their knowledge and skills on performing their respective tasks at different value adding chains through involvement in the discussions on detected problems and demonstration of problem solving techniques

viii. Mill supervisors would have realized the critical role of supervision in wood processing operations and be able to develop a practical yet effective monitoring procedures

ix. Mill managers, operators and supervisors would have realized that wood waste is a loss to the company that it has to be prevented from occurring or utilized as the raw materials for making marketable products

x. Kiln drying managers would have learned on the common problems occurring in wood drying process that adequate drying schedule must be put in place, proper stacking of timbers in the chambers practiced and quality of chamber construction insured

xi. Sawdoctors would have realized on the critical roles they play in influencing level of processing efficiency and product quality that enhancing technical competence over time is a must effort to do

xii. Mill managers should have recognized that damages to processed products destined for sales are too costly for the company to afford that adequate stockpiling and packaging should be assured to protect the products during storage and shipping.

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