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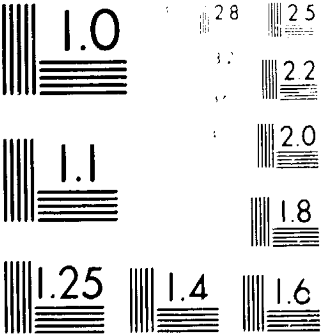
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RECENT DEVELOPMENTS IN PLYWOOD PRODUCTION *

by

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1. INTRODUCTION

Plywood is a semi-manufactured wooden product interesting world trade to a large extent. Developing countries have assumed an increasingly important role in the production and trade of plywood on a world-wide basis, because of their resources in valuable, large diameter, tropical hardwood logs.

In absolute terms, world production of plywood increased from 26.735 million cubic metres in 1967 to a peak of 42.171 million cubic metres in 1973, the figures for the last three years for which details are available are 38.813, 41.237 and 41.553 million cubic metres for 1976 to 1978 respectively. It appears from those figures that in the twelve year period under review, whereas world production increased by 55 percent that the developed countries increased only by 39 percent while the corresponding increase for the developing countries is 218 percent - i.e. an increase four times as large as that of the developed countries. However, in spite of this increase, their share of the world production only increased from 9 to 19 percent.

The corresponding figures for trade (export) of plywood are naturally far smaller, increasing gradually from 3.021 million cubic metres in 1967 to 7.102 million cubic metres in 1978. An analysis of these figures for the same twelve year period indicates that world trade in plywood increased by 135 percent exports from developed countries increasing by only 31 percent while those from developing countries increased by no less than 335 percent - over ten times the figure of the developed countries. Because of this spectacular increase their share of world trade increased over this period of time from 34 to 63 percent of world trade - i.e. doubling more or less.

Those figures are bound to increase still further in the coming years if the developing countries take the necessary measures to reduce exports of veneer logs and insist on processing them into plywood prior to export.

2. GENERAL TERMS

2.1 Raw Materials

One of the most decisive matters to be clarified before starting a planning - or possibly a reconsideration or improvement scheme - is the raw material that is available for the production. Basically we make the following differentiations:

- tropical hardwood
- softwood and
- hardwood

for the production, because production methods and machinery are quite different for the utilization of these different materials.

Certainly there are cases where none of the above is available in sufficient quantities - or where the production is so small that a wide mixture of species must be considered. But we are today not so much talking about the 'workshops' but about industrial production lines with the best possible efficienty.

And for this reason of efficiency it is essential to make clear the differences in the above mentioned raw materials. We shall find out in the later part of this lecture for what reason and to which extent these differences influence production.

In addition to the kind of raw material which will be considered, or is available, the questions of quantities, the time periods when these are available, the means of transportation etc must be carefully studied and resolved before a decision is made.

2.2. Markets

When looking into the question of which markets the production is going to be designed for, this must not only relate to economy and profit, but also the choice of production system and machinery.

After a clear decision is made in terms of which market the production will cater to, also in relation to the availability of suitable raw material, the actual production method and basic planning can then begin.

2.3. Capacities

Depending on the quantities the market will need or consume and based on the quantity of raw material available, the question of production capacities can basically be resolved. Here, it is useful to realise that all these considerations, at this stage are just generalisations, as only after detailed "balancing of the machines' capacities" will the precise capacity figures be known which will provide for the best possible machine utilisation.

2.4. Location

Another very basic and important consideration is that of the proposed location of the factory to be set up - or how efficiency could be improved even within an existing location.

Transport means for the raw material and the products will influence the decision of the choice of the location for the factory site.

Further considerations will also have to be given to the existence of water, electricity, infrastructure, soil conditions, weather conditions, etc.

2.5. Plywood Factory or Integrated Timber Complex

One of the before mentioned items mat also lead to the question of whether just a plywood factory is the best choice or if other production lines should also be considered.

Tropical hardwood logs are often not available in a selected form but just as they are brought out of the forest. In such a case, the addition of a sawmill will always be good for a better utilisation of the logs. To elaborate, some logs may be too big, or too bad, or even too good for the plywood production. These can then be channeled to the sawmill for a more useful product.

The same is valid for a sliced veneer production line which should be combined with some sawmill facilities to cut those logs or flitches into planks, which may, at first - from the outside of the log or the flitch - look good for slicing but found to be useless after beginning of the slicing operation.

2.6. Steam and Power Plant

Here, one should not only look at the availability of oil or coal when deciding whether the necessary production steam should be generated from such means or whether the production residues should be recycled for steam production. This question must also consider such facts as the existence of a chipboard, hardboard (fibre board) or even pulp and paper factory nearby, as possible consumers for these residues. However, in normal cases, production residues are good for the production of the needed steam in the factory.

The question of whether electricity will be available in sufficient quantity, is not always decisive, for the possibility of the production residues in producing steam which can generate electricity before the steam is used for drying, pressing etc, can often over-ride any deficiencies here.

All in all however, these are most of the basic considerations made before the real planning takes place.

Once again, I would like to emphasise that such a planning is not only related to the setting up of completely new factories but also to considerations for renewal, improvement, extension or rationalisation of existing lines.

In the following, we will now determine not only the way of doing detailed planning (for new or improvement) but also the diffence when use is made of the various raw materials. Each one of the following sections is designed to cover a different production line - and each one is covering the considerations as completely as is possible, within limits of the time made available for this lecture.

However, all these paragraphs are designed for a common focus:

To the maximum utilisation of the machines that are available for the production lines - and for the best possible balancing of the machine capacities of all the machines in one production line. Just as a chain is only as strong as its weakest link - a production line can porduce only as much as the one machine in the line, with the lowest individual capacity.

Therefore, a very careful balancing of these capacities in connection with location, raw material, quality requirements, operational and maintenance capabilities of the workers is essential for success.

3. TROPICAL HARDWOOD PLYWOOD

Throughout the world, there are two major kinds of plywood being produced. One such plywood is that produced from various species of conifers. This kind of plywood is known as softwood plywood. The other major kind of plywood is produced from various species of tropical hardwood and accordingly, is known as tropical hardwood plywood.

Both kinds of plywood differ so much in that machines have been developed in the course of the time, which are either not suited or just suitable to a limited extend, in the production of the other kind. This essentially means that no really general purpose plywood making machines are available as the science is now exact.

Also, the production methods are different and therefore, we should look at the two different kinds of plywood and their production methods separately too.

3.1. General Description - A Case Study

Preparation and Handling of Logs for Peeling

For the production of plywood, the factory considers that both sinker logs and floater logs will be used. Accordingly, these different types of logs will be stored in either the river (for floaters) or the log yard (for sinkers).

From the storage areas, there will be two different methods for handling of these logs later on. All floaters will be taken out of the river by winch, while sinkers will be brought from the log yard by conveyor. All logs are already debarked.

However, before the centering and charging, all logs have to be cut to the required sizes and this will be done by a stationary chain saw. Off cuts will be transported to a heavy duty chipper, where they will be chipped and then fed into the boilers.

The cut-to-size logs are then taken by hoist when needed for the peeling operation either from the log pond or from the sinker storage yard.

Log Charging, Peeling and Reeling

The log will be brought by electric hoist to the log centering and charging device which ensures that the log will be properly centered when being peeled. After the log has been centered, it is then charged into the rotary lathe.

During the peeling operation, the first products will be waste which is brought away by conveyor to the chipper. As the log rotates against the knife whih runs the full length of the log, it will be rounded. Round up pieces which results from this are collected for further use as core veneer.

The round logs will then be rotated to produce a continuous fan or back ribbon of veneer which, depending on the quality, will either be utilised as face/back veneer. In cases of bad quality, the veneer will be used for core.

Reeling and Unreeling of Veneer

Products from the peeling operation are collected by the reeling and unreeling magazines immediately in front of the lathes.

The peeled ribbon of veneer, will be simultaneously reeled onto bobbins which can be either stored in the reeling magazine or fed into the veneer dryer straight away.

Recent developments are now enabling factories to handle all round ups automatically. Previously, round ups were handled manually and resulted in a high percentage of wastage,as a result of breaking. Now, a tray deck system is available which automatically carries the round ups flat, via a carrying and top conveyor belt for automatic clipping. In this system, a high recovery is possible as the round ups do not break up as easily and as much as when handled manually.

According to the type of veneer that is peeled, the operator can decide whether the veneer will be fed into the tray deck system or the reeling and unreeling system, simply by activating the respective gates.

Veneer Drying and Clipping

This description, considers a plywood factory with two 8 ft. lines and a 5 ft line.

Behind the 8 ft line, the veneer will be dried in continuous veneer dryer, which is a long heated chamber through which the veneer is carried on continuous belts. The rate of feed and temperature are controlled according to thickness and species, so that each veneer emerges at the other end at a predetermined moisture content. After drying, the veneer is then clipped to predetermined sizes.

Behind the 5 ft line, there is a roller dryer. Veneers fed into this dryer is wet clipped and then fed into the dryer.

Jointing/Splicing of the Veneer

Following the drying of the veneer, all veneer pieces which are not of the required widths can be joined/spliced.

In this section, face and back veneers are joined/spliced with edger gluer through their entire width and not only spot glued. This can be the requirement of certain markets. For the core veneer, jointing/splicing is via turning threads which works for full sheets. The machine here is the core composer which is of the latest design and economically efficient.

It may be the intention to also sell core veneer and for this, sanding must be done. For this possibility, the production line will also include one core sanding machine.

Workers in this section, will carefully check all repairs and can further work on these veneer pieces in cases where further repairs are necessary. It is quite usual for such workers to carry out repairs with tapes and an ordinary household electric iron.

Lay Up and Glue Spreading

In this section, the individual veneers are built up into the requisite sandwich.

The core veneers are layed up before the glue spreader and on the outfeed side, face and back veneers are arranged in one stack consisting of alternate layers of face and back veneers.

Core veneers are passed through the glue spreader which regulates the spread of the glue. Both sides of the core veneer will be coated and on the outfeed side of the glue spreader, two sheets of veneer will be placed on the core veneer - one forming the face of this board, while the other will be the back veneer for the next core veneer which will fall onto it.

Table X-lifts before and after the glue spreader ensure a constant and convenient level for feeding and forming of the plywood layers.

Pressing of Plywood

From the glue spreading section, the assembled plywood sheets are taken by conveyors, to the pressing section. The individual plywood sheet is then checked again to ensure that there is no over-lapping and then asembled into packs. These are then brought to the cold press.

From the cold press, the plywood sheets are then brought to the hydraulic hot press which incorporates multiple heated platens between which the individual sheets are loaded automatically. When the loading is completed, the sheets are automatically fed into the heated platens which then press the plywood sheets. Platen temperatures, moisture content, pressure and time are all controlled to suit the particular batch being pressed. Control here is essential since an error in any one of these factors may result in defective bonding or otherwise mar the finished boards.

After the predetermined pressing time, the pressed plywood sheets are automatically unloaded and stacked to be brought for further processing.

Sizing and Sanding of Plywood

After the pressing section, the plywood sheets are brought to the sizing machine. At this machine, first the two opposite sides of one sheet are cut. Following this, the connecting conveyor brings the same sheet for another cut on the other two sides. The cutting units are ensuring parallel cuts and two such units operate at right angles connected by a conveyor system. Such an arrangement allows for the square cutting of the plywood sheets.

From the sizing, the plywood sheets are then taken to the sanding line where each sheet is then sanded. Both sides of the plywood sheet will be sanded and the finish will depend on the grade of plywood being manufactured.

Sorting, Repairing and Packing

After the sanding operation, the plywood sheets are ready for sale. However, at this point, it is also essential to have quality control and defective sheets can be taken out for possible repair work and then sanded again.

The sheets are then sorted out according to the requirements of the markets for which they are destined. These are then packed into crates which should be strong enough to ensure that the sheets are not damaged during shipment and transfer from the factory to the customer. For this reason, the sheet at the bottom of the crate and that at the top, will have their back veneer facing the crate bottom and top respectively.

Support Equipment for Plywood Production

For the production of plywood, it is necessary to have various auxiliary equipment not directly connected with the production.

These will include air compressors, electrical power plants or public supply of electricity to the plant, steam requirement for veneer drying and presses and a disposal system for the wood waste generated.

Additionally, further equipment essential for the maintenance of the production machinery will have to be considered. These include knife grinders, precision lathe, shaping machine, welding machines etc.

For the purpose of good efficient quality control, it is also important to have a laboratory for analysis of the product.

The equipment here will include moisture meters, shear testing machine, pyrometers, laboratory hot press, etc.

Under this consideration, it is important that further insight must be given to the boiler system as this not only supplies the required steam, but also disposes of wood waste and can be the possible source of electricity if required.

Boiler House, Waste Disposal and Electricity

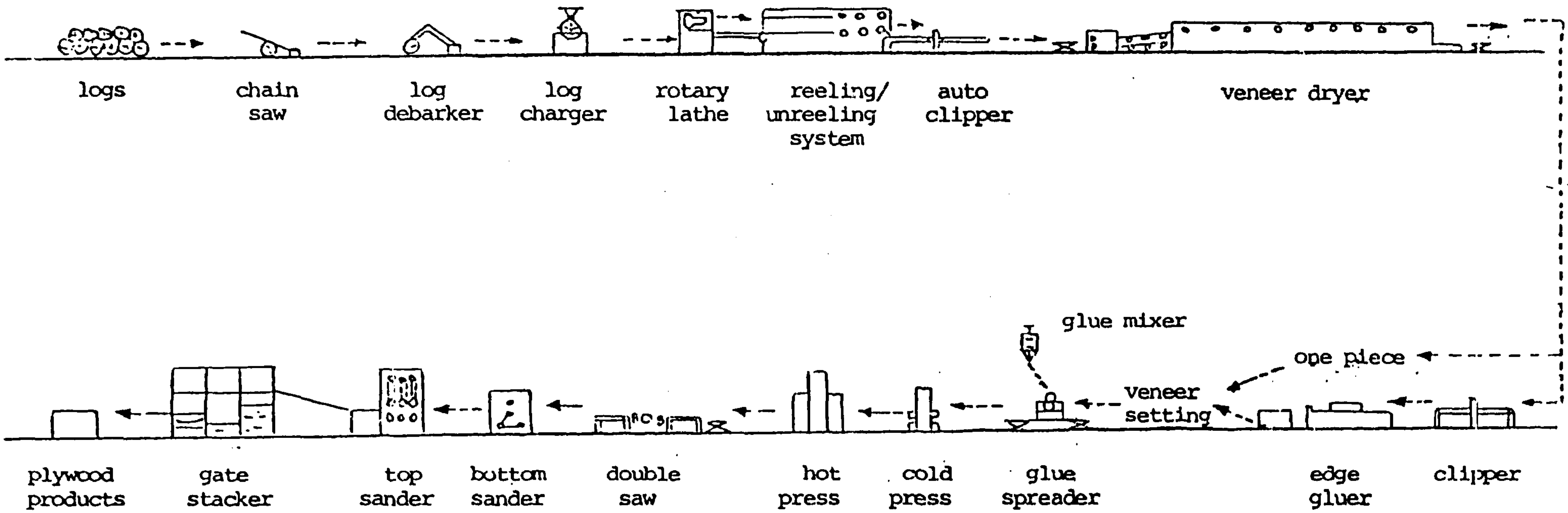
The waste generated from the plywood production, will all be chipped and stored into silos. A separate silo will be necessary for sanding dust as otherwise an explosive mixture can result.

The boiler will use the wood waste as fuel and this will ensure that the factory not only saves large fuel bills (from not having to buy diesel oil for boiler fuel), but also gets rid of its waste (at least a large quantity, if not all).

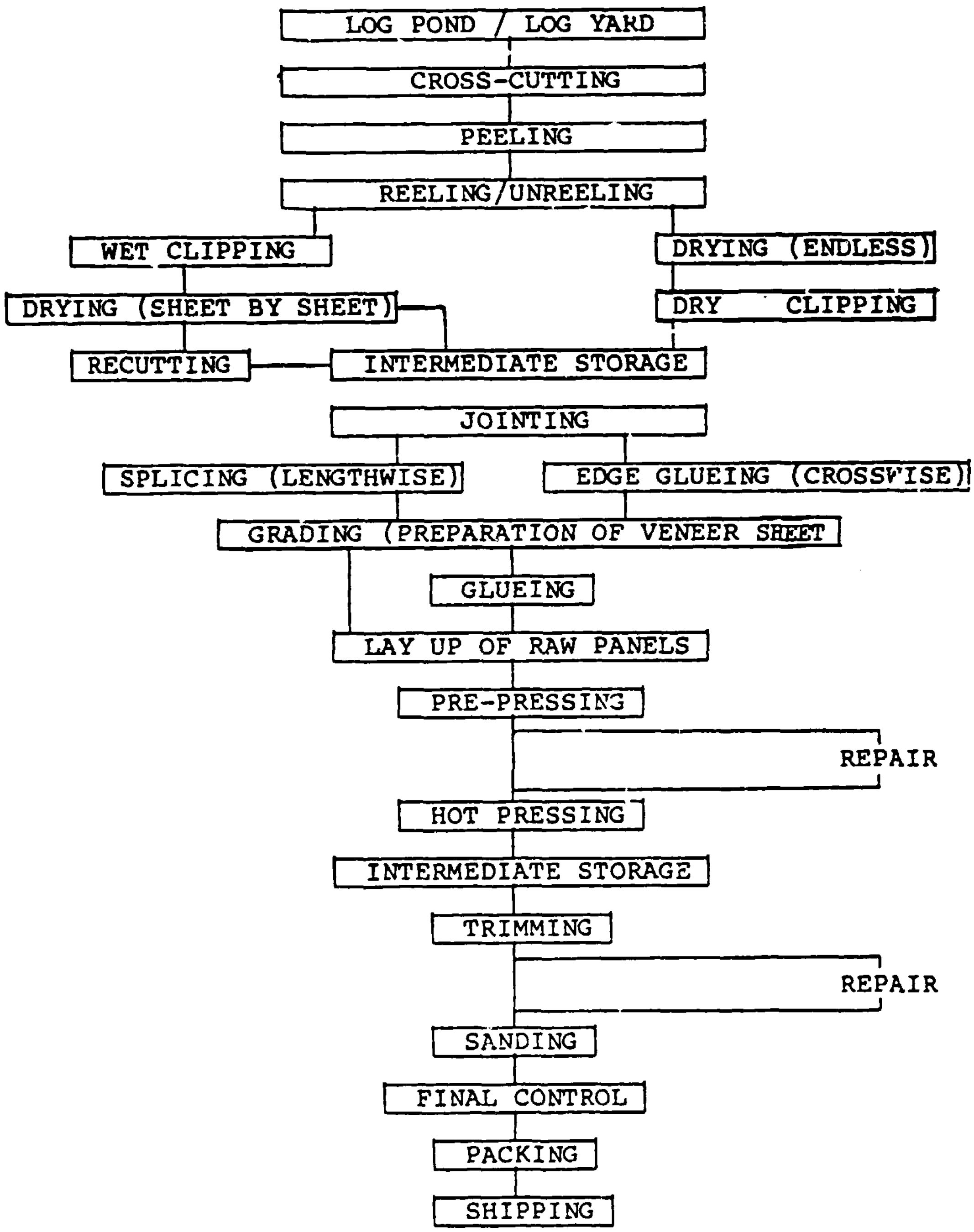
The boiler will generate steam which can be used by the veneer dryers and the hot presses and other possible steam consumers.

It is also possible to have the boiler producing steam to drive steam turbines, which can then generate electricity to power the factory. In such a case, the factory will be self sufficient and in view of today's rising fuel costs, this is indeed a very important point to consider.

FLOW SHEET FOR PLYWOOD PLANT



PRODUCTION OF PLYWOOD



3.2. Balancing of Capacities - Design Parameters

The design of the plywood factory is based on making a 3.6 mm x 1220 mm (4 ft) x 2440 mm (8 ft) plywood. The production capacity will be 10,000 panels per shift. The production will gradually reach full capacity after a period of 12 months.

1) Working time : 8 hours per shift (7.5 hours effective working time) 2 shifts per day, 300 days per year

2) Log input : 216 m3 per shift or 130,000 m3 per year

3) Output : 10,000 panels per shift or 108 m3 plywood per shift

4) Main product : 4' x 8' x 3.6 mm
face/back veneer 0.8 mm
core veneer 2.2 mm

5) Recovery : plywood 50%
green veneer 80%
round ups 20%

6) Pressing time : 4 min per cycle for 3.6 mm ply

7) Raw material : various species of tropical hardwood, mainly meranti, kapur, keruing.
Log diameters are varying, average log diameter 700 mm, max 1500 mm

8) All equipment must be well known, sophisticated and be simple to operate and maintain.

9) Waste wood shall be transported via conveyor system to the boiler house

10) Recovery and quality
A smooth, simple, straight-line flow to minimize handling damage, reduce breakage and to optimize recovery, grade and quality

11) The operation will have the flexibility of producing a range of thicknesses and grades in both moisture resistant (M.R.) and water proof (W.B.P.) plywood

12) Future product development
Blockboard
A natural addition to the plywood plant is a blockboard production unit. This can be easily incorporated in the present layout and will increase the recovery.

Specialty panels
Prefinishing, overlaying and/or grooving, tongue and grooving, shiplapping, etc may have to be added in any diversification programme in the future.

Boiler and Power House

Steam requirements (plywood)

Steam is used for the various drying and heating operations.

plywood drying	23.3 t/h
plywood pressing	2.7 t/h
others	2.0 t/h
Total	28.0 t/h

Power Requirement

The power consumption for the various production line (of a typical integrated complex being expanded) is:

sawmill I		600 kW
sawmill II		600 kW
plywood (3 lines)		2500 kW
office, workshop, hospital etc.		300 kW
housing area:	sawmill I	750 kW
	sawmill II	750 kW
	plywood	600 kW
Total demand		6100 kW

For the generation of electricity to meet with the demands of the factory complex, it is considered that the following equipment will be necessary:

Existing diesel gensets	2900 kW
2 Condensation steam turbines, each 1600 kW	3200 kW
	6100 kW

Since the intention is to utilize the raw material input into the factory complex, by as high a ratio as possible, this proposal investigates into the possibility generating the steam and electricity required, using the available wood waste as fuel.

Output (design) 100%	Plywood 20,000 sheets plywood/day 8' x 4' x 3.6 mm
Output (actual) 80%	Plywood 16,000 sheets plywood/day 8' x 4' x 3.6 mm
Working time	2 shifts of each 8.0 hrs = 16 hrs net working time = 15 hrs
Wood species	Meranti and similar species Initial moisture content 80% Final moisture content 8%

Plywood Line (100%)

log input	=	100%	=	432 m3/day
less wet waste	=	12%	=	52 m3/day
less peeler core (for sawmill)	=	8%	=	34 m3/day
= wet veneer	=	80%	=	346 m3/day
less shrinkage	=	5%	=	22 m3/day
= dry veneer	=	75%	=	324 m3/day
less dry waste	=	10%	=	43 m3/day
= spliced veneer	=	65%	=	281 m3/day
less loss for pressing	=	1%	=	4 m3/day
= pressed plywood	=	64%	=	277 m3/day
less dry waste	=	7%	=	31 m3/day
less sanding dust	=	6%	=	26 m3/day
less rejected plywood	=	1%	=	4 m3/day
= plywood	=	50%	=	216 m3/day

Rotary Lathe

432 m3 logs to be peeled per day : 15 hrs
28.8 m3 logs to be peeled per hour (refer Basic Figures)
to be used:
- 1 pc 5 ft lathe (peeling 20% of blocks)
- 2 pcs 9 ft lathes (peeling 80% of blocks)

average log diameter 0.7 m

$$28.8 \text{ m3/hr} : \frac{0.7 \times 0.7 \times 3.14}{4}$$

= 74.8 lin m/hr x 0.8 (80%)
= 59.9 lin m/hr to be peeled on twc 9' lathes : 2.54 m/block
= 23.6 blocks/hr : 2 lathes
= 11.8 blocks/hr/9' lathe, to be peeled
======================

74.8 lin m/hr x 0.2 (20%)
= 14.9 lin m/hr to be peeled on a 5' lathe : 1.27 m/block
= 11.8 blocks/hr/5' lathe, to be peeled

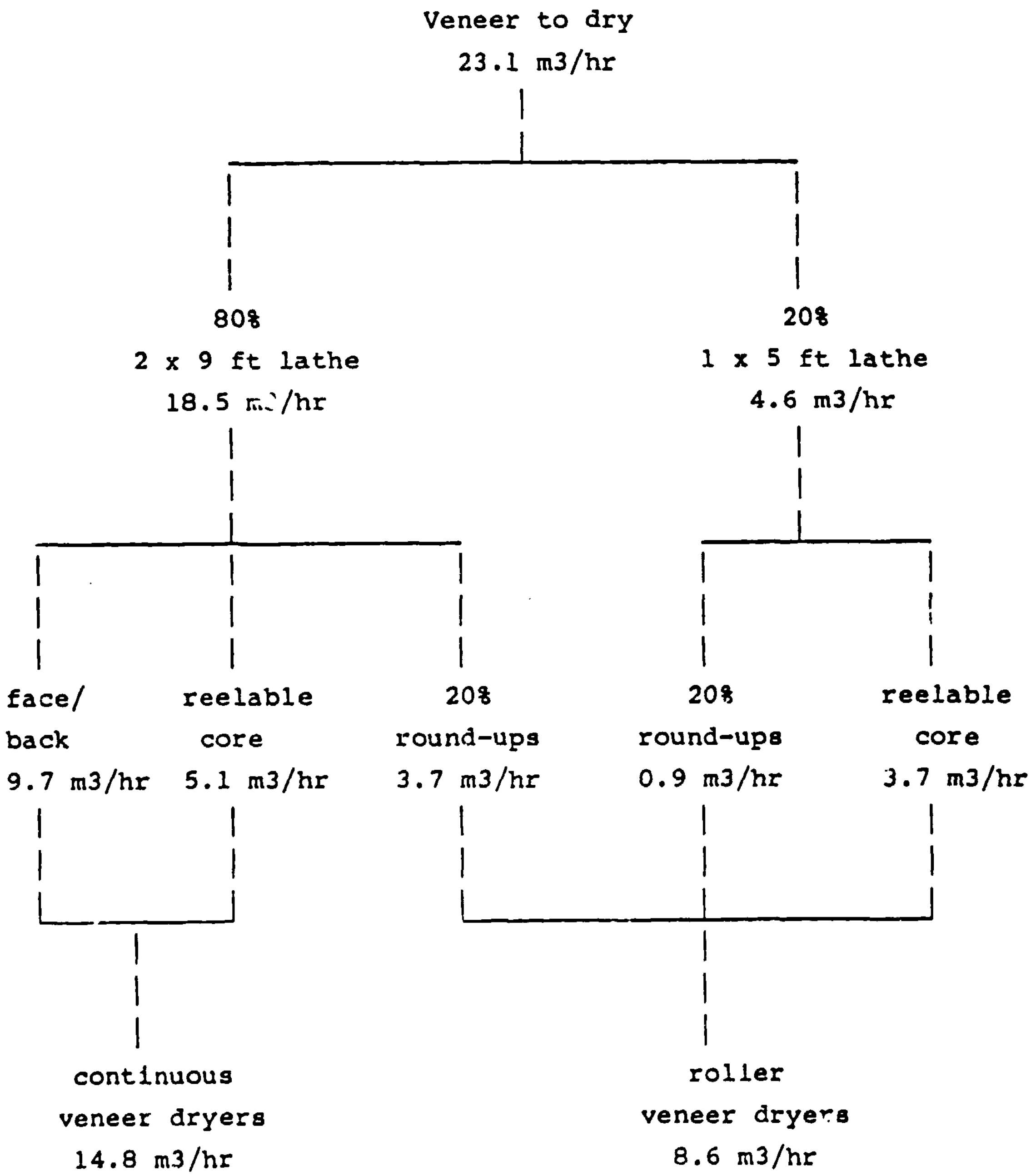
Veneer Dryers

346 m3/day : 15 hrs
23.1 m3/hr to be dried (refer Basic Figures)

3.6 mm plywood = 2 pcs face/back 0.8 mm = 42% = 9.7 m3/hr
+ 1 pc core 2.2 mm = 58% = 13.4 m3/hr

consequently:
- all face/back veneer represents 42% of the veneer to be dried, all in reeled condition.

- all core veneer represents 58% of the veneer to be dried. But only 38% of the core veneer wil be available in reeled conditions because 20% of the total core veneer usually are round-ups.



Roller Dryer

8.6 m3/hr veneer to dry of 2.2 mm thickness
drying time at 550 kg/m3 4.2 min
8.6 m3/hr : 60 min/hr : 0.0022 m veneer thickness
= 65 m2/min x 4.2 min drying time
= 274 m2/min : 13.2 m2 dryer surface (3 decks x 4.4 m)
= 20.7 m : 0.8 (80% cover factor) 25.9 = 26 m heated length

1 roller veneer dryer
heated length 26 m
plus 3 to 4 cooling sections
working width 4.40 m
3 decks
with automatic charger

Continuous Dryer

face/back veneer
9.7 m3/hr to dry of 0.8 mm thickness
drying time at 550 kg/m3 1.0 min
9.7 m3/hr : 60 : 0.0008 m : 2.54 m
= 79.6 lin m/min x 1.0 min : 0.85 cover factor = 93.6 m

core veneer:
5.1 m3/hr : 60 : 0.0022 m : 2.54
= 15.2 lin m/min x 3.8 min : 0.85 = 68.0 m = 161.6 m heated length
= 162 m : 2 decks = 81 m : 3 dryers
= 3 dryers of 28 m heated length

3 continuous veneer dryers
heated length each 28 m
plus 2 to 3 cooling sections
working width 2.80 m
2 decks each

Jointing/Splicing

20,000 sheets/15 hrs design output of plywood mill
this means 20,000 sheets core veneer
+ 40,000 sheets face/back veneer

core veneer:

60% to be spliced of total 20,000 sheets/15 hrs
= 12,000 sheets/15 hrs : 15 hrs
= 800 sheets/hr to be spliced
= core builder capacity = 160 sheets/hr design capacity
= 5 machines required
= machines = 3 x 4' (5') machines
+ 1 x 8' machine (double line)

face/back veneer:

20% of 40,000 sheets/15 hrs to be spliced
= 8,000 sheets/day : 15 hrs
= 533 sheets/hr to be spliced
1 splicer = 120 sheets/hr
= 5 machines required

Pressing

20,000 sheets of plywood to be pressed in 15 hrs =
1,333 sheets/hr =
22.2 sheets/min to be pressed
x 4 min cycle time for pressing 3.6 mm plywood
= 89 openings required

pre-presses and glue spreader required
each one per 15 hot press openings
6 glue spreader 9 ft
6 cold presses downstroke chain feeding
2 hot presses with loader/unloader each 45 openings
1 hot press 15 openings for manual loading/unloading

Sizing

20,000 sheets of plywood to be sized in 15 hrs =
1,333 sheets/hr or 22.2 sheets/min.

The infeed speed into the sizing line with 1/2 sheet space between the sheets will therefore be:
22.2 sheets/min x 2.54 m x 1.5 = 85 m/min
1 set double saw 4 ft and 8 ft with cross transfer

Sanding

20,000 sheets of plywood to be sanded in 15 hrs =
1,333 sheets/hr or 22.2 sheets/min.

The through-feed speed into the sanders without space between the sheets will therefore be:
22.2 sheets/min x 2.54 m/sheet
= 56.5 m/min

1 wide belt bottom sander
1 wide belt 3-head top sander with
  1 roller head
  2 cushion heads

Based on the detailed balancing just done, it is now possible to identify the machines that are needed.

3.3. Log Storage and Transport

Log handling usually starts with the delivery of the logs at the factory site. Such a delivery might be effected by boat with unloading from the vessel directly into the company's own log pond, and/or also by means of trucks or railway carriages, carrying the logs directly into the factory area and unloading it at the log yard or log pond.

Storage of the logs at the factory site is mainly dependant on the local conditions. Wherever it is possible in tropical countries, the logs will be stored in a log pond, which might also be a fenced part of the sea or of a river. The reason for such a storage of the logs in a log pond is mainly for green peeling, which means that the logs will be taken out of the log pond directly into the rotary lathe for the peeling operation.

Wherever such a natural log pond is not available or an artificial log pond might be too expensive, logs will be stored in the log yard. This is also the case for sinker logs.

Handling of the logs in the log pond and at the log yard usually starts with grading, which means that the logs after the unloading will be selected and graded according to further production requirements. From the storage area, the graded logs will then be brought by means of cranes, conveyors or sometimes manually to a cross cut saw, where the log ends will be cut away and where the logs will be cut to the required size for further operation. Bucking of the logs by means of a portable chain saw will be wasting of material, because the cut will never be rectangular. It is, therefore, advisable to install a stationery chain saw for the bucking process. Whenever conveyor lines for the log might be too expensive or too sophisticated, the logs should at least be carried on a railway carriage with V-shaped layers, whereby again it is decisive that the stationery chain saw installed is perfectly rectangular to the railway line.

An important part of the log handling before operation is also the debarking process. Whenever labour is cheap, debarking might be much more economical if done manually with simple debarking irons, whereas countries with higher costs for labour will prefer to install,conveyors and a mechanical debarking system. Small diameter logs will usually be sent through rotary debarkers, while large diameter logs will be debarked in machines rotating the log underneath of a travelling debarking head. Further transportation of the logs to the peeling operation can be either manual or mechanical. Operating on small log diameters requires a large number of logs to be handled per hour. For quantity reason such plywood factories will usually have a fully mechanized system for the log handling, including cutting to size and debarking, while only lower costs will decide whether large diameter logs will be handled in a mechanized system or not.

3.4. Steaming

Experience has shown that the structure of the logs must be relatively soft for a smooth peeling operation and good veneer surface results.

In countries where logs are available within a very short period of time after felling in the forest, the structure of the timber is usually still so full of water and so soft that peeling can be effected without any previous treatment.

Whenever however, logs are transported over long distances and whenever such logs are stored in the open air without being watered or without being in the water, it will often be necessary to consider steaming.

The same applies to very hard timber species where the steaming will result in the softening of the wood structure.

Actually, it is not so much the water alone which accounts for the softening of the logs but moisture and heat application together provides for this result

For tropical hardwoods, steaming will only apply for extremely hard species or wherever peeling of fresh logs or of logs which have been stored in the water is not possible.

3.5. Peeling

Particularly in this section of the production flow, it is decisive to select the machines and the production system in accordance with the diameter of the logs generally available. To keep the capital costs low it is necessary to have a certain high output which implies only small changes in the number of logs to be peeled per hour. On the extreme small diameters, such as in Finland or the Southern Pine plywood industry in the United States, it is necessary to peel as may as 200 to 300 pieces of logs per hour to get the necessary output figure, whereas in factories operating on tropical timber, it might be acceptable to peel only 6 to 8 pieces of logs per hour. A good figure here is the peeling of 10 - 12 pieces of logs per hour.

When operating on logs with large diameters, the machinery selected for peeling and drying is usually different. Logs might also be brought to the rotary lathe on conveyors and might also be mechanically centered and charged into the machine. However, it is not obligatory to do so. Sometimes, simple hoists are being used to carry the logs near to the machine. At this position the centering will be done manually by simple measuring of the diameter cross-wise and marking the center point. Loading onto the machine will then be realised by the same hoist. The operators are responsible for the centralised clamping of the log in the machine. Naturally, such operation takes more time. For this reason, the rotary lathe equipped with a centering and charging device will be producing approximately 40% more veneer than a machine that is charged and centered manually. The rotary lathe itself should preferably be also equipped with telescopic spindles, to allow for smaller diameters of residue peeler cores. Modern machines are working fast (up to 300 rpm). High powered variable speed drives enable optimum cutting speed according to log and veneer qualities.

Many plywood factories have a chain conveyor in front of the rotary lathe for the removal of the peeler cores and a waste conveyor after the rotary lathe for the removal of the peeling waste.

3.6. Reeling

When operating on large diameter logs, the veneer ribbon is much longer than that from smaller diameter logs. In such a case, the veneer ribbon being peeled off one log with 1 m diameter might be several hundred meters long. On such long veneer ribbons it is absolutely not practical to have a tray system in operation, because such a tray might mean a tremendous requirement in length. For this reason, the reeling system has been developed and particularly for thin veneer it is obligatory to use a fully synchronized one. In this case, the speed of the declining circumference of the rotating log will be electrically or electronically determined and will be synchronized to the surface speed of the growing circumference of the reeling bobbin. This process is fully automatic and the lathe operator has usually only one additional handle to control the reeling operation by just arranging for negative or positive adjustment of the synchronization.

3.7. Round-Ups

The round-ups are generally a problem in this system, because they cannot be reeled (without very expensive and very specialised equipment) and must be taken out of the line. This is done either manually, or by installing a rubber cross conveyor to carry the round-ups away from the production line to a carriage or conveyor from where the round-ups will be fed into the round-up clippers. Such round-up clippers operate usually automatically with photo-cell detecting and cutting out the defects.

3.8. Drying

Drying of veneer, which is peeled from large diameter logs can either be done continuously or in a roller dryer.

In the continuous drying system the veneer will be stored in reeled condition in the reeling magazine until it is brought to the unreeling station. A synchronizing device at the unreeling system must provide for sufficient but not too much veneer to be sent into the continuous veneer dryer. The veneer will then be dried as a ribbon and the design of the dryer must provide the veneer with sufficient possibility for shrinkage without any cracking or splitting. The veneer ribbon will then be sent to the clipper where defects will be cut out and the veneer will be cut to the required size. Usually a conveyor is installed directly after the clipper. From this conveyor, veneer will be graded and stacked according to quality and size. This system of continuous veneer drying provides the advantage of saving some 3 to 6 % of material, because no allowance for an uncertain shrinkage must be given to any precut veneer sheet. Instead, the veneer will first shrink in the veneer dryer and cutting after drying can be done very precisely, just considering a minimum of oversize for further production.

Operating a roller dryer also requires a reeling storage where reeled veneer will be stored for a certain period. Usually, this storage is much smaller, because cutting of the veneer in green condition can be done without consideration of thin or thick veneer (for either face and back or core), whereby the different veneer thicknesses will just be stacked on different veneer stacks. In the continuous veneer drying operation, however, it is necessary to provide sufficient veneer reeling storage. When changing the veneer thickness the drying time will be different and such a change always requires that the dryer must first be emptied before the change can be done. This again represents a considerable loss of time, if it is done every hour. For this reason, the continuous veneer drying system usually requires a large reeling rack; this is particularly important for feeding the continuous dryer with uniform veneer over longer period of time, even if species and veneer thicknesses differ or if the continuous dryer operates on three shifts but peeling only on two shifts. Also, these dryers are usually equipped with more than one deck with independent drives making it possible to utilize one deck for thin face and another deck for thick core veneer.

Reverting again to the so-called 'wet clipping system', the veneer will also be brought to an unreeling station, which, however, requires no synchronization system, but just a simple drive. The veneer ribbon will be sent through a green clipper where defects will be cut out and good veneer will be cut to the required size. This veneer must be given a considerable shrinkage allowance, which might be unncessary. Practice has shown that the shrinkage factor for a certain veneer species theoretically is a fixed figure. However, this does not apply in practice. In such an operation, it depends very much on the initial and final moisture content that is present as well as in a number of other drying conditions. According to such conditions, the shrinkage of the same species and veneer thickness might vary considerably between, for example, 6 and 12 %. In such a case, as can easily be demonstrated at any dryer, it is necessary to give the green veneer sheet generally the maximum allowance of 12% for shrinkage. The dry veneer will, however, show that actual shrinkage only sometimes was as high as 12% but in other cases as low as only 6%. Consequently, considerable quantities of material are wasted. This, hence, demonstrates the economical advantage of the continuous veneer drying system.

It is, however, not always possible to install exclusively, continuous veneer dryers. Roller dryers provide more flexibility and can also dry those round-ups cut to size in green condition and representing some 20% of the total veneer. For the reason of providing sufficient flexibility to a plywood mill, practice has shown that it is most advantageous to combine both systems in a way that a certain part of the veneer will be dried in a continuous dryer and all the rest passing through a roller dryer for those mills with a sufficiently large capacity. Smaller mills prefer just one roller dryer because it is more flexible.

Continuous and roller dryers are commonly jet dryers, using high velocity, high temperature air nozzles.

3.9. Jointing and Splicing

Before describing jointing and splicing practice, it must be mentioned that certain production systems allow for an operation without cutting away any defects. In the United States, quality requirement for soft wood constructional plywood are so low that only full size veneer sheets will be cut and the best of them will be used for face. In Japan, importers select their logs so carefully that, some factories using the highest quality range are getting logs with such a low percentage of defects that rotating clippers, installed after high speed continuous driers, cut equal size veneer sheets and those with acceptable defects will be used for back veneer while those without defects will represent the face veneer quality.

Usually, however, cutting out of defects is required and this results in a jointing and splicing section. This is the section of the production, where all veneer, which has not been produced in full size, will be handled. The operation of this section and the equipment being used will very much depend on quantity and quality requirements of the production, but in the same range also as the quality of the raw material.

In a simple operation, these veneer strips are neither jointed nor spliced together, but will usually be sent through the glue spreader in the small form and will just be laid together at the setting stack until the full width of the required size is reached. Any oversize will then not be cut, but simply torn away. Such a production usually also allows for patching of the core veneer, which saves cutting into smaller strips and keeps full size veneer sheets together, just patching out the defects.

When it comes to higher quality requirements, jointing and splicing of the veneer strips will be necessary. The same is required, if it comes to high production figures, not allowing for the time required for setting of unspliced core veneer.

The jointing of the veneer strips is done on travelling head jointers, on jointing machines, where the head is stationery and the veneer travels overhead of it, and on simple guillotines. Some of these machines provide also the glue application in one operation, while others require glue application afterwards.

For the splicing also, a wide range of machines is available. The old taping machines, has now been mainly replaced by zig-zag or spot glue splicers. All these splicing machines operate in the direction of the fibre. Also, splicers providing a close glue splicing of the veneer sheets are available and proving to be very successful in operation. These also operate in the direction of the fibre.

There are also cross feed splicers in the market, whereby the glue curing is either done in a pressing operation or during the passage of the veneer through the machine under a certain feeding pressure in connection with heat supply. Also, hot melt glue is used in cross feed splicers without heat application. All these cross feed splicers are equipped with clippers cutting the endless veneer ribbons into veneer sheets of the required size, with most including auto stackers.

Under simple conditions and particularly, where the labour costs are low, it is naturally possible to do the splicing operation manually by means of manual tape application. In some factories hardening of the glue will be assisted by the usage of electric irons.

In Japan, a type of machine has been developed and operates in many South East Asian mills, combining guillotining, spot glueing or spot taping and cutting to size in one operation. This system is very advantageous with respect to the requirement of labour, but it has the disadvantage that it does not provide a glue line between the veneer sheets, which is definitely required for certain plywood qualities.

3.10. Quality Control, Repairs and Setting

At the end of this section all veneer is available in full size as it is required for further processing. Usually this section also includes a careful repairing of the veneer sheets and the grading and setting. In the grading operation not only face and back qualities will be separated, but also the different qualities according to the grading rules. In the setting operation, it is quite common to have one face and one back veneer always laid together for the easier setting of the veneer stack after the glue spreader. This applies, however, mainly in such factories where pre-pressing is in use.

3.11. Glue and Glue Mixing

At this point, it must be considered whether powdered or liquid glue will be available for the operation. In the case of powdered glue, it will first be necessary to have a glue mixing device available where powdered glue can be mixed with water to bring it back to the original liquid glue condition. Where liquid glue is being used, this step of the operation is of course not necessary.

In any case, the glue manufacturer will give a formula of exactly how many parts of glue are to be mixed with how many parts of hardener, how many parts of water and how many parts of hardener.

The percentage of hardener will very much depend on the characteristics of the glue and hardener and thus has to be given by the manufacturer.

The water content will also be given by the manufacturer of the glue because this depends on how many parts or what percentage of solid resin are in the liquid glue mix existing already.

To save glue, extender is widely used and here, the glue manufacturer will rarely give any recommendation. Usually, it is a secretly treated percentage used by the individual plywood factories which has proven to them as being just right. The quantity of extender to be added to the glue mix is also very much dependant on the kind of extender being used, that means whether it is tapioca or any other flour grain.

3.12. Glue Spreading and Lay Up Systems

After the veneer have been carefully prepared and repaired, there are usually different stacks of veneer available for the transport to the glue spreader. One kind is the mixed setting of face/back veneers in one stack, another kind is the setting of full size cross band core veneers and for the production of thicker plywood also some long band core veneer stacks are required.

All these stacks will be brought to the glue spreader, while usually the cross band core veneer will be placed in front of the glue spreader and the face/back veneer stacks will be placed underneath of the disc roller conveyor of the glue spreader.

The operation goes then in a way that one operator will feed sheet by sheet of the cross band core veneer into a 9' wide glue spreader at which glue will be applied on both sides of the veneer surfaces To avoid too much damage of the glue application line on the lower side of the veneer, the veneer will be transported out of the glue spreader over disc rollers and will then be falling on the setting stack.

On this new stack, always one face veneer will be applied before the core veneer falls on coming from the disc roller conveyor and before two sheets of veneer (the back veneer + the face for the next plywood sheet) will be laid up together on top of the glued core veneer. The same sequence will follow continuously and very fast and makes it possible that after a short period of time, the stack of lay-up veneer will be available with a height of usually 60 cm up to 1 m. Such a stack of lay-up veneer is then ready for sending to the cold press.

There are lay-up systems already in use and available. The field operation for such lay-up systems where almost no manpower is required for the lay-up process is mainly regarded as being necessary for countries with high labour costs or labour shortage.

3.13. Quality Control and Repairs

After these stacks of lay-up veneer have been sent to the pre-press and emerging from the pre-press, there is usually an operation of quality control and repairs, if it is very thin plywood that is being manufactured. If very thin plywood is being manufactured it is also necessary to use vey thin core veneer and this may tend to over-lapping underneath of the face veneer. It is then unfortunately, necessary to cut the face veneer open and to cut away a little piece of the over-lapped veneer to get it to join properly again. The face veneer must then be closed again before the sheet goes into the hot press. As mentioned before, this kind of quality control and repair arrangement applies mainly to very thin plywood production such as for door skins.

3.14. Pressing

The pressing section usually begins with the glue spreader, where the core veneer is sent through and is glued on both sides. Other forms of glue application are used only in connection with automatic lay-up devices. This is still relatively unknown in developing countries because of the required production flexibility.

Depending on the production method, sometimes the plywood will then be laid together in single sheets but that means only the number of layers which are required for one plywood sheet that will be laid together. This method is mainly used where pre-pressing is not yet existing and where coils or tablets are still used for loading the hot press.

In modern operations, however, it is common to set veneer stacks of a height up to 1 m after the glue spreader, whereby always one face, one core and one back veneer are set on top of each other and always one sheet following the next until the stack height is reached. Such a set stack will then be taken via a roller conveyor into the cold press, where it will remain for some 12 to 15 minutes time for pre-pressing. Such a pre-pressing does not shorten the final pressing time and a technological effect can hardly be shown. However, it is mainly used to allow the veneer sheets to stick together and to allow easier handling when loading the hot press. This applies both for manual loading of the hot press as well as for automatic loading equipment.

Between the cold press and the hot pressing operation, usually quality control is effected to repair any possible overlapping which may have occurred during the pre-pressing operation. This is another advantage of pre-pressing because this overlapping may not be repairable after the hot press.

Practice has shown that hot presses up to 15 openings can be loaded and unloaded manually relatively fast, so it is not necessary to have any automatic equipment for them. Also from the economical point of view it is not advisable to have an automatic loading and unloading device for such hot presses because this equipment might nearly cost as much as a second hot press and might improve the cycle time by not more than just 20 to 30%.

Factories with high production having small fluctuations in thicknesses, sizes, and species usually install hot presses with more than 15 openings and automatic loading and unloading equipment. Pricewise, a hot press with 30 openings will not cost very much more than one with just 20 openings.

Usually only one sheet of plywood is loaded into one opening of the hot press, but there exist presses where plywood will be manufactured in double-size or where two sheets of plywood will be loaded into one opening, either one besides the other or one on top of the other.

There are also single opening hot presses available particularly for larger size of plywood. The largest of these single opening hot presses for plywood in Australia for many long years and produces a final plywood size of 50' x 9'. Otherwise, single opening hot presses are mainly in use for laminating of plywood or blockboard with fancy veneer or melamin paper.

3.15. Sizing

In the ordinary operation, the plywood is stacked after the hot press before being sent to sizing and sanding operations. Such a stacking and any further storage of the pressed plywood is not technologically required, but is mainly advisable if the range of sizes and thicknesses is large and the machines for sizing and sanding must be adjusted continuously. In such a case, it is better to collect a larger number of plywood stacks of the same size and thickness before sending them for the sizing and sanding operation.

In mass production factories however, the plywood is sent nonstop from the hot press to the sizing machine and to sanding and grading afterwards. Also, so-called cooling wheels, where the plywood sheets have been turned 180 degrees in a large wheel while being blown with fresh air, have proved unnecessary and have mostly been disassembled again.

3.16. Quality Control and Repairs

Usually after sizing, the plywood will be controlled for quality and these defects will be repaired before the plywood is sent through to the sanding operation.

In factories where the sizing line and the sanding line are not linked together this is simply done by checking through the stack sheet by sheet and restacking the plywood after repair again.

In a mechanised production however, it will be necessary to take some other precautionary measures. The distance between the cross sizing double saw and the cross transfer station to the sanding machine must be longer than usual. At this section, people will be placed to control the plywood from top and bottom. The latter control is nomally done by means of large mirrors and light to show the lower surface of the plywood very clearly.

Any sheets with defects will then be marked and taken out of the line by means of a pinch roller down to a stack.

After repair, these plywood stacks will be placed in front of the sanding line where an infeed is provided for. The same infeed is also being used if there is a change of paper at the sanding machine and temporarily, plywood coming from the sizing machines must be stacked.

3.17. Sanding

Sanding operation is different for different markets and wood species. On Asia's mass production plywood factories, for example, it is very common to operate with one bottom wide belt sander for calibrating the plywood and providing a rough sanding at the plywood back. Here usually an 80 grid sanding paper is used. The second sanding machine is then a 3-head top wide belt sander.

The first head usually is a contact roller with an 80 grid sanding paper. The second and the third heads are usually equipped with cushions and the paper is 150 and 250 grid.

From a technological point of view, of such an operation, the bottom sander provides for the main calibrating, while the first top head also gives a certain calibrating effect. The second and the third top heads, however, provide only polishing of the plywood surface.

3.18. Sorting, Repairs and Grading

The end of the production line is mostly seen with grading of the plywood and repair of any defects. Quality control in this section is most important, because right after this operation the plywood will be stacked and packed for delivery.

3.19. Packing

The packing of plywood will naturally depend on the distance the final products are to be transported. If plywood is manufactured for export purpose, it is common that the peeler cores will be cut into planks and those planks will be used to cover the edges of plywood stacks. Top and bottom are usually taken from thicker panels of very low grade so that the whole stack will become solid packets. These packets will then still be wrapped and marked and after that the plywood is ready for shipment.

3.20. Overlay Plywood

For special purpose, all kinds and thicknesses of tropical hardwood plywood may be overlayed with either veneer or different kinds of paper overlays. Usually this overlay process is done in a secondary process step and in a smaller hot press. Single opening hot presses for this purpose are slowly being introduced into the South East Asian markets, but they are already very commonly used in Europe.

Generally, it can be said that for the overlay process, neither heavy duty presses nor any special systems must be provided excepting for the normal spreader an area in the infeed line where the overlay can be assembled. Only when overlaying with real melamine paper, are special measures necessary, such as a very high specific pressure and a recooling system after the hot platen has been fully heated. But this system has become so complicated and costly that in most of the cases, it is not being used.

3.21. Large Size Plywood and Scarf Jointing

To my knowledge there is only one facotry in the world which produces large size plywood assembled out of large size veneer sheets. This factory is located in Sydney, Australia and it has been producing this type of plywood for the past 30 years.

All other factories producing large size plywood usually use scarf jointing for the assembly of several smaller sheets to build a big sheet of plywood. For scalf jointing the edges of the plywood to be assembled are first scarved and on one scarved edge glue will be applied. Then the sheets will be assembled together and brought into a scarf jointing press - which is mainly a heated pressing bar - for the glue curing.

3.22. Cutting to Size

If plywood is not being delivered in standard sizes and especially if it is going into a furniture production, it might become necessary to cut the sheets to size. For this operation, several machines are available whereby some of them are simple, double circular saws while more sophisticated ones are consisting of a table on which several sheets of plywood will be laid and which will then be pushed manually or driven by a motor through a series of circular saws for the lengthwise cutting. Usually for the crosswise cutting, a gantry saw is installed and the moving table will be stopped when the gantry saw is in operation.

This kind of saw is available with entirely manual adjustment and it is also on the market in a very sophisticated type in which all of the cutting operations can be pre-set and are then controlled by a mini-computer.

4. SOFTWOOD PLYWOOD

The significant differences between the utilisation of softwood or tropical hardwood for the production of plywood are the following :

- the utilisation of logs which usually have a much smaller diameter and
- the fact that softwood plywood is usually produced in greater thickness than tropical hardwood plywood and
- due to the fact that softwood has usually many knots the quality requirements on the finished products are much lower than on plywood made from tropical hardwood which is mainly used for decoration purpose.

When considering the first item, it is obvious that to get a substantial output from a softwood plywood factory, a much greater number of logs have to be sent to the rotary lathe for peeling.

To compare input figures, we have used the same figures as was used at the tropical hardwood plywood case study. This input figure was 432m3 per day. 40% of this input is going to one 9 ft lathe which means that this machine will have a daily input of 172.8 m3 per day.

On 0.7 m diameter and 2.54 m block length (100"), the number of blocks to be peeled on one machine is 177 blocks per day or 11.8 blocks per hour. This again means that the machine will be used for peeling of one block over a period of 5.1 minutes or 301 seconds.

When trying to operate a plywood mill on the same input but for logs which have never reached diameter of 0.25 m only and 2.54 m block length, the number of blocks to be peeled per day is 1,386 or 92.4 blocks per hour. This again means that one machine will be used for the peeling of one block for the period of only 39 seconds.

Consequently, the whole system must be arranged in a different way because if it takes between 30 and 60 seconds on a big rotary lathe only to bring in the new block for peeling, this has to be done on a machine for smaller diameter logs of the order of 5 to 10 seconds maximum.

This comparison still only considers input figures. If output figures should be equal the number of blocks to be peeled per hour is still going to be considerably higher because softwood plywood unfortunately cannot be produced on the same recovery rate as plywood from tropical hardwood. Here the recovery rate is usually around 50% while figures for softwood plywood vary between 30 and 40% only.

The second significant difference is the different composition of the plywood for thicker panels. While the majority of plywood made from tropical hardwoods is made in 3.6 or 4 mm thickness and is composed of 0.8 or 1 mm face/back veneer and usually 2.2 mm core veneer, the composition of thicker panels made from softwood plywood is very different. Here, it is usually common to operate on possibly one or maximum two veneers thicknesses only and to compose plywood out of them.

Due to the fact of thicker veneer, the peeling proceeds faster and the length of a veneer ribbon is much shorter.

The last significant difference is the lower quality of the material which also results in lower quality requirements on the products. This is also a fact which will influence the whole operation and we will try to get a better understanding when getting to the different points again.

4.1. Balancing of Capacities

The way to balance the capacities is basically the same as for tropical hardwood plywood. While the capacity of a plywood line for tropical hardwood plywood will usually be based on the peeling capacity of one machine which is somewhere between 10 and 12 blocks per hour, the capacity consideration on softwood plywood are somewhere in the range of peeling 1.5 to 2 blocks per minute on a rotary lathe for producing softwood plywood. The other items of the balancing procedure are very much the same as before.

4.2. Log Storage and Transport

In Finland, most of the logs are being kept in lakes or branches of the Baltic Sea and the storage in the water goes to the extent that even portions of the water will be heated in order to keep it free from ice, thus enabling water storage. When working this way, it is again not necessary to use steaming or boiling of the material.

But usually it is necessary to have the logs stored on the factory ground and to have a smooth operation, it is very useful to have a sorting and grading of the logs in the logyard whereby different species and roughly different diameters will be stored together.

Since a great number of logs must be handled per hour, any handling by means of overhead hoist or forklift is considered to be impossible and very heavy duty and fast operating equipment must be used. This refers also to the cross cut saw because if the peeler have time for the peeling of one block with only 39 seconds, it means that within this 39 seconds, two cuts at the cross cut saw must be done to get the block cut to size. Therefore, usually a fast operating conveyor system is needed to handle the logs at the logyard.

4.3. Steaming or Boiling

As mentioned before, it is necessary to consider steaming or boiling operation for those logs that are stored in the logyard. In Europe, people prefer to boil softwood before it is peeled, while in North America, steaming is widely used before peeling.

The period of time involved for boiling or steaming is not only depending on the diameter of the logs but also on the degree of softening which is required for the operation. Even though there is literature available for steaming and boiling, the way steaming and boiling are done is still different in different mills and depends very much on the experience of the foreman or the manager. While many mills operate on a 24 hour steaming or boiling time for softwood, others strongly believe that if must be at least 72 hours where the logs are staying in the water or in the steaming chamber.

For boiling, usually boiling pits are in operation, while for steaming both pits and chambers are used. The secret of this boiling or steaming procedure is usually to keep the doors or covers steam tight to avoid dissipation of steam as well as to secure a very good insulation of the walls and bottom.

Wherever steaming is considered necessary, it has been proven that the indirect steaming operation is better than blowing steam directly into the pit or the chamber. With indirect steaming operation, there are water beds where the water level is kept constant and where heating coils make the water boil constantly. The advantage here is mainly in the use of untreated water whereas for direct steaming, a large water treatment plant is required and treated water is then being used for the steaming operation.

4.4. Centering and Charging

Due to the high number of blocks to be peeled per hour, it is necessary to also have a very quick centering and charging system available. Latest developments have secured centering systems which work independently of operators influence and which center the logs mechanically from 3 or 4 points.

The charging of the blocks into the machine is usually done on a pendulum system because the horizontal move in, move out system as is used for larger diameter logs is much too slow.

On very fast operation being used in North America, it is quite common that the spindle of the rotary lathe will not be stopped for the exchange of the peeler block but will only be retreated to allow the peeler core to fall out and will be closed again once the new block is in, for immedaite rotation.

4.5 Peeling

The peeling operation must also be very fast but this is usually not the problem in the whole line, as the problem is more in the infeed and outfeed system of the peeling machine.

Due to the fact that mostly only one veneer thickness is used, there is no change of veneer thickness necessary and this also makes fast operation of the lathe possible.

4.6. Tray Systems or Reeling

Due to the fast operation, the quick change of logs and the short length of the veneer ribbon, the reeling system is practically ruled out in the production of sofrwood plywooa.

Tray systems may have 3, 4 or 6 (or even more) decks and are fed via a tipple system. Such a tipple usually covers 3 decks and if a 6 deck tray is existing or considered then a so-called double tray system must be installed where the first tray covers the entrance of two 3 deck tipple systems. On the outgoing side, there is the same tipple system existing again, where, the veneer will then be fed inco either a green clipper or into a continuous veneer dryer. Such continuous veneer dryers may have 2 or 3 decks and if there is a 6 deck tray system, then always two tray decks will feed 1 dryer deck.

4.7. Round-Ups

While round-ups need a very special handling system in the operation for tropical hardwood plywood, they do not represent special problems in the softwood plywood operation. Due to the fact that a reeling system is out and the tray system is used, those round-ups will usually feed together with the other veneer right into the tray and will be cut to size either on a green clipper or after the continuous dryer.

4.8. Drying

It was already mentioned that both roller dryer and continuous veneer dryer can be used. The drying is easier again since there is not too much consideration of different veneer thicknesses, and a continuous dryer can be brought and installed according to the exact capacity of the rotary lathe and it will give a through-going production line this way.

Whenever dry clipping is decided as being the most effective, then the intermediate storage is between the green clipping and the dryer infeed. Also in this case, the drying does not represent any specific problem.

Drying of softwood veneer has proven to be not difficult and also very high temperature can be used in order to achieve short drying times. In North America, many of the veneer dryers are directly heated by gas or oil and drying temperatures can reach 300 °C.

4.9. Clipping

The clippers being used in the softwood plywood operation are practically all in line, that means either at green clippers after the tray system or at dry clippers after the continuous veneer dryer. These clippers must be quite strong because softwood veneer with 2 or 3 mm thickness sometimes can require some hard clipping operation.

4.10. Jointing and Splicing

Due to the fact that softwood plywood is mainly composed out of equal veneer thicknesses and that the quality requirements are much lower than on the thinner plywood made from tropical hardwoods, the jointing and splicing operation in a softwood plywood line is either not existing or is a very small department only.

Usually, all the veneer strips will not be jointed and spliced together while being used for the core layers of the plywood. These are just put one by one through the glue spreader and then layed up, one beside the other. For the inner core layer, this way of operation is quite sufficient even though it is very labour intensive.

4.11. Quality Control and Repairs

This department in the factory is usually also only restricted to grading between better veneer which can be used for faces and the worst quality which are either used for cores or for backs. Major repairs are usually not done.

4.12. Veneer Grading

As mentioned in the paragraph before, veneer grading is practically reduced to separating the better sheets and utilising them for face and back, and keeping the lower quality ones for core.

4.13. Glue and Glue Mixing

Here, no difference is to be made between the production of plywood from tropical hardwood or softwood except that softwood plywood very often is being made using phenolic resin. For the utilisation of phenolic resin, the veneer moisture content must be lower and to secure the exact bonding, a higher pressure and temperature must be available.

4.14. Glue Spreading or Spraying

Basically, there is no difference between the operation on softwood plywood and tropical hardwood plywood. On the glue spreader smaller strips have often to be sent through the glue spreader and assembled in to a core layer after the glue spreader because fewer jointing and splicing operations are needed.

Wherever, however, lay-up systems are in use, glue spraying is quite common due to the better distribution also on buckled veneer.

4.15. Lay-Up Systems

Softwood plywood is mainly produced in North America and Finland and since both countries have high labour costs, lay-up systems have been developed. They basically work the same way as if being used for tropical hardwood plywood and feed veneer sheets from stacks holding face veneer only, such one holding back veneer only, such one holding cross band core and others holding no band core together in a proper sequence. Some of the systems use glue spreaders while others are equipped with glue spraying or curtain coating machines.

4.16. Pressing

For pressing operation and especially for planning the pressing operation, the longer cycle time must seriously be considered. Otherwise, the problems are very much the same as for making of plywood from tropical hardwood.

Because of the longer pressing cycles used in North America, hot presses accommodating double sized sheets are quite common.

4.17. Sizing

Also here, no specific problems have to be considered and basically the same machines are used as for production of other plywood.

4.18. Sanding

Since quality requirements are much lower, many of the softwood plywood operations do not have any sanding operation. And even if sanding is being done, it is usually not done for smoothening the surface but mainly for calibrating purposes and only one or two heads with rollers might be used for this calibrating purpose.

4.19. Sorting, Repairs and Grading

This section is also very much depending on the quality requirements for the final products and for certain products, neither sorting nor repairs or grading are to be considered altogether. However, when making a plywood for container boards or concrete shuttering, a smooth surface is necessary and this will definitely need sorting and grading and repairs up to a certain extent.

4.20. Packing

Usually, softwood plywood is manufactured for consumption in surrounding areas and in most of these cases, packing will therefore not be required. However, when softwood plywood is to be exported, then the same packing requirements as mentioned for the other plywood manufacturing, will be required.

4.21. Overlaid or Laminated Plywood

This paragraph is very important for softwood plywood production because quite a large percentage of this kind of plywood goes into the market for concrete shuttering boards or container boards. Both kinds of boards need a close surface and will not only have to be bonded by phenolic glue but also a phenolic glue overlay may be necessary. Sometimes, the overlay is replaced by lamination with phenolic paper glue.

If softwood plywood is being used for outside purposes, the similar requirements may have to be fulfilled, that means also then the bonding must be weather proof by means of phenolic glue and any overlay or lamination must protect the surface.

4.22. Large Size Plywood and Scarf Jointing

Here, the same refers to softwood plywood as to tropical hardwood plywood. Large size plywood wherever it is needed, is mainly being made by means of scarf jointing and cutting to size afterwards.

4.23. Cutting to Size

This will very seldom happen to softwood plywood since this kind of plywood is rarely going into furniture production, but is mainly used for building and construction purposes.

5. HARDWOOD PLYWOOD (TEMPERATE ZONE HARDWOODS)

In Europe and North America, there is also hardwood plywood (temperate zone hardwoods) made from local hardwood species. These species are usually not available in large diameters but have the same small diameters. Nevertheless, the production system is slightly different again from ooth the systems described before, though these differences are not so significant as to warrant investigation into each single step of the production again.

Usually, the fact that the diameters are small, similar machinery is being used as for making softwood plywood. Since the material is harder however, the operational speed is never so fast and the quantity of production is therefore, lower.

Specific items will be the drying process because a greater attention must be paid to the various species and the drying characteristics of these species. Usually, it is very necessary to make arrangements for a wide rnage of drying times to be used and these drying times may exceed the one to then range.

Also clipping must be carefully considered and it is useful to have clippers available with a wider daylight because some of the hardwood veneer will leave the dryer quite battered and thus will need a wider daylight when passing through a dry clipper for example.

For the production of hardwood plywood, both reeling systems and tray systems are in use and it is very often an individual preference as to which will be given priority.

Round-ups handling is important since due to the uneven shape of these trees and logs, there is usually quite a great quantity of round-ups available and they will represent a considerable amount of the raw material value.

Due to the many defects in such hardwood logs, jointing and splicing is one of the most important department in the whole operation and considerable attention must be given to the choice of machinery here. Whenever the products are intended for decorative purposes, Japanese machines can be widely used; whenever hardwood plywood is made as a kind of constructional or even technical plywood, a spot glued splicing might well not be sufficient, but a through-going glue line at the splicing might be required. Such machines are mainly coming from Europe and some of them from the United States.

Quality control will play an important role whenever technical plywood is produced from local hardwoods.

The rest of the production is not very different to the systems described before and no special mention need be made.

6. SLICED VENEER

It must be understood that the production of sliced veneer is entirely different when compared to plywood production and peeled veneer. Sliced veneer is produced for decorative purposes only and due to the fact that in addition to the very expensive raw material and the highly priced final products, it is necessary to have machines operating which pay great attention to the quality of the process and quality of the products thus produced.

6.1. Balancing of Capacities

The greatest difference in the balancing of capacities is between the four different processes that are available in this field viz

- vertical slicing

- horizontal slicing with European machines
- horizontal slicing with Japanese machines
- slicing in grain direction

The slicing machine is the only machine that is decisive for the output of the whole factory. Therefore, the different machines must be considered before deciding which system to approach and use.

Vertical Slicing

Machines for vertical slicing are always considered for high production. The machines will operate on 60 to 100 cuts per minute, which means that the same number of veneer sheet is being produced every minute. For the balancing of machine output, about 1/3 of the nominal capacity can be considered because 2/3 of the required time will be used for changing flitches, regrinding the knife, changing the knife, turning the flitches and many other reasons. Thus the actual capacity of such a line can be considered somewhere 20 to 24 cuts per minute.

Horizontal Slicing with European Machines

Such machines are usually operating in the range up to 40 cuts per minute and again about 1/3 can be considered as the actual production time.

While vertical machines are mainly being designed for mass production, the horizontal machines coming from Europe are mainly designed for achieving the highest quality of sliced veneer. Therefore, in most of the veneer factories, one will find both vertical and horizontal machines. On the 1/3 capacity, the outlining of a balancing for a line with horizontal machines coming from Europe can be considered for 13 cuts per minute.

Horizontal Slicing with Japanese Machines

The difference in such machines is not only the fact that mostly the flitch is moved over the stationary knife compared with the European machines where the knife moves over the flitch, but also the Japanese machines are mainly designed for the production of very thin veneer between 0.2 and 0.4mm only, while the range of European sliced veneer is mainly between 0.65 and 0.8 mm.

Slicing along the Grain

There are still machines existing where slicing is done along the grain. These machines are mainly used for very small capacity operations and cannot seriously be considered for on the scale of industrial production. Usually these machines are being used only for very thin veneer.

6.2. Log Storage and Transports

For log storage and transport, the conditions are not different to plywood making. Logs for the production of sliced veneer however, are mainly stored in logyards and therefore, it is quite useful to consider watering systems if storage is happening over a longer period on time and damage on the surface of the logs should be avoided.

Transport does not need serious consideration, since the number of logs to be handled is quite small and no special efforts are required.

6.3. Flitching

Logs are being taken from the cross cut saw to a bandsaw where they will be cut and where all the flitches will be made. This kind of operation in a sliced veneer production line needs the greatest attention and it requires personnel with the maximum of experience to be available. The cutting of the flitch out of a log is a real experience and on the high valued logs, the people making the decision at this point of the operation, can either generate a profit or loss, depending on their decision.

Special recipes can hardly be given because it all depends on how much experience the operator has to judge about the grain of the log without really cutting it yet or even after cutting and before making the flitch.

6.4. Steaming or Boiling - Flitches or Logs

For making sliced veneer, steaming is very common even though some people believe that certain species definitely need boiling instead of steaming. The equipment being used is the same as that already described.

One important question which is to be answered, is whether flitches or logs must be steamed or boiled. And another is whether steaming or boiling operation comes before the logs will be cut into flitches or whether the cut-to-size flitches will be taken into the steaming or boiling pits.

The fact on one side is that steaming or boiling time is much shorter if flitches are being taken in while on the other side, the risk of damage through cracking may occur more on flitches than on logs. It will very much depend on the opinion of the individual operator and the planning team as to which of the systems will be chosen.

6.5. Slicing

The various slicing systems have already been discussed under 6.1. Since a very high quality is necessary, it is very important to pay attention to the change of knives and the proper grinding of the knives because this is directly related to the slicing operation and hence the quality of the product.

6.6. Curing Time

There are certain species of timber which can go right into the dryer after the slicing. However, it has been experienced that other species need some curing time before they should go into the dryer. This is usually the time needed between slicing and drying and usually, some small bundles of up to 20 sliced sheets of veneer are kept for a period of up to 24 hours before the veneer is sent to the dryer. Veneer production people believe that this time is needed to let the oxygen of the surrounding air have access to the timber and thus, change the colour or cure the veneer to the extent which makes it dry for drying.

6.7. Drying

Drying of sliced veneer is not very different from other veneer drying except that the infeed must secure that the same sequence of sheets will be collected on the outcoming side again because this is very important for the book matching design of the veneer later on.

Veneer drying of sliced veneer is always being done in the direction across the grain as this makes for easier handling of the proper sequence from the outfeed side. Lengthwise veneer drying of sliced veneer has been tried but has not been proven successful.

Some species may need a lower drying temperature but most of the species can be dried at normal high temperature without any problems.

Special attention must be given to the staining during drying. It has been proven that this staining does not result directly from the drying but can be avoided if the veneer is being heated during slicing operation. For some very curious veneer species, it is necessary to use stainless steel belts for the veneer drying to avoid staining which will destroy the quality of the veneer.

6.8. Trimming

Usually, after the veneer has been dried and has been stacked to the bundles of approximately 20 sheets, these bundles will be taken to trimming clippers, where the ends and the edges will be trimmed. Whether combination of one, or two or even four trimming clippers are being used, is mainly depending on the capacity of the whole production line.

6.9. Bundling and Counting

These bundles of veneer will then be sent to a bundling device where a string will be put around and knotted together for later sale or delivery in bundles. On a very sophisticated outfit, these bundles are automatically counted and width and length is also automatically controlled by means of small computers and the results are then being typed in list by these computerised machines.