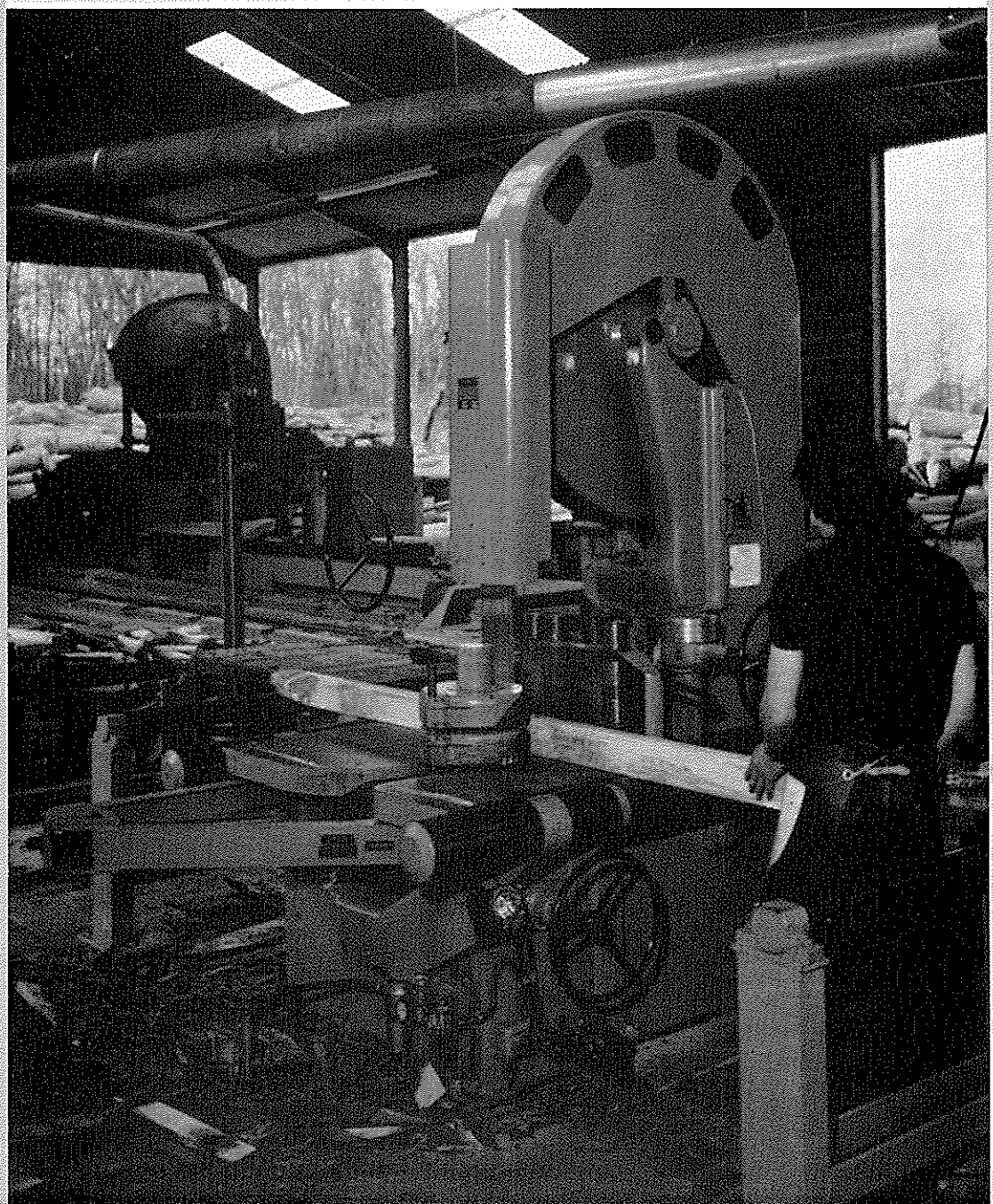
Manual on sawmill operational maintenance

FAO
FORESTRY
PAPER
94



FOOD
AND
AGRICULTURE
ORGANIZATION
OF THE
UNITED NATIONS

Manual on sawmill operational maintenance

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

M-39
ISBN 92-5-102913-X

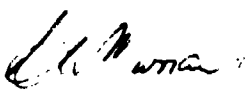
FOREWORD

It is a fallacy to believe that the economic viability of a sawmilling operation pivots around the most modern available machinery and equipment. Appropriate equipment is of course a necessity, but more important to a successful sawmilling operation is the performance of the machinery and equipment. This performance depends largely on the skill of the personnel involved in operating and maintaining them. Training of operators and technicians is, therefore, generally beneficial to the performance of the equipment, as is maintenance which sometimes does not receive the attention it deserves.

Proper operational maintenance will improve performance of sawmilling machinery and enhance, in the long run, the quantity and quality of the sawnwood produced.

This Forestry Paper, which embodies many years of extensive experience obtained in tropical countries, stresses the importance of operational maintenance. It is aimed at operators, technicians, supervisors and management staff of the sawmilling industries of developing countries.

It is hoped that this Forestry Paper will contribute to improving the performance and the quality of output of the sawmilling industry in developing countries and thus to the conservation of their forest resources.



C.H. Murray
Assistant Director-General
Forestry Department

ACKNOWLEDGEMENT

Grateful acknowledgement and appreciation is made to Armstrong Mfg. Co., Portland, Oregon, USA; Stenner of Tiverton Ltd., Tiverton, Devon, England; and Universal Grinding Wheel Company Ltd., Doxey Road, Stafford, England, for permission to use illustrations and information taken from their technical brochures and publications.

TABLE OF CONTENTS

ACKNOWLEDGEMENT v

INTRODUCTION ix

STATUTORY REGULATIONS 1

HOUSEKEEPING 3

WASTE DISPOSAL 4
Methods 4
Possible commercial utilization 5

PROGRAMMED PRODUCTION AND MACHINE MAINTENANCE 5

LOST PRODUCTION TIME 6

MACHINE MAINTENANCE 9
Introduction 9
Band headrigs and band resaws 10
Daily checks 10
Weekly checks 13
Monthly checks 15
Six-monthly checks 17
Annual checks 17
Circular headrigs 26
Daily checks 26
Weekly checks 26
Monthly checks 26
Six-monthly checks 27
Annual checks 28
Framesaws 28
Introduction 28
Daily checks 29
Weekly checks 30
Monthly checks 30
Six-monthly checks 30
Annual checks 31
Edger saws 34
Introduction 34
Daily checks 34
Monthly checks 34
Annual checks 34
Crosscut saws 35
Introduction 35
Daily checks 35
Six-monthly checks 36
Annual checks 36

Ancillary equipment 36
Headrig log deck and loading equipment 36
Daily checks 37
Weekly checks 37
Waste conveyor systems 37
Belt conveyors 37
Daily checks 37
Weekly checks 38
Dust extraction systems 38
Pneumatic 38
Daily checks 38
Weekly checks 39
Monthly checks 39
Annual checks 39

GUIDE FOR FAULT DIAGNOSIS 39
Band headrigs 39
Circular headrigs 41
Framesaws 42

BASIC WORKSHOP REQUIREMENTS 43

GENERAL INFORMATION 45
Bandmills 45
Circularsaws 47
Grinding wheels 52

GENERAL RECOMMENDATIONS 57
Departmental liaison 57
Technical training 58
Improved techniques 58

INTRODUCTION

For the benefit of all concerned it is hoped this manual will make all personnel who read it aware of the fact that everyone employed in a sawmill is part of a team and each must play his/her part and be encouraged to do so. Sawmill maintenance is not just a matter of repairing or maintaining machinery but also of organization and method whereby maximum production of sawn timber can be achieved to the financial gain of all involved.

This sawmill maintenance manual has been compiled with the intention that it will prove helpful to owners, management, technicians and other personnel involved in the sawmilling industry of developing countries. It is intended mainly for sawmills using bandsaw, circularsaw headrigs or framesaws for primary breakdown of hardwood logs of various species, sizes, shapes and quality. References to FAO manuals will be of added assistance.

The financial viability of any sawmilling enterprise is largely dependent on the performance of its mechanical equipment, which, in turn, is dependent on the knowledge and skill of the personnel responsible for its operation and maintenance. Although this manual is intended mainly as an aid towards improving machinery performance and maintenance, this can only be achieved and sustained if the necessary basic requirements are fully appreciated and put into practice by the sawmill management and personnel.

To assist in the implementation of these requirements, guidelines and suggestions are put forward covering statutory requirements and code of practice, housekeeping and data recording. The reasons for them, and the benefits to be derived from them, are dealt with under the various headings and the ensuing improvement in efficiency and performance should result in financial gains far in excess of any increased cost caused by putting them into practice.

Management of some sawmilling enterprises in developing countries will undoubtedly have been putting these procedures into practice for a considerable time. Hopefully the general appearance and efficiency of these sawmills will always impress visitors from other sawmills not so well organized and convince them of the need to change. Ever increasing operational costs make it imperative for any sawmill to operate at maximum efficiency if it is to remain a profitable enterprise in any country, and the need to organize and synchronize the working hours of men and machines is therefore paramount.

The most modern equipment with a constant adequate supply of top quality logs is no guarantee of a successful sawmilling enterprise if the management and personnel involved lack the necessary skill and cooperation to use and maintain it in the proper manner. Sawmill owners and management must therefore always endeavour to assist and encourage their employees in obtaining these necessary skills and experience, which together with the team spirit will achieve success. To achieve this, departmental liaison is of paramount importance.

It must be remembered that reputable manufacturers supplying the sawmilling industries with equipment from any country are always willing to help with advice and information and sawmillers should not hesitate to ask for it.

Improvements in performance, production and quality are very often brought about when the problems affecting them are shared with the makers of the machines and equipment concerned, which, in turn, helps the machine manufacturers to improve their machines.

STATUTORY REGULATIONS

The sawmilling industries throughout developing countries are generally subject to regulations covering the precautions and conditions necessary for ensuring the safety and well-being of the personnel involved. For the benefit of all concerned, owners, management and employees, it is necessary that these regulations are fully understood and put into practice. Failure to do so can only result in diminished efficiency, accidents, or enforced official action, all of which are a bad reflection on the management of the sawmill concerned.

Effective machine guards and protective clothing are specified safety requirements which are often available but not used by sawmill employees. Sawmill supervisors must accept the responsibility of ensuring that this equipment is used and maintained in good condition.

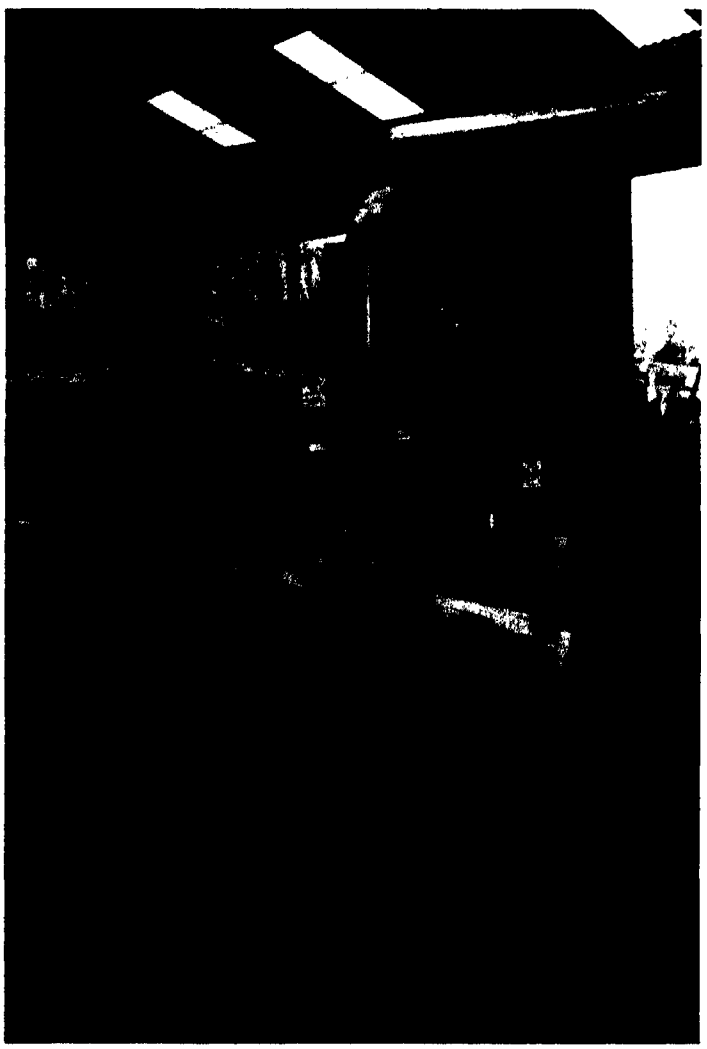
Although many sawmills throughout the world operate under conditions which are not criticized, it may well be that they are in serious breach of existing 'regulations' covering sawmilling operations. An accident occurring under such circumstances could result in heavy financial costs and penalties if strict enforcement of the regulations were applied. It is therefore advisable for all sawmill owners, management and employees, to be fully aware of their countries' relevant 'regulations' and to make sure they comply with them. Some regulations under the Factories Act covering sawmilling and woodworking machines, which have been drawn up by various countries, are based on Woodworking Machines Regulations imposed in the United Kingdom. These regulations are very comprehensive as laid down in the Woodworking Machines Regulations 1974 and the Health and Safety at Work Act, 1974, and cover the following:

- the provision and construction of guards;
- adjustment of machines and guards;
- use and maintenance of guards, etc;
- exception from obligations to provide guards, etc;
- machine controls;
- working space;
- floors;
- temperature;
- training;
- duties of persons employed;
- noise; and
- lighting.

Specific requirements under those regulations are also imposed for the operation of circularsaws, bandsaws and various other machines.

Similar requirements under Statutory Regulations may well be enforceable in many other countries, and, in addition, there may be regulations covering health and safety which include specified procedures for accidents and resultant injuries. It is therefore obvious that relevant existing Statutory Regulations of the country where sawmilling operations are taking place must be taken into consideration when a planned maintenance programme is being drawn up.

The foregoing information is intended to emphasize the importance and necessity for sawmill owners, management and employees, to respect any such regulations and endeavour to comply with them. Routine checks on safety guards, protective clothing and general good housekeeping within the framework of a planned operational maintenance programme will make it relatively easy. Woodworking machines of all kinds can be dangerous and it is for the benefit of all concerned that they should only be operated when properly maintained and properly used within the designed capacity of the particular machine by properly trained operators. Good lighting conditions, together with adequate floor space for operators to move around machines, which are properly guarded with good provision for dust extraction, are essential. The following illustration is typical of these requirements.



HOUSEKEEPING

Good housekeeping, whereby machines and the areas around them are kept clean and tidy, is one of the most essential requirements towards efficient machine performance and maintenance. Men or machines cannot work to their maximum efficiency if they are hampered by sawdust, waste and off-cuts from the logs or lumber being sawn. Apart from the lost production time which such conditions create, the possibility of accidents or machine breakdowns is greatly increased.

Under factory acts legislation, in many countries, an untidy mill can be an offence against the regulations covering safety precautions prescribed for sawmills, and factory inspectors can take action accordingly. Saving money by inadequate labour or time to maintain a clean and tidy sawmill is false economy as subsequent events will no doubt prove.

Lost production time is costly, as is shown under this heading later in the manual, and must therefore be kept to a minimum. To achieve this, maintenance of sawmill machinery must also be coordinated with good housekeeping. The cost of planned machine maintenance and good housekeeping will prove to be a lot less in financial terms when savings in lost production time are taken into account.

A factor which is rarely taken into consideration is the effect of good housekeeping on the morale of all sawmill staff. Working in a sawmill which is maintained in a clean and tidy condition is much more pleasant than having to work on machines surrounded by waste, off-cuts and lumber waiting to be moved. Pride of appearance must be established by the management of sawmills and if they fail to recognize the importance of this factor, it is a certainty that their general administration leaves much to be desired. Wood waste can be utilized in various ways and some of these are dealt with under the heading 'Waste Disposal' which, in many cases, can make this operation self-financing.

Tidiness is mainly confined to organized movement and stacking of sawn timber which represents the financial return of the sawmilling operation. Sawn timber left lying around in heaps by the side of machines or roadways for days on end, results in a considerable financial loss due to degrade. Having spent money to convert logs into sawn timber and then neglect it is a sure sign of inefficient organization. Good housekeeping must therefore be accepted as an essential basic requirement to efficient sawmill maintenance for the following reasons:

(a) machines are less likely to suffer damage or overheat caused by a build-up of waste material;

(b) the safety factor to personnel is increased;

(c) personnel morale and performance is increased;

(d) the financial benefits to be derived from it are greater than the cost of maintaining it.

WASTE DISPOSAL

Methods

In many sawmills the volume of wood waste created can often be as much as 50 percent of the true log volume being processed through the sawmill. The disposal of waste, therefore, is a major factor to be considered and dealt with if hold-ups to the production of sawn timber are to be avoided.

The layout of equipment and machinery must be organized in such a way that handling costs of sawdust and wastes are minimized and their handling effectiveness optimized.

Many sawmills will, of course have their own kilns for drying some of the sawn timber produced. The fuel for the boilers, in these cases, will take some of the wood waste material arising, but not all, and is unlikely to include sawdust, wood shavings or chippings. Unless outlets for the various waste materials arising can be found whereby the cost of their disposal can be covered or minimized, the financial effect on the sawmills concerned can be considerable if they are to remain competitive.

The larger pieces of wood waste arising do not often present a disposal problem as the need for solid fuel is always present. Local firewood contractors in such cases are usually willing to purchase all that is available from the small sawmills and supply their own transport and labour for loading.

High density hardwood species make excellent charcoal and the larger waste off-cuts arising from these can be sold on-site for that purpose or converted by the sawmill into charcoal for sale.

The main objective, however, regarding waste disposal must always be to keep the volume of wood waste produced as small as possible. Sawmill management must always be aware of the daily production figures relating log volume sawn to sawn timber produced. Various species will have varying conversion factors relevant to log shapes and sizes, inherent defects and the quality and age of the logs concerned. Any deviation from the recognized normal conversion factor for a particular species, whether up or down, should be immediately investigated and the reason identified. Consistent low conversion factors for a mixture of species may be due to the quality of logs involved, the size and thickness of the sawn timber commercially acceptable, the operational efficiency of the sawmill staff or the low standard of maintenance for saws and machines. Whatever the reason it will not be readily apparent if daily lost time and production performance records are not being kept and management must accept that responsibility.

Wood waste disposal from the sawmill is often regarded as an operation which has to be carried out when the accumulation of waste prevents further operation of the machines. This attitude is not only very dangerous but it also contravenes the requirements relevant to the operation of sawmills. Systematic regular disposal must be organized whether manual, mechanical or otherwise, and the cost involved must be carefully considered. Initiative and imagination on the part of management are essential if the cost of waste disposal is to be kept to a minimum and all likely wood research

institutions should be contacted for possible ideas, information and assistance.

Possible commercial utilization

The possible utilization of wood waste as a commercial product, which will create a financial return must therefore always be given very serious consideration. There are various possibilities which may be feasible and viable, but dependent on the type and volume of the waste material and the location of the sawmill. Some suggestions for possible outlets for sawdust, shavings, chippings and other small particles are as follows:

- consider the feasibility of a wood waste briquetting system whereby the materials are processed into high density fuel briquettes;
- look into the possible utilization of wood waste as a commercial mulch for use in agriculture or horticulture;
- investigate the likelihood of selling it as a litter for high density poultry or animal husbandry units;
- advertise the type and volume of material which is constantly produced for the attention and consideration of other wood waste processing industries or potential users;
- explore the possibility of getting local brick or tile-makers to use the sawdust as fuel for the kilns and also as a mix for producing porous bricks of reduced weight;
- contact local builders regarding the use of sawdust as a shield layer over concrete floors or roads to allow the concrete a change to obtain maximum, strength;
- carry out a feasibility study on compacting sawdust into plastic bags to reduce the volume and subsequent transport costs which may attract a wider range of customers using small amounts.

Local research establishments may help with these suggestions.

PROGRAMMED PRODUCTION AND MACHINE MAINTENANCE

For an efficient and viable operation it is necessary for sawmill management to have a planned annual production programme by which the performance of the sawmill can be assessed over any period of time within the year. The programme should be based on an estimated log input per working day throughout the year which is calculated to produce an estimated volume of sawn timber in the various grades arising from the various species being sawn.

To enable management and production staff to check the performance it is essential that daily records be kept showing the number of logs sawn by individual species and volume and the volume of sawn timber produced from them in the various grades. These daily production records will highlight species of timber which are not producing the estimated volume of sawn timber required and the reasons can be quickly investigated.

The type of form used does not really matter as long as it shows the date, the species and number of logs sawn, their individual measurement, with relevant comments on the quality and condition of sub-standard logs. Daily records of sawn timber produced can likewise be on any type of form providing it shows the date, species of timber, the grade, thickness and length of sawn timber produced. This information will allow a quick calculation to be made showing the actual daily performance which can be compared with the planned production programme relating log volume sawn to sawn timber produced.

During the period of the planned production programme, provision for machine maintenance must be made. Under normal working conditions, routine maintenance can be carried out at weekends with specific checks as required on the various machines and equipment. The possibility of a breakdown, however, is always present and this must be prevented, if possible, by a planned maintenance programme which will allow a major overhaul to be carried out on each machine at a pre-determined time. Such overhauls will reduce the production performance of the sawmill relevant to the actual breakdown of the logs by the machine involved. Under a planned production programme where planned machine overhauls are involved, such reductions in the working hours of machines which will affect the annual operational performance, can be calculated and the daily operational target figures adjusted accordingly.

The main problem which affects sawmills the world over, is lost production time, particularly when the operation calls for a high volume of log input and sawn timber output. To achieve and maintain the planned production programme, it is essential that all staff and employees are aware of this important factor. Hopefully the following chapter regarding lost time will help to show the importance of it and the adverse effects that can result from it.

LOST PRODUCTION TIME

Lost production time is a factor which, from a cost point of view, in many sawmills and in most developing countries, is almost totally ignored. A brief study of its financial effect will highlight the need to minimize it whenever possible and also the need to establish a planned maintenance programme designed to ensure maximum machine operational time during the working day.

Machine breakdowns, changing saws and waiting for logs are common reasons for temporary stops in the daily operation of many sawmills. These are often accepted as normal routine by many sawmill managers and no further thought is given to the financial effect they have on the overall performance of the company.

Let us imagine the case of a sawmill with one bandsaw headrig which feeds a number of band resaws and edgers. The scheduled log input per day is 160 m^3 = 5 650 ft^3 over eight hours. Let us assume the bandsaw headrig changes saws four times per day, each change taking 15 minutes. Let us also assume the graded sawn timber output is 50 percent of daily log input and the average selling price of it is US$ 100 per m^3 (35.314 ft^3). The financial effect of the four saw changes is as follows:

Lost production time of four saw changes	= one hour
Log volume sawn by headrig in seven hours	= 140 m^3 (4 944 ft^3)
Log volume sawn per hour	= 140/7 m^3 = 20 m^3 (706 ft^3)
Sawn timber produced per hour at 50% recovery	= 10 m^3 (353 ft^3)
Sales revenue per hour at US$ 100 per m^3 (35.314 ft^3)	= US$ 1 000

The loss of revenue due to the four saw changes which made a total of one hour is, therefore, US$ 1 000. Loss of revenue per minute is 1000/60 = US$ 16.66. Lost production time on the bandsaw headrig creates a loss of US$ 16.66 per minute in sales revenue which if the sawmill is only making ten percent profit over its operational costs still means a loss in true profit of US$ 1.66 per minute.

Lost production time due to saw changes can be reduced by having saws changed outside the scheduled working hours such as before or after the working day and during tea or meal breaks.

The use of saws with hard faced teeth can make a significant reduction in lost production time and appreciably outweigh the additional cost of their purchase and maintenance.

Lost time records must therefore be regarded as one of the essential daily returns which are essential to management in order to assess the performance and efficiency of the sawmill and take remedial action to offset lost production time. Lost time reports must be made out daily by the appropriate machine operators and submitted to the management staff concerned if they are to be effective. Sawdoctors, engineers (electrical and mechanical) together with production foremen and supervisors can then be made aware of production time losses for which their departments are responsible and remedial action taken. The format of the report is not important as long as it shows the machine involved, the time lost and the major factor, the cause. A typical lost time report is as follows:

TYPICAL LOST TIME REPORT

DATE:

MACHINE	STOPPED	STARTED	REASON FOR STOPPING	TIME LOST
No. 1 HEADRIG	10.10	10.30	OPERATIONAL Waiting for logs	20 mins
	11.05	11.20	Changing saw (dull)	15 mins
	12.00	12.15	Changing saw (hit stone)	15 mins
	3.05	3.20	MECHANICAL Live roll stopped	15 mins
	4.30	4.35	OPERATIONAL Sliver in bottom guide	5 mins
No. 2 HEADRIG	11.05	11.20	Changing saw (dull)	15 mins
	11.50	12.10	ELECTRICAL Top guide jammed	20 mins
	3.40	3.55	Changing saw (dull)	15 mins
	4.15	4.45	MECHANICAL Transfer chain broken	30 mins
BAND RESAW	11.15	11.25	Saw changed (dull)	10 mins
	4.10	4.20	Saw changed (dull)	10 mins
EDGER SAW	2.40	2.55	Operational Saws running hot	15 mins
			TOTAL TIME LOST	185 mins

On the evidence of such reports where the reason for lost time is given, appropriate action can often be taken to eliminate the cause by a change in planned maintenance or operational procedure.

In some cases the reason for lost production time may not be readily apparent if it is due to sawing logs which are larger than the designed capacity of the particular headrig. Such causes should be noted by the sawyer with the relevant lost time being calculated from the reduced volume of log input shown in comparison against the scheduled input per shift. Remedial action in such cases would be to reduce the size of these logs to the appropriate size before putting them up on the log deck.

Another reason may be due to log species having shape defects which make them difficult to handle with log turning gear.

MACHINE MAINTENANCE

Introduction

Periodic checks on all machines are essential if efficient and trouble free performance are to be maintained. The recommended servicing and lubrication routines specified by the manufacturers of the various machines should always be strictly adhered to and the various specified lubricants and spares always available. Likewise, it is essential that during the actual working operations the machines are not operated by anyone who is not fully aware of their designed capacity and competent to work that particular machine.

A priority requirement for successful machine operation and maintenance is therefore to ensure that the operational manual and maintenance manual of the machine manufacturers are always available and that personnel who are to operate and maintain the machines are properly trained and fully competent to carry out these duties.

Another essential requirement which is also a priority is a detailed illustrated spare parts list and the stock holding of any parts that may need replacing within a specified time as recommended by the various machine manufacturers

Sawmill machinery and equipment work under conditions which necessitate a strict, well-organized routine check with the appropriate remedial action and adjustments being carried out as necessary. Periodic maintenance checks are dealt with under the individual machine headings but it must always be borne in mind that good housekeeping is a very important requirement to minimize wear and unnecessary machine damage. Likewise, daily lost time records are essential for the reasons already dealt with under that heading but should also be regarded as an early warning system against potential breakdowns which could be avoided.

Modern materials and machine design have resulted in simplified maintenance, particularly in methods of lubrication where automatic oiling systems and sealed bearings are fitted. These attachments do not, in any way, reduce the need for a well-organized constant housekeeping programme whereby all machines are cleaned down at the end of each working shift. Operators on all machines must be fully aware of the importance of it and responsible for making sure it is properly carried out.

The following maintenance programmes together with good housekeeping should result in minimizing lost production time if they are carried out efficiently with everyone cooperating. Management must ensure, however, that the essential lubricants and spares are always available and appropriate records kept relevant to the stocks held and their usage over a period of time. These records will also serve as an indicator that things are going wrong and need checking when a sudden increase in their demand occurs.

Band headrigs and band resaws

Daily checks

(a) Saw guides

Check top and bottom guides after each saw change and adjust if necessary.

(b) Wheel scrapers and cleaning pads

Check top and bottom wheel scrapers and adjust if necessary so that they are bearing lightly and evenly right across the face of the wheels. Where pads or brushes are fitted they should be checked and adjusted accordingly.

(c) Lubricant tanks for drip feed lubrication, etc.

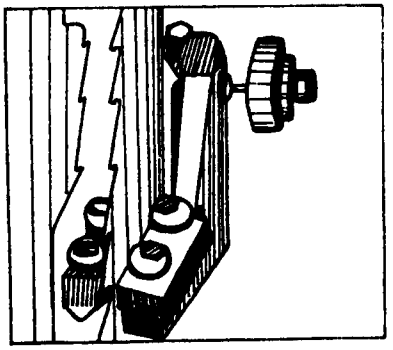
Check the lubricant levels and required feed flow.

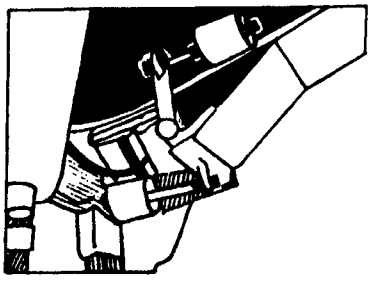
(d) Saw straining mechanism

Make sure the strain is taken off the bandsaw during non-working periods and the mechanism is working freely.

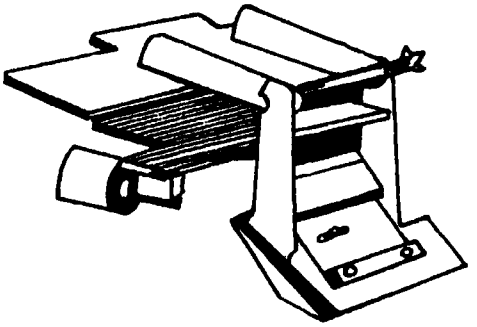
(e) Top wheel lifting screws

Brush or blow out accumulated sawdust and lubricate screws.

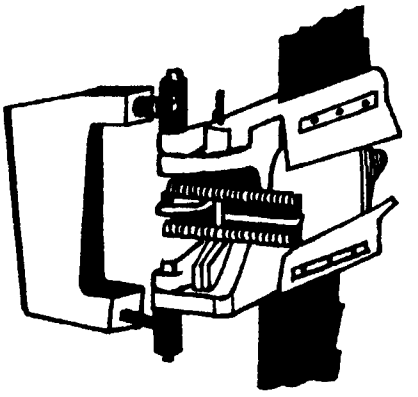




OIL PAD AND SCRAPER
(TOP PULLEY)



OIL PAD AND SCRAPER
(BTM PULLEY)



(f) Bandmill wheels

Remove any accumulated sawdust which has stuck to the inside of the rims or spokes. Check sawdust extraction system, whether pneumatic or mechanical, and make sure there is no build-up, particularly if a water spray is used on the saw.

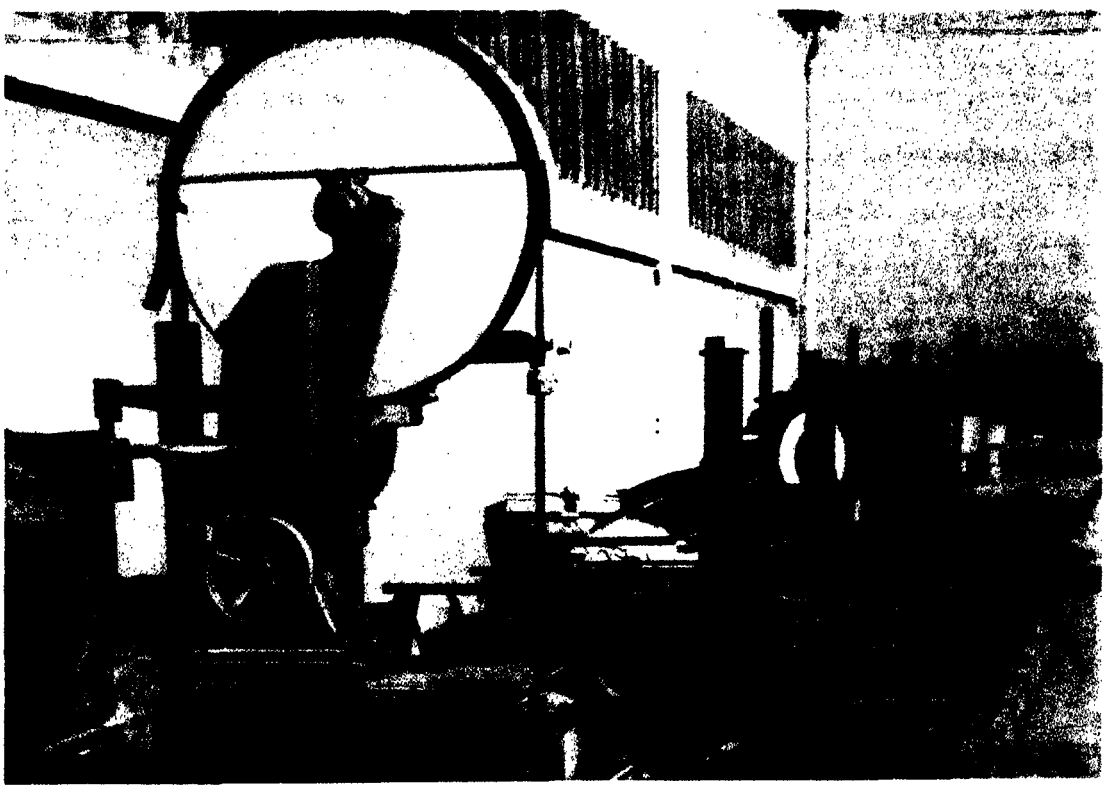
(g) Saw cleaning assembly

Check lubricant tank. Check felt pads for tension and wear.

(h) Log carriages

Log carriages range from the simple manually operated units to those fully mechanized with electric setworks, pneumatic dogging, cant flippers, etc. A powered infeed log deck, log loading and turning equipment, together with an outfeed conveyor fitted with off-loading arms, storage and reload chains, are used to make the latter a complete one-man headrig operation. These installations are often fitted with automatic centralized lubrication systems and relevant maintenance checks should be carried out strictly according to the manufacturers instructions.

Daily maintenance checks on carriages without centralized lubrication should cover the lubrication of axle wheel bearings, head blocks, setworks and offset operating mechanism.



A powered infeed log deck and fully mechanized carriage for complete one-man headrig operation.

Log carriage wheel and rail scrapers should be checked and adjusted if necessary to prevent any build-up of waste on wheel faces or rails. Check all keys, bolts and set screws subjected to shock loads for tightness.

(i) Log loading equipment

All log decks and the log loading equipment should be cleaned off daily and where the moving parts are not lubricated automatically, appropriate greasing and lubrication should be carried out. The structure and mechanism is subjected to frequent heavy shocks and all bolts and nuts need to be checked for tightness.

Log deck chain channels should be lubricated and drive chains checked for undue slackness.

(j) General lubrication and cleaning

Unsealed bearings should be greased with the recommended type of grease or its equivalent. Make sure the grease nipples and gun nozzle are clear and pump in sufficient grease to force out the old grease which may have picked up dust and dirt during working operations. Lubricate shaft drives or chain drives to live rolls and check safety guards. Clean and lightly lubricate all machined surfaces to prevent rust.

Remove any accumulation of sawdust and waste from electric motors, driving chains, gears or sprockets and ensure safety guards are in place.

A four headblock carriage for logs up to 6 m (20") long with hand operated dogging gear and hand setworks. Hand taper setgear is fitted to the first headblock.

Weekly checks

(a) Log loading and turning equipment (pneumatic)

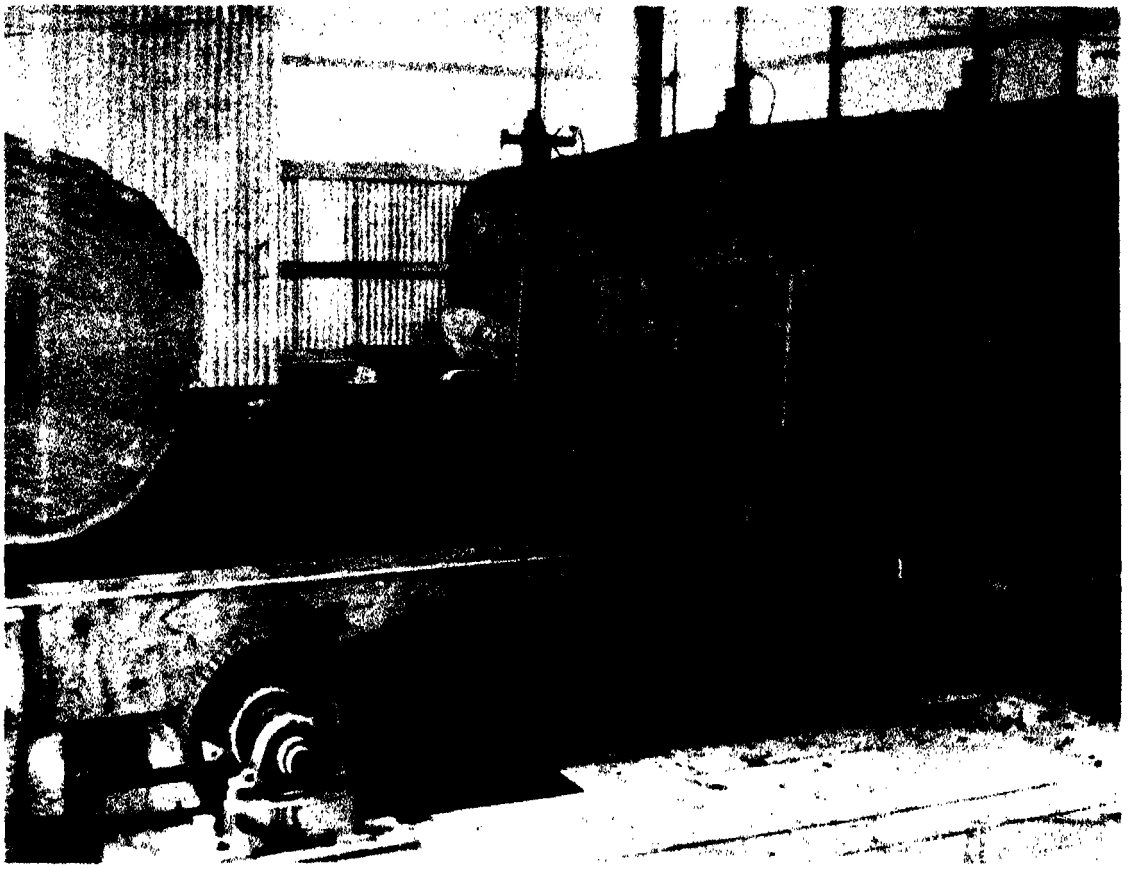
Check all piping for leaks; oil cylinder piston rods; grease or oil all linkage as required; check all bolts and nuts for tightness; and ensure all cylinders are left in the closed position when not in use to prevent rusting of the cylinder piston rods.

(b) Log loading and turning equipment (hydraulic)

Check all piping for leaks; check all bolts and nuts for tightness; check all chain drives incorporated in the equipment strictly according to the recommendations of the manufacturer; check the oil level in the tank of the hydraulic pressure assembly; and check oil filters according to instructions given on the filters or as specified by the manufacturer.

(c) Live rolls

Grease all bearings according to the specified instructions, but take care and ensure all grease nipples are wiped clean free of dust and dirt, likewise the grease gun nozzle.



Hydraulically operated log loading equipment for logs up to 1.52 m (60") diameter with a set of live log deck chains, 1.52 mm (6") pitch, log deck units with lifting skids, loader/turner arm and independent pusher arms.

(d) Chain drives

Clean and lubricate any drive chains as necessary.

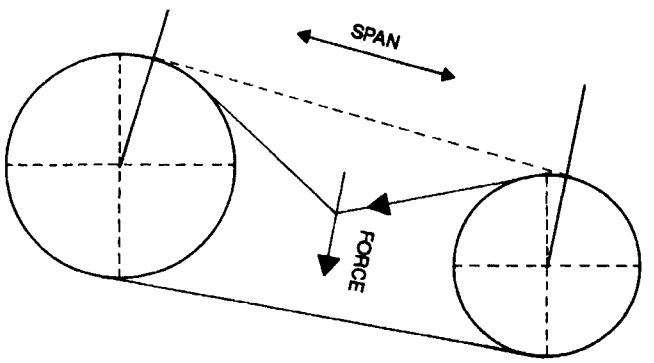
(e) Belt drives

Belt drives whether flat or Vee should be checked for tension. The tension should be sufficient to overcome belt slip but over-tightness should be avoided as it reduces the life of the belts and puts excessive loading on the shaft bearings.

The procedure for tensioning spacesaver wedge-belt drives is as follows:

Measure the span length. At the centre of the span apply a force at right angles to the belt to deflect one belt 16 mm per metre of span length, (5/8" to approximately 40" of span length). Compare this force with value in the table below.

If the measured force falls within the values given, the drive tension should be satisfactory. A measured force below the lower value indicates under-tensioning. If the force is higher than the upper value, the drive is over-tensioned; however a new drive should be tensioned to near the higher value to allow for the normal drop in tension during the running-in period. After the drive has been running for a few days the wedge-belts will have seated in the grooves and the drive tension should be re-checked.



Spacesaver belt section	Force required to deflect belt 16 mm (5/8" per meter (40") of span	
	Small pulley distance (mm) ins	Kilogram force (Kgf) lbs
SPB	160 to 224 mm 6 to 9 ins approx. 250 to 400 mm 10 to 16 ins approx.	3.6 to 5.1 kg 8 to 11 lbs approx. 5.1 to 6.6 kg 11 to 14 1/2 lbs approx.
SPC	224 to 355 mm 9 to 14 ins approx. 400 to 560 mm 16 to 22 ins approx.	6.1 to 9.2 kg 13 to 20 lbs approx. 8.2 to 12.2 kg 18 lbs to 27 lbs approx.

Monthly checks

(a) Bandsaw wheel bearings

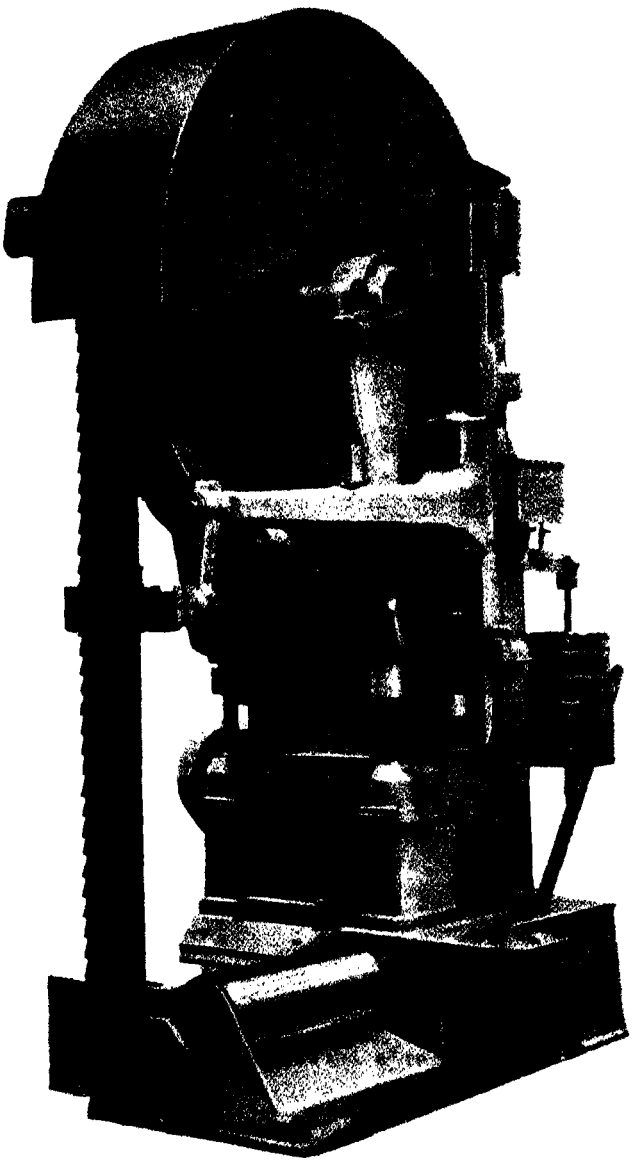
Apply grease according to the manufacturer's instructions but do not over-grease as this can cause bearings to heat up.

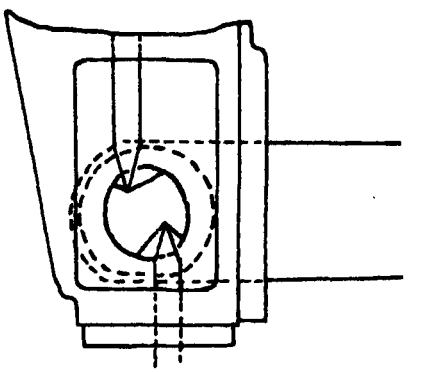
(b) Top wheel assembly

Clean and lubricate slides and lifting screws. Check for freedom of movement over the full length of slides. Adjust jib strips if necessary but check again after adjustment as they must not jam on the slides of the main column.

(c) Saw straining mechanism

Check the fulcrum shaft seatings for the top and bottom knife edges on each side of the top wheel assembly. Clean and lubricate seatings to prevent rust and to ensure freedom of movement. The saw straining fulcrum lever should not be positioned above the horizontal position when the saw is working as this reduces the sensitivity of the straining mechanism.





Six-monthly checks

(a) Log carriage wheels and track rails

Check all vee grooved wheels for damaged flanges and clearance above the top of the carriage track vee rail. The check for clearance should be carried out along the full length of the track with a log on the carriage. Check carriage cable and pulleys for any damage or misalignment. Check carriage rail track joints for alignment and fixing bolts and nuts for tightness.
Check log carriage offset mechanism for any lost movement and adjust as necessary. Check setworks according to manufacturers instructions.

(b) Top guide arm assembly slides

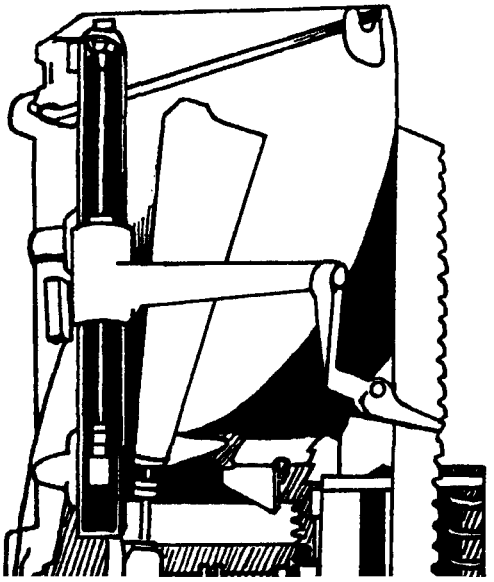
Check the vertical movement of the top saw guide by fixing a dial indicator on the guide block housing with the blocks removed. Bring the indicator against the saw and run the guide up and down the slides to check for deviation. Adjust as necessary to compensate for slide wear.

Annual checks

(a) Carriage track rail alignment

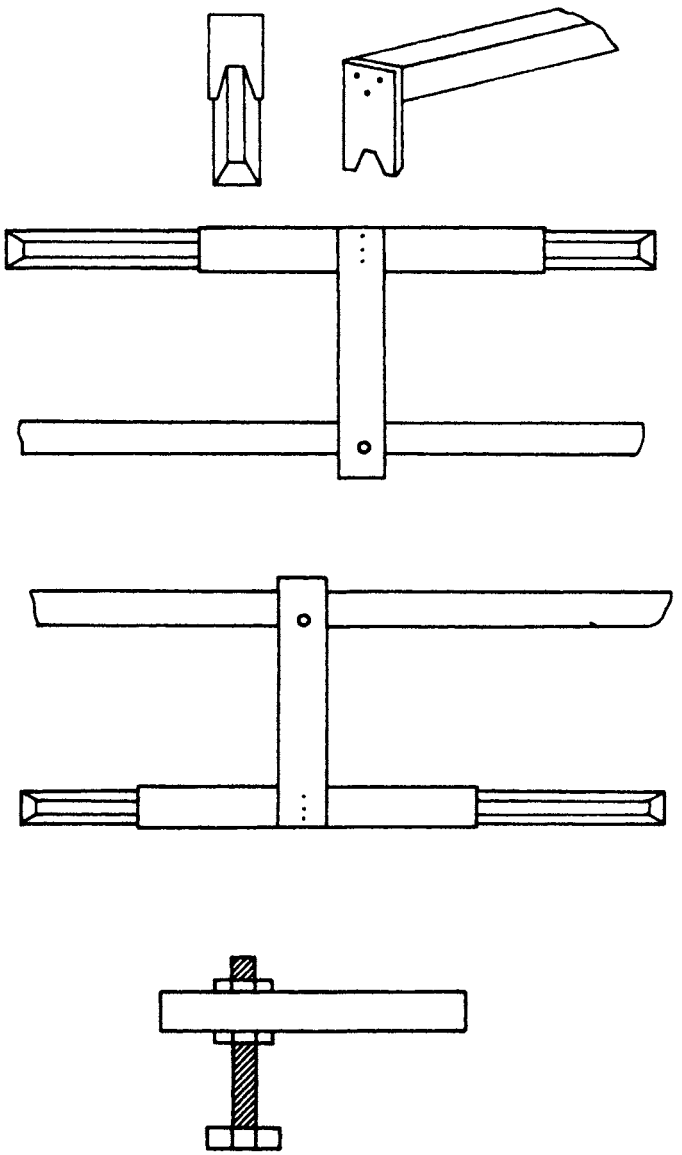
Check the vee rail which is the guide rail of the carriage. It should be the one farthest from the saw for alignment.

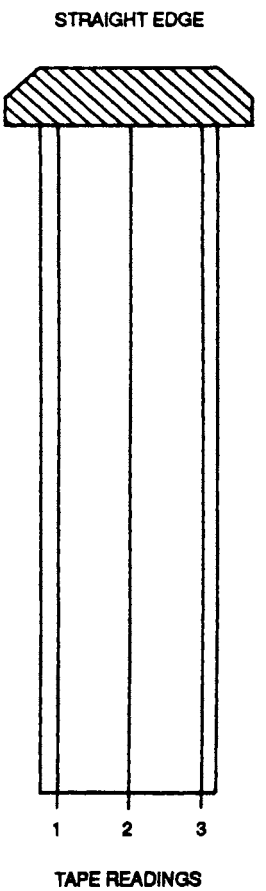
By using a simple jig the vee rail and flat rail can be checked for constant level at the same time the vee rail is being checked for straightness. The jig can be made from angle iron or a length of 75 mm (3") square hardwood which is made up into the form of a T. The stem of the T must be long enough to span the distance between the vee rail and flat rail and the head of the T should be a minimum of 90 cm (3 ft) long. At each end of the head of the T a piece of high density hardwood or flat steel bar about 150 mm (6") long should be cut to make a good true fit on



the vee rail and fixed firmly to each end of the head of the T. At the flat rail end of the stem of the T above the centre of the rail a hole should be drilled to take a 12 mm (1/2") bolt threaded right down to the head and locked into position with two nuts, the bolt head riding on the centre of the flat rail. A line can now be stretched taut from one end of the track to the other, taking care to make certain each end is equidistant from the centre of the vee rail. The line will need to be positioned so that it is not in contact with the log carriage when it is moved.

By using a clamp to hold a slotted gauge fixed on the centre point of the T head with the line in the centre of the slot, the jig can be moved down the track and the relative straightness of the vee rail can be easily seen.





By placing a level on the stem of the T and using the bolt at the end to adjust it for level, any variation in rail heights can also be checked at the same time. With the carriage on the rails it will mean checking one half of the track first and moving the carriage to the other end in order to use the jig to check the other.

It is well worthwhile making up a good robust jig which can be used time and time again.

Another method which is a quick check on tract alignment is to stretch a line above the front section of the carriage, say 50 mm (2") from the saw line above the head block slides, and clamp on a similar slotted check gauge. Move the carriage from end to end and make sure the line is in the centre of the slot at both ends and then, preferably with an average size log on the carriage, move the carriage slowly along the track. Any deviation of the vee rail will be readily apparent on the indicator and likewise, if a spirit level is also placed on one of the head block slides any change in the relative height of the carriage rails will also be shown.

(b) Checking bandsaw wheel faces

The condition of bandsaw wheel faces is very important to the efficient operation of the saw. Wheel faces should be checked annually as follows:

Thoroughly clean the wheel faces and make sure they are completely free of any compressed gum or resin deposit. Remove the wheel scrapers, cleaning pads or brushes. Check with a straight edge to see if the wheels were flat faced or crowned.

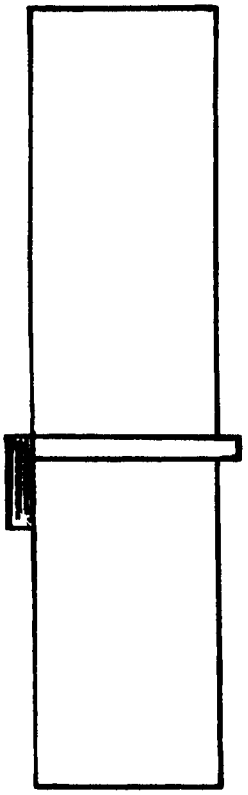
Take a steel tape and fix it on the face about 25 mm (1") from the front rim of the wheel. Keeping even tension on the tape, rotate the wheel full circle and take the reading. Repeat the process for the centre of the wheel and again for the back edge just off the rim. The three readings will give a true picture of the wear that has taken place. In most cases, the front edge will show the greatest amount of wear and the highest point will usually be around 1/4 distance from it. A dial indicator can then be fixed and brought into contact with the wheel face and the wheel rotated to see how far it is out of round.

(c) Checking bandsaw wheel bearings

Top and bottom bandsaw wheel bearings should be checked according to the instructions given by the machine manufacturer. If bearings have been running hot they should be thoroughly cleaned and repacked with appropriate grease recommended by the manufacturer.

(d) Refacing bandsaw wheels

If checks on the bandwheel faces show them in need of refacing, it is essential to make sure the wheel bearings are in good condition before carrying out the operation. Having made sure the wheel bearings are good, it is most important to make sure the whole wheel assembly is absolutely clean. Sawdust deposits on the inside of the wheel rim can put the wheel out of balance when it is running at full speed.



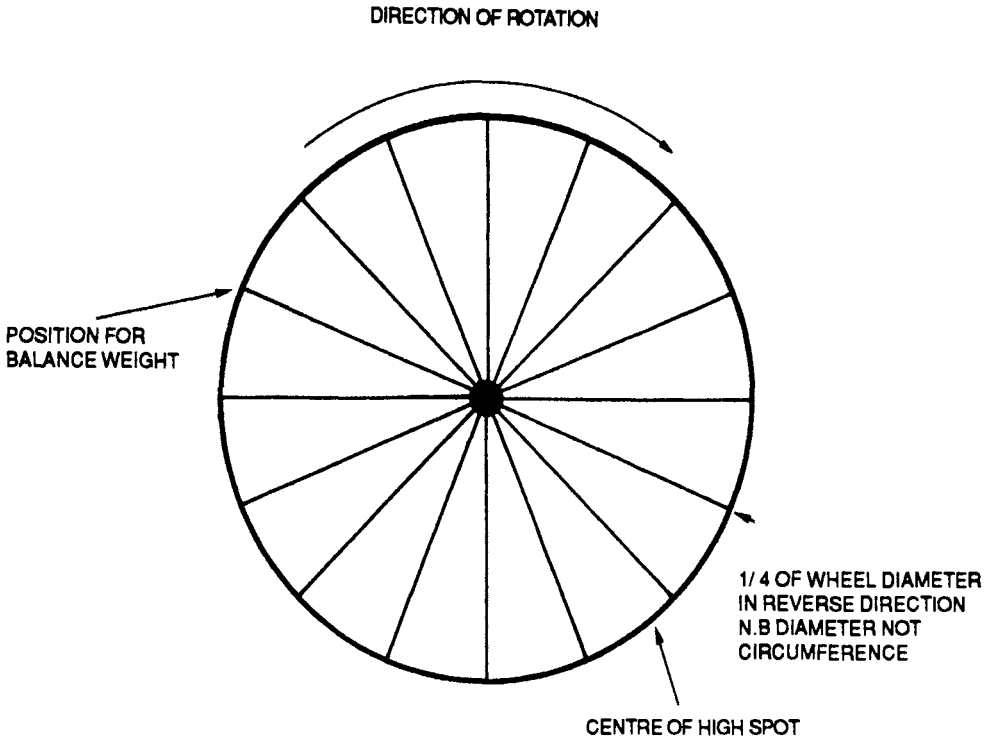
Another factor which must not be overlooked when the top wheel face is to be reground is to lock up the saw straining device. Failure to do this can result in the top wheel finishing fractionally out of round.

There are various kinds of bandwheel grinders but the one most commonly used is probably the Barnhart Wheel Grinder which can be supplied with a motorized wheel head and remote control for the cross slide traverse. It is most important to ensure that the wheel face does not finish up hollow after grinding, as the bandsaw will not stay in position and will tend to wander back and forth. To make sure the grinder is set up correctly for grinding a perfectly flat wheel face the following procedure should be adopted:

Using a set square held against the rim of the wheel which is known to be running true, mark a line right across the face of the wheel.

Set the grinder in position with a steel pointer fixed to the grinding wheel head and brought up in line with the marked line on the bandwheel face.

Traverse the grinding wheel head across the bandwheel face and adjust the grinder as necessary until the pointer follows the marked line on the wheel face and finishes exactly above it at both ends.



The grinding operation should not be carried on beyond the point where the front edge of the wheel is barely cleaned up. It is better to take the least possible metal off the front face of the wheels as this section will have developed a work hardened skin and will therefore be more wear-resistant. If the last 6 mm (1/4") of the front edge is left unground it is quite in order as a small chamfer ground on the extreme front edge will help to keep the saw tracked in position. A careful check with the straight edge and steel tape will show how the wheel face has been affected by the grinding. Three identical measurements at the front, centre and back edge of the wheel face when taped will show a flat wheel face. When grinding it must always be borne in mind that a hollow ground wheel face must be avoided and a slight crown which shows a tape reading of 0.8 mm (1/32") more than the edges at the high point of the face is preferable. This high point should be roughly where the centre of the narrowest bandsaw used will be contacting the wheel face when it is in its tracked running position. Where checked with a straight edge it should rest flat from the front edge to the high point and flat again from the back edge to the high point.

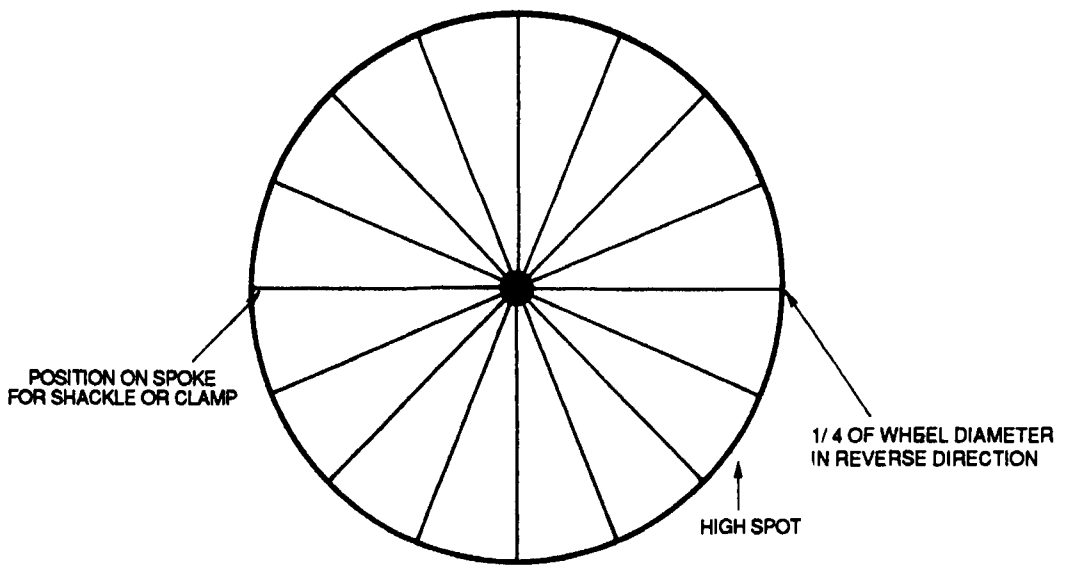
After checking the wheel face to make sure the desired result has been achieved, the wheel can be checked for round using a dial indicator conveniently fixed to the machine while the wheel is rotated. A reading of ± 0.0025 mm (± 0.001") should be obtained.

(e) Balancing bandsaw wheels

Bandsaw wheels can go out of balance dynamically for various reasons which will cause the machine to vibrate when the saw is running at full speed. This condition cannot be prevented completely by planned maintenance, although thorough cleaning of the wheels at frequent intervals will eliminate the possibility of sawdust build-up on the rims or spokes being the cause. The condition can also arise after bandwheels have been reground, but, whatever the cause the condition needs to be rectified.

If the wheel cannot be dealt with by people with the necessary expertise and equipment to do a professional job, the following procedure will put the wheel back into a reasonable running condition:

Run the wheel up to full speed and mark the high spot by holding a piece of chalk against the centre of the wheel facer as a centre lathe turner would mark his work piece. Take the centre of the length of the line marked and from there measure in the reverse direction of the wheel rotation 1/4 of the wheel diameter and mark it. From there across the diameter of the wheel directly opposite, mark the position. This will be the spot to put on a counter weight to correct the balance. The weight required can be found by sticking putty onto the inside of the rim and weighing it, when by trial and error, the amount used puts the wheel in its most accurate running state.



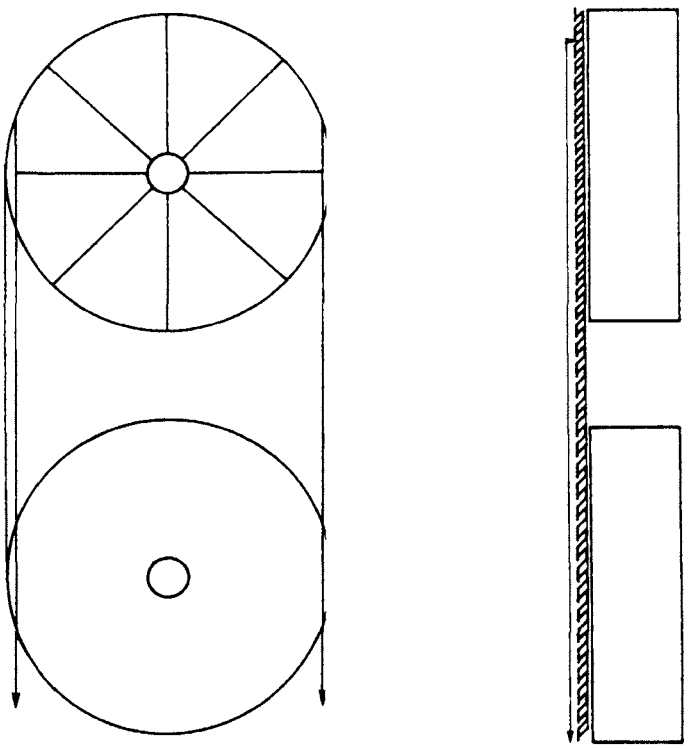
A metal section of equal weight can then be suitably fixed to the rim of the wheel. If it is a spoked wheel, a cable shackle or clamp can be fixed onto a spoke and moved towards or away from the rim until the best position is found. Vibration caused by wheels dynamically out of balance should not be ignored and although this method will not give perfect results it will certainly lessen the chance of various problems arising at a later date.

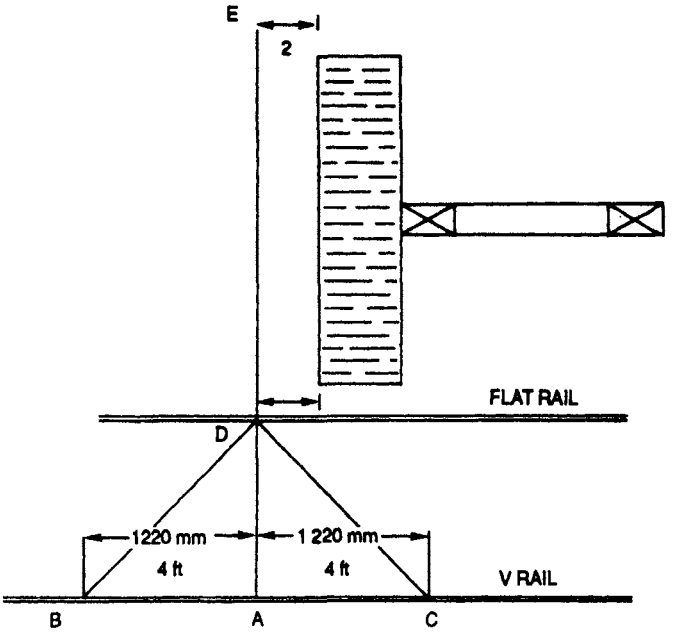
It should be noted that bandwheels should not be refaced if after many regrinding operations the thickness of the rim has become less than the recommendations of the manufacturer.

(f) Bandmill wheel and carriage track alignment

Checks on bandwheel alignment with carriage track should be carried out annually or as considered necessary. It is advisable, however, to make sure the bandwheels are in correct alignment with each other before checking their alignment with the carriage track. Bandwheels can be checked for cross alignment as follows:

With a bandsaw on the wheels under the correct strain with the saw properly tracked in its running position, drop a plumb line from each side of the top wheel where the saw makes contact. The plumb lines must be at exactly the same distance from the rim of the wheel in front of the saw teeth and should drop beyond the point where the saw contacts the bottom wheel.





Preferably if the plumb lines are 50 mm (2") from each face of the top wheel, they should be the same distance from each face of the bottom wheel. The main objective is to have identical measurements at each side of the bottom wheel although they may be slightly different from the top wheel measurement. If the top wheel measurement is 50 mm (2") from each face of the top wheel and the bottom wheel measurement is 44 mm (1 3/4") from each face of the bottom wheel, this is acceptable if each side of the bottom wheel measurement is the same.

Unequal measurements between the plumb lines and the opposite faces of the bottom wheel denotes cross alignment of the wheels which will cause a twist to develop in the bandsaws.

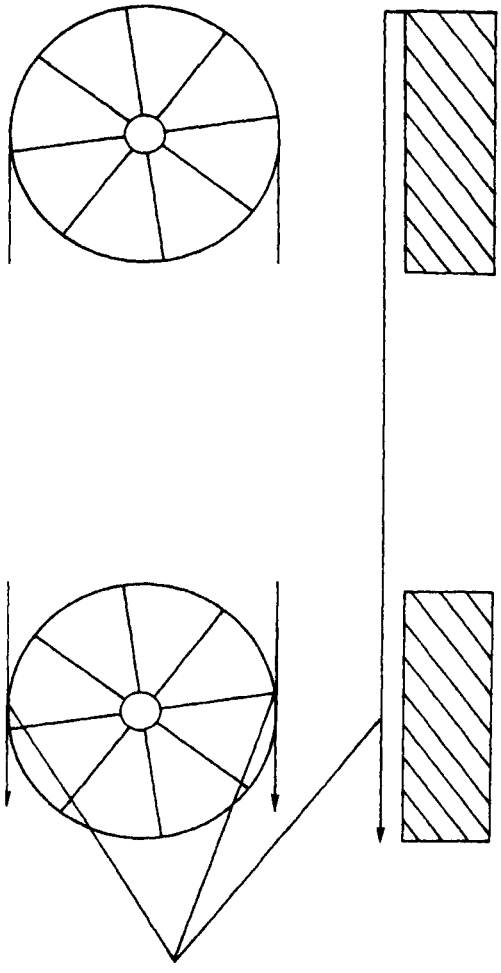
Having made sure there is no cross alignment between the top and bottom wheels of the bandmill and knowing the vee rail is straight, the alignment of the saw relative to the track can be checked as follows:

Centre punch a mark in the centre of the vee rail which is say, 254 mm (10"), in front of the bottom wheel rim face Mark A.

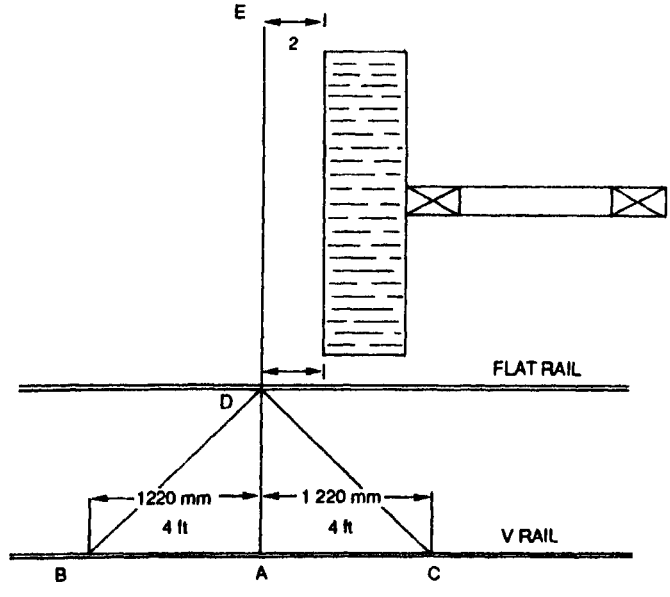
Measure off or use a trammel and mark off another point say 1 220 mm (4 ft) in the centre of the vee rail to one side of it and centre punch Mark B.

Do the same again on the opposite side of Mark A and centre punch Mark C at the centre of the vee rail.

From points B and C trammel off and centre punch in the centre of the flat rail Mark D.



THESE MEASUREMENTS MUST BE EQUAL ON EITHER SIDE



A line stretched tight immediately over Marks D and A and continued past the back rim face of the bottom wheel to point E will allow measurement to be made between the front rim face and rear rim face of the wheel.

Identical measurements at these two points 1 and 2 will show the bandmill in perfect alignment with the carriage track.

Circular headrigs

Daily checks

General daily maintenance of circularsaw headrigs is much the same as the procedure for bandmills (bandsaw headrigs), in so far as the log carriages could be identical. Checks on the saw guides should be made after each saw change, and adjusted if necessary. If a smaller saw is put into use it will be necessary to adjust the spreader (guide knife, circular disc splitter) closer behind the saw.

(a) Log carriage and setworks

Check rail and wheel scrapers. Maintenance on log carriages and setworks without sealed bearings on centralized lubrication systems should cover the lubrication of axle bearings, headblock and knee assemblies, setworks and offset mechanism.

(b) Lubricant tanks

Check oil levels in lubricant tanks supplying drip feed, oil mist or centralized lubrication systems.

(c) General lubrication and cleaning

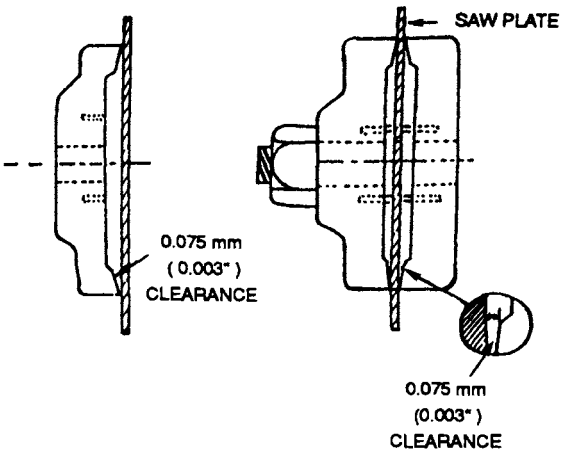
Unsealed bearings should be greased with the recommended type of grease or its equivalent, making sure the grease nipples and grease gun nozzle are wiped clean. Clean and lubricate all machined surfaces to prevent rust. Lubricate shaft drives or chain drives and check safety guards. Remove any accumulation of sawdust and waste from electric motors, driving chains, gears or sprockets and ensure safety guards are in place.

Weekly checks

Check belt drives for correct tension. Check all bolts and nuts on equipment subject to shock for tightness. Grease any bearings as recommended by the manufacturers.

Monthly checks

Check all chain drives for tension and alignment with sprockets. Clean and lubricate as necessary. Check main frame holding bolts. Check guide knife (spreader, circular disc splitter, riving knife) for alignment. Check driving pins (lug pins) for wear and tightness, replace if grooves are developing. Check saw collar faces for spring or wear. Ideally the saw collars should be slightly concave to ensure they grip the saw on their outer edges. When checking, a clearance of 0.0762 mm (0.003") between a straight edge and the inner edge of the collar flanges will be sufficient to make sure the outer edge of the saw collars grip the saw when it is tightened and overcome the spring that takes place.



Six-monthly checks

(a) Log carriage wheels and track rails

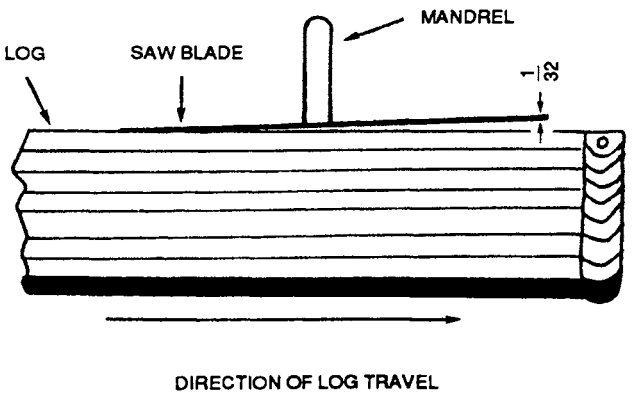
Check all carriage wheels for damaged flanges and clearance above the top of the vee rail. Check carriage rail joints for alignment and fixing bolts and nuts for tightness.

(b) Circular headrig and log carriage

Check saw mandrel bearings and if running hot wash out and regrease. Check saw and log carriage track alignment. A simple method is as follows:

Mark a saw tooth and measure the distance between the saw tooth and a carriage head block.

Move the carriage forward and turn the saw until the marked saw tooth and the same head block are in exactly the same relative position, then measure again. If a 1 220 mm (48") diameter circularsaw is on the machine, a 0.80 mm (1/32") increase on the last measurement means the saw is leading slightly into the log by 0.8 mm in 1 219 mm. (1/32" in 4 ft) which is generally regarded as beneficial. When checking alignment in this manner, care must be taken to ensure the log carriage does not move backwards before either measurement is taken. Any movement backwards could cause the offset mechanism to start to operate and create a false measurement.



Annual checks

(a) Log carriage track rail alignments

Check for straightness. The same methods for checking can be applied as already described under the annual checks for log carriage track rails and band headrigs.

(b) Saw and carriage headblock alignment

Check the saw for hanging plumb and check the head block slides for being level. If the carriage is level and the saw is not hanging plumb the last board will be wedge shaped. The saw, if out of plumb, can be adjusted by fitting shims, as necessary, under the mandrel bearing housings or by levelling up the entire main frame (husk) if settlement has taken place.

(c) Log carriage offset and setworks

Check offset mechanism for lost movement to make sure it is operating to its full extent. Check setworks for wear and lost movement.

Framesaws

Introduction

Framesaws, or gangsaws as they are often called, can, when properly maintained, produce very accurate well-sawn timber. Many different kinds are manufactured and used successfully.

Feed mechanisms are usually of the types described in detail in FAO Forestry Paper No.39, Frame Saw Manual, Rome 1982.

Due to the vibration which is set up by the actual working motion of any framesaw, the need for well-organized planned maintenance competently carried out is of paramount importance. Automatic oiling and greasing systems and saw tensioning devices have made this a less difficult task but the need for the machine to be operated by skilled personnel remains just as essential. Maintenance personnel and the machine operators must be fully conversant with the designed operation and production capacity of the machine and ensure that the recommendations of the manufacturer are strictly adhered to.

Specified production figures for machines are very often based on achievements from sawing softwood logs and to try and saw high density hardwood logs or cants at the same feed speed is asking for trouble and will end in disaster.

The maintenance of the saws and the accuracy of their alignment within the sash are vital requirements to efficient operation and if properly carried out will not cause any unnecessary mechanical breakdowns.

A framesaw should be kept working at all times as running empty is far more likely to cause mechanical problems.

Logs or cants should be kept butted up so that the work load is constant and maximum production is achieved without subjecting the machine to idle running period or intermittent high speed feeds.

A constant work load of logs or cants well within the feed speed capacity of the machine relevant to the species of timber being sawn is therefore a priority objective of the sawyer.

The alignment of the saws within the sash must be accurate with the correct amount of overhang according to the instructions of the machine manufacturer. Some machines have setting bars which are bolted across the top and bottom of the sash before fitting another set of saws. This or any other type of fixture which speeds up the change of saws is an advantage but accuracy should never be sacrificed for saving a few moments in time.

Before fitting a change of saws it is most important to make sure the spacer blocks which are fitted between the saws are free of sawdust and the top and bottom hangers are also clean. A small deposit of sawdust or gum deposit will put the saws out of alignment.

Like bandsaws or circularsaws the performance of framesaws is, to a large degree, dependent on the condition of the saws themselves. It is always better to change any saw before it gets really dull as this will only cause mis-sawn lumber, cause damage to the saw blade itself and possible mechanical problems with the machine. Running dull saws in framesaws should be avoided even though they continue to cut straight. A good indication of the need to change saws is when the fibres of the timber start to raise up on the faces of the boards being produced.

Planned maintenance programmes for framesaws should always be in strict accord with the recommendations of the manufacturer. Log carriage track rails should be kept clean and in good alignment, likewise, the fence and infeed rolls for machines sawing cants.

A maintenance programme should be based on the following:

Daily checks

(a) Before sawing

Check lubrication systems and level in lubricant tanks before starting the machine. Make sure infeed and outfeed rolls are clean and pressure rolls are working freely. Lubricate rolls or grease as necessary, making sure grease nipples and grease gum nozzles are cleaned beforehand and old grease is forced out. Check air pressure or hydraulic pressure for correct operational requirements. Check saw blade tension and setting.

(b) After sawing

Thoroughly clean the machine when the saws are removed and make sure no small pieces of timber are hung up anywhere near or on the machine which could fall into feed chains or sash frames when the machine is started up again.

Check connecting rod bearings and sash block guides by touch for overheating. If they are too hot to handle remedial action is necessary. Connecting rod bearings may need washing out and regreasing or the cause may be due to lack of lubrication to the guide blocks which has caused them to overheat and overload the connecting rod bearings.

Weekly checks

Carefully check the connecting rods after they are thoroughly cleaned and make sure they have not suffered damage resulting in deep cuts or scratches which should be ground out. Check chain and belt drives for tension.

Monthly checks

Check and tighten all bolts, do not forget anchor bolts. Check sash blocks for wear and side play in guides. Check all chains and adjust as necessary. Check feed roll bearings and check rolls for alignment. Check fence for alignment in the case of a machine sawing cants. Check feed mechanism.

The need to adjust sash blocks and eliminate excess side play in the guides is usually indicated by a shallow groove left in the face of the boards when the feed is stopped with the saws still running in the cant or log. A chalt mark at this position will prove the point if the groove is obvious on the board faces. The side play can then be checked by placing a piece of timber of suitable size and length between the sash and guides, applying pressure and getting an assistant to check the amount of clearance by inserting feeler gauges. Sash guides should not be adjusted too tight which will make them over heat.

If the feed mechanism is a friction drive it is essential that the faces of the friction wheel and the friction rollers are kept clean and dry.

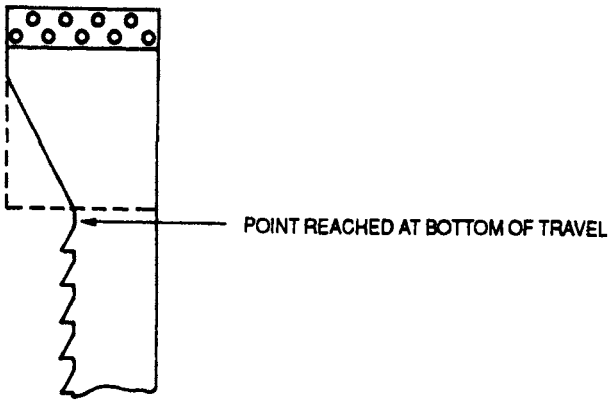
Oil or grease on these faces can cause intermittent feeding and loss of drive.

Six-monthly checks

All bearings should be checked according to the recommendations of the machine manufacturer and replaced if necessary.

One very essential requirement regarding framesaw operation and maintenance, which cannot be designated as a routine check, is also explained and illustrated as follows:

After retoothing or regrinding ensure the ends of the blade are cut or ground off at an angle to prevent overloading the end gullets and also to make sure the untoothed section of the top of the blade does not hammer against the top of the log or cant when the sash is at the bottom of its travel.



Annual checks

This particular check should be in the form of a general overhaul when the machine is thoroughly cleaned and all moving parts are inspected for wear or damage.

Repairs or replacements must be in strict accordance with the recommendations of the manufacturer.

A careful check on all lubrication pipes for leaks or insufficient supply to the various destinations should now be carried out.

(a) Guide system

The guides should be checked for alignment and wear. Worn guides should be repaired or if this is no longer possible, replaced.

Alignment checks may indicate that a movement of the actual machine base has taken place. This must be checked and if necessary the fault corrected.

The upper and lower guides must be aligned after repair or replacement when fixed in the machine. Alignment must be within the tolerance limits specified by the makers.

(b) Sash movement

Deviation in the sash movement is often identified by an increase or a change in the vibration tempo of the machine. A possible cause may be excess free movement of the sash blocks within the guides, but whatever the reason the condition must be rectified without delay and should not be left until the annual check is due.

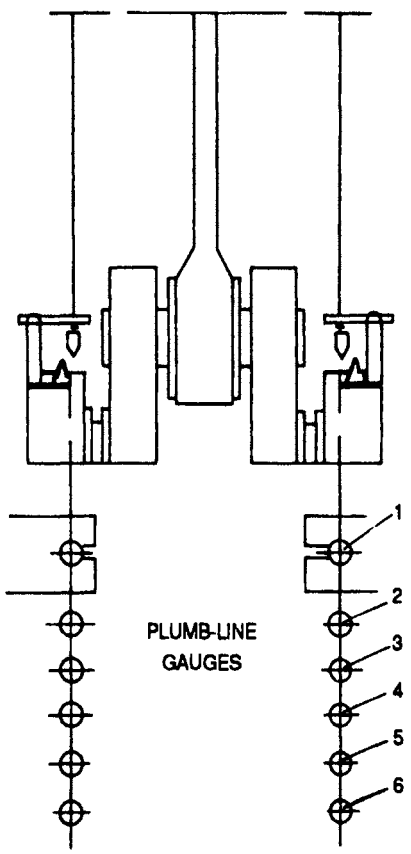
If checks on the guides and sash blocks show them to be within tolerance limits, the fault may well be in the lower bearing of the connecting rod which can be checked as follows:

Where possible open the caps of the lower connecting rod bearing and measure the distance between the rollers and the outer ring by use of feeler gauges. The measurement should be the same when the sash is moved to different positions.

An alternative method with a more accurate result can be achieved by using two plumb lines and two metal sheets with a hole in the centre (see figure) by the following procedure:

Attach the two metal pieces to the crank shaft bearing housing as shown in figure.

Pull the plumb lines through the holes in the metal pieces and attach the line to the lower cross beams of the sash directly above the holes when the sash is in its top position.



1 GOOD
2-3 ACCEPTED
4-6 CORRECTION REQUIRED

Adjust the metal pieces to position the plumb line in the centre of the hole and mark the position of the lines where they are suspended from the lower cross beam.

Lower the sash to its bottom position and accurately replace the plumb lines over the marks on the lower cross beam. The position of the lines relevant to the centre of the holes in the metal pieces will now give an accurate indication of any deviation in sash movement and if remedial action is necessary.

Regarding frame saws with a connecting rod on each side of the machine the movement can be checked in the following manner:

Carefully mark the top end of each connecting rod in accurate alignment to a marked position on each side of the main frame when the connecting rods are in the mid-stroke position. Crank the shaft round in the reverse direction and check if the marks on the connecting rods reach the marks on the main frame at the same time.

If one reaches the aligned mark before the other and the measured difference between the mark on the other connected rod and its aligned mark on the main frame exceeds the makers recommendations, the condition must be rectified. All the connecting rod bearings should be checked and replaced if necessary, but if no fault is found in the bearings the locking device of each connected rod fixing it to each flywheel should be checked and the movement of the connected rods synchronized.

(c) Feed mechanism

Saw speed in a framesaw is not constant as it is virtually nil at the top and bottom of the stroke with the maximum speed being reached at the middle of the stroke between these two positions. These factors are taken into consideration by machine manufacturers in the design of their frame saw as the timing of the log or cant travel is critical if efficient trouble free operation of the machine is to be maintained. Feed mechanisms are therefore timed at the factory to ensure varying feed speeds in order to allow the saws to cut smooth, straight lumber at all times. The varied types of feed mechanisms in use on different frame saws make it essential for the makers manual to be available to personnel for the make and model of the particular machine they are maintaining. Without a manufacturer's manual, it is highly unlikely that the timing of the feed mechanism on many frame saws could be repaired and correctly adjusted without some problems arising. This may result in reduced production from the machine and also the possibility of serious mechanical or saw problems quickly developing.

The feeding mechanism on all frame saws must therefore be checked in strict accordance with the specifications of the manufacturer. Lost movement caused by excessive wear in the timing mechanism is often the cause of mechanical or saw problems arising. These problems are usually preceded by a noticeable change in the vibration and working noise of the machine. Such changes should not be ignored and should be investigated and remedial action taken. Although the feed mechanism check is normally carried out annually, it must never be overlooked as a possible cause of trouble and must be checked.

Edger saws

Introduction

The maintenance of edger saws follows the same pattern of procedure as laid down for all other machines having the work pieces fed to the saws by rolls and the aid of a fence for alignment. For efficient operation and accurate sawn timber the saws must be maintained in first-class working order and the feed rolls and fence kept in perfect alignment.

As always there is nothing to be gained by trying to work these machines beyond their designed capacity, which, in any case, will almost certainly be based on a performance achieved when sawing the lower density softwood species.

With this in mind and the relative density of the timber to be sawn, mechanical breakdowns should be rare if the machines are worked within their capacity and the routine maintenance is efficient.

Daily checks

Clean down and lightly lubricate all machined surfaces. Check lubricant tank levels and ensure system is working if centralized. Lubricate rollers and feed chains as may be necessary. Check hydraulic or air pressure supply for correct operation of pressure feed rolls. Excessive pressure can result in damaged bearings and misaligned fences. Check dust extraction system for efficient working. Check saw guides if necessary when saws are changed.

Monthly checks

(a) Multi-saw edgers

Check belt and chain drives for correct tension. Check all hydraulic or air pipes for leaks or damage. Thoroughly clean feed rolls and check bearings, lubricate according to the recommendations of the manufacturer. Check dust extraction system if pneumatic for leaks. Replace or reface guide blocks. If a multi-edger is equipped with shadow lines, check saw alignment with shadow line. Check saw setting mechanism for lost movement and accuracy. Check guide block cooling and lubrication system.

(b) Single saw edgers

Check belt and chain drives for correct tension. Check pressure roll bearings. Check saw collars and guide pins. Thoroughly clean rollers and fence and check saw alignment. Check dust extraction system for damage and leaks if pneumatic. Check guide blocks and replace or reface as necessary.

Annual checks

Thoroughly clean all parts of the machine and inspect for damage or wear. Check all bearings according to the recommendations of the manufacturer and replace if necessary and also make sure saw collars are fitted and replace or reface if worn.

Check: all feed rolls for wear and alignment, reface or build-up, the reface and regroove as may be necessary if segments are not replaceable; chain or belt drives for wear, adjust or replace if required; saw shaft for alignment with fence; dimensional setting devices for lost movement and accuracy; all air pipes or hydraulic pipes for leaks and change filters as may be necessary; all bolts and nuts for tightness; and saw cooling and guide lubrication systems if fitted; the condition of the safety devices according to the maintenance manual.

The foregoing are intended only as a general guide to effective maintenance on circular saw edger machines as it is not possible to cover the individual requirements of all the many different types of machines manufactured. In conclusion it must be again stated that the manual of the manufacturer covering the operation and maintenance of the particular machine is an essential requirement if efficient performance and safety are to be maintained.

Strict adherence to the recommendations given by the manufacturers is therefore of paramount importance.

Crosscut saws

Introduction

Crosscut saws do not normally cause any serious maintenance problems if they are operated in a proper manner and the saws are maintained in good condition. The saws are usually somewhat thicker than rip saws and as they are not under working load for the same length of time, the need for changing and resharpening is less frequent. Crosscut sawing machines will vary immensely according to the type of work they are designed for, but as this manual is intended for sawmillers, the following maintenance procedures applicable to the types of crosscut that may be used in sawmills will be dealt with.

As always the condition of the saw blade itself will be a major factor in the performance of the machine. A crosscut saw should always be kept perfectly round and sharp without any hook angle on the teeth and with sufficient set on the teeth to ensure enough blade clearance is created by the teeth in the kerf to prevent the saw binding and heating up. The tooth faces should be sharpened with alternate bevel angles to give a shearing action across the grain of the timber and a smooth finish across the end of the sawn sections. The number of teeth in the saw blade will be dependent on the size of the blade and the maximum thickness and density of timber to be sawn.

Maintenance routines for crosscut machines are suggested as follows:

Daily checks

Grease any rollers without sealed bearings. Grease or oil pivot bearings on pendulum crosscuts and chain drive bearings on trimmers. Check oil tank if it is any hydraulically operated machine. Check safety guards and sawdust extraction system.

Six-monthly checks

Check: saw shaft bearings; belt tensions; any hydraulic piping for leaks; saw collars and drive pins; fence alignment is 90° to saw travel; feed chain travel is parallel to saw line on edge trimmers and multi trimmers; and chain drive sprocket shaft bearings for wear.

Annual checks

Thoroughly clean the machine and check for damage. Check: saw collars for wear and reface if necessary; saw shaft bearings and replace if necessary; dust extraction system; bolts and nuts for tightness; safety guards; feed chains for wear; chain sprockets for wear; actual framework of infeed and outfeed system for damage or instability and all hydraulic or pneumatic pipework and controls as may be fitted.

Once again the maintenance checks specified should only be used as guidelines for a basic programme. Modern machines, especially multi-saw trimmers, will incorporate remote push button controls with noise control systems and all the necessary appropriate safety guards. These machines will require a planned maintenance programme in accordance with the instructions of the manufacturer.

Ancillary equipment

Headrig log deck and loading equipment

Most medium-sized sawmills have some form of mechanical equipment to carry the logs onto the log deck ready for their loading onto the carriage. This may be some type of front-end loader which would pick them up from a log pile and deposit them onto the log deck where a chain conveyor would carry them forward within reach of a log loading and turning assembly. Alternatively, they may be brought from a log pile by gantry crane and loaded directly onto the carriage if log loading and turning equipment is not installed. However, whatever type of mechanical aid is used or whatever method is employed, the major factor which must always be considered at this stage of any sawmilling operation is the need to minimize log loading time without causing any unnecessary damage to the log carriage. The headrig must always be the pacemaker of production flow in a sawmill as lost sawing time through this machine cannot be recovered. It is therefore essential to plan the operation in a manner whereby the equipment available is used and maintained accordingly.

Large logs are invariably the cause of extended log loading times and it is therefore well worthwhile to have all logs which will obviously present problems reduced to a size which can be easily handled without extra loading time. Various types of chainsaws are available for this purpose and the cost involved may well be recovered by savings in lost production time alone in one year. This, of course, will depend on the number of oversize logs which will be dealt with although it only needs one oversize log to roll during a cut and cause damage to the saw or machine which could be even more costly.

Regarding the maintenance of the equipment used for log loading, this must be carried out in accordance with the recommendations of the manufacturer, particularly so in the case of gantry cranes where electro-magnetic devices are involved. Wire ropes and slings should also receive regular checks and attention with care being taken to keep them properly lubricated as a protection against wear, weather and rust. Regular weekly checks on crane assemblies, in addition to the normal daily lubrication and maintenance checks will prove worthwhile as they are often exposed to torrential rain, dust and heat. When not in operation park under cover.

In the case of raised headrig log decks where a chain haul is incorporated, it is essential that the structure of the main frame is inspected weekly and all bolts and nuts are checked for tightness in order to keep the assembly firm and solid. The chain drive unit should be checked daily to ensure the correct oil level is maintained.

Daily checks

Brush off and lubricate chains and channels. Check chain drive unit lubrication level. Check area under log deck is free of broken timber or anything likely to get between chains and sprockets.

Weekly checks

Inspect all structure for damage. Check all bolts and nuts for tightness. Check chain drive unit anchor bolts for tightness. Check drive chain for tension, clean and lubricate.

As the headrig log deck should be carrying sufficient logs to keep the headrig working for preferably an hour the maintenance work should be planned accordingly. The daily checks on the log deck chain haul unit can be carried out at the end of the work shift whilst the crane is used to fill up the log deck. The daily routine checks and maintenance can then be carried out at the beginning of the next work shift on the crane.

Front-end loading vehicles used for feeding the log deck should be maintained strictly according to the manual issued by the manufacturers and parked under cover when not in use, and a weekly check on bolts for tightness carried out on the lifting gear. Recommended spare parts should always be available for fitting when required.

Waste conveyor systems

Maintenance on waste conveyors is generally a question of good housekeeping and lubrication where necessary and it is carried out as follows:

Belt conveyors

Daily checks

Make sure there are no pieces of timber waste caught underneath between the belt and rollers. Check belt fasteners for damage and belt travel for correct tracking. Where sealed bearings are not fitted, grease

as necessary after cleaning grease nipple and grease gun nozzle. Pump in sufficient grease to force old grease out but clean any spillage off belt. Where possible run conveyors at the end of the work shift until the belt is empty. Check drive gear unit for correct oil level.

Weekly checks

Check: drive chain for tension, clean and lubricate; drive gear unit anchor bolts for tightness; rollers for freedom of rotation; and belt conveyor assembly for any spilled pieces of wood waste that may be caught up in the frame and rubbing on the belt.

Dust extraction systems

Pneumatic

The main cause of reduced efficiency with pneumatic dust extraction systems is usually due to holes in the ducting created by impact of dust particles travelling around bends. This leads to loss of suction which, in turn, can result in the heavier particles of wood waste being left in the machine and causing a build-up which has to be cleared by hand. Holes in the ducting on the suction side of the system are not always easy to locate and any build-up of waste material at the machine warrants further investigation and remedial action.

On the exhaust side of the system any holes created are made apparent by dust which is blown through them making their location much easier to find.

The power unit of the system, which is a large motor driven fan, does not call for any involved maintenance and is usually confined to periodic bearing lubrication on the motor and fan unit with checks on the assembly bolts and nuts for tightness. Fan blades can get damaged by small chunks of high density wood waste being drawn up and hitting them at high speed. This can be avoided by fitting heavy wire mesh or a metal grille at the mouth piece of the ducting which will prevent the passage of pieces large enough to cause damage to the blades or ducting.

Suggested routine checks for these dust extraction systems are as follows:

Daily checks

(a) Suction side

Check dust systems not in use are closed off. This will increase the efficiency of the others. Check frequently during the working operation that dust is being removed. If dust is not being removed, investigate the cause.

(b) Exhaust side

Check ducting for any dust blow-out or any dust deposit below it.

Weekly checks

Check joints along the ducting system and make sure they are all sealed and secure. Check also mouth piece mesh or grilles and make sure they are secure, clear and undamaged.

Monthly checks

Fan and motor assembly.

Check belt drive tension to fan and fan blades for any damage. Check bolts and nuts on unit assembly for tightness, and check and lubricate bearings, if necessary, according to the recommendations of the manufacturer.

Annual checks

These checks should be in the form of a general inspection where the whole system is looked over and any section of ducting which has suffered more severe abrasion should be replaced. A close scrutiny for corrosion or rust should be carried out to minimize the possibility of unforeseen lost production time in the future.

GUIDE FOR FAULT DIAGNOSIS

Some of the more common faults which are often experienced in most sawmills are listed with the most probable causes for them as follows:

Band headrigs

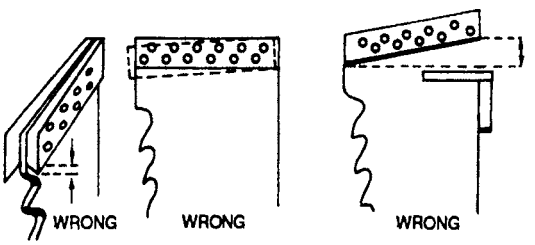
Fault	Probable cause
Last board on carriage is wedge shaped from edge to edge (top to bottom).	Carriage knees and bandsaw out of vertical alignment. Top saw guide slide out of alignment with bandsaw. Possible error in setting the pressure guides.
(If pressure guides used)	
Variation in thickness on boards throughout their length.	Inefficient saw maintenance. Saw guides improperly set. Carriage speed too fast, too slow or irregular. Carriage track rails out of line.
Variation in thickness between boards.	Setwork worn or inaccurate. End play on carriage axles. Dogging not positive. Carriage speed irregular. Saw guides need adjusting. Backlash in headblock movement.

Fault	Probable cause
Last board on carriage varies in thickness from end to end.	Carriage headblocks out of line. Spring in the log sawn. Dogging not positive.
Saw runs back on wheels when sawing and gives a variation in board thickness.	Wheel scrapers not working properly. Shear board (sawdust chute) allowing sawdust to go between saw and bottom wheel. Dull saw. Insufficient hook angle. Feeding too fast with top guide too far above the timber being sawn. Insufficient strain. Insufficient crown on back of saw.
Saws cracking after a short working period when still sharp. Cracks appear around the gullet area.	Band wheels need refacing. Saw strain mechanism not working freely. Shear board (sawdust chute) needs adjusting up to saw blade. Too much crown on the back of bandsaw blade. Tension in blade carried too close to the gullet line. Burnt gullets caused by grinding too heavy or improperly dressed grinding wheel. Feeding too fast into the cut. Saw tracked too far forward.
Saws cracking in various places around the blade. Strain lever shows small movement up and down.	Inefficient saw maintenance involving irregular tension, irregular crown on back edge. Saw blade too thick for the diameter of bandwheel. Bandwheels out of round in need of refacing.
Saw tends to lead out of the log when entering the cut.	Feeding into the log too fast. Top guide too far from the cut. Saw and carriage track out of alignment. Side play in carriage axles. Saw dished away from log.
Saw gets hot.	Accumulation of sawdust between lower bandwheel and main frame making wheel face hot which is transmitted to saw. Sliver of timber caught between saw and guides or shear board (sawdust chute) and saw. Insufficient swage on saw teeth.

Circular headrigs

Fault	Probable cause
Last board on carriage wedge shaped from edge to edge (top to bottom).	Carriage knees out of alignment. Carriage track rails not level. Saw not hanging plumb. Dogging inadequate.
Last board on carriage wedge shaped and varies in thickness from end to end.	Spring in the log sawn. Inadequate dogging. Carriage knees out of alignment. Carriage track rails not level. Saw not hanging plumb.
Boards are acceptably straight but vary in thickness from one to another.	Setworks are inaccurate. Side play on carriage axles. Backlash on head block movement. Excessive end play in saw shaft bearings. Bearings loose in housings.
Variation in thickness within the length of individual boards.	Carriage track rails and saw out of alignment. Carriage track rails not level and vee rail not straight. Saw speed not constant when sawing. Saw collars need refacing. Saw guides not properly set. Carriage feed speed too fast, too slow or erratic. Saw not hanging plumb. Saw is dished.
Saw gets hot in the centre.	Bearing nearest saw running hot. Saw dished out from log. More lead into log needed. Saw collars need refacing. Insufficient set or swage on teeth. Saw needs sharpening. More water spray required.
Saw gets hot around the rim area.	Saw guides set too close. Saw speed too high. Tooth set or swage too small. Water spray needs adjusting. Carriage speed too slow making tooth bite too small. Saw collars need refacing. Inserted tooth holders (shanks) worn. Less teeth and larger gullet areas needed in saw.

Fault	Probable cause
Saw cracks around the outside of the collar line.	Saw collars need refacing. Saw not hanging plumb. Shaft bearings defective. Misalignment in carriage track rails. Side play on carriage axles between vee wheels and carriage. Incorrect alignment between saw line and carriage track. Incorrect tension for saw speed.
Framesaws	
Poor surface on board faces and some tooth damage on saws.	Teeth out of alignment. Incorrect overhang. Over feeding. Unsuitable tooth shape or tooth pitch for timber being sawn. Uneven set or swage.
Acceptable surface on board faces but some blade breakage occurring with centre saws.	Straining too tight, centre saws not being strained last. Over feeding. Incorrect overhang. Burnt saw gullets causing cracks leading to blade breakage.
Uneven thickness in the length of individual boards.	Feeding too fast. Insufficient strain. Saws out of alignment. Spacers between saw blades worn or dirty. Feed rolls worn or out of alignment. Incorrect tension in saw blades. Saws dull or not swaged and ground properly. Incorrect overhang. Insufficient crown on back of saws. Incorrect swage or set on saw teeth for the type of timber being sawn.
Clamping tabs pulling away from saw blades. Rivets breaking.	Tabs not correctly positioned each side of blade.



Heavy hammering on clamping tabs when changing saws. Clamping tabs not riveted firmly to the blade. Excessive strain on blade.

Fault	Probable cause
Increased vibration arising.	Too much overhang. Feeding too fast or too slow. Too much hook on saw teeth. Excessive side play between sash blocks and guide frames. Feed mechanism's timing needs adjusting. Excessive play in crankshaft or connecting rod bearings. Foundation anchor bolts need tightening. Insufficient pressure on top infeed and outfeed rolls. Dull saws.

BASIC WORKSHOP REQUIREMENTS

Staff and equipment required for effective planned maintenance will obviously be dependent on the type and number of machines involved, the volume of logs sawn per annum and the location of the sawmill regarding its proximity to mechanical engineering repair workshops willing to carry out repairs on sawmill machinery.

Effective planned maintenance also involves carrying a stock of spare parts for the various machines which on the recommendation of the manufacturers should be replaced periodically. This entails the need for a store or spare parts section to be incorporated with the workshop and staffed accordingly.

The following maintenance equipment is suggested as the basic minimum requirement for a sawmill in a remote forest area sawing around 16 660 m^3 (500 000 ft^3) of logs per annum. Staff requirements specified do not include personnel for the maintenance of logging vehicles and lumber transportation as these could be contracted vehicles inclusive of maintenance. The actual buildings suggested do, however, take into consideration the need for a covered area with a heavy load carrying beam and a pit, which would allow engines to be removed from or various repairs carried out from underneath such vehicles. The number of staff quoted below are foreseen as a minimum requirement:

one foreman fitter/centre lathe turner;
one general fitter;
one welder oxy/acetylene and electric;
one storekeeper;
one electrician.

Any additional labour required could be available from sawmill production personnel when machines with which they were involved were undergoing repairs or planned maintenance.

The machine shop, general workshop, stores and covered bays are usually adjacent to the sawmill and should preferably be situated where the prevailing wind is not blowing dust into the workshops and stores.

The size of the buildings given below may appear to be somewhat large and therefore more costly in construction than some companies or owners consider necessary, but the following reasons may help to convince them otherwise.

Working in small buildings with little ventilation or light in tropical heat makes the quality and quantity of work output sub-standard.

Confined space often prevents machines, or large sections of machines, from being brought into the workshops for major repairs or overhauls. This can result in much longer time being taken for carrying out the work involved and a considerable increase in financial loss due to lost production time.

Various units of sawmilling equipment, or sections of it, can be prefabricated in the sawmill workshops. Confined space can make production difficult and their storage even more so.

Personnel are far less likely to suffer injury through accidents when moving heavy sections of machinery around in the workshops. Confined space is likely to cause accidents and damage to equipment.

A reasonable size and plan for these buildings to accommodate the machinery and stores required for the size of sawmill mentioned is as follows:

6 m (20')	MACHINE SHOP	WORKSHOP	STORES	6 m (20')
	8 m (26'8")	8 m (26'8")	8 m (26'8")	

In addition to the usual necessary spanners, socket wrenches and other various hand and portable electric tools, the following equipment will be required to enable routine repairs and maintenance to be carried out:

one centre lathe;
one shaper;
one bench grinder;
one pedestal drilling machine;
one power hacksaw;
one small hand forge and anvil (preferably 70 kg (155 lbs) weight);
one mobile electric welding plant;
one oxy/acetylene welding set complete with cutting equipment;
one Barnhart bandwheel grinder.

Covered bays for vehicle maintenance can be adjoining or near the workshop provided the general location of the sawmill and roadways for log and lumber transportation allow this.

Like all other machinery, vehicles transporting logs or lumber require planned maintenance if they are to operate efficiently, and if the sawmill is not using contract vehicles provision for this must be available. Facilities for washing the vehicles are most important as forest roads are often deep in mud during the rains or deep in dust during the dry season; both conditions being conducive to a high rate of wear on moving parts in a short space of time.

Maintenance of the vehicles must be in strict accordance with the manufacturers' instructions relevant to the climatic conditions in which they are used. Oil filters and air cleaners, in particular, should always be changed on time and spares must be available. General washing and lubrication should be frequent and thorough as this will minimize the wear due to mud and dust and make damage to chassis or other sections due to bad road surfaces much more easily seen. Vehicles transporting logs or lumber over bad road surfaces should not be overloaded as this will quickly prove to be false economy.

GENERAL INFORMATION

The following information is regarded as necessary basic knowledge for the safe and efficient operation of sawmill machinery and equipment.

Bandmills

(a) Causes of cracks in bandsaw blades

Cracks in bandsaw blades can arise from various causes. Checks on the following conditions are usually successful in stopping them.

(b) Cracks in the tooth edge

(i) Lumps in the blade, rubbing tight in the guide blocks, causing case hardening and subsequent cracking.

(ii) Saw blade not cleaned properly before being put in the sharpening machine causing the grinding wheel to pick up sawdust, gum, resin or other debris from the gullet area. The grinding wheel is then unable to cut freely and grinds hot. This causes burnt gullets, case hardening and then cracks.

(iii) Insufficient tension in the front section of the saw. This will usually show up in the form of one or two long cracks about one to two inches in length.

(iv) Too much tension in the front section leaving no tyre under the gullet line, thus putting excess strain when cutting on the extreme edge, causing small cracks.

(v) Too much crown on the back of the saw making the tooth edge too taut and causing a lot of small cracks around the front edge.

(vi) Shear board on the bandmill not properly adjusted, allowing sawdust, knots, chunks of wood or other debris to fall between the saw blade and the bottom wheel.

(vii) Bandwheel scrapers not in good condition allowing a build-up of sawdust and gum to take place on the wheel, causing the saw to run too far forward or back on the wheels.

(viii) The sawyer feeding the saw too fast in high density timbers, when the teeth are dull.

(ix) A bad bearing or bearings in the bandmill wheels causing vibration.

(x) The straining device is not working freely, thus putting too much strain on the tooth edge when sawing.

(xi) Too much weight on the strain lever making the tooth edge too taut. This will result in quite large cracks under the gullet.

(xii) Bandwheels in bad condition with faces worn, making them run out of true causing vibration and uneven stress on the tooth edge.

(xiii) A build-up of sawdust and other debris on the bottom wheel causing the machine to vibrate and put intermittent strain on the tooth edge when sawing.

(xiv) Grinding wheel not properly dressed causing sharp ridges to be left in the gullet area.

(xv) Incorrect thickness of grinding wheel being used and sharpening machine not correctly adjusted which allows sharp ridges to be created in the gullet area.

(c) Cracks in the back edge

(i) Not enough crown rolled into back edge, thus making back edge too tight when sawing.

(ii) Too much tension or too little in the back edge.

(iii) Back edge of saw case hardened by continued rubbing on steel saw support frames when sharpening.

(iv) Back edge of saw too sharp created by the same cause, or saw having been pushed back on the wheels when sawing, causing it to rub against the frame of the bottom guides. These two conditions, (iii) and (iv), can be rectified by holding a piece of old grinding wheel against the back of the saw while it is running and honing off the sharp edges and the case hardened surfaces.

(v) Uneven crown on the back edge, causing the saw to move backwards and forwards on the wheels when running.

(vi) Uneven tension in the saw creating vibration and movement on the wheels.

(vii) Saw not properly levelled with lumps in the blade hitting the saw guides. This causes vibration and will cause undue metal fatigue.

(viii) Bandwheels in bad condition.

(ix) Wheel bearings have too much play.

(x) Wheel scrapers or shear board need adjustment.

(d) Cracks in the centre

(i) Too much tension in centre section only.

(ii) Too little tension in centre section only.

(iii) Saw blade too thick for the diameter of bandwheels on which it is being used.

(iv) Bandwheels in bad condition.

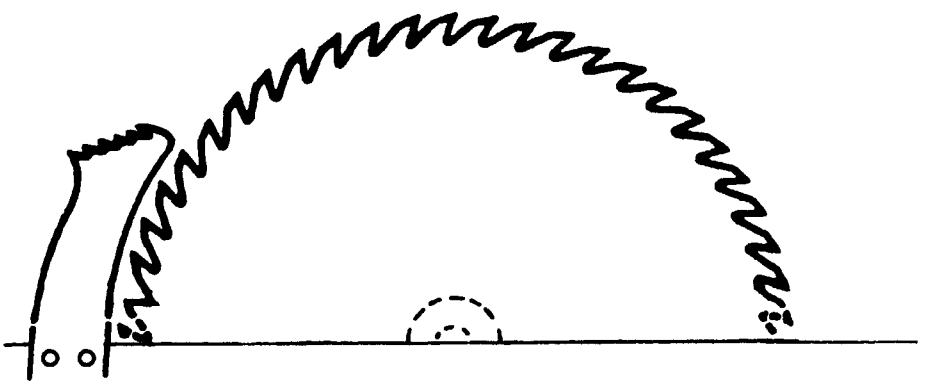
The main causes of cracks in bandsaws can usually be attributed to lumps, incorrect tension and incorrect crown in the saws, grinding wheels not correctly dressed causing sharp ridges to be left in the gullet area or burnt gullets.

Circularsaws

The riving knife, cleaving knife, guide knife spreader, circular disc splitter, or whatever the local name may be, is often set too far away from the saw blade (or is unsuitable) to fulfill its intended function which is to safeguard the sawyer.

As is well-known, the saw blade cuts with that part on which the teeth are directed downwards during rotation. When rip-sawing, therefore, there is a considerable risk that the teeth opposite the cutting side will throw up the workpiece when it has been sawn through so far that the blade has entered it completely. In actual fact, certain stresses are always set up in the wood so that the sawn kerf either becomes narrower or wider at the end. If the gap is narrower, this may cause the saw teeth moving upwards to bind and hurl the work against the sawyer with serious accidents as a result. In order to prevent this happening, a riving knife (cleaving knife) is employed. This knife should be placed as close to the saw as possible, and exactly in line with it, in order to eliminate the risk of slabs and the like coming between the saw and the knife and thus, causing accidents. It should be provided with teeth as a precaution against any throw-back. The teeth
exert a braking effect on wood which may have moved backwards with the table to be pressed up by the knife against the teeth of the saw blade.

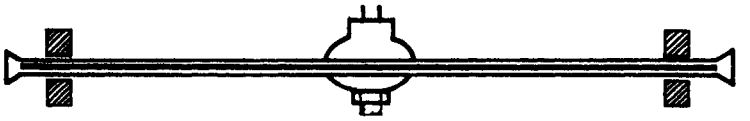
The riving knife should be thinner at the edge facing the saw but thicker than the latter on the opposite side. It thus widens the gap already formed in the wood so that the saw teeth cannot come into contact with the edges.



The riving knife should be located as close to the saw blade as possible.

Another factor often overlooked is the need to keep rear guide pins correctly set on large diameter circularsaws. Their sole purpose is to prevent the saw from cutting into the table if the saw flutters. They should be located about 5 mm (3/16") from the blade. These rear guide pins should not be left out, as occasionally happens. Do not forget to alter the position of the guide pins when changing over to a larger saw. (See illustration.)

The rear guide pins should be located about 5 mm (3/16") from the blade



The distance between the blade and the front guide pins should correspond to the thickness of a double-folded newsprint sheet

Saw blade with guide pins.

Sizes, speed and power required

It is always advisable to use a saw of the smallest diameter for the job in hand as it will take less power and be easier to maintain.

The power required for various saw sizes is dependent on many factors, including:

density of the wood to be sawn;
tooth pitch of the saw;
diameter and thickness of saw blade;
type of tooth and shape of tooth point;
depth of average cut to be made;
maximum feed speed of work piece;
peripheral speed of the saw.

The following tables shown overleaf are given as an indication of saw sizes, thickness, speed and power requirements for low density timbers but high density hardwoods would require a decrease in saw speeds of around 25 percent and an increase in power requirement of the same amount.

Suitable sources of power for:

A saw	200 mm	(7.9")	diameter	1	HP motor
"	300 mm	(11.8")	"	1.5	"
"	400 mm	(15.7")	"	2.5	"
"	500 mm	(19.7")	"	4	"
"	600 mm	(23.6")	"	6	"
"	700 mm	(27.6")	"	10	"
"	800 mm	(31.5")	"	14	"
"	900 mm	(35.4")	"	24	"
"	1 000 mm	(39.4")	"	30	"
"	1 100 mm	(43.3")	"	40	"
"	1 200 mm	(47.2")	"	46	"
"	1 300 mm	(51.2")	"	50	"
"	1 400 mm	(55.1")	"	60	"

For high density hardwoods, increase by 25 percent, but as already stated, the power required will be dependent on the factors mentioned.

The speeds given in the table shown overleaf should be regarded as the maximum RPM likely to be used to advantage with safety. In most cases, high density timbers can be sawn more easily and efficiently with considerable reductions in the peripheral speed of the saws. Whenever possible a reduction in RPM or a smaller diameter saw is well worth trying, as a maximum of 2 140 m per minute, (7 000 feet) is often found to be most suitable.

(2 140 m/minute = 7 000 ft/minute = 36 m/second.)

For the maximum speed, reference should be made to the following table which also gives the standard diameters and thicknesses.

Diameter		Thickness		Suitable
mm	approx. ins.	mm	approx. G	speed r.p.m.
250	9.8	1.4	17	3 600
300	11.8	1.6	16	3 000
350	13.8	1.8	15	2 500
400	15.7	1.8	15	2 250
450	17.7	2.0	14	2 000
500	19.7	2.4	13	1 800
550	21.7	2.4	13	1 600
600	23.6	2.6	12	1 500
650	25.6	2.6	12	1 350
700	27.6	3.0	11	1 270
750	29.5	3.0	11	1 200
800	31.5	3.0	11	1 100
850	33.5	3.0	11	1 050
900	35.4	3.0	11	1 000
950	37.4	3.2	10	950
1 000	39.4	3.2	10	900
1 050	41.3	3.2	10	850
1 100	43.3	3.6	9	800
1 150	45.3	3.6	9	780
1 200	47.2	4.0	8	750
1 250	49.2	3.6	9	720
1 300	51.2	4.0	7	680
1 350	53.1	4.5	8	660
1 400	55.1	4.5	7	640
1 450	57.1	4.5	7	620
1 500	59.1	4.5	7	600

N.B. For high density hardwood a decrease in the given r.p.m. of 25 percent may well be necessary.

It is not advisable to run circular rip saws at a higher peripheral speed than 47 m/second (154 ft/second).

If the saw wobbles, the collars should first be examined before attributing it to the levelling and tensioning. This investigation can best be carried out by tightening up the saw and then turning it slowly round while marking where the warp is located. The nut should then be slackened, the blade rotated a half turn and the nut tightened again. If the marked warp then remains in the same position as before the saw is usually faulty. If the warp has assumed some other position, the fault is due to the collars or the nut.

If the toothing of a saw idling at speed is poked at with a stick of wood or similar it will flutter, but is satisfactory as far as the tension is concerned, if it rapidly regains its position and runs steadily and straight. If fluttering continues, the tension is incorrect and the blade must be re-tensioned.

Retain the original tooth shape and hook and take precautions against cracks by keeping the gullets well-rounded. Never blue-burn the tooth points when grinding them.

Always keep the teeth well-sharpened. The saw must cut and not wear its way forward.

Never undertake any work of adjustment on the saw, such as boring out the centre-hole, pin-hole or the like, unless someone competent re-tensions the saw afterwards.

Never carry out major repairs on circular saws such as welding up cracks or welding in new teeth unless someone highly competent can do the job with the necessary skill and experience to properly level and tension the saw afterwards. To avoid possible danger to personnel and damage to the machine, these repairs need to be as near perfect as possible.

If a crack develops, investigate the possible causes and find the reason for it as damaged saws lose their efficiency and are expensive items to replace.

When the cause of any problem relating to damaged saws, or bad sawing is difficult to trace, remember that close cooperation between sawyers, saw doctors, mechanical and electrical engineers becomes more essential in order to put things right.

Diameter of saws suggested for various log diameters

Saw diameter required inches	Average diameter of largest logs inches	Saw diameter required millimetres	Average diameter of largest logs millimetres
40	18	1 016	457
44	20	1 118	508
48	22	1 219	559
52	26	1 321	660
56	30	1 422	762
60	34	1 524	864

Recommended sizes of bandmill wheels to bandsaw blades

Wheel diameter Feet	Metres	Blade width Inches	Centimetres	Blade thickness Inches	Millimetres	Ratio Wheel-blade diameter thickness
5	1.52	5-9	12.70-22.86	0.058	1.473	1 034
5.5	1.68	7-11	17.78-27.94	0.065	1.651	1 015
6	1.83	8-12	20.32-30.48	0.072	1.829	1 000
7	2.13	10-14	25.40-35.56	0.083	2.108	1 000
8	2.44	12-16	30.48-40.64	0.095	2.413	1 000
9	2.74	14-16	35.56-40.64	0.109	2.769	1 000

The above table is intended as a guide in order to prevent fatigue cracks in bandsaws being caused by running blades too thick on the wheels concerned. The relationship should always be a minimum of 1 000 times the blade thickness to the diameter of the wheel.

Grinding wheels

The efficient and safe use of grinding wheels

Mounting should only be performed by a competent person and the following recommendations should always be observed.

(a) Wheel inspection

Before mounting abrasive wheels on any machine the speed of the machine should be checked to ensure the wheel will not exceed the safe maximum RPM specified by the manufacturers.

The wheel should then be inspected for damage and a further check carried out by means of the 'ring test' in which the wheel is suspended vertically and tapped with a light non-metallic implement. If the wheel is sound it will emit a clear ringing tone; if it is cracked, it will sound dead. A cracked wheel is unsafe and must not be used under any circumstances.

(b) Blotting paper washers

Blotters or flange facings of compressible material should be used to ensure even clamping pressure, apart from the exceptions listed below. Blotting paper washers should cover the entire contact area of wheel flanges. Blotters should not be used on the following types of wheel:

(i) Mounted wheels and points;
(ii) Abrasive discs, threaded hole wheels, plugs and cones;
(iii) Plate mounted wheels;
(iv) Cylinder wheels or segments mounted in chucks;
(v) Type 27 depressed centre wheels;
(vi) Type four taper sided wheels;
(vii) Small internal wheels less than 20 mm (3/4") diameter.

Saw gauge thickness converted to inches and millimetres

Birmingham gauges		Fraction of inch	Thousandths of inch	Millimetres
		1 = 1.000	1 000	25.40
		7/8 = 0.875	875	22.225
		3/4 = 0.750	750	19.05
		5/8 = 0.625	625	15.875
		1/2 = 0.500	500	12.70
		15/32 = 0.46875	468	11.905
0000		29/64 = 0.454	454	11.53
000	Full	27/64 = 0.425	425	10.70
00	Full	3/8 = 0.380	380	9.65
0	Scant	11/32 = 0.340	340	8.64
1	Scant	5/16 = 0.300	300	7.62
2		9/32 = 0.284	284	7.21
3	Full	1/4 = 0.259	259	6.57
4		15/64 = 0.238	238	6.04
5		7/32 = 0.220	220	5.59
6		13/64 = 0.203	203	5.18
7	Scant	3/16 = 0.180	180	4.57
8	Full	5/32 = 0.165	165	4.19
9	Scant	5/32 = 0.148	148	3.76
10	Full	1/8 = 0.134	134	3.40
11	Scant	1/8 = 0.120	120	3.05
12		7/64 = 0.109	109	2.77
13		3/32 = 0.095	95	2.41
14	Full	5/64 = 0.083	83	2.10
15	Scant	5/64 = 0.072	72	1.82
16	Full	1/16 = 0.065	65	1.65
17	Scant	1/16 = 0.058	58	1.47
18		3/64 = 0.049	49	1.24
19		= 0.042	42	1.06
20		= 0.035	35	0.89
21		1/32 = 0.032	32	0.81
22		= 0.028	28	0.71
23		= 0.025	25	0.64
24		= 0.022	22	0.56
25		= 0.020	20	0.51
26		= 0.018	18	0.46
27		1/64 = 0.016	16	0.41
28		= 0.014	14	0.36
29		= 0.013	13	0.33
30		= 0.012	12	0.30

(c) Hole size

The grinding wheel should be a good fit on the spindle and remain free under all grinding conditions.

Wheels which are a tight fit on the spindle or have excessive clearance between wheel and spindle should not be mounted.

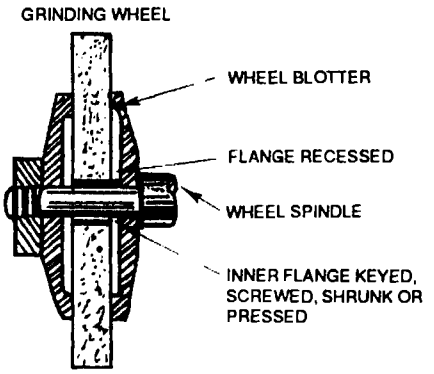
(d) Machine sideplates

In general, abrasive wheels should be mounted between sideplates made of mild steel or similar strength material, that are not less than one-third the diameter of the wheel. Flanges should have sufficient contact area to drive the wheel and be of proper design to prevent distortion causing damaging stresses in the wheel.

The following recommendations on sideplate design and condition should always be observed:

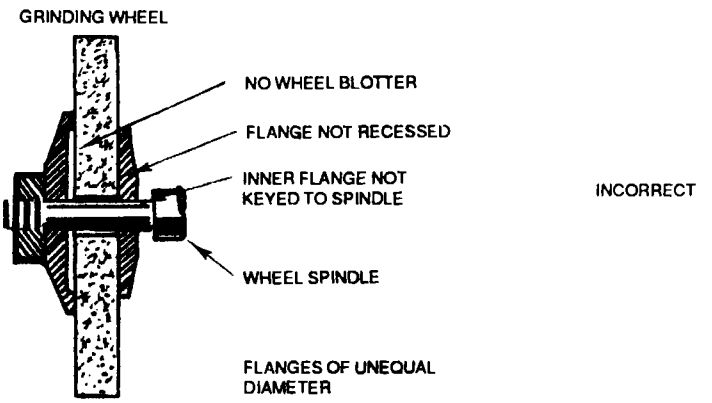
(i) Both wheel flanges should be of equal diameter and have bearing surfaces of equal area;

(ii) The driving flange should be keyed or otherwise secured to the guiding spindle;



(iii) With the exception of the single flange used on threaded hole wheels, sideplates should be recessed or undercut on the side next to the wheel so that pressure is not exerted near the hole;

(iv) Flange bearing surfaces should be flat and machined true with no exposed, rough edges. Wheels should not be mounted between worn, sprung or damaged sideplates.

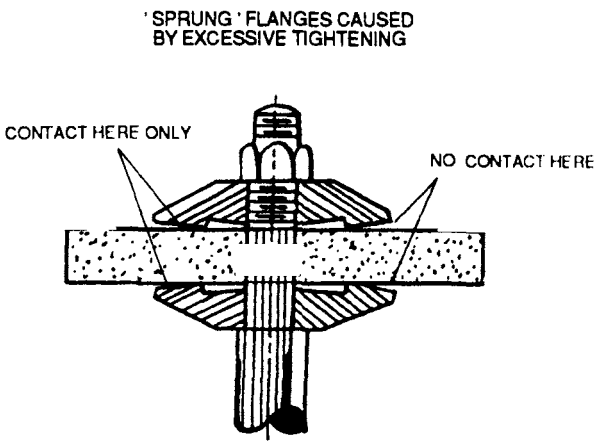


(v) The following types of wheel are not mounted between flanges:

Mounted points and wheels;
Abrasive discs and threaded hole wheels;
Plate mounted wheels;
Cylinder wheels or segments mounted in chucks;
Type 27 depressed centre wheels.

(e) Tightening of mounting nuts

Spindle nuts should not be overtightened and should only be tightened sufficiently to drive the wheel.



Multiple screw flanges should be tightened uniformly to prevent springing of the flanges and to ensure even distribution of mounting pressure over the entire surface of the flanges.

Torques of 2 to 2.75 mKg are common with single wheel mountings, although some exceptionally severe operations require greater pressure.

(f) Maximum operating speed

The initial speed of the wheel at full diameter should not exceed the maximum operating speed specified for the wheel.

The maximum operating speed is not necessarily the most efficient grinding speed. Better results can often be obtained at lower than maximum operating speeds.

(g) Using the wheel

(i) Starting the wheel

Before running the wheel guard and work rest, if fitted, should be properly adjusted and secured.

New wheels should be run free at full operating speed for one minute before they are used. During this trial run, all personnel should stand clear.

(ii) Balancing, truing and dressing

These operations should only be performed by a competent person. Wheels should be balanced, trued and dressed by the user when and as often as necessary.

(iii) Wheel guards

Wheels should only be used on machines fitted with a guard of adequate strength and designed to ensure that:

In the event of breakage, fragments of wheel are contained by the guard. As far as possible, the operator cannot come into contact with the wheel.

Mounted wheels, threaded hole wheels and other wheels used for internal grinding are exceptions to this rule.

(iv) Work rests

Work rests, when fitted, should be kept adjusted as closely as possible to the wheel to prevent the work from being caught between the wheel and the rest.

The work rest should be securely clamped after each adjustment and adjustments should not be made while the wheel is in motion.

(v) Side grinding

Side grinding should only be performed with wheels designed for this purpose.

Grinding on the flat sides of straight wheels is dangerous and should not be allowed. This does not preclude their use for form grinding and shoulder grinding.

(vi) Grinding fluid

Before shutting off a wet grinding operation, the grinding fluid should be switched off and the wheel allowed to rotate until the coolant has been spun out.

(vii) Machine condition

All spindles, adaptors, flanges or other machine parts on which wheels fit, should be periodically inspected for wear and maintained to correct specification.

(h) Statutory regulations

Many countries have specific regulations laying down codes of practice governing the use of abrasive wheels.

It is essential that users are aware of the relevant regulations and conform to their requirements. The statutory regulations relevant to the use of abrasive wheels for the United Kingdom are the Abrasive Wheel Regulations 1970, and many countries overseas have similar regulations.

GENERAL RECOMMENDATIONS

Departmental liaison

Production targets are much more likely to be achieved if all persons concerned are aware of them and the part they must play to achieve them. The role of management is, therefore, to keep up-to-date information relevant to the production schedule sent to the various departments involved and also to arrange periodic meetings for members from those departments to discuss and review the current performance.

Cooperation between departmental personnel is most essential if targets are to be achieved and management must always be aware of the adverse effect that friction between departments can create. Periodic meetings involving members from all departments can go a long way in creating an atmosphere where meaningful discussions can take place without ill-feeling arising. The role of management in maintaining a good relationship between the various departments must be accepted as one of their most important responsibilities and should be dealt with accordingly.

The timing of the meetings and the period between meetings can be at the discretion of the sawmill management concerned, but a weekly meeting may well prove to be most beneficial. The advantage of weekly meetings is that points brought up for discussion are usually connected with something that happened during the week. This allows any factor having adverse effects on sawmill performance to be discussed whilst it is fresh in the mind. Lost production time in particular can be checked and decisions taken regarding remedial action necessary if the cause is recurrent and can be avoided. Such action invariably involves cooperation in the form of a change of routine between personnel of different departments which, without the frank and open discussion of the meetings would not be so readily forthcoming.

The meeting should be regarded as a 'Joint Consultative Committee Meeting' and should be made up of representatives from all the various departments including a member of those responsible for the general cleanliness of the sawmill, walkways, roadways and surrounding areas. Minor problems becoming major problems can be avoided with the establishment of such Consultative Committees and management can get closer cooperation and better results from all the various departments through the

meetings they hold with them. Discussions, however, must be frank, open and factual when problems are discussed and all concerned must realize the main objective of the meeting is to find the answer to problems and not to make excuses or apportion blame for them.

The effect on morale through discussions at the meetings can be very advantageous. To be a member of a successful team and also be complimented for it is always pleasant. Working in clean and tidy surroundings is likewise pleasant and usually creates a better standard of workmanship. Management who have already established such committees will readily confirm their value in dealing with problems relevant to production through suggestions that are often put forward during the meetings.

To be successful Consultative Committee members will need evidence to prove to their various departments they represent that management are aware of their efforts or shortcomings as the case may be and that they are also prepared to make awards for sustained efforts resulting in achieved targets.

Problems are bound to arise within some section of a sawmilling enterprise at some time, but, if the personnel involved are competent and a true spirit of cooperation exists between departments, the adverse effects on production will be minimized.

Technical training

Overall operational efficiency of a sawmill can only be achieved and maintained if the personnel in all the various departments of the sawmill are fully conversant with their duties and responsibilities and are competent to carry them out.

Management must, therefore, appreciate the need for appropriate technical data to be available to personnel for reference and instruction relevant to the machines and equipment involved with their various duties. Expenditure on training courses, seminars, study tours, videos and technical manuals, etc., may appear to be costly, but relative to the gains arising from the increased efficiency that should result, they ought to be negligible. The results will, of course, be dependent to a large degree on the ability and willingness of the person, or persons, attending training courses to pass on their acquired knowledge to others and instruct them accordingly. Personnel selected to attend training courses in order to train others should be made fully aware of this obligation and be prepared to carry it out.

Improved techniques

Technical advances in the design of sawmilling and saw maintenance equipment make it essential for sawmill management to be aware of these improvements. It is therefore recommended that training facilities, seminars and study tours be utilized whenever possible and technical training aids, such as manuals or videos, be obtained for on-site use.

Hard facing of saw teeth is not commonplace and the utilization of timber species which previously were not considered commercially viable, due to their quick dulling effect on saws and knives, are not a feasible raw material. Sawmill management is, therefore, reccomended to look into the possibility of using hard-tipped tooth saws for the utilization of difficult species which may well be abundant in areas adjacent to their sawmills.

Hard-tipped tooth saws are more expensive to manufacture and the cost of equipment to maintain them is also high but the volume of lumber output from them is much higher and the lost production time through saw changes much lower. These factors, together with the higher selling prices normally commanded by the high density, more difficult sawing species, make them increasingly popular with sawmillers. Such saws, however, need highly skilled personnel to maintain them and the necessary training and knowledge must be made available if the saws are to be used to advantage. Manuals and periodical data covering saws and saw maintenance techniques and equipment should likewise be made available in order to keep the personnel involved aware of progress in their field of work.

Old established companies manufacturing saw maintenance machinery and equipment enhance their reputation by the technical advice and assistance which they make freely available to the sawmilling industry.

Maintenance manuals for machines and saws are a source of knowledge which will be used to advantage by the genuine technician who is keen to improve his standing and reputation at work. Failure to provide them may well influence such men to go elsewhere.

The various manuals published by FAO and by other publishers, together with the relevant technical data of the manufacturer, covering the equipment used in a particular sawmill, should therefore be regarded as essential aids in establishing a well-maintained, efficient and modern operation.

FAO TECHNICAL PAPERS
FORESTRY PAPERS

1. Forest utilization contracts on public land, 1977 (E* F* S*)
2. Planning of forest roads and harvesting systems, 1977 (E* F* S*)
3. World list of forestry schools, 1977 (E/F/S*)
3. Rev. 1 — World list of forestry schools, 1981 (E/F/S*)
3. Rev. 2 — World list of forestry schools, 1986 (E/F/S*)
4. World pulp and paper demand, supply and trade
   Vol. 1, 1977 (E* F* S*)
   Vol. 2, 1978 (E* F* S*)
5. The marketing of tropical wood in South America, 1978 (E* S*)
6. National parks planning, 1978 (E* F* S***)
7. Forestry for local community development, 1978 (E* F* S*)
8. Establishment techniques for forest plantations, 1978 (Ar*** C* E** F* S*)
9. Wood chips, 1978 (C* E* S*)
10. Assessment of logging costs from forest inventories in the tropics, 1978
    1. Principles and methodology (E* F* S*)
    2. Data collection and calculations (E* F* S*)
11. Savanna afforestation in Africa, 1978 (E* F*)
12. China: forestry support for agriculture, 1978 (E*)
13. Forest products prices, 1979 (E/F/S*)
14. Mountain forest roads and harvesting, 1979 (E*)
14. Rev. 1 — Logging and transport in steep terrain, 1985 (E*)
15. AGRIS forestry: world catalogue of information and documentation services, 1979 (E/F/S*)
16. China: integrated wood processing industries, 1979 (E* F* S***)
17. Economic analysis of forestry projects, 1979 (E* F* S*)
17. Sup. 1 — Economic analysis of forestry projects: case studies, 1979 (E* S*)
17. Sup. 2 — Economic analysis of forestry projects: readings, 1980 (E*)
18. Forest products prices 1960-1978, 1980 (E/F/S*)
19. Pulping and paper-making properties of fast-growing plantation wood species
    Vol. 1, 1980 (E*)
    Vol. 2, 1980 (E*)
20/1. Forest tree improvement, 1985 (E* F* S*)
20/2. A guide to forest seed handling, 1985 (E*)
21. Impact on soils of fast-growing species in lowland humid tropics, 1980 (E* F* S*)
22/1. Forest volume estimation and yield prediction, 1980
    Vol. 1 — Volume estimation (E* F* S*)
22/2. Forest volume estimation and yield prediction, 1980
    Vol. 2 — Yield prediction (E* F* S*)
23. Forest products prices 1961-1980, 1981 (E/F/S*)
24. Cable logging systems, 1981 (E*)
25. Public forestry administration in Latin America, 1981 (E*)
26. Forestry and rural development, 1981 (E* F* S*)
27. Manual of forest inventory, 1981 (E* F*)
28. Small and medium sawmills in developing countries, 1981 (E* S*)
29. World forest products, demand and supply 1990 and 2000, 1982 (E* F* S*)
30. Tropical forest resources, 1982 (E/F/S*)
31. Appropriate technology in forestry, 1982 (E*)
32. Classification and definitions of forest products, 1982 (Ar/E/F/S*)
33. Logging of mountain forests, 1982 (E* F* S*)
34. Fruit-bearing forest trees, 1982 (E* F* S*)
35. Forestry in China, 1982 (E*)
36. Basic technology in forest operations, 1982 (E* F* S*)
37. Conservation and development of tropical forest resources, 1982 (E* F* S*)
38. Forest products prices, 1962-1981, 1982 (E/F/S*)
39. Frame saw manual, 1982 (E*)
40. Circular saw manual, 1983 (E*)
41. Simple technologies for charcoal making, 1983 (E* F* S*)
42. Fuelwood supplies in the developing countries, 1983 (Ar* E* F* S*)
43. Forest revenue systems in developing countries, 1983 (E* F* S*)
44/1. Food and fruit-bearing forest species, 1983 (E* F* S*)
44/2. Food and fruit-bearing forest species, 1984 (E* F* S*)
44/3. Food and fruit-bearing forest species, 1986 (E* S*)
45. Establishing pulp and paper mills, 1983 (E*)
46. Forest products prices 1963-1982, 1983 (E/F/S*)
47. Technical forestry education design and implementation, 1984 (E*)
48. Land evaluation for forestry, 1984 (E* S*)
49. Wood extraction with oxen and agricultural tractors, 1986 (E* F* S*)
50. Changes in shifting cultivation in Africa, 1984 (E* F*)
50/1. Changes in shifting cultivation in Africa — seven case-studies, 1985 (E*)
51/1. Studies on the volume and yield of tropical forest stands
    1: Dry forest formations, 1984 (F*)
52/1. Cost estimating in sawmilling industries: guidelines, 1984 (E*)
52/2. Field manual on cost estimation in sawmilling industries, 1985 (E*)
53. Intensive multiple-use forest management in Kerala (India), 1984 (E* F*)
54. Planificación del desarrollo forestal, 1985 (S*)
55. Intensive multiple-use forest management in the tropics, 1985 (E* F* S*)
56. Breeding poplars for disease resistance, 1985 (E*)
57. Coconut wood, 1985 (E* S*)
58. Sawdoctoring manual, 1985 (E*)
59. The ecological effects of eucalyptus, 1985 (E* F* S*)
60. Monitoring and evaluation of participatory forestry projects, 1985 (E*)

61. Forest products prices 1965-1984, 1985 (E/F/S*)
62. World list of institutions engaged in forestry and forest products research, 1985 (E/F/S*)
63. Industrial charcoal making, 1985 (E*)
64. Tree growing by rural people, 1985 (E* F* S*)
65. Forest legislation in selected African countries, 1986 (E* F*)
66. Forestry extension organization, 1986 (E*)
67. Some medicinal forest plants of Africa and Latin America, 1986 (E*)
68. Appropriate forest industries, 1986 (E*)
69. Management of forest industries, 1986 (E*)
70. Wildland fire management terminology, 1985 (E/F/S*)
71. World compendium of forestry and forest products research institutions, 1986 (E/F/S*)
72. Wood gas as engine fuel, 1986 (E*)
73. Forest products: world outlook projections, 1986 (E/F/S*)
74. Guidelines for forestry information processing, 1986 (E*)
75. An operational guide to the monitoring and evaluation of social forestry in India, 1986 (E*)
76. Wood preservation manual, 1986 (E*)
77. Databook on endangered tree and shrub species and provenances, 1986 (E*)
78. Appropriate wood harvesting in plantation forests, 1987 (E*)
79. Small-scale forest-based processing enterprises, 1977 (E*)
80. Forestry extension methods, 1987 (E*)
81. Guidelines for forest policy formulation, 1987 (E*)
82. Forest products prices 1967-1986, 1988 (E/F/S*)
83. Trade in forest products: a study of the barriers faced by the developing countries, 1988 (E*)
84. Forest products: world outlook projections (Products and country tables), 1988 (E/F/S*)
85. Forestry extension curricula, 1988 (E*)
86. Forestry policies in Europe, 1988 (E*)
87. Small-scale harvesting operations of wood and non-wood forest products involving rural people, 1988 (E*)
88. Management of tropical moist forests in Africa, 1989 (E*)
89. Review of forest management systems of tropical Asia, 1989 (E*)
90. Forestry and food security, 1989 (E*)
91. Design manual on basic wood harvesting technology, 1989 (E*)
92. Forestry policies in Europe, 1989 (E*)
93. Energy conservation in the mechanical forest industries, 1990 (E*)
94. Manual on sawmill operational maintenance, 1990 (E*)

Availability: March 1989

Ar - Arabic
C - Chinese
E - English
F - French
S - Spanish

* Available
** Out of print
*** In preparation

The FAO Technical Papers can be purchased locally through the authorized FAO Sales Agents or directly from Distribution and Sales Section, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

M-39/T0270E/1/4.90/1500
ISBN 92-5-102913-X