UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

08953

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.277/17
5 June 1979

ENGLISH

Technical Course on Criteria for the Selection of Woodworking Machinery

Milan, Italy, 8 - 19 May 1978

TOOLS FOR MACHINING WOOD *

by

G. Melloni **

* The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

** Selector of lumber manufacturing equipment.

id.79-4847

Contents

1. INTRODUCTION

1.1 Sawmilling

The division of wood is obtained by the use of saws of which one must consider the following categories: gang saws (frame-saw), band saws, circular saws (disc-saws) and chain saws, either stationary or portable.

The latter category is used for felling trees, for processing (limbing, bucking) logs and, finally for some miscellaneous work in the lumber yard: We shall not discuss the topic here.

The gang saws which were among the first saws to be used to saw logs into boards, beams and other timbers, have their sphere of application occurring when there is much work to be carried out on large quantities of wood which is homogeneous from the view point of variety, log dimension and size of the timber to be obtained.

The advantages presented by this type of saw are the following:

- a reduction of the time needed to place the log on the carriage, since one single course is sufficient to transform the log into sawn timber as it is usually equipped with several blades which all work in unison;
- the solidity of the machine in its assembly;
- the easy revision and servicing of the blades;
- the good quality of the surface obtained;
- the relatively moderate driving force.

On the other hand, it posses some disadvantages, such as:

- the work being carried out blindly: once started, the direction of the log cannot be changed in relation to the position of the blades;
- the complexity of the machine's structure which requires a very heavy foundation and whose perfect control requires highly experienced operators;

Gang-saws with more than one blade are especially useful in sawing conifers of forests in temperate zones but band-saws are preferable for the processing of trees in tropical forest areas.

Band-saws have the following advantages:

- the opportunity to adapt themselves in the course of work to the real state of the wood by changing the position of the log on the carriage or by modifying the thickness of the timber;

- the very easy control of the machine and the speed with which the blades are changed;
- the reduction of filing time due to the swaging of the blades which are of a small thickness;
- the good quality of the surfaces obtained.

The disadvantage to be found are as follows:

- the lost time in the reverse course of the carriage where the blade is only single cutting;
- the danger to the operators by an unprotected blade over a great length;
- the danger of causing injury to those engaged in transporting blades to and from the filing room.

On the whole, it may be said that band-saws are useful for processing wood which does not have homogeneous characteristics as in the case of tropical woods.

The circular saws are normally used for the sawing of timber by a single blade, but where large dimension logs are involved two blades are brought into action, both being lined up with one over the other.

The advantages of using a circular saw are the following:

- the opportunity to change the position of the log or timber on the carriage to adapt it to the internal conditions of the wood;
- the work speed;
- easy operation of the machine and changing of the saw blades;
- an advantage of using it either as a stationary or portable operation;

Disadvantages of using a circular saw are:

- the time lost in reverse travel time of the carriage;
- the hazard to the operators where the saw blade is not guarded;
- the exessive loss in sawdust resulting from the extra thickness of the blade and cutting technique with the use of wide saw teeth.

In summarizing this introduction, it might be said that for the sawing of tropical logs into boards or timber, the band-saw machine seems to be the most suitable.

For subsequent operations, such as carpentry and joinery work, both the band-saw and circular saw have their respective places.

1.2. Band saw blades for log break down

The typical elements of a band saw blade which is capable of guaranteeing sufficient rigidity are:

- its dimensions;
- the assembling stress;
- the body constraint of the blade due to tensioning.

On the other hand, the quality of the product produced is based on the condition of the saw teeth. This including their shape, pitch and setting.

Dimensions:

Thickness: included between 1/1000 and 1/1250 of the flywheel's diameter;

Width (initial); equal to the width of the rims + the depth of the teeth;

Assembling stress: This should be approximately 200 N/mm^2 (= 20 kg/mm^2) for normal bands and about half for the very large bands;

Tensioning constraint: The constraints are difficult to measure but for tensioning, the measurement is in the order of 80 to 100 N/mm^2 (8 to 10 kg/mm^2).

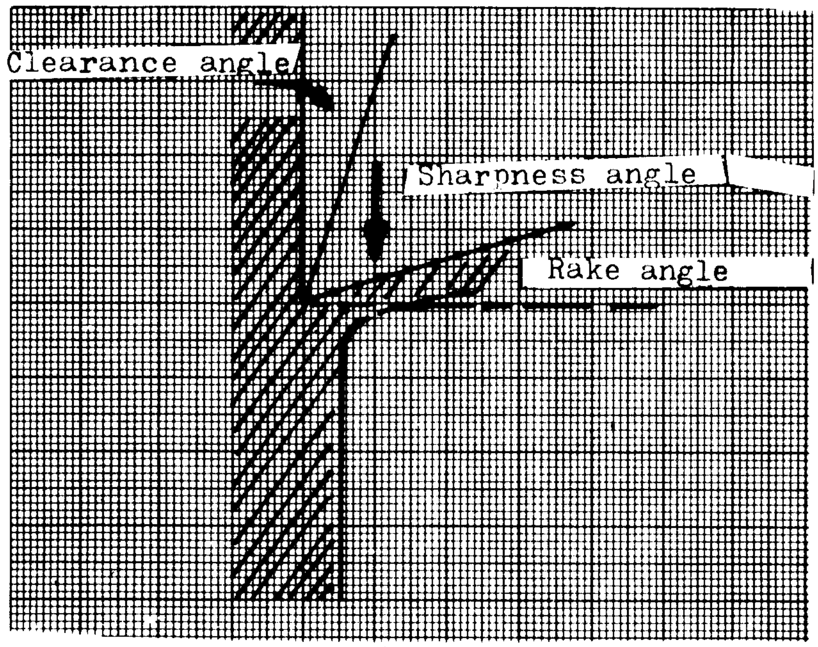
Saw teeth: The shape of the cutting edges is determined by the cutting angle, the hook angle and the dorsal clearance angle, but the profile connection of the two successive teeth are most important, especially in the clearance of sawdust. Generally it is considered that the cutting angle could be greater for the sawing of easy wood; if the clearance angle is maintained at an average value of 10^{o} (between 8^{o} and 12^{o}), the Centre Technique du Bois of Paris recommends the adoption of the data supplied by the following table in which due consideration is given to the fact that to guarantee a sufficient resistance to the base of the tooth, the thickness of the blade also plays an important role.

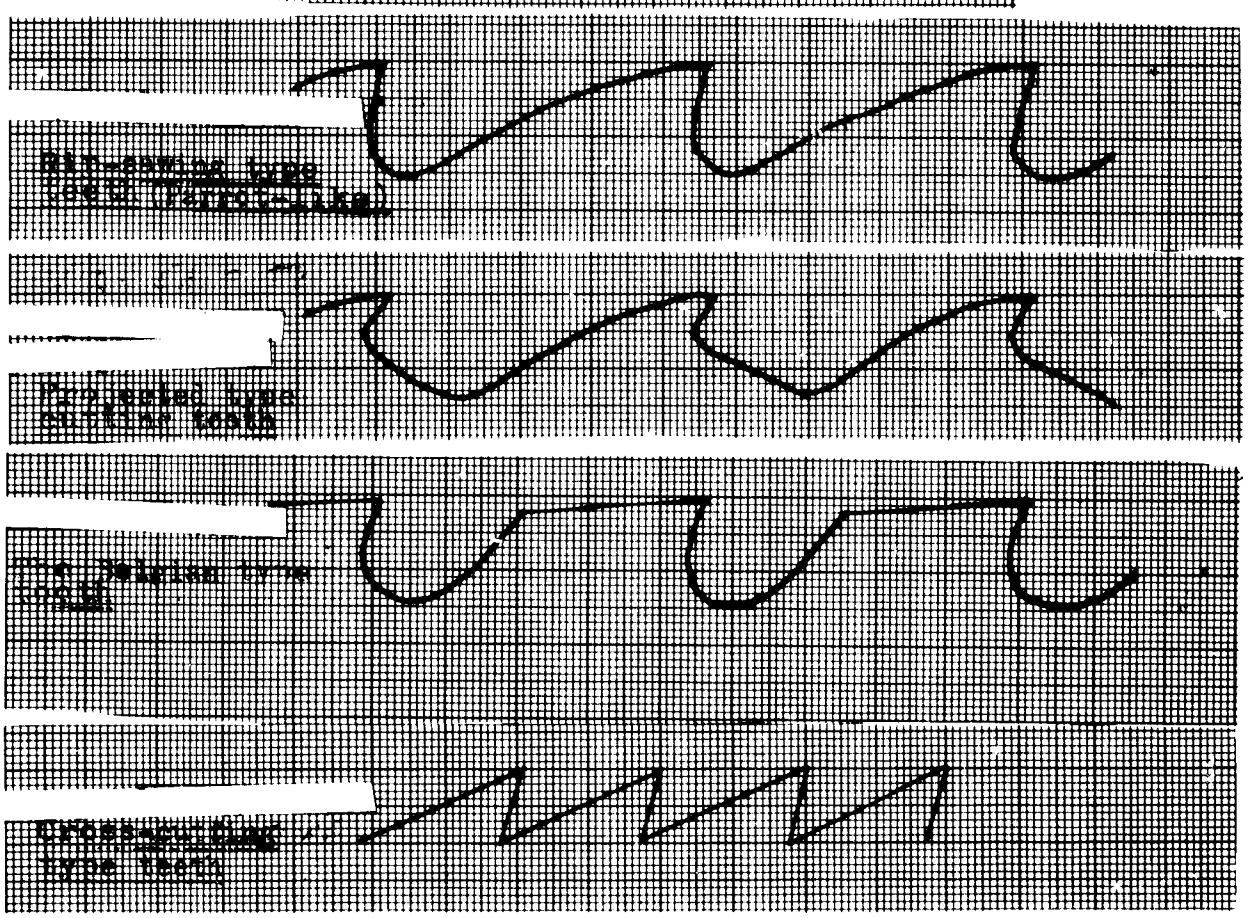
Cutting angle values for a flywheel diameter of

Variety	of 110 to 120 cm	130 to 140 cm	150 to 160 cm	beyond 180 cm
Hard wood(+)	20^{o} to 22^{o}	25^{o}	28^{o}	32^{o}
Soft wood(+)	20^{o} to 28^{o}	30^{o}	33^{o}	35^{o}+

+ Note- The adjectives "soft" and "hard" should be understood in their literal meaning of "easy to work" or "difficult to work" and not in the sense of "resinous" or "hardwood" corresponding to the English terms "softwoods" and "hardwoods".

Concerning the shape of the teeth, it must be understood that the information provided by the different laboratories does not always correspond to the same principles but, in the case of large tropical logs, the most satisfactory results seem to be those obtained by the 'parrot-like' tooth or the 'projected cutting' tooth, or still by the type which one might refer to as the 'Belgian' tooth (because of its origin). Note the following outlines-





With regard to the pitch, it may be said that the average values (35 - 40 mm) (1.3 - 1.5. ins.) apply to relatively small flywheels and to difficult-to-saw timber, while higher values (50 - 60 mm) 1.9 - 2.3 ins.) are valid for flywheels of large diameter and for easy-to-saw timber.

As for the setting, its value depends on the thickness of the blade and the characteristics of the variety: the set will be larger for the thick blades and for the easy wood to work upon. Normally, this is indicated with the letter "s" for the thickness of the blade in tenths of mm, and the set "v" may be thus fixed:

Easy wood to work upon: $v = 3 + \frac{12}{10} - \frac{16}{10}$ mm.

Difficult wood to work upon: $v = s + \frac{6}{10} - \frac{8}{10}$ mm.

The setting may be obtained by torsion or by swaging: at present, for teeth of blades utilized in the sawing of large logs from tropical areas, the trend is to prefer the setting by swaging. Finally, for particularly hard wood or that which contains silicon dioxide, it would be preferable to resort to tungsten carbide tipped saws or stellite.

The height of the gullet-tooth is generally maintained at 1/10 of the width of the blade if the latter is small and about 1/12 - 1/13 of the blade if it exceeds the width of 140 mm.

An extremely important facet is that of the blade's tensioning which requires to be checked often and in particular, each time the saw is ground. For these two operations, appropriate tools are available today which provide full satisfaction, although it must be stressed, that good results may only be obtained from the preparation and servicing of the blades only if the operators responsible for these two tasks are knowledgeable and experienced in their profession.

1.3. Bandsaw blades for table band-saws

Bandsaw blades for workshop operations and especially for the finishing of pieces of reduced dimensions, are normally between 30 to 60 mm (1.1 and 2.3 ins.) in width, thickness of 5/10 to 10.10 mm and with the simpliest set of teeth, generally, at a slanting angle which renders servicing easy.

1.4. Circular saw blades for circular saw benches

Saw blades with punched teeth

These blades are in the form of a steel disc with outlying teeth. Generally the two faces are parallel but there could be certain types with divergent or convergent conical faces. The latter are particularly used for the re-sawing of timbers of large thickness.

The diameter may vary within the remotest limits, but for workshop operations they always remain under 5000 mm (19.6 ins.) while the thickness is fixed to either one or the other of the two formulae:

Thickness = 0.005 D

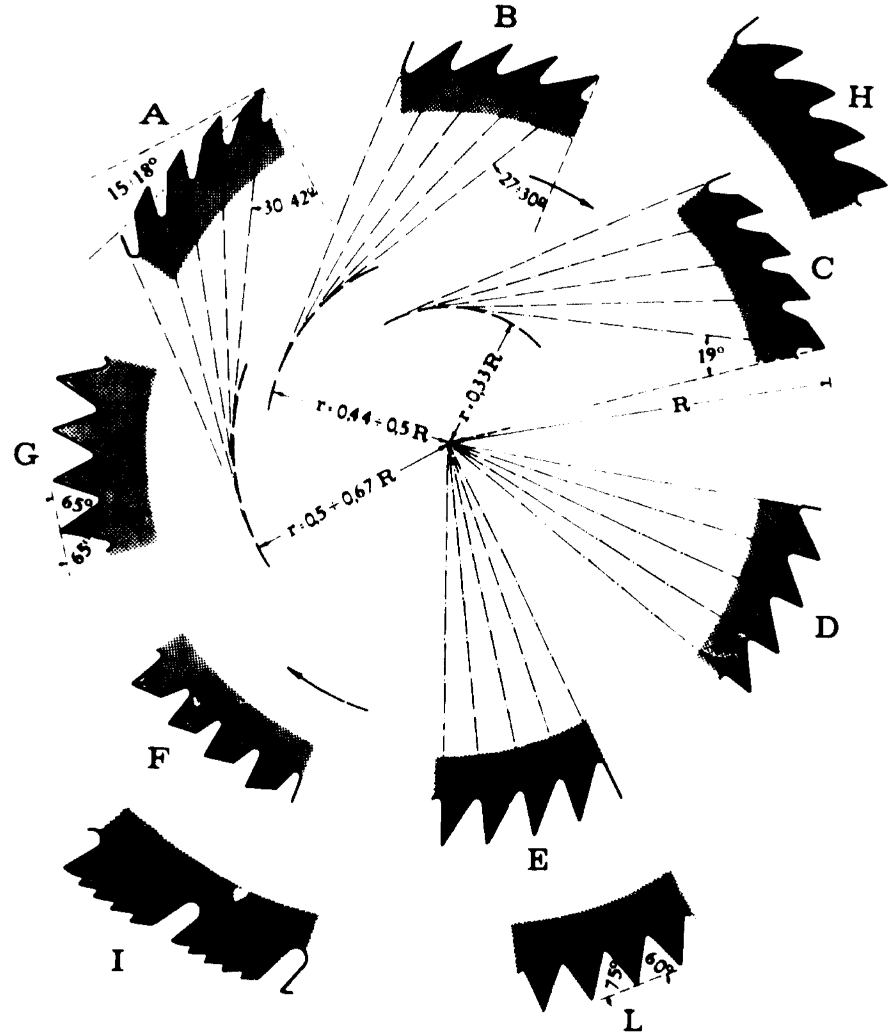
Thickness = $0.07 + 0.14\sqrt{D}$ or D is the diameter in mm.

For some time technicians have conducted considerable research on the form of saw teeth and the most interesting results of their findings are summarized below:

<u>Rip sawing</u>: use type of teeth as per A, B or C. The cutting edge must tangent to a circumference which is indicated in figures; type H may also be used.

<u>Cross cutting</u>: use type of teeth as per D, E, F, or G; type L is used in the Soviet Union for resinous woods; the type I tooth (one plain tooth and four cutters swaged alternatively) is suitable for all directions of sawing.

Should one choose to saw in a direction conforming with that of the wood it would be preferable to use a tooth with a negative cutting angle.



This sketch relates to saw tooth types, as well as to the foregoing comments on the use of various types of teeth.

2. Carbide tipped tools

Sinterized metals are the most important material for making cutting tools for the removal of chips.

They have gradually taken the place of the high speed steel tools which were traditionally used in woodworking.

Now tungsten carbide tools are being used more extensively for cutting wood and plastics with removal of chips.

These tools last longer than the ones made out of other materials.

TABLE 1

Quality characteristics of tungsten carbide in the main chip removal group which is group K:

Main chip removal group K	Chip removal group					
	K01	K05	K10	K20	K30	K40
Widia Band (old)	H3	H2	H1	G1	G69	G2
Widia Band (new)	TH03	TH05	TH10	TH20	TH30	TH40
Special gravity g/cm^3	15.0	14.5	14.8	14.8	14.6	14.3
Hardness HV30	1800	1750	1650	1550	1400	1300
Percentage of Cobalt	4	6	6	6	9	12
Cutting material properties	Increasingly hard Increasingly wear resistant (cutting edge more fragile)					

Properties of carbides

Carbide is an alloy with practically no iron; basically, they contain hard metal carbides, such as tungsten carbide, titanium carbide and cobalt which act as binding agents. They are manufactured in the form of metallurgical powders. Besides being hard, these metals are also long lasting and heat resistant. Unlike high speed steel, and other tool metals, carbide is naturally hard and, therefore, it does not require any heat treatment. Many types of carbide are made to satisfy the different chip removal characteristics of all types of materials. Referance herein has to do only with examining the types of carbide tools which are principally used for processing wood and plastics.

2.1 Standardized toughness of Carbide tools

The DIN standard 4990 divides carbide into three main groups: P, M and K. We are only intersted in group K, which is for chip removal. The cobalt/tunsten carbide alloys fall into this group.

These carbides are the most suitable ones for working wood, material derived from wood and plastics.

All these types of carbide tools have a very wear resistant surface; this resistance is inversely propoitionate to the amount of cobalt in the alloy.

As this wear resistance increases, i.e. as the amount of cobalt decreases, the carbide becomes more fragile. (See Table 1).

In general, K40 and K30 carbides give good results for working solid wood. But when there is more friction (cutting wood which is impregnated with synthetic resin, for example), type K20 is better. Type K10 or K05 (which is more wear resistant) give better results when highly abrasive wood or plastics are worked.

Table 2 shows some appropriate combinations of cutting metal/work piece material.

2.2 Required characteristics of woodworking machines

The main requirements of a machine tool are: wide range of adjustments so the best working conditions can be obtained, vibration resistance and satisfactory controls. Even if it is possible to use a cutting speed between 25 m/sec and 125 m/sec for chip removal with wood and plastics with carbide tools, the best working speed will be somewhere in the upper half of this range, depending on the abrasive qualities of the material being cut.

Therefore, carbide tipped tools can be used economically when the spindle speed is high and a relatively wide range of spindle speeds are available.

The increase in the initial cost of machine tools due to adding extra devices will pay for itself in a short time due to the increase output which will develop.

This technical solution will lead to some important advantages because from now on relatively small tools with a limited number of edges will be used; with high spindle speeds. These tools will be long lasting and tool costs will decrease quite noticeably.

The life of a cutting tool largely depends on machine tool vibrations. Resonant vibrations can be eliminated, or at least reduced.

Furthermore, efficient machine bearings guarantee silent and continuous power transmission, even when the machine is subject to static and dynamic stress.

All rotating parts must be dynamically balanced. Both these parts and the transmission must be mounted on the frame or in an easily accessible and protected position.

Because of competition, the companies with mass or large scale production have had to make even wider use of automation in the production process.

The principal companies in the wood and plastics industry feel that this tendency towards full automation is very important and they are, therefore, planning new investments in plant and machinery. In this connection it would be a good idea to invite experts from the tool manufacturing sector to take part in the preliminary discussions.

These experts are able to make practical economic calculations and anticipated increased output is therefore, easily expressed in figures.

Table 2

2.3 Type of Carbide in relation to workpiece material:

Main group	Workpiece material		Carbide used when the following are particularly important	
	Subdivision	Properties	Long life	Toughness
Solid wood	Broadleaf wood Coniferous wood	Natural physical and mechanical properties	K 30	K 40
Densified wood	Treated wood, compressed wood, resin impregnated wood	Much more marked physical and mechanical properties	K 20	K 30
Laminated wood	Plywood, laminated wood, compressed laminated wood	Physical and mechanical properties much more marked than natural wood	K 20	K 30
Panels	Panels faced with various substances, decorative panels, honeycomb panels	Surface facing or core largely affects longlevity of the tool edge.	K 10	K 20
Thermo-settings	Material for forms	Synthetic resins with organic and inorganic filter material	K 05	K 20
Thermoplastics	Material for forms	Low resistance and low heat resistance	K 20	K 40

The most wear resistant carbide should always be used with fibre glass reinforced resins.

2.4 Application of carbide tipped circular saw blades

Circular saws with carbide tipped teeth are excellent tools. Excellent quality and precision manufacture guarantee both good quality cuts and longer life.

The different types of circular-saw blades are suitable for many applications. The correct choice of the type of tools shown on the following pages increases tool life.

2.5. Factors affecting cutting quality

Besides the general factors mentioned above, the following affect cutting quality with wood and plastics: first of all, the geometry of the cut, the number of teeth, the blade mounting and working conditions.

According to the AWF, there are three categories of cutting quality, as indicated in the following table:

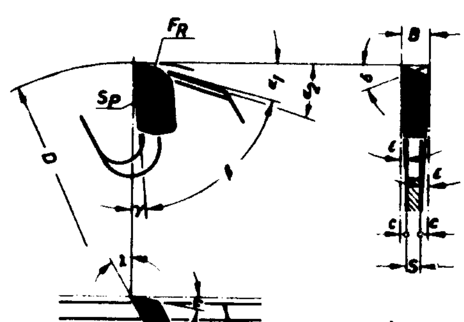
Cutting quality Category	use	Cahracteristics of the cut surface	Sawn surface quality
AWF I	Ready for gluing	Surface which can be veneered	fine sawn
AWF II	Ready for veneering	Surface which can be planed	average sawn
AWF III	Ready for construction work	The surface is good enough for building lumber	rough sawn

TABLE 3: Cutting quality (according to AWF; depends on type of sawing).

Cutting quality with carbide tipped blades always corresponds to AWF I or AWF II.

Carbide tipped circular-saw blades should make a very narrow kerf. Consequently, the usual large diameter blades are rather unstable; but their stability can be increased by "straightening" and "tensioning".

Unlike chrome-vanadium alloy circular-saw blades, carbide tipped blades are not set; they are sharpened on the periphery and the sides. The following angles are important for describing carbide tipped blades (Fig. 1)



1

2.6 Tool edge geometry

α clearance angle

β lip angle

γ radial rake angle

δ vertex angle

ε side angle

η lateral clearance angle

λ axial angle

$B \sim 0.2\sqrt{D}$ = minimum cutting thickness set (normally 0.5 mm)

$S = (B - 2C)$ saw blade body thickness

FR free surface

SP lip area

TABLE 4

The proper angles for circular-saw blades according to material to be sawn

Material to be sawn							
Solid wood Densified wood Thermoplastics	15	17	5..15	15	1	5	5..10
High density wood products (including those treated with synthetic resins) thermoplastics	15	17	5	0	1	4	0

The cutting width (B) of carbide tipped circular-saw blades varies with blade diameter (D). Normally the following approximate formula is used B = 0.2 D.

Another formula is used to calculate blade thickness: S = (B - I).

Consequently, the set is: c = 0.5 mm.

In practice, this amount of set has proven to be particularly good for cutting all species of wood: coniferous, broad leaved, dense green, dry, and all types of synthetic materials.

In some cases, different values may be used, ranging from 0.25 mm to 0.75 mm.

For good clean cuts, accurate sharpening on both sides of the angle is important ε. This is also true for the tooth angle δ, which normally relies on the chip removal characteristics of the material to be sawn.

Angles δ and λ are partially interdependent; the ratio of their size influences the lateral stability of the circular-saw blade.

The lateral clearance angle η should be as large as possible. However, the size of this angle is limited by the technical aspects of shaprening. Unlike other processes, the radial rake angle γ does not paly an important role in circular sawing.

Cutting edge geometry and the size of the angles on carbide tipped circular-saw blades are mainly adjusted according to the chip removal characteristics of the material to be sawed. The different specific gravity, hardness and moisture content of natural woods, together with the different resistance properties of wood products and plastics make it impossible to use circular-saw blades with the same type of teeth for all these materials.

Therefore, every shape of tooth for carbide tipped circular-saw blades must be limited to a particular application.

2.7 Determining the number of teeth

The number (Z) of teeth on the circular-saw blade can play a very important role as far as the quality of the cut is concerned.

For cross-cutting wood, or for cutting faced wood accros the grain, a large number of teeth are required.

For cutting panels which are faced on both sides with plastic material without splintering, the maximum number of teeth should be used.

The number of teeth depends on the desired cutting quality and the conditions under which the sawing is done.

The pitch can be calculated as follows:

(1) $$t \text{ (pitch)} = \frac{D \times 3.14}{Z}$$

where D is in millimeters.

For carbide tipped circular-saw blades, the pitch must be at least 12 mm, otherwise it will be very difficult to sharpen them.

The more teeth there are, the better the tool will behave during sawing.

It is best to use blades with a large number of teeth when cutting thin work material.

On the other hand, it is preferable to use blades with a small number of teeth when cutting thick work material (especially solid wood when chip discharge is important).

2.8 Position of the circular-saw blade in relation to the material.

The exact set value must be determined each time by trial and error.

If the blade is moved upwards - i.e. if the projection (U) increases - the edges of the cut underneath the wood will be less precise, but they will be more precise on the top.

And vice versa: when the projection decreases, the edges of the cut underneath the wood will be more precise.

2.9 Approximate speed (rpm)

The blade diameter (D) depends on the depth of the cut (a) to be made and the available spindle rpm (n).

It will be difficult to obtain an economically suitable cutting speed (v) if the spindle has only one speed.

As the number of rpm increases, the circular-saw blade becomes more stable and cutting quality improves.

The following formula may be used to calculate rpm:

$$\text{rpm } (n) = \frac{v \times 60}{D \times 3.14}$$

where the cutting speed (v) is in m/sec and the diameter (D) is in meters.

A low cutting speed should be used for sawing tool wearing wood products and heat sensitive thermoplastic materials. But for soft wood and plastics with good chip removal characteristics medium and high cutting speeds should be used.

For manual feed sawing (u) = 6 m/min, high rpm should be used because less feeding force is required.

Table 5 shows some approximate cutting speed values.

TABLE 5 - Approximate cutting speed values (v) for circular sawing machines

Main group	Material to be sawn Properties	Approximate cutting speed (v) in m/sec
Solid wood	Natural physical and mechanical properties	70...100
Laminated wood	With or without low specific gravity wood	60...90
Densified wood	High specific gravity and impregnated wood (for example, compressed laminated wood and plywood, etc.	35...70
Solid densified wood	Much more marked physical and mechanical characteristics than natural wood	35...70
Thermosettings	Laminated panels with organic or inorganic cores	35...70
Thermoplastics	Low strength, heat sensitive material	25...50

The following formula can be used to calculate cutting speed:

$$\text{cutting speed} = \frac{D \times 3.14 \times n}{60}$$

where the diameter (D) is in meters and (n) is the number of rpm. Blade diameter can be calculated as follows:

$$D = \frac{60\ v}{3.14\ n} \qquad 20\frac{v}{n}$$

The average theoretical chip thickness (hm) depends on the depth of cut (a) and the material to be sawn (see Fig.14).

This average chip thickness should not be less than 0.02 mm; thinner chips shorten tool life appreciably. Relatively thin chips are caused by unstable blades.

Table 8 gives the feed rate per tooth (sz) in relation to depth of cut and blade diameter.

The following formula can be used to calculate the feed rate per tooth (in mm):

(3a) $(a) \times (sz) = (b) \times (hm)$

where (b) is the cutting arc. Therefore: 3 (b) $sz = \frac{(b)\ (hm)}{a}$

2.10 Cutting speeds for sawing boards and panels with a circular sawing machine

Cutting speed: VT (in m/sec)

1)	Coniferous	70–100 m/sec
2)	Broad leaved	50–80 "
3)	Very hard tropical wood	30–60 "
4)	Chipboard and plywood panels	40–70 "
5)	Dense chipboard panels (more than 720 kg/m^3)	35–50 "
6)	Compressed wood treated with synthetic resins (specific gravity = 0.9 - 1.4 kg/dm^3)	30–60 "
7)	Plastic laminates	30–60 "

Feed rate per tooth (distance between two teeth which have the same characteristics) = SZ

	mm/tooth
1) Plastic laminates	0.03-0.05
2) Thin or coniferous wood panels - sliced wood 0.6 mm thick bonded on panels or veneered. Low or medium density particle board (with low screw holding force) Extruded or continuous pressed (with tube holes) particle board Thermoplastic panels (PVC, etc.)	0.05-0.08
3) Chipboard, plywood, fibreboard; veneered panels	0.07-0.10
4) Cross-cutting solid wood	0.09-0.12
5) Rip sawing hardwood	0.12-0.15
6) Plain particleboard	0.09-0.12
7) Rip sawing coniferous wood	0.15-0.20

Note: When down-milling : lower speed

When up-milling : higher speed

These are approximate values for thicknesses up to 40 mm

The number of teeth should be determined on the following basis:

S = feed rate in mm

n = rpm

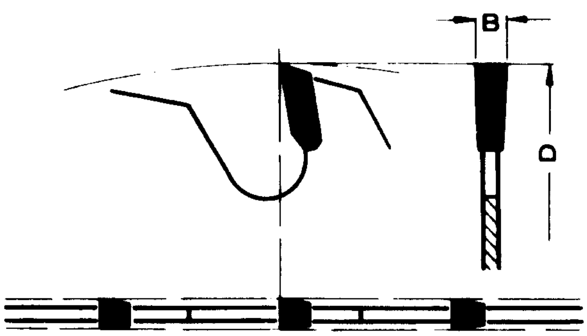
Sz = Feed rate per tooth

Z = number of teeth

$$Z = \frac{S}{(n)(Sz)}$$

3. Tooth space for carbide tipped circular-saw blades

Straight teeth (Fig. No. 3)



Applications: 1) Cutting all materials in direction of feed

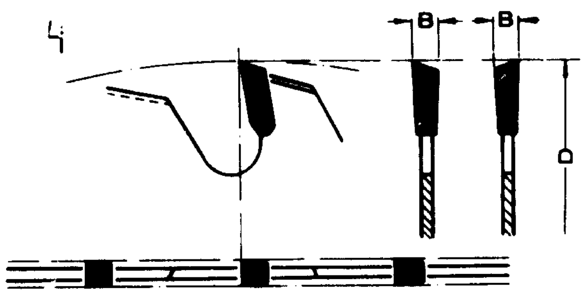
2) Rip sawing solid wood (either broad leaved or coniferous) down-milling

Advantages: a) greater longlevity

b) easy maintenance

c) can be used on wood which does not splinter easily

Alternating teeth (Fig. No. 4)



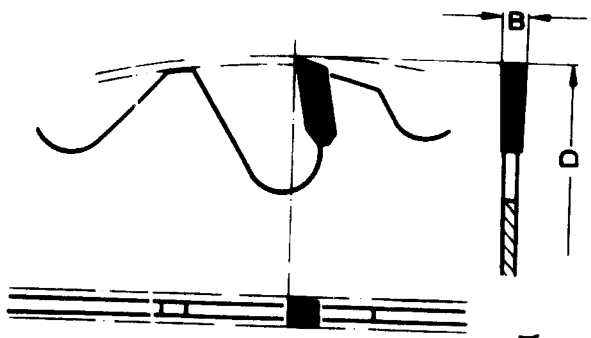
Applications: 1) down-milling with Universal blade for sizing and squaring

Advantages: a) cuts gradually from the point to the base of the tooth

b) cutting width is only half: less splintering

Disadvantages: Only every other tooth on each side is actually cutting.

Straight teeth with chipbreaker (Fig. 5)



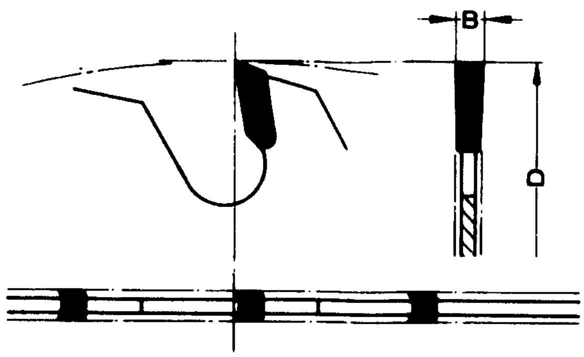
5

Applications: 1) for single blade manual fed sawing machines; down-milling suitable for ripping coniferous wood.

2) Also used on multiblade sawing machines.

Advantages: The chipbreaker also pushes the wood away so feed is silent and uniform and the teeth are not broken by knots or splinters.

Concave teeth (Fig. 6)



Applications: 1) For cutting down-milling

Advantages:
a) The two points lead the center of the tooth
b) The cut is always gradual, but not as gradual as with alternating teeth.
c) The symmetrical curvature of the teeth makes for easier edge penetration.

Disadvantages:
a) The cut is not subdivided.
b) The number of teeth for a given diameter blade is limited because enough space must be left for sharpening.
c) Increased maintenance cost
d) Cutting quality is immediately affected if feed is not perfectly horizontal
e) The teeth are smaller than usual because the grinding wheel has to discharge while it is making the gullet

4. Milling cutters

Choosing the right material for cutters, the right feed rate and cutting speed is very important in woodworking. If these factors are correctly established, chip thickness wil be good and output will increase.

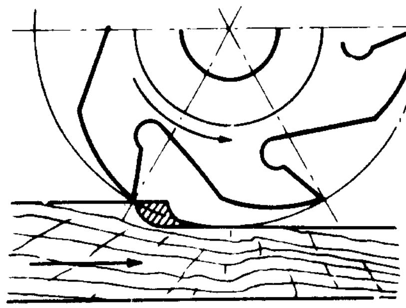
Only high quality materials — such as high speed steel and carbide — can be used for these tasks.

Avoid using the cutter to remove very thin chips because this is closer to friction cutting than chip removal and the tools will not last very long.

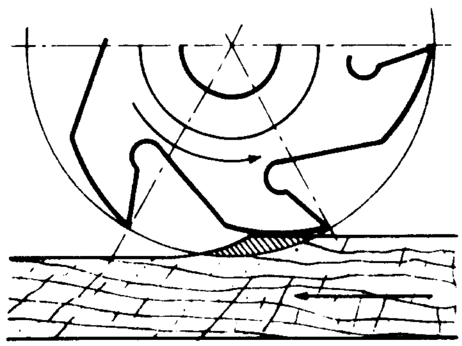
But on the other hand, there will be more splintering with thicker chips.

Direction of rotation

Cutters can either rotate in the same direction as workpiece travel (Fig. 7) or in the opposite direction (Fig. 8).



(Fig. 7)



(Fig. 8)

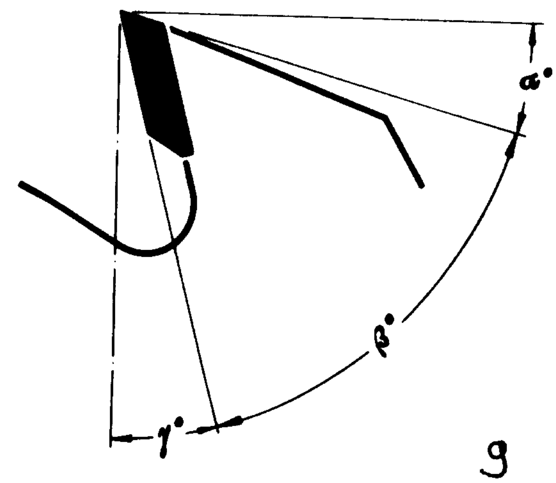
When they rotate in the same direction as workpiece travel the wood will have a better finish, because the cutter starts removing the thickest part of the chip first. Thus the chip is gradually separated from the workpiece without splitting or splintering. Furthermore, higher feed rates can be used.

But this system cannot be used with manual fed machines (because the cutter pulls the workpiece); it calls for larger clearance angles and this serves to shorten the life of the tool.

When the cutter rotates during down-milling operation, it starts removing the thinest part of the chip first and the cutting edge cannot get a good bite: first it compresses the wood, then it begins to penetrate. Chip thickness increases rapidly and it is removed violently from the workpiece.

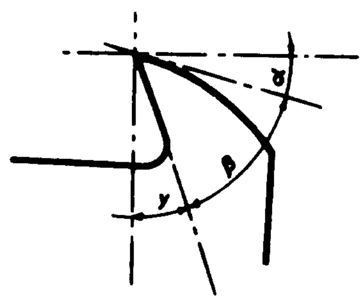
This system is noramly used in woodworking.

<u>Working angles</u> (Fig. 9, 10 and 11)



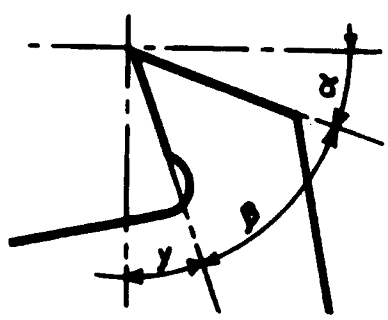
9

(Fig. 9)



10

(Fig. 10)



11

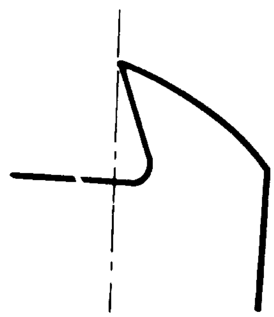
(Fig. 11)

α Clearance angle

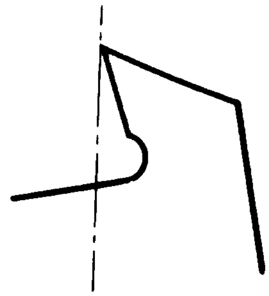
β Lip angle

γ Radial rake angle

Edge clearance (Fig. 12)



12



The edges must have a logarithmic clearance so they will maintain a constant profile during sharpening. (The clearance angle is a circular arc). All the other cutters have a straight clearance.

Cutter oharacteristics

Woodworking cutters may be mede out of:

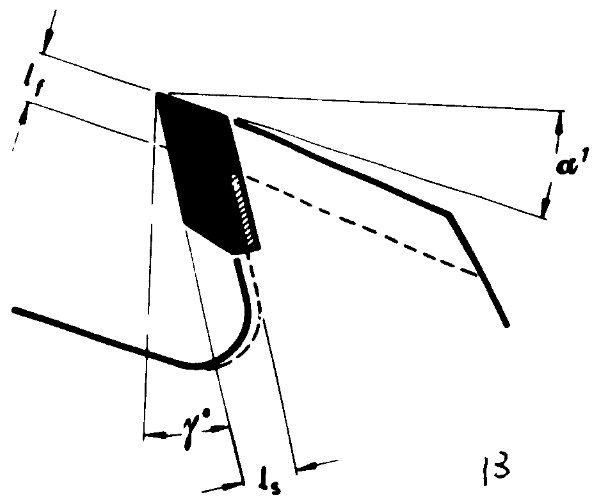
HSS - The whole tool is made out of high speed Cr-W-Mo-V alloy steel; especially suitable for normal cutting speeds; reasonable tool life. Recommended for all types of natural wood; These cutters are not widely used today.

HSSR - Tools with high speed Cr-W-Mo-V-Co Alloy steel tips. Such tools are suitable for high cutting speeds while at the same time giving inoreased life to the tool edge. This type of tool has almost completely replaced the above type. Recommended for all types of solid wood and large scale production.

HM - Carbide tipped tools; very high abrasive resistance; recommended for working very hard wood and plastics. (See the paragraphs in the section on circular-saw blades).

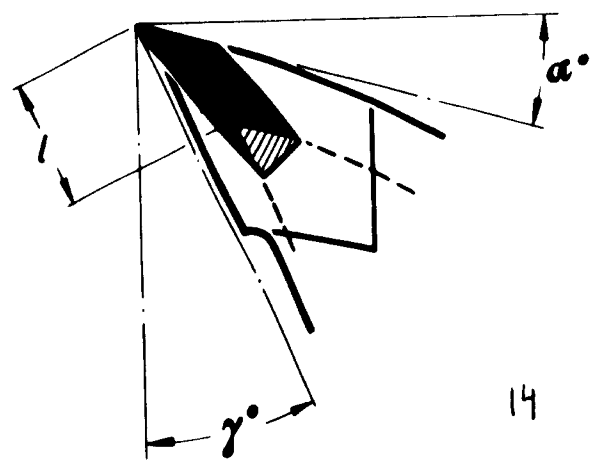
Tip position

Radial — This sytem is normally used because both manufacture and maintenance are easy. This tip can easily be replaced. (Fig. 13)



13

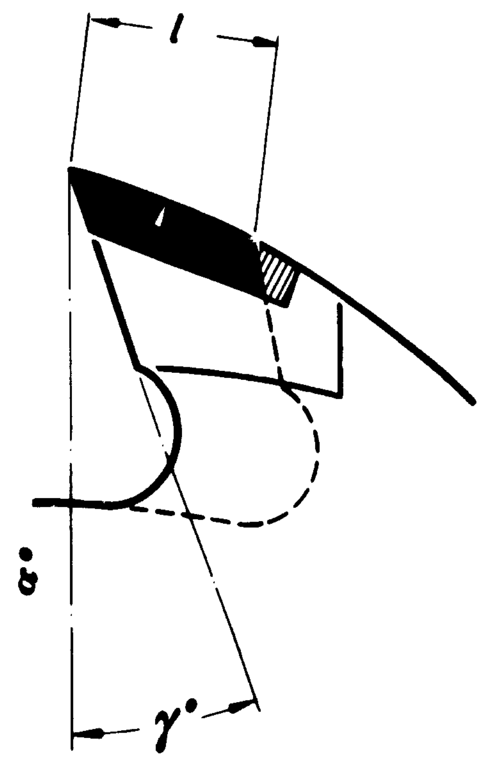
Inclined — Allows constant and proportional edge wear during sharpening. Not widely used because of high production costs. Tip cannot be replaced. (Fig. 14)



14

Tangent

Normally used on constant profile cutters (with logarithmic clearance angle) and on cutters which must maintain their maximum diameter (their maximum diameter must decrease as little as possible during sharpening). (Fig. 15).



15

Edge arrangement

a) **Edges parallel to the axis:** for working wood and plastics in general. Sometimes used on shaping tools; frequently used on cutter-blocks and cutter-heads.

b) Edges inclined in different directions: for working solid wood and plastics without splintering the edges of the cut (Fig. 16).

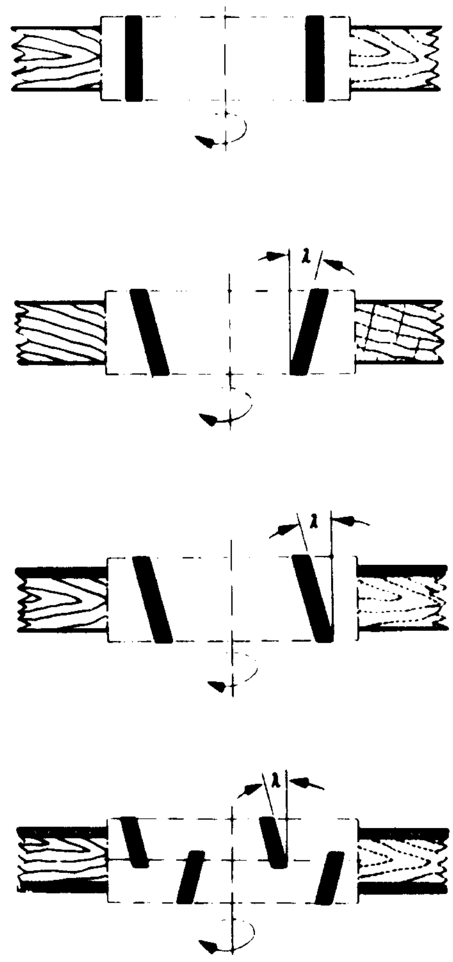


Fig. 16

c) Edges inclined in the same direction: for working wood with a plastic or wood veneer on one side.

d) Edges inclined in the same direction and covering towards the center: for working wood with plastic, linoleum, etc., facing, on both sides.

The angle λ makes the cutters "tear through" the wood. This arrangement is always advisable when very clean cuts are required. The size of this angle ranges from 5^{o} to 15^{o}, depending on the thickness of the edge. Carbide edges have the same arrangements, which vary according to the type of work.

4.1 Cutters for jointing, mortizing and tenoning

a) Without notchers: edges inclined in different directions; cuts on both sides. (For cutting joints, mortises and tenons in solid wood and chipboard.)

b) With notchers on both sides; edges inclined in different directions; cuts on both sides (Fig. 17 and 18).

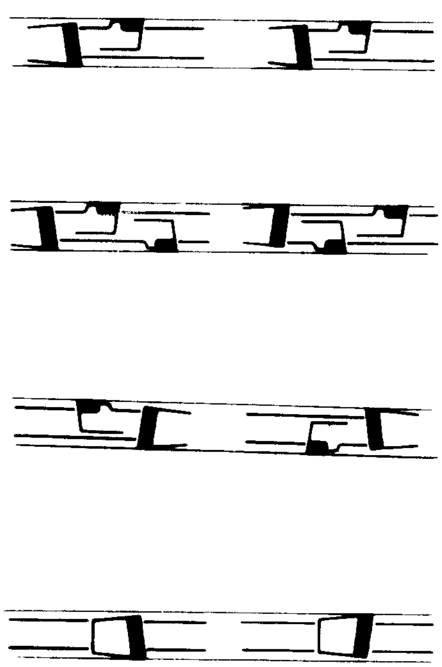


Fig. 17

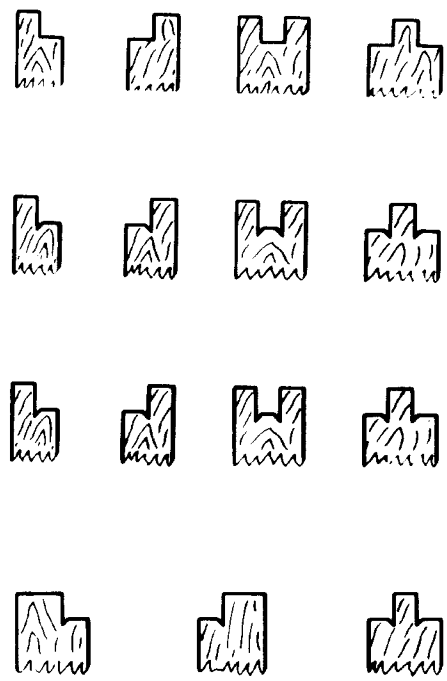
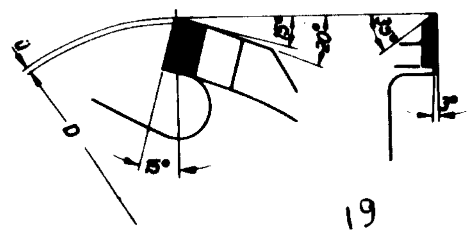


Fig. 18

c) With two notchers on each side; edges inclined in different directions cuts on both sides. (For cutting joints, mortises and tenons in solid wood, laminated wood board and chipboard).

d) With two notchers on one side (either right or left); edges inclined in the same direction (For cutting joints and tenons in veneered or plastic-faced panels when perfect cuts are necessary).

The notchers are always necessary in woodworking when the tool cuts against the grain or when veneered or plastic-faced panels are being cut. Furthermore, the number of notchers on each side of the cutter depends on the desired edge finish and the feed rate (u). (Fig. 19)



19

<u>Working angles</u>

Material to be machined	HSS cutters			Carbide cutters			Cutter heads		
	α	β	γ	α	β	γ	α	β	γ
Softwoods	15	45	30	15	50	25	15	55	20
Hardwoods	15	50	25	15	55	20	15	55	20
Laminated wood board, plywood (not compressed)				15	60	15	15	55	20
Compressed and glued laminated wood board				15	63	12	15	63	12(o)
Thermoplastios				15	63	12	15	63	12(o)
Thermosettings				15	55	20	15	55	20

(o) Carbide tipped knives must be sharpened for 0.3 mm to reinforce the cutting edge.

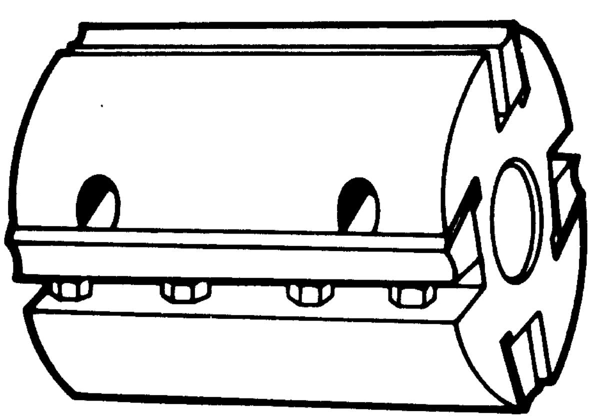
Approximate cutting speeds (v) for cutters

Material	Material to be worked Properties	Cutting speed Straight edges	m/sec Profiled edges
Natural wood	Natural physical and mechanial properties	30-70	30-65
Laminated wood	Low specific gravity (plywood, etc.)	30-60	25-50
Laminated wood	high specific gravity and impregnated wood (compressed wood, laminated wood, compressed plywood, etc.)	25-50	20-45
Solid compressed wood	Much more marked physical and mechanical characteristicts than natural wood	25-50	20-45
Hard plastic materials	Laminated panels with organic or inorganic cores	30-60	25-50
Thermoplastics	Low strength, heat sensitive material	25-50	20-45

4.2 Cutter heads

Cutter heads are widely used for planing with the grain. These tools are basically the same for all types of machines: planing machines, moulding machines, etc.

They are made out of high strength alloy steel; usually they are fitted with four knives which are held in place by wedges and a series of screws. (Fig.20)



The wedges are the same length as the knives and they are hardened and shaped so that the knives will be firmly held in place during working. The knives can be quickly changed.

Calipers or templates are used to align the knives; a spring built into the cutter head presses against the back of the knives.

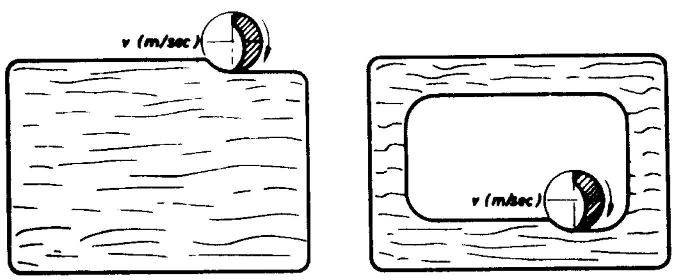
Special, very high strength light alloy cutter heads are presently used on moulding machines. The breaking load of this alloy is equivalent to UNI C10 steel. The heads are built the same way.

4.3 Routing Bits

For greater stability, most small cutters are made with a Morse or cone mounting.

The shank mounted tools have a relatively small cutting diameter, so when they are used on normal moulding machines they often work below their optimum cutting speed. Therefore, it is best to use these tools on machines with a high number of rpm, such as copying machines with 12.000 rpm or even more.

Copying machines are used for template controlled shaping; single edge cutters are usually used. These must be mounted on the eccentric spindle so the edge can cut the base of the hole without exerting pressure on the outside of the cutter. Therefore, the radial rake angle can only vary within a certain range (Fig. 22). When $\eta = 30^\circ$, the radial rake angle γ reaches the optimum value. This is especially true for chip removal with softwoods.



22

For larger angles — $\eta \approx 50^\circ$ — the radial rake angle γ and the cutter diameter D_F decrease proportionally.

This eccentric adjustment is always recommended for working laminated wood, plastics and light metal alloys. The amount of eccentricity is equal to the average distance between the secondary edge and the cutter axis.

These cutters usually work against the direction of workpiece travel. This prevents the workpiece from splitting in the direction it is travelling in. A shaped panel on the lower part of the machine is used for making internal and external cuts.

A limit stop in the corners is sufficient for cutting simple shapes which are parallel to the outside edges of the workpiece. Templates are required for more complicated cutting tasks.

If there is a lot of play in the shaped panel, the cutter should rotate against the direction of workpiece travel.

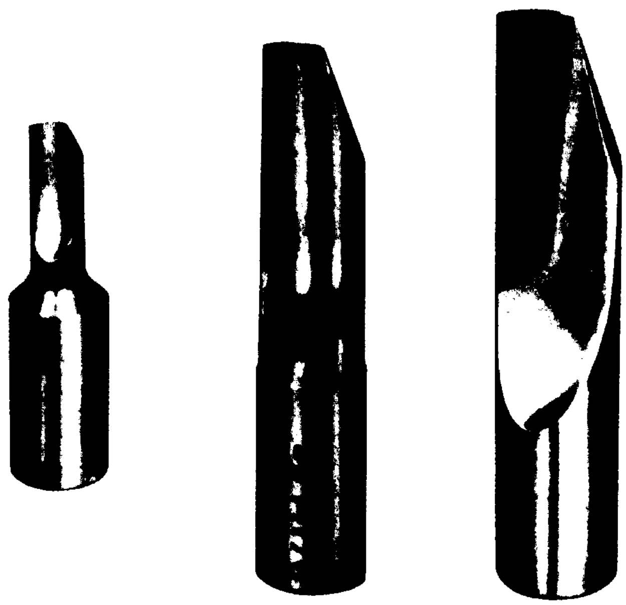
Furthermore, both arms should be used to shift the template table; the operator should never lean against it because incorrect feed increases the risk of breaking the tool.

Spindle and cutter mounting angle (η) selection

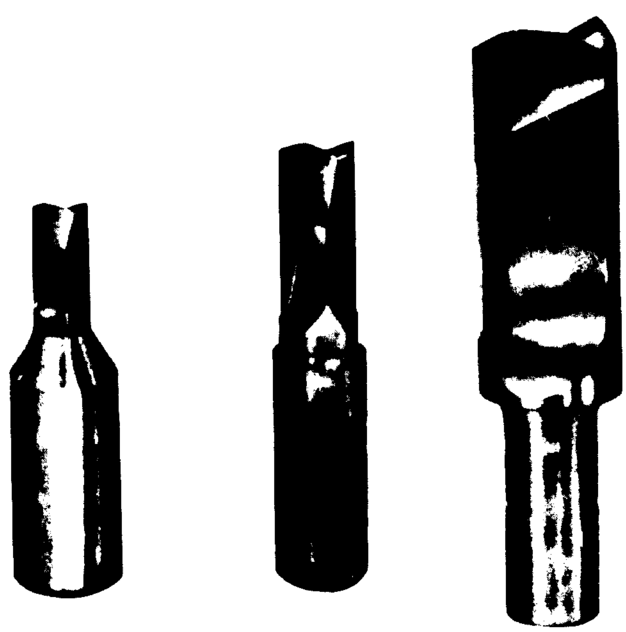
Cutting diameter D_F	Cutter diameter D	Spindle No.	η

(η is marked on the spindle so the cutter can be mounted correctly).

Because of their shape, single edge copying machine cutters are unstable (see Fig. 23).



This situation is particularly evident when deep cuts are being made and the tool is subject to high, intermittent pressure. In these cases, the double edge copying machine cutters (Fig. 24) are more suitable because they have a more stable shape.



These tools are mounted centrically on the spindle; they have either a cylindrical mounting (tolerance h_6) or a Morse cone DIN 228.

Maintenance

A cutter with inserted carbide knives or a circular-saw blade with inserted carbide teeth is a valuable tool and it deserves the best treatment. These tools are not particularly delicate, but they must be kept in good condition. The carbide tips must be protected from blows; never lay them on hard surface.

Always put the tools in their case when not in use.

The cutter hubs, spacers and locking flanges must always be kept perfectly clean. The knives must also be kept clean because resin deposits or other material can cause overheating during cutting (when this happens, the tools take on a bluish colour). This overheating shortens tool life and destroys tensioning. This normally puts the tool out of balance and it no longer rotates concentrically.

Special solvents for removing these deposits are available (but if it is impossible to find them, the tools oan be immersed for a short time in a water and caustic soda solution).

Carbide tipped and high speed steel tools must be sharpened before it is late.

Using tools which have lost a great deal of their cutting power is not economical.

Sharpening badly worn cutting edges is more expensive and circular-saw blades and cutters will not last as long (more time is required for sharpening, more abrasive grinding wheel and tool tip material is consumed).

Therefore, periodic inspection of edges is advisable. The cutting edge must never be more than 0.2 mm thick because dull edges increase cutting pressure.

5. Tool maintenance equipment

Good sharpening is indispensable for keeping tools in good working order. The original working angles must be maintained.

Therefore the sharpening department must be equipped with the following:

a) Universal tool sharpening machine: it must be solidly built, vibration free and the grinding wheel spindle must be mounted on a bearing which allows it to rotate around two axis.
The spindle must have at least two speeds - 2800 and 5500 rpm — so the correct speed can be used with different diameter wheels.
A movable slide mounted on guides and provided with devices for micrometric positioning.
Tool holder which can be turned and inclined along two axis; it must be provided with a standard disc with 24 divisions and a micrometric screw so the angles can be set correctly.
Cutter spindles which can be mounted on the tool head (tolerance with H7 holes); flat parallel spacers; device for concentric adjustment.

b) Automatic sharpening machine for carbide-tipped circular-saw blades; this machine is able to sharpen any shape tooth with absolute precision.

c) Automatic sharpening machine for making carbide-tipped circular-saw blades perfectly circular.
This operation used to be done (and some times it still is) by hand; it took a long time and it was not very precise. The diamond grinding wheel only removes metal from the carbide tip: it does not remove the steel from the body of the blade (this would greatly decrease the life of the grinding wheel).

d) Automatic sharpening machine for chrome-vanadium circular-saw blades; normally also used for sharpening band-saw blades.

e) Saw setting equipment for band-saw and chrome-vanadium saw blades.

f) Automatic sharpening machine for planing machine cutters.

g) Automatic sharpening machine for log sawing machine blades.

h) Bench-mounted grinding wheel for normal roughing.

5.1 General rules for sharpening

1) Remove the same amount of material from all the edges; this will keep the tools balanced and avoid eccentrioity.
2) For integral HHS tools, grinding wheels having the same radius as the original must be used to work the base of the edges; avoid local overheating. Grinding wheels with sharp edges and overheating cause initial breakdown in tool steel and make your tools dangerous.

3) Always use cooling fluid during sharpening.

4) Sharpening can be divided into three steps: roughing, finishing and lapping. The last operation is often thought to be superfluous, but it is a good way of increasing edge life.

5.2 Specific sharpening rules

1) Since the cutters for jointing usually have a constant profile, only the backs of the edges are sharpened so the size of the joint will always be the same (Fig. 7 a).

2) The notchers on rebating and jointing cutters are only sharpened on the back, they must project 0.3 - 0.6 mm (Fig. 8 a).

3) The chipbreaker is lowered by circular grinding, so that it is 0.6 - 0.8 mm lower than the edges (Fig. 10 a).

4) The profiling cutters are always sharpened on the face, without changing the original working angles so the profile will always be the same (Fig. 5 a).

5) When sharpening the circular cutter units for double end tenoning machines, unscrew the circular edging saw blade; the sector teeth are not removed for sharpening.
If the sector teeth are in the "step cut" position, they should be set in the circular position before sharpening.

6) Carbide-tipped circular-saw blades must be sharpened both front and back; never sharpen the sides.

7) Chrome-vanadium circular-saw blades and band-saw blades are normally sharpened by automatic sharpening machines which restore the original profile. Band-saw and narrow blades are also set while they are being sharpened.

8) Thin grinding wheels should be used for sharpening HSS bits so both the cutting edge and the notcher will be sharpened at the same time.

9) Carbide-tipped bits are normally sharpened on a profiled diamond grinding wheel. (see Fig. 17a).

10) Copying machine cutters are sharpened as shown in figures No. 1a, 2a, 3a, and 4a.

11) Carbide-tipped planing machine knives are sharpened as shown in Fig. 14 a and 15 a.

5.3 Safety rules

a) Never use a tool with too big a hole without using the right reducing bush with calibrated tolerance.

b) Never angle the tool (in relation to the direction of workpiece travel) in order to obtain a wider cut.

c) Do not weld broken or seriously damaged tools.

d) Avoid unbalanced tools. These are usually caused by improper sharpening. Make sure that the tool is concentric to the shaft; if it is more than ± 0.01-0.02 mm off center this defect must be corrected.

e) Never exceed the maximum rotation speed marked on the tool or shown in the catalogue.

Always use the ideal cutting speeds indicated for the various materials.

f) Always mount all necessary guards before using the tools.

Grinding wheel for Fig. 4 Fig. 16a

Grit size D 100

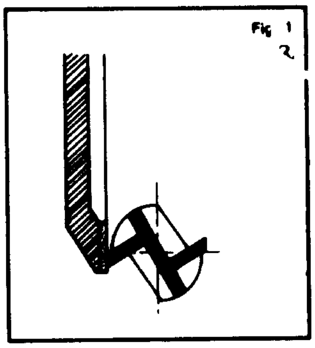
Concentration Kz 70

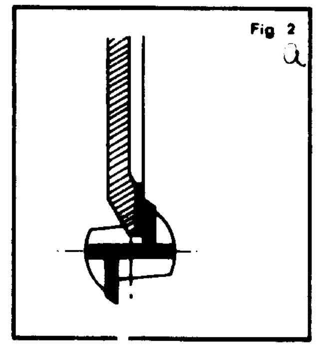
For preliminary sharpening of copying machine cutters

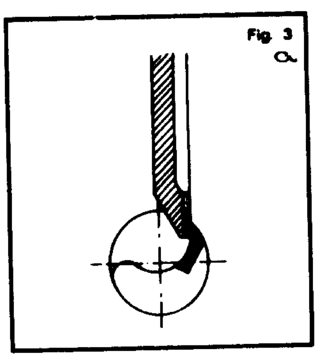
Fig. 17a

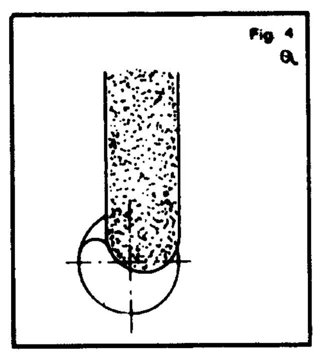
Grit size D 50 Concentration Kz 100

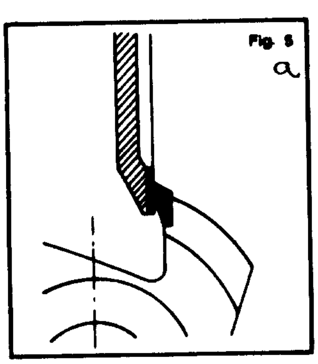
For sharpening carbide-tipped bits.

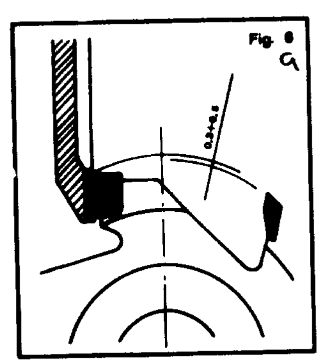












APPENDIX "A"

Figures as appearing on pages No. 35, 36 and 37 depict sharpening techniques for saw blades and bits; planer knives, cutters, etc.

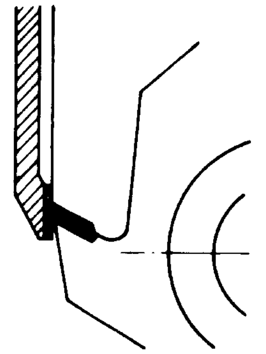


Fig. 7a

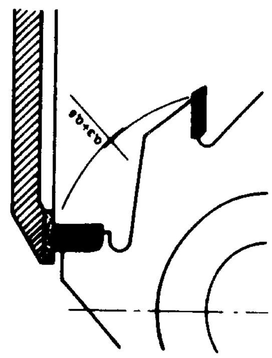


Fig. 8a

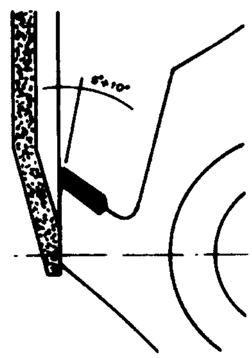


Fig. 9a

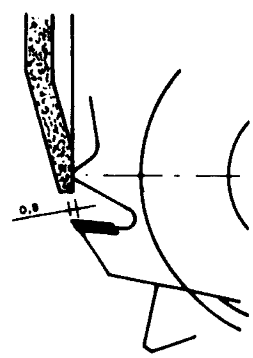


Fig. 10a

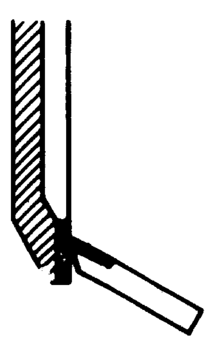
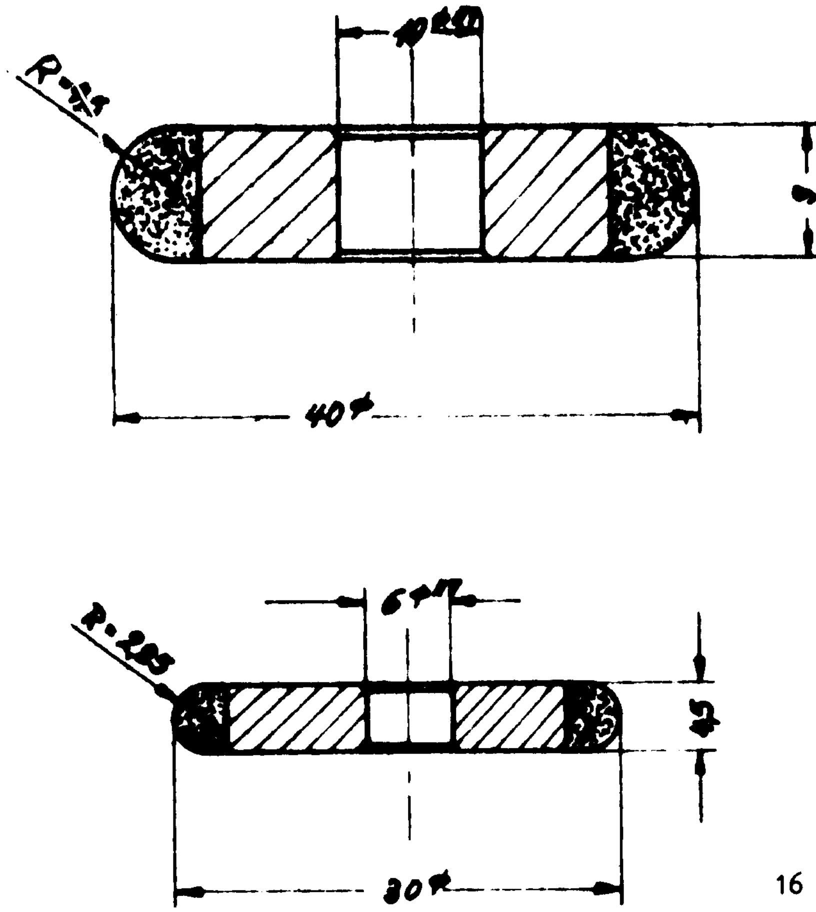
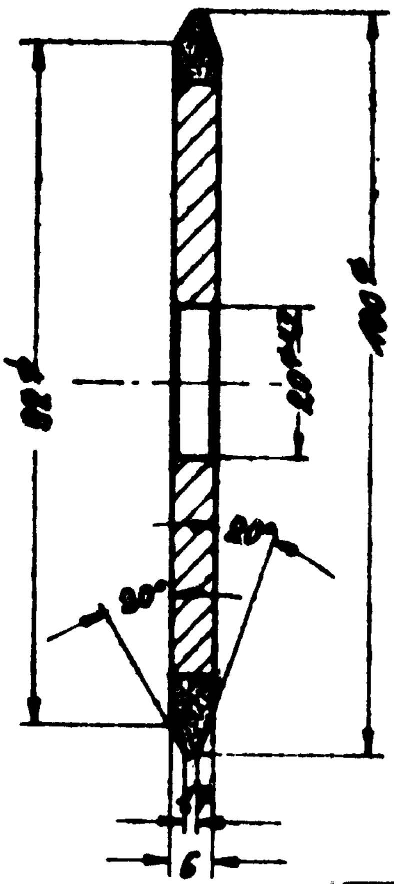


Fig. 14a

Fig. 15a



16 a



17 a

B-89

80.02.07