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Determining the Chip Load

In order to determine the chip load of an existing tool on a machine, you need to know the following things.

T	**Number of teeth in the tool.**
RT	**Required Number of Teeth to make a complete kerf cut.**
RPM	**The RPM of the spindle rotating the tool.**
FT/MIN	**The Feed Rate in feet per minute.**

SUBSTITUTE THE ABOVE INFORMATION IN FORMULA BELOW

Chip load = $\frac{\text{FT/MIN x 12}}{\text{T x RPM}}$ x RT

Formula

Saw Blade example:

Determining the Chip load for a 42 tooth blade rotating at 3450 Rpm and a material feed rate of 55 Feet Per Minute.

CHIP LOAD $\frac{\text{55' x 12}}{\text{42 x 3450}}$ x 2

CHIP LOAD $\frac{660}{144{,}900}$ x 2

CHIP LOAD .0046" x 2

CHIP LOAD .0091"

Cutter Head example:

Determining the Chip Load of a 3 wing MTP cutter at 10,000 Rpm and a material feed rate of 20 feet per minute.

CHIP LOAD $\frac{20' \times 12}{3 \times 10{,}000} \times 1$

CHIP LOAD $\frac{240}{30{,}000} \times 1$

CHIP LOAD .008

Determine the Number of Teeth

In order to determine the required number of teeth for a given application, the following information is required:

C/L **The Required Chip Load recommended for the species and application.**

RT **Required Number of Teeth to make complete kerf cut based upon the tooth style you have selected.**

RPM **The RMP of the spindle rotating the tool.**

FT/MIN **The Feed Rate at which the customer wants to feed the material.**

SUBSTITUE THE ABOVE INFORMATION IN THE FORMULA BELOW:

Required Number Of Teeth $= \frac{FT/MIN \times 12}{C/L \times RPM} \times RT$

Saw Blade example:

Determine the required number of teeth for a saw blade rotating at 3600 RPM and a material feed rate of 130 Feet Per Minute. The customer will be cutting mostly hardwoods so we will use a recommended Chip Load of .012".

Substituting for the above example:

Required Number = $\frac{130' \times 12}{} \times 1$

Of Teeth .012” x 3600

Required Number = $\frac{1{,}560}{43.2}$ x 1
Of Teeth

Required Number = 36.1 Teeth
Of Teeth

Cutter Head example:

Determine the required number of teeth for a MTP Cutter rotating at 8000 RPM and a material feed rate of 35 Feet Per Minute. The customer will be rip cutting mostly softwoods also we will use a recommended Chip Load of .019”

Substituting for the above example:

Required Number = $\frac{35\text{”} \times 12}{.019\text{”} \times 8000}$ x 1
Of Teeth

Required Number = $\frac{420\text{”}}{152}$ x 1
Of Teeth

Required Number = 2.76 Teeth
Of Teeth

Determining the Pitch

In order to determine the Pitch of a tool, (distance from tooth to tooth) you must have the following information:

D	**Diameter of the Tool**
T	**Number of Teeth you wish to place in the tool**

Simply substitute the above information into the formula below:

$$\text{PITCH} = \frac{\pi \times D}{T}$$

NOTE: $\pi = 3.1416$

NOTE: A pitch distance of .392" or less will have a locked in tooth style with straight backing.

Saw Blade example:

Determine the pitch of 12" diameter saw blade with 72 teeth.

Substituting for the above example:

$$\text{PITCH} = \frac{\pi \times 12"}{72}$$

$$\text{PITCH} = \frac{3.1416 \times 12"}{72}$$

$$\text{PITCH} = \frac{37.6992}{72}$$

$$\text{PITCH} = .5236"$$

Determining the Pitch Cont.

Cutter Head Example

Determine the pitch of a 6” diameter 3 wing MTP cutter.

Substituting for the above example:

$$\text{PITCH} = \frac{\pi \times 6”}{3}$$

$$\text{PITCH} = \frac{3.1416 \times 6”}{3}$$

$$\text{PITCH} = \frac{18.8496}{}$$

PITCH = 6.2832”

Determining Surface Feet Per Minute

In order to determine the Surface Feet Per Minute (SFM) for a given tool, the following information is required:

D **Diameter of the tool**
RPM **The RPM of the spindle rotating the tool**

Simply Substitute the information above into the formula below.

Surface Feet Per Minute (SFM) = .262 x D x RPM

Saw Blade Example

Determine the Surface Feet Per Minute (SFM) of a 14” diameter saw blade rotating at 3600 RPM.

Surface Feet Per Minute (SFM) = .262 x 14” x 3600

Surface Feet Per Minute (SFM) = 13,204.8 FT/MIN

Cutter Head Example

Determine the Surface Feet Per Minute (SFM) of a 6” diameter MTP cutter rotating at 8,000 RPM.

Surface Feet Per Minute (SFM) = .262 x 6” x 8,000

Surface Feet Per Minute (SFM) = 12,576 FT/MIN

NOTE: The maximum allowable SFM of any brazed carbide tool is 19,650 SFM.

NOTE: The maximum allowable SFM of an insert knife tool is 15,750 SFM.

Determining the Feed Rate

In order to determine the proper Feed Rate for an existing tool, the following information is required:

T	**Number of Teeth in the tool.**
RT	**Required Number of Teeth to make a complete kerf cut.**
RPM	**The RPM of the spindle rotating the tool.**
C/L	**The Recommended Chip Load for the material being cut.**

Simply substitute the above information into the formula below:

$$\text{Required Feed Rate} = \frac{C/L \times T \times RPM}{12} + RT$$

Saw Blade Example

Determine the feed rate required for a 96 tooth saw blade rotating at 3450 RPM cross-cutting Oak.

$$\text{Required Feed Rate} = \frac{.003" \times 96 \times 3450}{12} \div 2$$

$$\text{Required Feed Rate} = \frac{993.6}{12} \div 2$$

$$\text{Required Feed} = 41.4 \text{ FT/MIN}$$

Determining the Feed Rate Cont.

Cutter Head Example

Determine the required feed rate for a 3 wing MTP cutter rotating at 8,000 RPM and used for both cross-cutting and ripping oak. (Note: You must figure two feed rates due to the application)

RIP CUT EXAMPLE

Required Feed = $\frac{.012" \times 3 \times 8{,}000}{12} \div 1$
Rate

Required Feed = $\frac{288}{12} \div 1$
Rate

Required Feed = 24 FT./MIN.
Rate

CROSS CUT EXAMPLE

Required Feed = $\frac{.003" \times 3 \times 8{,}000}{12} \div 1.$
Rated

Required Feed = $\frac{72}{12} \div 1$
Rated

Required Feed = 6 FT./MIN.
Rated

NOTE: A cutter that is going to be used for both ripping and cross cutting must be fed at different feed rates due to the recommended chip loads for each operation.

Determining the RPM

In order to determine the RPM of a tool, the following information is required.

SFM **Surface Feet Per Minute recommended**
D **The Diameter of the tool.**

Simply substitute the following information above into the formula below.

$$RPM = \frac{3.82 \times SFM}{D}$$

Saw Blade Example

Determine the RPM of a 14" diameter saw blade that is going to rip cut pine (Softwood).

Substituting for the above example:

$$RPM = \frac{3.82 \times 15{,}750'}{14}$$

$$RPM = \frac{60{,}165}{14}$$

$$RPM = 4{,}297.5$$

Cutter Head Example

Determine the RPM of a 8" diameter MTP cutter machining Oak (Hardwood).

Substituting for the above example:

$$RPM = \frac{3.82 \times 9{,}850'}{8"}$$

$$RPM = \frac{37{,}627}{8"}$$

$$RPM = 4{,}703.4$$

NOTE: Most of the wood working machines that utilize saw blades do not have variable spindle speed and therefore, can not be changed. However, most of the shapers on the market do have variable spindle speeds for various cutter diameters. This formula is generally used to determine the RPM of Shaper machines or if a customer is designing a machine and asks you for RPM recommendations.

Determining Knife Marks Per Inch

In order to determine the number of Knife Marks Per Inch a Moulder head will produce, you need the following information.

T	**Number of Straight Effective Knives in the head.**
FT/MIN	**The Feed Rate that the customer is feeding the material.**
RPM	**The RPM of the spindle that the moulder heads are running on.**

Simply substitute the above information into the formula below.

$$\text{KNIFE MARKS PER INCH} = \frac{\text{RPM} \times \text{T}}{\text{FT/MIN} \times 12}$$

Moulder Head Example

Determine the Knife Marks Per Inch for a Moulder Head rotating at 3,600 RPM and a feed rate of 90 FT/MIN

Substituting for the above example:

$$\text{Knife Marks Per Inch} = \frac{3{,}600 \times 4}{90' \times 12}$$

$$\text{Knife Marks Per Inch} = \frac{14{,}400}{1{,}080"}$$

$$\text{Knife Marks Per Inch} = 13.3$$

REQUIRED NUMBER OF STRAIGHT KNIVES

To determine how many knives you need in a Moulder Head, you need the following information.

K	**Recommended Knife Marks Per Inch**
FT/MIN	**The Feed Rate that the customer wants to run.**
RPM	**The RPM of the spindle that the moulder head is mounted on.**

Simply substitute the information above into the formula below:

$$\text{Required Knives} = \frac{K \times FT/MIN \times 12}{RPM}$$

Moulder Head Example

Determine the Number of Knives required for a Moulder Head machining Oak and running at 4,800 RPM.. The customer wants to feed at 120 FT/MIN

Substituting for the above example:

$$\text{Required Knives} = \frac{13 \times 120' \times 12}{4{,}800}$$

$$\text{Required Knives} = \frac{18{,}720}{4{,}800}$$

Required Knives = 3.9 Knives

CALCULATION OF OPTIMUM SPINDLE SPEED (RPM)

FORMULA:

$$RPM = \frac{Vc \times 12}{\pi \times D}$$

WHERE:

π	=	3.14	
D	=	Diameter of Tool (MAX)	[Inches]
Vc	=	Cutting Velocity	[Surface Feet Per Minute]

Recommended Vc for insert tools = 11800 SFM

THEREFORE:

$$RPM = \frac{11800 \times 12}{3.14 \times D}$$

$$RPM = \frac{45000}{D}$$

EXAMPLE:

What is optimum spindle speed for an 8” diameter toolhead?

$$RPM = \frac{45000}{D} \qquad RPM = \frac{45000}{8}$$

$$RPM = 5625$$

MINIMUM CUTTING CIRCLE = (2 X 28) + BORE
= 56 + 19.05
= 75.05
THEREFORE 76.2 (3") IS 'OK'

MAXIMUM CUTTING CIRCLE = MIN C'CIRCLE ÷ (2 X PROFILE DEPTH)
= 76.2 + (2 X 15)
= 106.2

MAXIMUM # OF INSERTS = $\frac{\text{MAX C'CIRCLE X 3}}{40}$
= $\frac{106.2 \text{ X } 3}{40}$
= 8

FOR 5.5 WIDE GROOVER,
8 INSERTS = Z=2+2, V=2+2

CALCULATION OF FEEDRATE

FORMULA:

$$\text{FEEDRATE} = \frac{CL \times RPM \times Z}{12}$$

WHERE:

CL = Chip Load [Inches]
Z = Number of Teeth in Tool

RECOMMENDED CL VALUES FOR SOLID WOOD:

Cross Grain	=	.010”
Longitudinal Grain	=	.020” to .040”

EXAMPLE:

What is expected feedrate of 3-knife tool cutting cross grain at 6000 RPM?

$$\text{Feedrate} = \frac{CL \times RPM \times Z}{12}$$

$$\text{Feedrate} = \frac{.010 \times 6000 \times 3}{12}$$

Feedrate = 15 Feet Per Minute

CALCULATION OF RIM SPEED

$$\frac{\text{RPM} \times \text{Saw Diameter}}{3.8197}$$

$$\frac{10000 \times 8}{3.8197}$$

Rim Speed

20944

WOOD SPECIES CLASIFICATION

FOR HARDWOODS, MEDIUM HARDWOODS AND SOFTWOODS

HARDNESS CLASSIFICATION OF VARIOUS WOOD SPECIES

HARDWOODS	MEDIUM HARDWOODS	SOFTWOODS
WHITE ASH	BLACK ASH	ASPEN
RED ALDER	BUTTERNUT	BALSA
APITONG	CEDAR	BALSAM FIR
BEECH	CHERRY	BASSWOOD
BIRCH	CYPRESS	BOX ELDER
CHESTNUT	DOGWOOD	COTTONWOOD
EBONY	SOFT ELM	DOUGLAS FIR
ROCK ELM	FIR	HACKBERRY
HICKORY	BLACK GUM	HEMLOCK
LEMMONWOOD	RED GUM	LARCH
LIGNUM VITAE	HOLLY	RED MAPLE
LOCUST	MAGNOLIA	MYRTLE
MAHOGANY	RED MAPLE	YELLOW PINE
HARD MAPLE	PRIMA VERSA	WHITE PINE
SOFT MAPLE	ROSEWOOD	YELLOW POPULAR
WHITE OAK	TANBARK	REDWOOD
PECAN	TULIP	SASSAFRAS
PERSIMMON		SPRUCE
SYCAMORE		
WALNUT		

RECOMMENDED CHIP LOADS AND SFM
FOR WOODWORKING SAW BLADES AND CUTTERS

NATURAL WOODS

Material To Be Cut	Crosscut Chip Loads (C/L)		Rip Chips Loads (C/L)		Recommended SFM Range	
	Secondary ↓	Primary ↓	Secondary ↓	Primary ↓	Saws	Cutters
Hardwoods	.003"	.003"	.012"	.020"	11,800 - 15750	9,850
Medium Hardwoods	.003"	.003"	.015"	.025"	12,000 -15,000	10,000 – 13,000
Softwoods	.003"	.003"	.019"	.025"	13,800-17,700	11,800-15,750

GLUE JOINT FINISH CHIP LOADS FOR RIPPING

Hardwoods	.008"
Medium Hardwoods	.010"
Softwoods	.012

PLYWOODS WITH FACE VENEERS

Material To Be Cut	Crosscut Chip Loads (C/L)		Rip Chip Loads (C/L)		Recommended SFM Range
	Secondary ↓	Primary ↓	Secondary ↓	Primary ↓	Saws
Hardwood Veneers	.003"	.003"	.005"	.005"	8,000 – 14,000
Softwood Veneers	.003"	.003"	.008"	.010"	10,000 – 16,000

MAN MADE MATERIALS

Material To Be Cut	Chip Loads (C/L)		Recommended SFM Range	
	Secondary ↓	Primary ↓	Saws	Cutters
Laminated Plastic	.002"	.005"	6,000 – 12,000	
Lucite, Acrylics	.001"	.003"	4,000 – 10,000	
Masonite, Hardboard	.003"	.012"	10,000 – 14,000	
MDF Board	.010"	.015"	10,000 – 16,000	
Particle Board	.010"	.020"	7,850 – 9,850	7850
Wafer Board	.010"	.012"	10,000 – 14,000	
Wall Board, Gypsum	.003"	.007	10,000 – 16,000	

RECOMMENDED HOOK ANGLES

FOR WOODWORKING MOULDER HEADS

Material to Be Cut On the Moulder	Hook Angles for Kiln Dried Lumber	Hook Angles for Wet or Green Lumber
ASH	15°	10°
BASSWOOD	10°	20°
BEECH	10°	15°
BIRCH	10°	15°
CEDAR	5°	10°
CHERRY	10°	15°
CHESTNUT	5°	10°
COTTONWOOD	5°	10°
CYPRESS	5°	10°
ELM, HARD	0°	5°
ELM, SOFT	5°	10°
FIR	10°	15°
GUM	20°	25°
HEMLOCK	15°	20°
HICKORY	5°	10°
MAHOGANY	10°	15°
MAPLE	5°	10°
OAK	10°	15°
PINE, YELLOW	20°	25°
PINE, WHITE	25°	30°
PINE, PONDEROSA	25°	30°
POPULAR	30°	35°
REDWOOD	5°	15°
SPRUCE	20°	25°
SYCAMORE	5°	10°
WALNUT	5°	10°

RECOMMENDED KNIFE MARKS PER INCH

FOR WOODWORKING MOULDER HEADS

Below is the excepted range of knife Marks Per Inch for the given species of wood to be cut. By remaining within the specified range on the chart, the best finish and tool life will be experienced**.**

Species Of Wood	Knife Marks Per Inch
ASH	**11 - 14**
BASSWOOD	**8 - 12**
BEECH	**12 - 14**
BIRCH	**12 – 14**
CEDAR	**8 – 12**
CHERRY	**12 – 14**
COTTONWOOD	**8 – 12**
CYPRESS	**8 – 12**
ELM, HARD	**10 – 12**
ELM, SOFT	**8 – 12**
FIR	**8 – 12**
GUM	**9 – 13**
HEMLOCK	**8 – 12**
HICKORY	**12 – 15**
MAHOGANY	**12 – 14**
MAPLE	**12 – 14**
OAK	**12 – 14**
PINE, YELLOW	**9 – 13**
PINE, WHITE	**9 – 12**
POPULAR	**9 – 13**
REDWOOD	**8 – 12**
SPRUCE	**8 – 12**
SYCAMORE	**11 – 14**
WALNUT	**12 – 14**