Traditionally, most people in the metal working industry have regarded the sawing operation as a necessary evil, something in the same category as sweeping up chips. The principals of band saw cutting have not been widely known. The resulting approach too frequently has been, “Just stick the material in the machine and chop it off.”

As knowledge of band saw cutting increases with publications such as this one, wise shop owners are beginning to realize that sawing is a legitimate operation, much like the more obvious lathe or mill operations.

Under the right conditions, in-house sawing has the potential of actually MAKING MONEY, but a foundation consisting of certain factors must be established. First a knowledge of the elements affecting the physical operation of cutting, such as blade speed, material size, material composition, feed rate and pressure. Second, the ability to maximize the efficiency of bandsaw cutting in terms of time, accuracy, and blade life; and third, the selection of a saw which will provide superior performance in terms of unit cost, overhead cost and long range profitability.

This booklet has been designed to give instructions in these areas and answer other important questions. If you should have more specific questions, please let us know. We will be happy to answer your questions with specific information tailored to your particular requirements.

Doug Harris
President of HE&M Saw
HE&M Saw takes these pages to salute its employees. We are very proud of their dedication to HE&M Saw and to you, our customer.

We have been growing steadily for 50 years. Through the efforts of our people, we build a top quality product, back it with reliable, dependable service, and continue to make startling technological advances that are sure to give our customers the edge they may need for the future.

HE&M Saws have earned a reputation for their high quality and dependable performance. We realize this is a direct reflection on our people. From the machinists who skillfully craft components for our equipment, to our service people who deftly handle customer problems over the phone and in the field, to our technicians in the factory making sure all parts of your HE&M Saw are assembled perfectly.

Our engineering and electrical departments are staffed by people aware of the newest technologies available, and possess the applications knowledge to put it to effective use; HE&M Saw people have always put the customer first, and always will.

We at HEM INC. Stress Safety, Knowledge and Production.

Safety First and Always

All machinery is potentially dangerous. Obviously the safety of the operator or anyone entering the sawing area is important. That’s why OSHA, NFPA, and federal, state and local government agencies have developed certain safety standards. In addition, your company has adopted safety policies and saw manufacturers publish recommended procedures.

Although safety is everyone’s responsibility, the best way to prevent accidents is to anticipate potential hazards and to educate the saw operator with basic instruction. Any operator must know exactly how all machines, material handling and support equipment work and how each function relates to the others. This knowledge allows the operator to anticipate any factor that could be dangerous. The operator should also understand maintenance, even though they may not perform it, and have knowledge of all moving components.
Pre-Operational Safety Check

Before operation, all personnel who work the band saw machine or associated equipment should review the following:

1. Has the operator received and understood proper instructions, including reading the instruction manual?

2. Is the operator attired in accordance with applicable regulations, including eye and ear protection, safety shoes, head protection, gloves (while handling blades, sharp material, etc.), long hair pulled back, and appropriate attire (no loose fitting clothes and no jewelry)?

3. Is the machine in proper running order such as maintenance emergency stops, and limit switches, and are safety features in use. Check interlocks, guards, access covers, awareness barriers and posted safety rules.

4. Is the machine and immediate area in good housekeeping order? Obstacles such as tools, clip boards, and paper should be kept away from the saw arm and controls.

5. Is the operator aware of electrical, hydraulic and pneumatic procedures such as power source, emergency shut-off, disconnects, and fire-fighting procedures?

6. Is the operator properly trained in material handling such as lifting, pushing, pulling, or any other initiated force to give motion to or stop the material? Does the operator know to always handle material carefully to avoid slipping or dropping the material on parts of their body?

Avoid Potential Hazards

1. Never stand, sit, lie, or lean on the machine.

2. Never put fingers, hands, head or any other part of your body under, in front of, or near the saw arm or blade (area of operation) at any time.

3. Never put any part of your body or clothing in the vising areas.

4. Never put any part of your body, including clothing, in front of, between, or near any part that moves, such as material handling vises, rollers (input and output), material that may move, or chip conveyor.

5. Never have someone else operate the machine while you are anywhere near the moving parts of the machine. For example, if someone closes the vise and your hand is in the vise, you could be seriously injured.

6. Check to be sure that material is always clamped before cutting and that guides are positioned as close to the material as possible.

7. Check the material supports. Falling material could injure you. Make sure that material is fully supported. No part should be un-supported.
8. Be sure that blocks or guards are in place to prevent material from rolling off the support tables.

9. Never hold or support material with your hands or any other part of your body while cutting or moving material.

10. Never use a welding or cutting torch on or near the saw. Hydraulic lines, electrical lines, or airlines may be burned and someone could be hurt or burned by mechanical failure. Also mechanical components can get damaged.

Cleaning Precautions

1. Do not clean the machine while the saw is cutting. Raise the saw arm out of the cutting area and stop the blade. Block arm in position and disconnect electrical power. Only reach into the cutting area with tools or a scraper. Never put any part of your body (especially your hands, arms or fingers) near the blade, even if it is stopped. The weight of the saw arm pushing on the thin blade can still cause severe injury or dismemberment.

2. Make certain that all guards, access doors, and awareness barriers are returned to original positions after cleaning.

Maintenance Precautions

1. Turn off and lock out all the power when performing maintenance duties or doing maintenance checks.

2. Make periodic checks to insure that all wire, cylinder, and vising connections are tight.

3. Keep all motors, heat exchangers, pumps, and power units free of obstructions, dust, and debris. Plugged cooling fins may cause excessive heat.

4. Make sure all lubrication is in accordance with the operation manual.

5. Make sure all guards, access doors, and awareness barriers are secure and fastened.

6. Check all built in safety devices and interlocks to make certain they are operational.

7. Shut off and lock out all electrical power when performing maintenance.

8. Shut off and lock out all power air or hydraulic power when performing maintenance.

9. Never weld on the machine since this can destroy the computers that run the saw. Electric, air, or hydraulic lines may also burned, break or mechanical components may be destroyed.

NOTE: Circumstances may require the use of special safety equipment or precautions not outlined in this section.
Rules of Safe Operation

Sawing can be dangerous. You work with it every day. Even machines that run automatically can be hazardous if you don’t stay continually alert to potential danger while operating them.

One of the keys to safe operation is to know your band saw machine and understand all proper operating procedures. Familiarize yourself with all switches, knobs, controls, guards, etc., and read the instruction manual from cover to cover before you start.

To operate a band saw in the safest manner possible, there are a few things you must always remember:

1. Never put your hands or any part of your body underneath or by the band saw blade.

2. When installing a new blade or removing an old one always wear gloves to keep from cutting yourself. Be certain that the machine is de-energized and no one is around who might accidentally start the machine while your hands are exposed to the band saw blade.

3. Make sure to keep your hands and arms out of the vise closing area.

4. Always handle the material in such a way that if it slips or falls off the machine, it will not drop on your feet or contact any part of your body. Or if the operator slips and drops the material the operator will not be injured.

5. With automatic machines, be certain that your body is clear of the indexing vise system. This is the vise that moves the material into the machine with an automatic feed system.


7. Be sure there are guards to prevent material from rolling off the side of the support tables.

8. Never roll material off the end of the support table.

9. Do not have someone else operate the saw while you are in an area where the motions of the machine could contact your body. For example, if you are installing or removing a blade and someone turns on the motor, the blade could cut your hand or fingers.

10. Exercise great care when the saw is cutting material to be sure that no hands, fingers or any part of your body is near enough to the blade to be cut off.

11. Proper balance is important. If you’re standing, walking or moving near the saw and you slip or lose balance, your body could come in contact with a moving part of the machine and sustain serious injury.

12. Make sure the floor is clear of any obstructions and is not slippery.

13. Wear safety shoes and safety glasses when operating the machine.

14. As with all machinery, do not wear gloves during operation. Gloves can get caught in the moving parts of the machine or the blade. Only wear gloves when installing a new blade, removing an old blade or handling material.
15. Do not wear loose fitting clothing or allow your clothing to get too close to the saw blade because it could be caught and draw you into the blade.

16. Never operate a machine unless all guards and awareness barriers are in place so you will be properly alerted and protected.

17. Always make safety practices your first priority and check the saw for safety before you begin operation each time. If the saw is not safe, alert your supervisor.

18. If you don’t know what the safety practices are, be sure that someone teaches them to you before you operate the machine. Ask your foreman or supervisor.

19. Never hold material with your hands or any part of your body when cutting.

20. When moving material be sure that it is properly supported, don’t force it on the support tabling. If the material falls while you are holding it you could be hurt.

Saws that cut steel can cut people!

Steel is heavy and if it falls, you can be hurt!
Given an unusually capable saw and ideal conditions, it is possible to cut at a maximum rate of approximately 30 square inches per minute. Laboratory tests have obtained up to 130 square inches per minute with a bandsaw, but this is not practical for real world cutting operations. This rate could only be obtained by using a material easy to cut, such as C-1212 cold finish bar. It would also require the correct blade tooth and spacing, the right blade speed and feed rate, and an appropriate high quality cutting fluid.

Under more normal conditions, a cutting rate of 15 square inches per minute for mild steel is practical and readily obtainable when using a high speed electron welded blade. When working with more difficult materials, of course, slower cutting rates may be required. Each type of material has its own characteristics and some require unusual measures to obtain satisfactory cutting performance.

Calculating the square inches of a rectangular bar

\[ 3 \times 4 = 12 \text{ square inches} \]
Factors Effecting Machinability of Materials

There are four main factors that affect machinability. These factors are tool life, tool forces and power consumption, surface finish, and chip formation. A metal's machinability is its relative measure of how easily a material can be machined when compared to 160 Brinell AISI1112 free machining low carbon steel. Many things, such as heat treating, affect a metal's machinability. Adding oxides, carbides, and/or inclusions will decrease the machinability. The thermal properties like low thermal conductivity, will also affect machinability. A low thermal conductivity will not allow the metal in dissipating its heat well; this means the machining tools will get very hot and this will decrease their tool life. A large thermal expansion coefficient of a metal means coolants are required. This is because the metal will expand significantly as its temperature increase, decreasing both the machinability and the accuracy of the cut with changing temperatures.

The blade being used can also affect machinability through cutting geometries. There are three main types of cutting geometries used to cut metals. These are Positive,

![Diagram of cutting geometries](image)

Negative, and Neutral/ Zero. The terms positive, negative, and zero refer to the rank angle (\(\gamma\)) at the face of the tooth. The smaller the rake angle on the tooth, the stronger the tooth will be. However, smaller rake angles increase the cutting forces on the blade. More positive angles are used of metals with a higher machinability, while negative and neutral rank angles are used for materials with lower machinability.

Cutting fluids also play an important role in machining metals. They serve many purposes including, but not limited to, decreasing the friction, decreasing the wear, keeping temperatures more stable, wash away chips from the cutting area, protect the metal from corrosion, increase the tool life, improve surface finish, and reduce the cutting forces and power consumption and therefore increase a metals machinability. There are two main types of cutting fluids, Petroleum based and Water-miscible. Petroleum based fluids usually contain mineral oils, fatty oils, and sulfur. They are also non-soluble. Water-miscible fluids are soluble and typically contain fatty oils, fatty acids, wetting agents, emulsifiers, sulfur, chlorine, rust inhibitors, and germicides. The use of sulfur and chlorine in cutting fluids increases the easiness of cutting.
Plain Carbon steel varies in its machinability. This is because the machinability is primarily dependent on the carbon content of the steel and on how the steel has been heat treated. When the carbon content of steel is 0.20% and below, the steel is soft, ductile, and gummy. This gives it a lower machinability. At 0.20% to 0.35%, the steel has slight hardening, at its best machinability, and is considered ideal. Above 0.35%, the steel is abrasive, has an increasing hardness, and a lower machinability. An annealed alloy machines on average up to 30% better than its non-annealed identical alloy. However, if an extreme heat treated material will be more difficult to machine.

There are three main types of carbon steel; low-carbon steel, medium-carbon steel, and high-carbon steel. Low-carbon steel ranges from 0.05%-0.30% carbon. When low-carbon steel is cold-rolled, it is then referred to as cold rolled steel. Medium-carbon steel ranges from 0.30% to 0.60% carbon, and is stronger than low-carbon steel. Tempering can be used to increase the Rockwell-C hardness of medium-carbon steel to between 40 (medium hard) to 60 (very hard) depending on the carbon content and the thickness. High-carbon steel, also known as Carbon Tool Steel, ranges from 0.60% to 1.50% carbon. It can be shaped and up to 0.80% carbon steel can be hardened to a Rockwell hardness of 60-66, but when hardened the material becomes very brittle. Free machining carbon steels can be produced which are specifically made to have high machinability.

High-speed Steel (HSS), also known as high-speed tool steel, have a carbon content of 0.70%-1.5%. High-speed cutting tools have the ability to retain their hardness without a significant softening up to temperatures of 11,000°. Whereas plain carbon tool steel begins to significantly soften at 450°F. Generally HSS will contain more than one metal. Chrome, Vanadium, Molybdenum, and Tungsten are used to create carbides which are very hard and wear-resistant and therefore typically used for cutting tools. Cobalt is good for increasing hot-hardness; however, it will not form carbide.

There are 3 classes of alloy steel along with many additives used. The 3 classes consist of Construction alloy steel, Alloy tool steel, and Special alloy steel. Construction alloy steel has an alloy content of 0.25%-6.0% and is generally used for parts and construction purposes. Alloy tool steel has a typical alloy content of 0.25%-38.0%. It is generally used in making, cutting, and forming tools and/or for high quality drills, reamer, milling cutters, or other similar products. They must be hardened in oil or air, but harden deeper than most plain carbon tool steels and are more shock resistant. Special alloy steels use steel that gets harder with use and are specially designed for extreme service requirements such as high heat resistance, corrosion resistance, and wear resistance.

There are around 26 elements used alone or in combinations to make alloy steels. A few of the major elements are Chromium, Cobalt, Manganese, Molybdenum, Nickel, Tungsten, and Vanadium.

- Chromium (chrome) is the basis of stainless steel. It is often used to increase hardness and ultimate strength over nickel, and is also used to increase toughness, resist rust, stains, shocks, and scratches. However, it does decrease ductility.

- Cobalt is generally 5%-12% of high-speed steels, and 35%-55% of cast alloys. It is used to increase hot-hardness and improve wear resistance. When combined with aluminum and nickel it created Alnico permanent magnets.

- Manganese steels can stand hard ware, stains, hammering, and shocks. It will also remain hard even when cooled slowly, and wear will make the surface harder. Manganese increases strength better than nickel, increases toughness better than chromium, and increases ductility.

- Molybdenum increases strength and hardness approaching that of vanadium. It also increases tolerance to heat and shocks without any ductility loss.

- Nickel is used to increase hardness, toughness, ultimate strength, elasticity and resist rust. Although ductility remains the same, it makes alloys more prone to work hardening. Nickel tolerates vibrations, shocks, jolts, and wears by bouncing back to its original shape. Nickel also combines with chromium to create stainless steel.
Tungsten is rare and has the highest melting point of all metals. It is used in tool steels, high-speed steel, and in cemented carbides. It increases hardness, improves tolerance to heat, and creates a fine grain structure.

Vanadium increases strength, hardness, and toughness when compared to manganese, but greatly lowers ductility.

Chrome-Nickel is used to increase ductility, toughness, and wear resistance. However, it distorts easily, has a decreased stability under heat, and is gummier to machine.

Chrome-Molybdenum in comparison to Molybdenum alone has an increased hardness, and wear resistance but a decreased ductility.

Chrome-Vanadium increases tensile strength, wears resistance, and in comparison to Chrome-Nickel has an increased hardness, impact strength, and toughness. However, it is not brittle and gummy to machine.

Nickel-Molybdenum has similar qualities to chrome-molybdenum only with an increased toughness.

Stainless steel is at least 10% chromium by mass and is organized into 5 categories; Austenitic (300 series), Ferritic (400 series), Martensitic (400 series), Duplex (50% ferritic and 50% austenitic), and Precipitation hardening (grade 630). All of these are difficult to machine excluding Ferritic which has good machinability.

Many other kinds of metal are also used in machining processes. Nickel alloys, including Inconel, are an example of such metals. Nickel alloy machinability is directly correlated to its nickel content. If the nickel content is low the metal becomes gummy, and if the nickel and chrome content are too high the metal has bad machining properties. Most nickel alloys are best machined with carbide at 120 sfpm or less. Inconel for example need to be machined at slow speeds around 20 or 30 sfpm. This is because nickel alloys are ductile and prone to work hardening. Annealing a nickel alloy also decreases its machinability. Unlike most carbon steels, the cold worked metal is preferred. Titanium alloys are another commonly machined metal. Titanium, which has a machinability of 30% or less, is difficult to machine because it becomes more reactive to cutting metals as temperatures increase. This means it’s important to maintain a sharp cutting tool and use a generous amount of cutting fluid to help maintain thermal stability. Using a dull cutting tool will increase heat.

Aluminum and Copper alloys are two more commonly machined metals. When machining Aluminum it’s important to use positive cutting grades and also to pay attention to which grade of aluminum you are machining. This because the machinability grades of aluminum can be easily machined, but the weldable grades are difficult to machine because of their gumminess. Copper alloys are dependent on the other components of the alloy for their machinability. However, high copper alloys tear easily but are also tough and abrasive. This makes them difficult to machine.

There are two main additives to alloys that are used to increase its machinability. These two elements are Sulfur and Lead. Re-sulfurized carbon steels contain around 0.08%-.033% sulfur, and have an increased machinability when compared to plain carbon steels. For example, AISI 1112 is re-sulfurized steel which has a machinability of 100%. Lead is also added to re-sulfurized steels to increase their machinability. Lead is typically added in the proportion of 1/3lb for every 100 lbs. of steel. Both lead and sulfur can increase materials machinability so that it can have up to a machinability of 300%.
Factors Affecting Cutting Performance

Material Composition

As the material machinability lowers, so does the cutting rate. For example, stainless steel is slower to cut than C1212, which in turn is slower than B1113.

Surface conditions will also affect the cutting rate. If there are places on the surface or in the material which are hard, a slower blade speed will be required or blade damage may result. Tough or abrasive materials are much harder to cut than their machinability rating would indicate.

Material Size and Shape

Each blade configuration will have an optimum width of material to be cut. Below this width, tooth loading may become excessive and the cutting rate must be reduced. When the material is wider than the optimum width, blade control begins to diminish, as will be discussed later.

For example, a band saw blade 1 inch wide by .035 thick would successfully cut mild steel material whose optimum width is between 4 and 5 inches. But a 1.25 inch blade by .042 thick will have optimum cutting in stock which is about 6 inches wide. This is because the heavier blade has nearly twice the beam strength, which allows higher pressure and straighter cutting in heavier material.

Since the blade "sees" only the material actually being cut, the shape of the stock being cut will also affect cutting speeds, particularly if the piece is excessively wide or if it varies in the dimensions being cut. The actual area of a solid round can be found by using the following formula:

\[ A = \frac{\pi D^2}{4} \]

where:
- \( D \) = Diameter
- \( A \) = Area
- \( \pi \approx 3.14 \)
Cutting tubing presents special problems such as the fact that the blade must enter the material twice and that maintaining adequate cutting fluid flow on the blade as it enters the second side is nearly impossible.

Thus, whenever the inside diameter begins to approach 50% or less of the outside diameter, it is best for practical purposes to treat the material as a solid. In other words, as wall thickness increases, the tubing begins to more and more closely resemble a solid in terms of cutting speed.

Guide Spacing

The rigidity of the blade is a function of guide spacing, with rigidity being reduced to the third power as the distance between the guides’ increases. For example, with guides spaced 2 inches apart, blade deflection might be approximately .02 inches. Under the same conditions, but with the guides spaced at 4 inches apart, blade deflection would be approximately .16 (.02 x 8) inches.

\[
i(\frac{O.D.^2}{4} - \frac{I.D.^2}{4})\text{ - Area being cut}
\]

Where:
- O.D. = Outside Diameter
- I.D. = Inside Diameter

A simplified formula is: \[Y_{max} = \frac{1WL^3}{48EI}\]

Where:
- \(Y\) = Blade Deflection
- \(W\) = Load on Blade
- \(L\) = Spacing of Guides
- \(E\) = Modulus of elasticity
- \(I\) = Moment of Inertia

This is a simplified version of the formula because it does not consider band tension or guide design. It is important to recognize, for example, that rollers are not considered anchored supports. A more complete derivation, including band tension and guide design, is included in “Roark’s” Formulas for Stress and Strain.
The greater the distance between the guides, the greater there is the probability of a crooked cut. The solution is to reduce cutting pressure. However, if the material is hard or tough, cutting may stop all together. Thus, when cutting wide stock, a compromise between too much and too little cutting pressures must be found. Trial and error may be the only satisfactory method.

**Blade Selection**

There are many types of blade materials used, ranging from carbon to carbide. Each specific blade material has its own application. Carbon blades, both hardback and flex back, cannot be generally recommended for production cutting because the blades have poor resistance to heat and abrasion.

However, certain applications may exist where a hardened carbon blade may be used for cost effectiveness. An All High Speed blade, very popular a few years ago, is replaced by the Bi-Metal blades. Bi-Metal blades come in many configurations. However, they generally consist of a tool steel (M30 to M42 and M42 to M51) electron beam welded to a tough backer material. There are many variations on this construction to provide high resistance to heat or shock.

The Bi-Metal blade has the greatest versatility and utilization in the metal sawing business. Additionally, there are other blades available for special applications. For example, there are Carbide-Tipped blades to permit cutting of extremely abrasive or hard materials. All blades have their particular advantages. In the right application, carbide blades with their ground teeth will provide a better finish and higher production rates than more conventional sawing methods.
Tooth Form and Spacing

The selection of a tooth form is generally determined by the material to be cut. There are three general factors to consider:

1. tooth form, the style or shape of the teeth
2. tooth spacing, the number of teeth to the inch
3. tooth set, which provides clearance for the body of the blade.

Three styles of teeth are shown here:

In general, a coarse hook tooth blade is the most efficient in materials where it can be used. Mild steel and aluminum would be appropriate applications.

In wide cuts, a skip tooth blade would be effective since it simply reduces the number of teeth per inch.

The standard tooth blade is a blade for general applications or where a variety of materials are being cut. It is also particularly useful in cutting fragile materials, such as castings and brass.

Hammer Set

The hammer set changes the rake angle and the side profile. The greater the rake angle, the easier it is for the blade to penetrate the material. The penetration of the material is due to the self-feeding action of the rake angle.

Hammer setting the side changes the tooth cutting edge from the same angle as the set to a smaller angle. This helps the blade cut straighter. The larger the rake angle the greater the self feeding action of the blade.

This self feeding lowers the cutting pressure. But it comes at a price, the teeth are more fragile.
The high tooth cuts a small chip in the center of the cut.

The wide tooth cuts both edges and widens the cut. This tooth cuts on both sides at the same time. The wide tooth also prevents the blade from binding in the cut. On bi-metal or carbon blades, the set prevents the blade from binding in the cut. It may be either a “Regular Set” (also called a “Raker Set”) or a “Wavy Set”.

The regular or raker set is most common and consists of a pattern of one tooth to the left, one to the right and one (the raker) which is straight, or unset. This type of set is generally used where the material to be cut is uniform in size, and for contour cutting.

Wavy set has groups of teeth set alternately to the right and left, forming a wave-like pattern. This reduces the stress on each individual tooth, making it suitable for cutting thin materials or a variety of materials where blade changing is impractical. Wavy set is often used where tooth breakage is a problem. Today, however, the variable pitch has replaced most of the wavy tooth applications.

When this tooth enters the material the right tooth will take a larger bite on the side, hence the pattern on the material being cut.
Stepped Back Blades

Stepped or ground backed blades are a relatively new development for metal band sawing. They are designed specifically for the cutting of large cross-sectional sizes or hard materials. The blade tends not to perform well on servo controlled or constant feed rate band saws.

Wavy Tooth

With a wavy tooth blade the changing height of the tips is an attempt to improve cutting in the same manner as the stepped back blade.

Tooth pitch, or spacing, is generally determined by the material and its thickness in a cross-section. It is generally specified in “teeth per inch”, as indicated below.
Vari- Pitch Teeth

A relatively new development is blades with variable tooth spacing. On blades of this type, the tooth spacing might, for example, vary from 3 to 6 teeth per inch on a particular blade. Or, on a less coarse tooth blade, it might vary from 6 to 10 teeth per inch.

The purpose of this type of tooth spacing is to prevent vibration, which will be discussed in more detail later on.

When cutting narrow shapes, more teeth per inch will be required to prevent damaging the blade. Wider shapes will require a coarse blade with fewer teeth per inch.

Blade Sharpness

It comes as no surprise that a dull blade will cause problems. But it is also true that a very sharp blade can be a source of difficulty - namely vibration.

Vibration occurs like this: When a very sharp point enters the material, it immediately begins to dig itself into the material. At some point, it gets in too deep and “bounces” up. The next tooth does the same thing, and the result, of course, is vibration. Excessive vibration will greatly reduce blade life and will also cause excessive wear on other parts of the saw. As the blade begins to dull just slightly, the points of the teeth stop digging in and the vibration stops. Now the teeth must be pushed into the material by the saw, permitting proper cutting pressure to be applied.

How to Break-in Blades

The “honing” process is best accomplished by careful breaking in of the new blade immediately after installation.

1. Set blade speed according to material type and size.
2. Reduce the cutting pressure on the blade to the minimum required to achieve cutting.
3. Gradually increase the cutting rate until the desired square inch /minute is achieved.

Some manufacturers of blades actually sandblast their blades to remove the very sharp points. This may be an advantage only in situations involving inexpert saw operators and difficult materials. Careful break-in of a new blade is by far the best method of obtaining the maximum blade life.

A dull blade cannot be expected to cut straight. An example will serve to illustrate why. Picture a 10 pitch blade with .001 flat on each tooth. (One thousandth of an inch is smaller than the naked eye can detect. A human hair is generally from .0025 to .003). If you were cutting a piece 4” wide, you would have forty teeth engaged in the material at one time. That is a total of .040 flat on the point.

In addition, a dull blade will not cut efficiently. As the blade gets dull, it penetrates more slowly and it generates more heat. The additional heat tends to dull the blade more quickly. The blade becomes duller still, generates even more heat, and so on. Soon the teeth will fail and the blade won’t cut at all, or
it will make crooked cuts. Since a dull tooth cannot be detected by the naked eye, cutting time is the most reliable indication of a dull blade. Typically, as a blade begins to dull, the cutting time will begin to show a significant increase. It is possible, but not economical, to leave the blade on until cutting time has increased to two or even three times the normal time. But maximum efficiency and straight cutting require that the blade be changed as soon as the dulling begins to become apparent.

It is worth noting that if a blade is too dull to cut stainless or similar materials efficiently, it may still be satisfactory to use in mild steel. However, a blade which is too dull for mild steel will not be satisfactory in aluminum.

**Blade Speed and Feed Rate (Traversing Rate)**

Blade speed is generally limited by vibration and by the ability to keep the blade sufficiently cool to avoid dulling the teeth. A blade which is running fast and taking a very shallow cut will dull quickly because the tips of the teeth will overheat from the rubbing action. If, however, we force the blade teeth deeper into the material, the blade will be less sensitive to heat because the teeth are cutting more and rubbing less. This increased pressure may also prevent vibration. Thus, up to a point, a higher pressure on the blade may actually permit higher blade speeds.

If we have a sharp tooth with a .0002 radius on the tip, and we apply only enough force to cause penetration of .0002, the tooth will not penetrate and cut. If, however, we apply enough force to cause penetration of .001, the tooth still has .0008 of a sharp edge to cut with. This is similar to the “dull tip effect” observed frequently in lathe and milling operations. When making a finish cut with a dull tool, a fine adjustment may make no cut at all, but an additional fine adjustment will cause the tool to dig in deeply.

If, on the other hand, we apply too much penetrating force, the teeth will be ripped out of the blade. The maximum feed rate is determined by the saw, material size, material shape, guide spacing, cutting fluid, and the size and shape of the teeth. The greater the blade speed, the greater the feed rate can be, up to the limits imposed by the factors just discussed.

Thus, for each blade and material being cut, there is an optimum balance between blade speed and feed rate. This rate will give maximum blade life and most satisfactory cutting.

In general, we recommend:

1. Coarse tooth blade so that each tooth has adequate force on it.
2. Guides set close to the work to permit relatively heavy feed pressure and still control the blade.
3. Carefully controlled feed rate to prevent the teeth from tearing out.
Saw Engineering to Improve Cutting

Feed rate or Pressure Control System

The most efficient cutting is accomplished by the proper balance between cutting pressure and feed rate. Soft, low strength materials present different difficulties than hard, high strength materials. In soft, low strength material, pulling the teeth off the blade is unlikely, but over-filling the gullet may occur. With high strength material, pulling the teeth off the blade is a major problem. Carbide blades present other difficulties because of its shock sensitivity, and sensitivity to pulling the teeth off. The feed rate must be set right in order not to over-stress the teeth.

Traversing Rate System: (Feed Rate)

Traversing speed (Feed Rate) is used to maintain a uniform speed through the material. The pressure on the saw teeth will vary during the cut.

Advantages are:

1. Uniform chip thickness
2. As the blade teeth get dull the chip thickness will remain constant
3. If the material work-hardens the blade will be forced into the material
4. Cutting time will remain constant

Disadvantages are:

1. Slower cutting time in non uniform cross sections
2. As the blade teeth get dull the blade may cut crooked
3. When the blade teeth are too dull to cut the blade will stall and slip on the wheel
4. Each different width material will require a different traversing rate. The operator must make the change or the teeth may be over-loaded. It is best to have a “maximum-force-allowed” safety device on traversing rate saws.

Slow entry means light blade force, and that may dull the blade in work-hardening material or in bars with hard or abrasive scale.

Constant Feed – Variable Force

Cut marks are evenly spaced

In the wide section, the blade gullets may be over filled, stripping the saw teeth out, or the blade may stall.
Cutting Pressure System:

Cutting pressure systems are used to maintain the best cutting rate in all shapes, also for ease in setup. But, the feed rate will vary as the cross section varies.

Advantages are:

1. Gullet loads are more consistent.
2. Best cutting rates in shapes.
3. Cutting rate slows as the blade dulls thereby maintaining a straight cut.
4. Ease of set up. Changing the width of the material does not require a change in cutting pressure, as the material gets wider the traversing rate of the saw slows but the square inches per minute cut remains the same.

Disadvantages are:

1. In thin sections the chip load may be too large and the teeth may pull out.
2. In work hardening material the saw teeth may quit penetrating, and the material may work harden under the teeth. The saw will stop cutting.
3. Cutting time will slow as the blade becomes dull.
4. Different tooth configurations may require a different pressure.

It is best to have a maximum traversing speed adjustment with the cutting pressure control.
Blade Tension

Blade tension is an important factor in straight cutting. Adequate tension prevents the center of the blade from being deflected to the side, causing a crooked cut. It also prevents the blade from achieving reduced penetration of the teeth in the center of the cut. From the cutting standpoint, the more tension, the better. The limiting factor is blade strength.

Blade Vibration

Blade vibration is caused by a blade tooth as it enters the material. A force is required to make the tooth penetrate the material; the resisting force causes the blade to rise up slightly at the time of contact. The raising and lowering of the blade causes vibration. If the vibration is allowed to build up, it will affect the blade fatigue life. This might cause the blade to break.

To eliminate blade vibration, increase blade tension and or blade feed rate, change blade speed, or use a different tooth form. The new blades with variable tooth spacing may be very helpful in eliminating vibration in some applications. Spacing the guides farther apart will allow the blade to vibrate freely in the cut without this vibration being transferred to the sawing machine. Thus, the vibration will appear to stop, but will actually continue and, of course, blade control is reduced with this wider spacing.

Cutting Fluid

Cutting fluid is so important it cannot be overstressed. A good quality cutting fluid in a band saw is one of the most important factors in straight cutting. The cutting fluid keeps the blade teeth cool; it prevents the chips from welding to the tooth; and it lubricates the chips, allowing them to move easily through the cut.

If cutting fluid is unable to cool the blade teeth, they will soften and become dull. If the cutting fluid is distributed to only one side of the blade, the opposite side will become dull. This will cause the blade to move toward the side which has the most cutting fluid and the cut will be crooked.

If we compare sawing to milling, we immediately see that in sawing there is much less room for the chip. The chip must lodge in a small place between the teeth and be carried smoothly out of the cut. Without proper cutting fluid, either of two things will happen.

First, the chip may become welded to the tooth. This will change the form of the tooth, which in turn will change the amount of force required for the blade to cut. The result is an unbalanced blade which will produce a crooked cut.

The second possibility is that the chip will wedge in the cut. Since the chip is work hardened and harder than the stock from which it came, the blade will cut into the stock beside the chip. Again, the result is a crooked cut and a dull blade.

In selecting a cutting fluid, pick one which is of high quality. Avoid thinly mixed soluble oils. Some of the new synthetic oils are highly satisfactory in difficult operations.

If optimum cutting and blade life are the desired result, before selecting a cutting fluid and mixture for your saws, ask yourself the question “Would I tap this material with this fluid?”
Saw Design and Construction

As indicated in the previous discussion, satisfactory and profitable cutting performance is determined by a wide variety of factors, most of which involve the design and construction of the saw. Let’s look at a few of the more important design features and how they affect straight cutting and blade cost.

The first objective of proper saw design is straight cutting because this permits work to be done with a minimum of reprocessing, material waste, and rejects. Straight cutting is so important to profits that it almost goes without further comment.

The second objective is efficient use of blades. To grasp the importance of this, compare the difference between using one electron welded blade costing $50 for one day, with using the blade for two days. On the basis of a five day week, fifty weeks per year, a machine which uses one blade per day will require $12,500 in blades per year. However, a machine which will extend the life of the blade to two days will require only $6,250 in blades. In less than 5 years the savings in blade costs alone would pay for a $30,000 saw; and this does not even take into account such factors as reduced labor time, a lower reject rate, or less material waste due to dull blades.

Another objective of good saw design is maximum production efficiency which includes the greatest reliability, ease of adjustment and repair, and the best possible return of investment. What should you look for in order to obtain these benefits? Here are a few specific design features which have a direct effect on performance:

Blade Guides

Absolute square-ness of the blade is essential to straight cutting. It cannot be obtained by the use of roller guides since they act as pivotal contacts rather than as anchored supports. A flat guide that squeezes the blade to keep it absolutely vertical and to align it in the horizontal plane appears to be the best method of keeping the blade square. The blade guides must, of course, be positioned as closely to the work as possible. And they must be held rigidly by guide arms which have a large section modulus and adequate mass. Look for adequate weight and dimensions in the guide arms themselves.
Types of Saw

Horizontal Column Saws

Column or “guillotine” type saws must be extremely rigid to prevent flexing when the arm is at maximum capacity. The saw arm must also be massive and strong, to reduce flex and to permit proper blade tension. Vibration is also reduced with more massive arm structure and wheels. The columns themselves should be perfectly aligned and parallel to ensure straight cutting at any height. The saw arm guiding design is very critical. The arm columns must be parallel or they will twist as the saw arm raises and lowers, binding the saw arm guides. Control of the arm while cutting is also important. Ease of adjustment of traverse rate and cutting force is critical to achieve a wide range of cutting options.

Horizontal Scissor-Type Saws

Since the saw arm holds the blade guides and blades, it follows that it is critical to the control of the blade. The saw arm must have adequate mass and beam strength to avoid flexing. It must anchor the blade guide arms in order to prevent their getting out of alignment, and must permit proper blade tension. It must also pivot from the proper location on a pivot which allows no lateral motion. Again, look for a heavy arm of sturdy construction. Look for a pivot as far from the work as possible and at the level of the work in order to minimize the weight shift factor. And look for a pivot bearing which has no play.

Vertical Saws

Vertical saws have several advantages over column or scissor machines. The saw itself can take up less floor space than a horizontal saw with the same capacity, and provides for angle cutting. HE&M vertical saws provide angle cutting up to 60 degrees in both directions, giving nearly unlimited versatility. The work height is higher than horizontal saws, which can also be a benefit. Construction of vertical saws is substantially different from the horizontal machines. The arm itself must, like the horizontal saws, have enough mass and strength to allow proper blade tension, to eliminate twisting and to reduce vibrations. The requirements for supporting the arm section include the ability to tilt in both directions, and to allow the arm to move freely through the full capacity. This is best accomplished by having the guiding system integrated from the arm pivot section back to the rear support area. This gives not only a rigid (yet tiltable) arm, but keeps the guide system away from the chips and cutting fluid area.

Cutwatcher

The Cutwatcher Holds the blade in position and watches for deviation. If the blade begins to cut crooked the saw automatically shuts off. The Cutwatcher can prevent the loss of a part. Checking for damaged or dull blades prevents errors.

Cutting Fluid Control

As indicated earlier, the quality and distribution of the cutting fluid is a major factor in preventing crooked cuts. Simply squirting the cutting fluid against one side of the blade or dribbling it on the top invariably results in uneven cutting fluid distribution with the effect of dulling one side of the blade and causing crooked cuts. A more satisfactory system is one which pumps the cutting fluid into the blade guides on each side of the blade. This permits the blade to carry the cutting fluid into the cut on both sides where it can adequately fulfill its function. By injecting cutting fluid into both the leading and the following blade guide, the blade is also cooled and cleaned before and after the cut.
Blade Cleaning

Positive mechanical cleaning of the blade teeth prevents the work hardened chips from being carried into the cut on the blade’s next rotation, which would cause crooked cutting and excessive blade wear. A stationary brush quickly loses its effectiveness, while one which turns too fast will require constant replacement. The best system is one in which the brush speed is directly proportional to the blade speed, turning just rapidly enough to clean each tooth.

Blade Speed Control

The speed of the blade should be suitable to the blade design and the material being cut. If only one type of material were ever to be cut, a single speed would be adequate. However, since most saw users will use their saw to cut a wide variety of materials, an infinitely variable speed control should be included in the drive system.

Saw Arm Control

A horizontal saw arm with gravity down feed design must be very heavy. Because of this design, as indicated earlier, precise control of the feed rate and the cutting pressure is absolutely essential to maximum cutting speeds and long blade life, both of which are required for profitable cutting.

Operator Convenience and Safety

Efficient operation requires rapid set up and convenience for the operator during the cutting process. Automation of the feeding and cutting operations can provide significant savings by allowing the operator to perform other duties during repetitive cutting operations. Look for a saw with controls grouped conveniently where the operator can reach them without moving from a central control station and without endangering himself by reaching near the blade or the stock. Remember, too, that if an operator dislikes a particular piece of equipment, he will work less efficiently, have a higher reject rate and be more likely to damage the equipment.

Factors Affecting Cutting Speed

Determining Cutting Rate Based on Material Factors

1. Using C1018 as a base of 1, multiply the machinability percentage rating of the material to be cut against C1018. For example, assume you are cutting stainless steel with a machinability rating of 30 percent. Reduce the “normal” rate of 15 square inches per minute to 30 percent resulting in a cutting rate of about 4.5 square inches per minute.

2. Cutting rates in tubing are reduced by assuming twice the cutting surface area until the cut area equals that of a solid bar. Heavy wall tubing will behave much like solid stock except that blade life will be reduced by approximately 50 percent. For medium wall tubing multiply the machinability rate by about 7.5 instead of the normal 15 square inches per minute used for solid stock. For thin wall tubing use a factor approximately 3.2. Structural shapes, such as “H” beams and angles, behave like tubing.
3. Scale will reduce the cutting rates shown above and blade life by a factor of 0.3 on solid and 0.5 on tubing. Scale is very abrasive and is dragged through the cut, dulling the blade. Scaled tubing is the worst because the blade teeth have to cut through the scale twice in each cut and because there is less cutting fluid on the blade as it cuts the second side.

4. Stacked material will have voids between the pieces, making it more difficult to cut than solid bar stock. Chips may turn sideways in these voids and have to be cut again. To complicate matters, the chips are work hardened. If there is scale on the material, there will be more scale in the cut. The only saving in cutting stacked material is reduced handling time, which must more than offset lower blade life, slower cutting, and reduced accuracy to pay off.

For your reference we at HE&M have cut at rates of 105 square inches per minute in 5” diameter free machining steel. These rates have been achieved with a bi-metal blade many times, and even faster cuts can be achieved with a carbide blade. Of course these rates would not be used in the real world of production cutting, but are an example of how fast steel may be cut.

Factors Affecting Stress in a Blade While Cutting

**Blade Hangs Up**

At the start of a cut, the corners are cut first with the center of the blade riding on the center of the material. As the cut is started, the blade is bent up in the center. The center of the blade does not cut at the same rate as the edges until the forces at the center line of the blade equal the forces at the edge. If the blade hangs up at the exit, this is what causes the hang up.
As the blade begins to exit the material a hang up can occur like this.

To prevent the teeth from suddenly piercing the remaining thin metal section:

1. Reduce cutting force.
2. Increase tension.
3. Increase blade speed to a higher surface feed per minute.
4. Choose a blade with more teeth per inch.
5. Set blade at angle.
THE ABOVE CHART WAS GENERATED COMPARING ONLY WHEEL WRAP STRESS AND BLADE BENDING STRESS BETWEEN GUIDES. ALL OTHER FACTORS AFFECTING BLADE LIFE WERE HELD CONSTANT.

1. Minimum recommended wheel diameter for good blade fatigue life.

2. Recommended blade size for wheel diameter.

3. Stress in blade due to wrapping around wheel = \( \frac{ET}{D+T} \)

   \( E = \) Modulus of elasticity \( 30.35 \times 10^6 \) PSI
   \( T = \) Blade thickness
   \( D = \) Wheel diameter

   
   Average tooth spacing = \( \frac{\text{course pitch} + \text{fine pitch}}{2} \)

5. Force per tooth should always produce a surface stress at least twice the tensile strength of the cut material.

6. Total down force of the blade pushing on the material.

<table>
<thead>
<tr>
<th>1 Wheel Dia</th>
<th>2 Blade Size Thickness</th>
<th>3 Blade Wheel Wrap Stress (PSI)</th>
<th>4 Tooth Spacing (Teeth In)</th>
<th>5 Force Per Tooth</th>
<th>6 Total Force</th>
<th>7 Guide Spacing (W)</th>
<th>8 Tooth Cutting Area (IN)</th>
<th>9 Cutting Stress (PSI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>1 x .035</td>
<td>66,200</td>
<td>4-6</td>
<td>6.7#</td>
<td>200#</td>
<td>6.3&quot;</td>
<td>.000035</td>
<td>130,500</td>
</tr>
<tr>
<td>18</td>
<td>1 1/4 x .042</td>
<td>70,600</td>
<td>3-4</td>
<td>8.0#</td>
<td>290#</td>
<td>10.4&quot;</td>
<td>.000042</td>
<td>139,700</td>
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<tr>
<td>22</td>
<td>1 1/2 x .050</td>
<td>68,800</td>
<td>2-3</td>
<td>9.5#</td>
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<td>13.8&quot;</td>
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<tr>
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<td>68,100</td>
<td>2-3</td>
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<td>34</td>
<td>2 5/8 x .075</td>
<td>65,800</td>
<td>1.2 - 2.5</td>
<td>14.3#</td>
<td>760#</td>
<td>28.8&quot;</td>
<td>.000075</td>
<td>190,200</td>
</tr>
</tbody>
</table>
7. Guide spacing is the distance from the inside of the guide arm to the inside of the guide arm. Calculations were made as if the material filled the entire area between the guides.

Area = .001 in. X Blade Thickness

USING A BROKEN BLADE WORN TO .001. BROKE IN BLADE. A DULL BLADE WITH .003 FLAT WILL TAKE 3 TIMES THE TOTAL FORCE TO REMOVE THE SAME SIZE CHIP.

8. Total force = average tooth spacing x guide spacing x tooth cutting area

To cut wider material, do one or all of the following:

- Cut lower tensile strength material.
- Use a sharper blade.
- Use less teeth per/inch blade (Coarser Pitch)
- Use a sharp, positive rake tooth form.

Cutting Fluid Functions:

Cutting fluid prevents chip welding to either the blade or the parent material by chemical interface. When chips weld to the blade, the tooth form is changed resulting in cut deviation or lack of penetration. If chips weld to the parent material, the usual result is a stripped blade. Note that not all cutting fluids are suitable for all materials to be cut. Also some cutting fluids are hazardous to your health.

Cutting fluid lubricates the blade and, more importantly, the chips as they pass up into the gullets of the blade.

Cutting fluid tends to cool the blade and the material being cut by absorbing heat. Heat is always generated because “work” has occurred from the cutting action as well as from friction. Note that when wide material is being cut, the blade gets much hotter than when narrow material is cut. This happens even when both materials are cut at the same rate in square inches per minute.

Factors Affecting Blade Performance

1. Tough material can tear the teeth out of the blade because the load on each tooth can exceed the shear strength of the tooth.

2. Hard material will require heavy feed pressure per tooth for penetration. A coarse tooth blade will give better tooth performance.

3. For fragile materials such as cast iron, a fine tooth blade works best.

4. Work hardening material requires a very heavy feed pressure to prevent the blade from riding on top of the material and dulling the teeth. Again, a coarse hook tooth blade works the best.
5. Abrasive material will appear to cut easily, but will dull the blade quickly.

6. A blade which is too dull to cut tough material like stainless steel may cut mild steel satisfactorily.

7. Proper cutting fluid for the material being cut will substantially increase blade life. Incorrect cutting fluid often results in crooked cuts or damaged blades.

**Factors Affecting Machine Performance**

Inaccurate cutting and short blade life usually have simple causes. The following points need to be checked frequently:

1. There must be enough cutting fluid to cover the pump.

2. The cutting fluid lines and internal passages of the guides must be open. It is sometimes necessary to blow them out with compressed air.

3. Check the cutting pressure. Extremely high or low pressure puts unnecessary hardship on the blade.

4. Fluctuating between very fast for aluminum and very slow for stainless steel often will also reduce a blade’s working life.

5. Vibration may damage the tooth tips.
**Glossary of Terms**

**Terms Concerning Band Saws**

- **Blade Speed:** The rate of travel of the saw blade through the material; expressed in feet per minute.

- **Chip Load:** The average tooth advance into the work. It is calculated by dividing the feeding rate by the blade speed and by the number of teeth per foot.

- **Cutting Rate:** The area of the cross section of the work cut divided by the number of minutes for the cut; expressed in square inches of cutting per minute.

- **Feed Pressure:** The pressure exerted by the cutting edge of the band saw blade against the work; expressed in pounds.

- **Feed Rate:** The linear travel of the saw blade into the work; generally expressed in inches per minute.

**Terms Concerning Band Saw Blades**

- **Band Tension:** The tension on the band caused by the saw wheels being forced apart. The limiting factor is the strength of the band.

- **Beam Strength:** The resistance a band has to feeding force; i.e., the degree to which it rests bending up between the guides.

- **Camber:** The amount of negative curvature in the blade measured with the blade laid out flat. Positive Camber is when the teeth point toward the center of the curvature while Negative Camber occurs when teeth point away from the center. Either type denotes a blade quality problem.

- **Gauge:** The thickness of the back of a saw band. It is best expressed in thousandths of an inch.

- **Gullet Depth:** The distance from the tooth tip to the bottom of the gullet.

- **Lead:** The wander of the blade from a straight course.

- **Raker Set Pattern:** One unset tooth followed by two oppositely set teeth.

- **Set:** The distance from the extreme corner of the teeth bent toward one side to the extreme corner of the teeth bent to the other side of the band. Set provides clearance for the back of the band and for chips.

  The “balance of the set” is the relationship between the side clearances on one side to that on the other. An unbalanced set is a blade quality problem.
Side Clearance Angle: The angle of bend of each set tooth.

Tooth Face: The surface of the tooth on which the chip is formed as it is cut from the work.

Tooth Back: The surface of the tooth opposite the face.

Tooth Gullet: The throat within the curved area at the base of the tooth, face and back of the next tooth.

Tooth Rake Angle: The angle of the tooth face from a perpendicular line to the back edge of the band.

Tooth Spacing: The distance from the face of one tooth to the face of the next.

Tooth Pitch: The number of teeth per inch of the blade.

Twist: The tendency for a blade to spiral after use. A blade quality problem.

Tensile Strength: The amount of directly applied pull a band will stand before breaking. Usually expressed in pounds per square inch.

Wavy Set Pattern: Setting of teeth in groups, with one group to the left and the next group to the right.
Troubleshooting Checkpoints

At this time we cannot overemphasize the absolute requirement of a good cutting fluid. It is vital to blade life that the blade be cooled and lubricated properly in all cutting operations. When your saw is not providing controlled, accurate cutting, the problem can often be traced directly to the cutting fluid; either the fluid is the wrong concentration, an improper supply, or the wrong type for the kind of material being cut.

Inaccurate Cutting: Short Blade Life

1. Insufficient cutting fluid, wrong type of cutting fluid or concentration of cutting fluid allows heat to be generated at the tooth tips, reducing wear resistance. Cutting fluid should be the proper type for the material being cut.

2. If the blade is dull on one side, the blade will cut toward the sharp side: Change blades.


4. Vises not clamping securely: Adjust clamping pressure.

5. Cutting force too high or low: Adjust cutting pressure.

6. Blade speed too slow or fast for material you are cutting: Adjust blade speed.

7. Blade tension: Check blade tension with tensiometer.

8. Blade alignment: Check blade alignment.

9. Moveable guide arm: Check to see if guide is too far from material or not locked securely. Also make sure there is no dirt or chips between the blade and the carbides that would cock the blade to one side.

Rough Cutting

1. Improper blade tooth selection: Check tooth selection chart for material you are cutting.

2. Bad set up: Support work firmly.

3. Wrong cutting fluid.

Blade Stretches Excessively, Forming Cracks

1. Reduce blade tension.

2. Use a better blade.

3. Saw is out of alignment: Get machine properly realigned.
**Stripped Teeth**

1. Slow down arm feed rate; adjust feed rate control.

2. Check cutting force. It may be set too high causing too much force on the teeth and, therefore, taking too much of a chip.

3. Check cutting fluid to see if it is flowing properly and is correct for the material being cut.

4. Blade too fine; chips loading in gullet: Change to a coarser tooth blade.

5. Not enough blade speed: Increase blade speed to reduce chip load.

6. Tensile strength of material above 100,000 PSI: Use a finer pitch blade (more teeth per inch).

7. Hard spots in material: Use a blade with a harder and finer pitch.

**Chips Welding to Gullets**

1. Cutting fluid level low; improper cutting fluid for material being cut or improper concentration (should be a 5 to 1 ratio).

2. Blade brush not operating: Check it closely and replace if necessary.

3. Excessive cutting speed: Reduce cutting rate.


5. Use coarser tooth blade.
**Blade Vibration**

1. Harmonics: Change the feed and/or blade speed. Use a vari-tooth type blade.

**Blade Edge Swage**

1. Worn backup guides. Replace.

2. The cutting force is too high, exerting too much force on the blade. Reduce the cutting force.

**Blade Stalls During the Cut**

1. The arm feed rate is too fast. Use the feed rate control.

2. The arm feed is inconsistent.

3. Too much cutting force. Reduce the cutting force.

4. Chip welding, stopping the blade. Change the cutting fluid or blade tooth configuration.

5. Use a coarser tooth blade.


7. Guides are too tight.

**Material Chips**

Chips are the indicators that show how the saw is performing in the cut. Then classification of the material determines the appropriate chip appearance.
Reading the Chip

Generally speaking, the following applies:

Curled chips are what to expect in ductile materials like 1018 (Figure 1).

Also expected when using a sharp blade.

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Blue, brown, or burned chips indicate lack of coolant or incorrect feed and/or speed (Figure 2).

Also caused when using a dull blade.

---

Powdered chip of medium size in brittle material like brass or cast iron (Figure 3).

Also apparent when using a very dull blade.

---

NOTE: If there is a change in the blade appearance or the chips while cutting, examine your cutting procedures.

When a radius on the tooth becomes visible, this means the blade is dull and the chips may appear to look burned and decrease in size. As the blade dulls, the chips will change from Figure 1 to Figure 3.

A dull blade will look shiny when looking at the teeth.

---

Flats on the cutting edge.
**BUNDLE CUTTING**

Bundle cutting makes cutting more difficult because of vibration, wide guide spacing, coolant getting to the teeth, and cutting through work hardened chips.

**Solid Bars**

Solid bars clamped on 4 sides.
Solids not distorted by clamp force.
Bar “x” is slightly smaller than the rest and is not firmly clamped in the bundle.

1. Will vibrate
2. Can spin
3. Can change length position
4. Tack welding ends of bars will prevent spinning but not vibration

**Tubes**

Thin wall tubes clamped on 2 sides.
Tubes slightly distorted by clamping force.
Tube “x” is slightly smaller than the rest, but is held in place by the distortion of the larger tubes.

NOTE: Restraint bar normally used to keep tubes in bundle formation.

Moderate clamping of undersize tube.
Thin Wall Tubes Clamped on 4 Sides

Tubes are slightly distorted by clamping force. Tube “x” is slightly smaller than the rest but is held in place by the distortion of the larger tubes marked “z”. Bundle cutting increases sawing problems.

![Diagram of tubes clamped on 4 sides](image)

Thin Wall Tubes Clamped on 4 Sides with Rubber Faced Jaws

Moderate clamping force
All tubes restrained with very low distortion.
Facing helps hold bars
Rubber faced jaws work best with solid bars.

Disadvantages:

1. Rubber wears out rapidly.
2. Rubber may be torn loose during feeding.
3. Out of square cuts may result due to “elastic” vise jaws.
**Reading the Cut Surface**

**Constant Feed Variable Force**

Cut marks are evenly spaced. Slow entry at the top of the bar may dull the blade because of work hardening of rubbing on the surface scale. In round bars, the center is the danger zone. Over feeding may stall the blade or over-load the gullet, then chip welding may occur.

**Variable Feed Constant Force**

In round bars, the top and bottom are the danger zones. Too large of a chip may tear out the teeth. The gullets may fill, could shear the teeth.
Defective Blade Tooth

Vertical travel of blade during one revolution

Repeat pattern of deep gouge marks caused by defective blade tooth.

Chip Welding

Normal pattern

Blade tooth may be imbedded

Random interruptions in cut pattern which are slightly raised from main surface often appear polished.

Tooth Stripping From Chip Weld

“Welded” chip blocks cutting path of teeth and may tear the teeth out.

Teeth stripped from blade.
Coolant

**Horizontal Sawing Insufficient Coolant**

Escaping steam can keep coolant from reaching “hot spots”.

**Horizontal Sawing Coolant Delivery**

Extra coolant

Gravity assisted coolant delivery floods entire cutting area

Improve cutting
**Material Placement**

**Material Standing**

1. Less sensitive to dull blade.
2. Less heat generated due to tooth being in cut a shorter amount of time. (Producing a shorter, thicker chip)
3. More difficult to handle material.
4. Less sensitive to coolant problems.
5. More accurate cutting. (Due to guide arms being closer together)

Note: Tooth Pitch compatible to both sections. Same blade speed for both. Same cutting Rate (sq. in/min) for both.

**Material Lying Down**

1. More sensitive to dull blade.
2. More heat generated due to tooth being in cut a longer amount of time. (Producing a longer, thinner chip)
3. Easier to handle the material.
4. More sensitive to coolant problems.
5. Less accurate cutting.

NOTE: Using a blade with more positive rake lowers cutting pressure and cuts easier because the tooth is more self-feeding. The negative side is it will break easier and dull sooner.
An Example of Three Cuts with the Same Blade

1. **Guide Close to the Material.**
   Blade cut within tolerance.

2. **Guide Spacing Doubled.**
   Blade bends up in center and coolant from the guide may not reach the material.

3. **Larger Material.**
   Blade bends up in the center. Demand on the coolant is greater to prevent chip welding and to cool and lubricate the cut. The cut deviation may be 8 times more than example 1.

This example is true if the first bar size cut is 20” and the second bar size cut is 40”.

\[
y = \frac{WL^3}{48EI}
\]

L = Guide spacing and y = blade drift

First L = 20” so \(L^3 = 20 \times 20 \times 20 = 8000\)

Second L = 40” so \(L^3 = 40 \times 40 \times 40 = 64000\)

64000 is 8 times 8000 so the second cut deviation (4) is 8 times the first cuts

**WHAT CAN YOU DO**

1. Keep the guides as close as possible.
2. Break the blade in properly.
3. Cutting pressures.
4. Use a quality cutting fluid.
5. Use the blade enhancer to reduce the cutting force.
6. Let the cut watcher monitor the cut.
7. A coarser tooth blade uses less cutting force.
8. Use hook or positive tooth.
SETTING CUTTING PRESSURE

WHY ONE SETS THE CUTTING PRESSURE AND FEED RATE

1. CONSTANT SPEED - Many saws use a constant speed feed rate control to regulate the rate at which the blade travels through the material. Regardless of the variables encountered while cutting, the blade will move at a constant rate. This method either does not cut straight, or it doesn’t cut quickly. It cannot compensate for hard spots, soft spots, or a worn blade. It abuses the blade in many ways. In soft materials it tends to overfill the gullets. If the feed rate is too slow it can wear the ends of the teeth off. It provides no feedback to the saw.

CONSTANT FEED -- VARIABLE FORCE

CUT MARKS ARE EVENLY SPACED

Slow entry means light blade force, and that may dull the blade in work hardening material or in bars with hard or abrasive scale.

MAXIMUM FORCE

In the top and bottom section the saw teeth may penetrate too deeply, over-loading the saw teeth and causing them to pull out.

In round bars the center is the danger zone.

2. CONSTANT FORCE - Another method is to use a constant force between the blade and the material. This allows the saw to slowdown when hard spots or a dull blade is encountered. However, this approach does not work well when the cross sectional area is reduced during the cut. The force exerted becomes too great for thin sections.

The better the grade of cutting fluid the better the blade life.

WIDE SPACING AND FAST FEED RATE

NARROW SPACING AND SLOW FEED RATE

WIDE SPACING AND FAST FEED RATE

In the wide section the blade gullets may be over filled, stripping the saw teeth out, or the blade may stall.

In round bars the top and bottom is the danger zone
3. THE HE&M SAWING SYSTEM - The HE&M Saw System uses a dual control system to achieve a near constant cutting rate (square inches/minute) and the fastest and straightest cutting possible for all conditions. The blade provides feedback to the saw, telling the saw how to cut. To do this, the pressure that the blade exerts on the material is controlled. As the material cross section increases, the rate that the saw arm falls decreases and vice versa. The result is a constant cutting rate in square inches per minute and a much straighter cut.

4. In addition to the pressure control, the HE&M Saw System has control to regulate the maximum rate that the blade travels through the material. This control is used to regulate the rate at which the blade enters the material and also to prevent the blade from moving too fast through thin sections.

There is a relationship between cutting rate, blade wear, and cutting straight. In general the faster the cut the faster the blade wear and the less straight the cut. You will have to determine the cutting rate you wish to use based on the blade costs, the accuracy required, and the labor rates etc.

NINE FACTORS THAT AFFECT CUTTING
SETTING FEED RATE

This control is used to set the rate that the arm moves when entering material or when cutting through thin sections. When set properly it has no effect on the cutting pressure or how fast the arm will raise. When cutting solid materials, its primary function is to keep the saw from entering the cut too fast. When “in the cut” on solid material, the feed rate could be wide open. However, any setting that allows the arm to move faster through free air than it cuts through material will allow the cutting pressure to control the saw arm. If the saw is set as described, the cutting speed through a material at a particular cutting pressure can be determined.

When cutting other materials (i.e. structural shapes, tubing, etc.) the feed rate regulates how fast the saw will move through thin sections. When cutting structural shapes the feed rate valve is set so that the arm will not move so fast as to damage the blade when moving through thin sections of the material. Normally, the feed rate is first set so that the blade will not be damaged as the blade contacts the material. Then when it enters the thin section, it is reset to the desired cutting speed. It is now properly set for entering and cutting that material. It is not necessary to reset so long as the same material is being cut.

Assume that the cutting pressure has been set for cutting the full width of the material. This is the normal setting. As the blade cuts through the wide section as in position 1, everything is all right, but as the blade enters the narrow section, as in position 2, the area being cut decreases. Since the force on the blade is still the same but the area has decreased, the loading in the teeth will increase. The speed that the arm is moving will also increase. If the tooth loading and rate of travel increase too much, the teeth will be ruined. To prevent this, the feed rate sets the maximum speed by reducing the cutting force on the arm. A pressure drop across the feed rate valve is developed which then reduces the force on the arm and slows the cutting. This prevents blade damage.
When cutting high strength materials, it is very important to take the correct size chip. Therefore, the speed of entry is critical, especially when the material is round or a corner is the starting point.

For Example: In a case as described above, the first teeth entering the cut would be taking a chip too large. The tooth would be damaged, stripping the tooth out of the blade, dulling it, or fracturing the cutting edge. If this occurs the part will most likely be cut, but the number of pieces that the blade can cut will be reduced.

BUNDLE CUTTING

If you want or need to make bundle cutting, here are some guidelines to help you make it easy, reliable and fast. Remember: bundle cutting makes cutting more difficult because of vibration, wide guide spacing, coolant not getting to the teeth, and cutting through work hardened chips. Bundle Cutting Guidelines.

1. To perform bundle cutting as efficiently as possible, keep the jaws opened between 4” and 6” and set just one row of material (see figure below). If the bundle gets wider, the cutting performance may drop and the material handling time increases. The 4” - 6” dimension is a conservative number.
2. Use the hold down clamp and the hold down clamp extension to prevent the material from lifting up. These parts are supplied with your machine for both the saw vise and the feed vise. If needed you can cut or make another hold down clamp extension as required.

NOTE: THE USE OF THIS HOLD DOWN FIXTURE MAY PREVENT THE OUT OF STOCK LIMIT SWITCH FROM FUNCTIONING BECAUSE THE FEED VISE MAY CONTACT THE EXTENSION AND THINK IT IS MATERIAL. THEREFORE, THE OUT OF STOCK WILL NOT BE ACTIVATED.
CUTTING PROBLEMS:

NOTE: THE NEED TO USE A GOOD QUALITY CUTTING FLUID CANNOT BE OVEREMPHASIZED. IT IS VITAL TO THE LIFE OF THE BLADE THAT IT BE COOLED AND LUBRICATED PROPERLY DURING ALL CUTTING OPERATIONS. MORE OFTEN THAN NOT, CUTTING PROBLEMS CAN BE TRACED DIRECTLY TO THE CUTTING FLUID.

A good quality cutting fluid in a band saw is one of the most important factors in straight cutting. The cutting fluid keeps the blade teeth cool. It prevents chips from welding to the tooth as well as lubricating the chips, allowing them to move easily through the cut.

If cutting fluid is unable to cool the blade teeth, they will soften and become dull. If the cutting fluid is distributed to only one side of the blade, the opposite side will become dull. This will cause the blade to move toward the side that has the most cutting fluid and the cut will be crooked.

In selecting a cutting fluid, pick one that is of high quality. Avoid thinly mixed soluble oils. Some of the new synthetic oils are highly satisfactory in difficult operations.

CROOKED CUTS

1. Improper cutting fluid or mixture: either the wrong concentration, improper supply, or wrong type for the material being cut. To extend the life of the blade, keep it cooled and lubricated in all cutting operations.

2. Wrong guide cap adjustment. Check to see if the clamps are loose. Inspect carbide guides for buildup of metal chips or debris that may block coolant or prevent the guide caps from being properly tightened.

3. Wrong blade tension. Use tension meter to check tension.

4. Cutting force is too high. Adjust cutting pressure regulator.

NOTE: Decrease blade force by raising the cutting pressure. The higher the indicated cutting pressure, the lower the blade force.

5. Adjustable guide arm loose or too far from the material being cut.

6. Improper blade alignment.
   a. Blade riding back on wheels, knocking set out of teeth.
   b. Blade not riding against bumper block correctly.
   c. Blade not square to saw vise.
   d. Blade is dull on one side. Check that blade brush is properly adjusted. The wires should extend just through the tooth gullet.

7. Fixed vise is loose or not square to the blade. Check that there is no buildup of chips in the clamping area.
INACCURATE CUTTING --- SHORT BLADE LIFE

1. Wrong type or concentration of cutting fluid allows heat to be generated at the tooth tips, reducing wear resistance. Cutting fluid should be the proper type for the material being cut.

2. Guide Clamps Loose. NOTICE The clamps must not be over-tightened. If they are too tight they will cause excessive drag and heating of the blade.

3. Cutting pressure too high or low. Adjust cutting pressure.

4. Blade speed too slow or fast for the material being cut. Adjust blade speed.

5. Improper blade tension. Check tension with tensiometer.

   a. Blade riding back on wheels, knocking set out of teeth.
   b. Blade not riding against bumper block correctly.
   c. Blade not square to saw vise.

STRIPPED TEETH

1. Adjust arm feed rate control to slow the fall of the arm when the blade enters or exits the material.

2. Check cutting pressure. Too much blade force will cause the teeth to take a chip that is too large. Decrease blade force by increasing the indicated cutting pressure.

3. Old or improperly mixed cutting fluid. Check for proper flow of coolant through the guides. Make sure the blade guides are free of chips and debris.

4. Blade too coarse for material being cut, causing a heavy chip load. Change to a blade with finer teeth.

5. Blade too fine for material being cut, causing chips to be loaded up in the gullet. Change to a blade with coarser teeth.

6. Blade too slow, causing excessive shock as the blade enters the material. Increase blade speed to reduce chip size.

7. Tensile strength of material is above 100,000 psi. Use a blade with finer teeth.

8. Hard spots in material overloading the teeth. Sometimes increasing the cutting force (by decreasing the indicated cutting pressure) will force the teeth under the hard spots.

BLADE VIBRATION

1. Harmonics. Change the feed rate or blade speed, or use a vari-tooth blade.
ROUGH CUTTING

1. Wrong blade. Check the blade selection chart for material being cut.
2. Wrong blade speed. Check the speed chart for material being cut.
3. Old or improperly mixed cutting fluid.

CHIPS WELDING TO GULETTES

1. Check cutting fluid. Problems may be caused by low cutting fluid level, wrong cutting fluid for material being cut, or wrong concentration. Follow directions from coolant manufacturer for correct dilution rate.
2. Blade brush not adjusted properly. Check that the brush is not worn out, and that the wires sweep through the gullets.
3. Excessive feed rate, Reduce feed rate.

BLADE EDGE SWAGING

1. Worn back-up guides or bumper blockcarbide. Replace carbides if necessary.
2. Check floating guides in the guide caps. Clean if necessary.
3. Blade is running against flange on wheels, knocking set out of teeth. Check blade-tracking alignment.
4. Cutting force too high. To decrease the force on the blade, increase the indicated cutting pressure.

BLADE STALLS DURING CUT

1. Arm feed rate too fast. Use feed rate control to reduce speed of the arm as it falls.
3. Too much cutting force. To decrease the force on the blade, increase the indicated cutting pressure.
5. Chips welding to teeth, stopping blade. Change cutting fluid, reduce blade force or use a coarser tooth blade.

BLADE STRETCHES EXCESSIVELY

1. Check blade tension it may be set too high.
2. Use a better quality blade.
3. Saw is out of alignment: Get machine properly realigned.
SAW CUTTING OUT OF SQUARE

1. Improper cutting fluid or mixture. Either it’s the wrong concentration, improper supply or wrong type for the material being cut. To extend the life of the blade, keep it cooled and lubricated in all cutting operations.

2. Improper guide cap adjustment. Check to see if the clamps are loose. Inspect carbide guides for buildup of metal chips or debris that may block coolant or prevent the guide caps from being properly tightened.

3. Blade tension. Use a blade tension gauge to assure proper tension.

4. Cutting force on the blade too high. To decrease the force on the blade, increase the indicated cutting pressure.

5. Adjustable guide arm is loose. Check to see if the guide arm is too far from the material being cut. The guide arm should be as close to the material as possible.

6. Improper blade alignment.
   a. Blade riding back on wheels, knocking set out of teeth.
   b. Blade not riding against bumper block properly.
   c. Blade not square to vise.

7. Blade dull on one side. The blade will tend to cut toward the sharp side. Check for proper adjustment of the blade brush.

8. Main vise loose or out of square.

9. Bar-feed vises not aligned with saw vise, or barfeed not level with saw base. Check alignment.

10. Material distortion after cutting.