Jowitt&Rodgers Co.
quality in performance

Spring Grinding Guide

1. Introduction

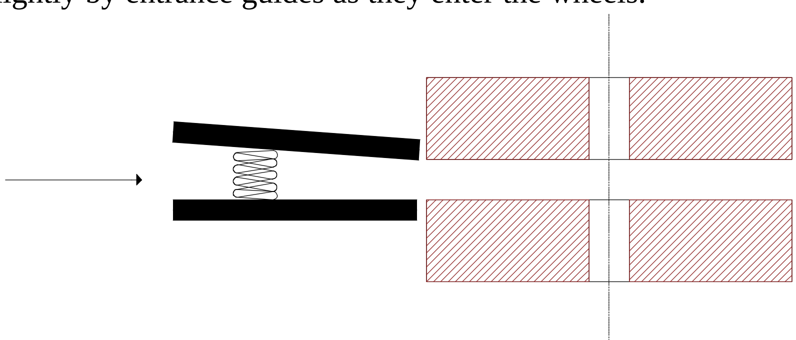
The vast majority of end coil grinding of springs is done on compression springs. Grinding is required if the spring is to stand straight, mate flush with a flat surface, exert a uniform pressure on a flat surface or maintain a more consistent length. Grinding is a relatively slow and expensive process. Therefore, it is important that it be done efficiently.

2. Machine Types

There are three basic types of grinding machines used for spring end grinding, 'crash' grinders, 'crush' grinders and single end grinders. The first two types, crash and crush, grind both ends of the spring simultaneously and are the most common.

a. Crash Grinders

Crash grinders pass the springs between two rotating disc grinding wheels on a rotating table. The grinding wheels are a fixed distance apart from each other and the springs are compressed slightly by entrance guides as they enter the wheels.



The upper grinding wheel is adjusted to have a wider gap between the wheels at the point where the spring enters the wheels. This gap is typically set to be somewhere between ¼ and ½ the wire diameter of the spring. The springs are passed only once between the grinding wheels. Machines are available in a variety of sizes, employing different diameter grinding wheels. Typically, larger machines with larger diameter wheels are used to grind larger diameter wire springs.

For springs that require two passes through the grinding wheels to remove all of the stock necessary, some machines come with two sets of heads. The springs are passed between

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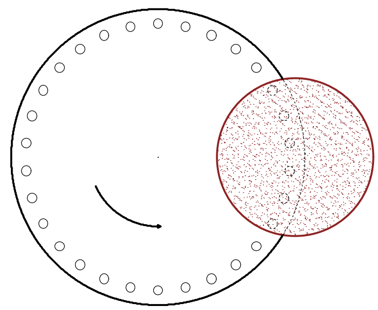
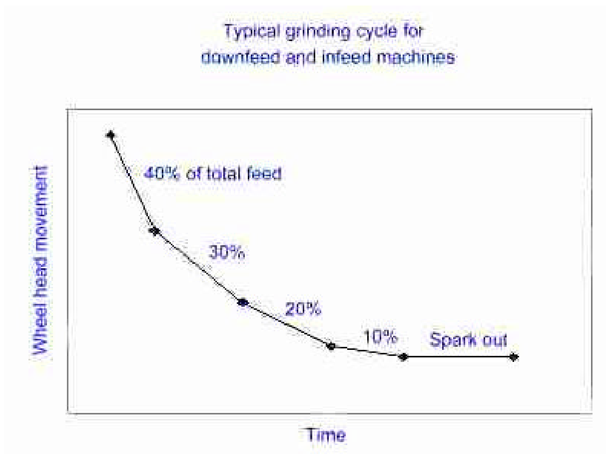
both sets of heads, the first set usually referred to as 'roughers' and the second set as 'finishers'.



The springs are feed into the machine by means of a rotary table with bushings to hold the springs. It is important that the springs are carried across the entire face of the wheel. If the grinding wheels have a center hole, the springs should break into the center by approximately ¼ of the spring diameter. If the springs do cross the entire grinding wheel face, the wheel will not wear evenly and develop a high center. This will require frequent dressing and will cause problems keeping the springs square.

b. Crush Grinders

Crush grinders, also known as downfeed grinders, look very much like crash grinders, but grind the springs differently. The grinding wheels are kept flat and parallel to each other. The springs are placed in a rotary carrier and passed between the wheels many times while the top wheel is fed down incrementally, as depicted in the graph.



The carriers for downfeed grinders typically run at a faster speed than crash grinders. The grinder will often have two carriers, one that can be loaded while the other is grinding. It is claimed that downfeed grinders can hold tighter tolerances for squareness and free length than crash grinders, but they typically sacrifice speed.

Most spring grinders are run without coolant and have vertical spindles.

c. End Grinders

At times, only a single end of the spring needs to be ground, or the spring is too large to fit between a conventional spring grinder's wheels. A single spindle end grinder is most often used in this case.

These machines typically have a horizontal spindle. The springs are clamped into a fixture that is rotated across the face of the grinding wheel.

3. Machine Evaluation

Periodic inspection of the grinders is important. The machines should be maintained in good condition to assure the quality of the grinding operation. The manuals provided by the machine manufacturers' should be the primary source of the correct operational parameters for the machines. However, the following general comments are also offered as a guide.

a. Spindle heads – Run the spindles and check for vibration or shaking motion. Listen to the spindle bearings with a stethoscope or equivalent to evaluate the integrity of the bearings. Clicking, knocking or squealing noises are an indication of problems. After shutting the spindles down, mount an indicator to the housing and take a measurement for endplay to the hub by prying on the spindle. Endplay should not exceed .002 inches.

b. Gibs and ways – The gibs and ways attach the spindle heads to the vertical column and facilitate adjusting the heads up and down. The gibs should be adjusted to eliminate movement and the slides inspected for corrosion and proper lubrication. Badly worn slides amplify vibration and make it nearly impossible to maintain a consistent head setting.

c. Feed screws – Feed screws position and adjust the spindles for set-up and compensation of wheel wear. Check the screws for corrosion and proper lubrication. Operate the hand wheels to make sure that the screw and nut operate freely. Binding would indicate a badly worn or corroded assembly.

d. Dressers – The dressing mechanisms are one of the most critical components on a spring grinder. They are often one of the most neglected components. Check that the dresser travels freely all of the way in past center and back out. Bearing surfaces and rollers should be checked for corrosion and wear. There should be no more than a couple of thousandths of an inch play at any position. The dresser cutters should rotate freely but have no vertical play. An improperly maintained dresser will not efficiently dress a wheel and be the source of frustration and frequent wheel re-dressing.

e. Feed wheel/part holders/tooling – These components need to carry the springs through the grind zone in a secure and stable fashion. Check the feed wheel to insure that it is not bent or ground too thin. Also see that it tracks concentrically through the machine. Worn spindle bearings in the carrier spindle can also adversely affect the travel. Check the part holders for wear and damage. The bore may become oversized or out of round. Check the length of the holders for the proper size. A general rule of thumb is to allow one coil exposed at each end of the holder.

f. Motors – Check the motors for vibration and noise that might indicate a bearing problem. Check the spindle RPM on each motor to insure that they are operating at the same speed. This is particularly important on older machines that may have had motor replacements.

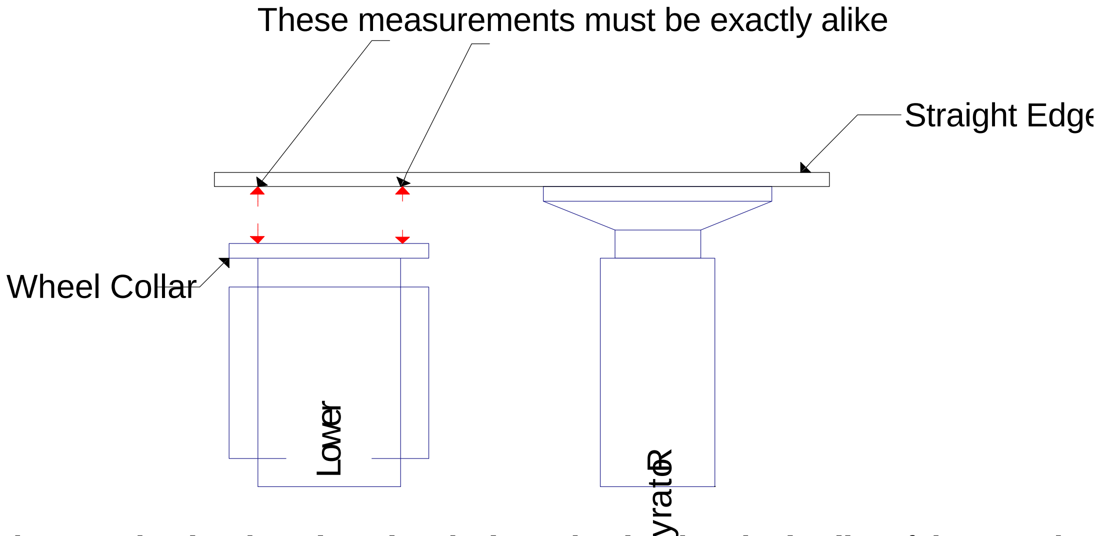
g. Cooling – Since forced air is the primary source of cooling, it is important that the correct volume and direction of airflow is maintained. Check the impellers, ducts, seals and filters for general condition and blockages.

The machine needs to be in good operational condition to be able to perform in a repeatable and consistent manner. A poorly maintained machine will be the source of many problems.

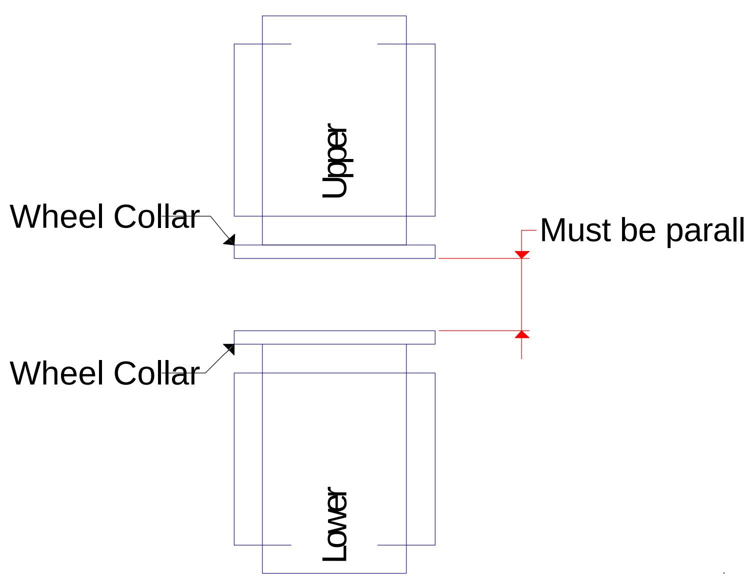
4. Grinder Alignment

Proper grinder setup is essential to be able to grind spring with any degree of precision. Good alignment of the grinding heads is necessary to be able to properly setup the machine.

On vertical spindle spring grinders, the bottom head is typically aligned first. The head is aligned to the rotary fixture of the feed wheel. Usually, the feed wheel is removed from the fixture and a straight edge (3' to 4' long and flat to with .002") is clamped to the rotary fixture. The lower head is then raised and the head is adjusted so that it is parallel to the straight edge. The wheel collar should be rotated so that measurements can be taken at several locations. All measurements should be exactly the same.



The upper head is then aligned to the lower head. The wheel collar of the upper head is aligned to the wheel collar of the lower head. This is accomplished by using a dial indicator clamped to the lower wheel collar.



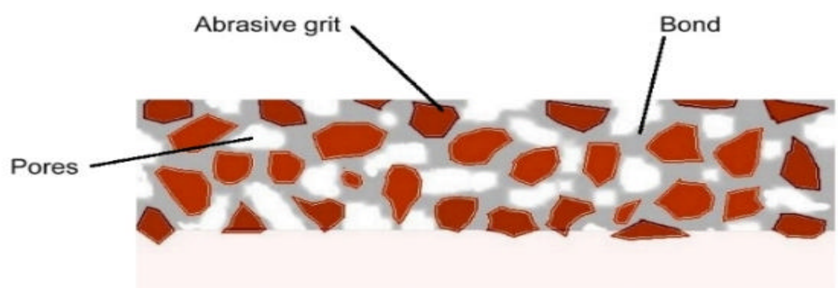
Once these steps have been accomplished, both heads should be exactly aligned to the rotary feed wheel. Now the heads can be given the appropriate settings for the springs to be ground.

5. Wheel Selection

The selection of the most appropriate grinding wheel for grinding spring ends is a task that requires an understanding of both the components of a grinding wheel and the variables in the grinding process.

Let's start with the basics of a grinding wheel. A grinding wheel is comprised of two fundamental components:

- abrasive grain (grit)
- bond



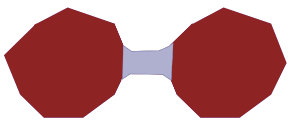
These materials are packed together to make the wheel. In the process, voids are left between the materials creating a natural porosity to the wheel.

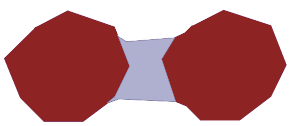
The actual composition of a grinding wheel is contained on the manufacture's label. In general, the label will use the following format:

GRAIN GRIT HARDNESS [STRUCTURE] BOND

The first marking, grain, indicates the type of abrasive grain in the wheel. The abrasive grain is the actual cutting material. The most commonly used grains for spring grinding are aluminum oxide and silicon carbide, aluminum oxide the most common. It is available in several forms and purities. Each of these has different characteristics of sharpness and durability and are often used in blends. Silicon carbide is harder and sharper than most forms of aluminum oxide, but it is more expensive and incompatible with some steels. It is most often used to cut stainless steel. The newest abrasive grain used in springs is a ceramic form of aluminum oxide (Cubitron™) that is extremely sharp and durable but expensive. Each manufacturer has their own codes to denote which grains are being used, and they can provide you with a cross reference.

The second marking, grit, refers to the size of the grain. All of these grains are available in a wide range of sizes (referred to as grit size) denoted by a number. The number corresponds to a standard sieve size. The larger the number, the smaller the grit size. The smaller the grit, the lighter the cut.


WEAK BOND POST


STRONG BOND POST

The next marking, hardness, deals with how firmly the grain is being held in the wheel by the bond. The bond forms what are called bond posts between the individual grain pieces. The size and strength of these posts are varied to modify how firmly each piece is held. Wheel hardness is graded on a letter scale, from ‘A’ to ‘Z’ with ‘A’ the weakest and ‘Z’ the strongest. This is a relative scale and the actual hardness for a single letter grade will vary from one manufacturer to another. For most spring grinding, hardnesses from ‘L’ to ‘O’ are used.

Many manufacturers identify a structure in the marking. The structure of the wheel is spacing between the grain particles. It is indicated as a number, the smaller the number the more tightly packed the grain.

The next marking deals with the bond. Bond is the ‘glue’ that holds the grain in place. There are several types of bonding materials that can be used. However, only two are common for spring grinding, resin (phenol formaldehyde) and oxychloride (magnesite). Resin is usually denoted by the letter B and magnesite by the letter O. Both of these bonds have their advantages and disadvantages.

Resin is a stronger material and is the most commonly used bond for the manufacture of abrasive discs. Most resin bonded disc wheels are safe for speeds of 6,000 to 7,000 surface feet per minute (sfpm.). It also has a short curing time (roughly eight hours) and is cured at relatively low temperatures.

Magnesite is a slow curing bond similar to concrete. Its curing time is eight to ten weeks and the bond is not as strong as resin. Therefore, magnesite wheels are typically reinforced to add strength. Magnesite wheels are usually limited to less than 6,000 sfpm. There also are limitations to the size of wheel that can be made from magnesite. The principal advantage of magnesite over resin in spring grinding is that it can withstand a higher temperature. This is important in spring grinding, as most springs are ground without the benefit of any coolant. The temperatures generated when grinding hard and heavier wire springs can cause resin bonded wheels to break down. Therefore, the magnesite will wear longer than resin in many of these cases.

Additional markings on the label are manufacturer’s markings denoting particular additives or fillers. Fillers are added for two general purposes. They can be added to aid in the bonding of the wheel and they can be used to enhance the grinding performance of the wheel.

To select the correct wheel for the spring you wish to grind, we need to know some information about the spring and the type of grinder that will be used.

The choice of grain is mostly decided by the wire material and diameter. For most steel springs, aluminum oxide is used. For finer wire, white aluminum oxide is used for its sharpness. Heavier wire demands tougher forms of aluminum oxide, many times blended with the sharper forms. Stainless steels typically demand silicon carbide, either alone or in combination with aluminum oxide. The silicon carbide will stay sharper and generate less heat, often a problem in cutting stainless steel.

The grit size of the grain is typically determined by the wire diameter. Generally, the following guidelines apply:

Wire Diameter	**Grit Size**
.010” to .025”	120 grit
.025” to .040”	60 or 80 grit
.040” to .080”	24 or 36 grit
.080” to .120”	24 grit
>.120”	16 grit

Other factors that impact on the grit size selection are the hardness of the wire, the speed of the grinding spindle, the desired finish on the spring and the speed at which they are being ground.

Hardness and structure are more difficult to predict. As a very general rule, finer wires will use harder, more closed structures than heavier gauge wires. However, wire material and machine type are also factors.

Many grinders require wheels that have different hardness zones, usually a harder zone at the O.D. and a slightly softer one near the center. This is done to keep the wheel wear more consistent across the face of the wheel so it will remain flat. This is particularly true for most ‘crash’ grinding machines that use wheels 23” in diameter and larger. Crash grinding, which is typically a single pass operation, also usually requires a harder grade wheel then downfeed grinding.

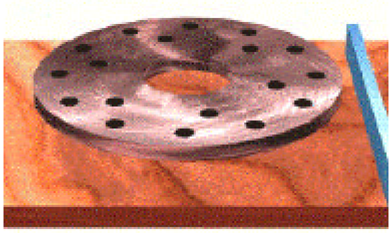
As mentioned earlier, there are two common bond types for spring grinding wheels; resin and magnesite. Most wheels for smaller diameter wire are made from resin. These springs do not normally generate the extreme heat that will break down the resin bond, so there is no performance advantage to magnesite. Most large diameter wheels, 42" and larger, are also made from resin as the masses of these wheels exceed magnesite's limitations. Many downfeed grinders are operated at spindle speeds higher than similarly sized crash grinders. Resin is normally used for these machines because of its greater strength. However, magnesite wheels are very common for grinders in sizes ranging from 23" to 36" in diameter. Grinders of this size are normally used to grind moderately heavy gauge wire and considerable heat is typically generated. Magnesite will out perform resin bonded wheels using conventional abrasives for most of these applications. However, the new ceramic grain, Cubitron™, is changing the rules. This grain cuts exceptionally cool and retains its sharpness much longer than conventional grains. Resin wheels containing Cubitron™ will out last magnesite wheels by a factor of two or better. This is particularly true in wire sizes from .080" and up and where the wire material is hard. The grain does not generate the hot temperatures that cause the resin to break down, so the higher resistance to heat of magnesite is no longer an advantage. Cubitron™ wheels are much more expensive than conventional grain wheels, but the extended life of the wheel typically justifies the higher price. However, Cubitron™ has not proved cost effective for most finer wire springs.

The selection of the proper grinding wheel is a complex equation. Most of the guidelines mentioned here are generalizations. Making the correct selection comes from experience and some trial and error. Many times, a wheel will have to be used on a wide range of springs, so compromises will have to be made.

6. **Wheel Handling and Mounting**

Grinding wheels are by nature brittle and easily cracked or broken by mishandling or rough treatment. Since they are run at high speed, care needs to be exercised while handling and mounting the wheels.

A general inspection of the wheels prior to mounting is important. Check the wheel for cracks and other damage that may have occurred during shipping and storage. If a wheel shows any signs of cracking, do not mount the wheel. Check the wheel to see if it is the proper dimension. Make sure that the O.D. of the wheel matches that of the mounting plate. Insure that the thickness does not exceed that allowed by the grinder. If there is a center hole, insure that it is concentric with the O.D. Insure that the safe operating speed marked on the wheel is not exceeded by the grinder. Check to insure that the back (mounting face) of the wheel is flat and that the nuts are not raised.



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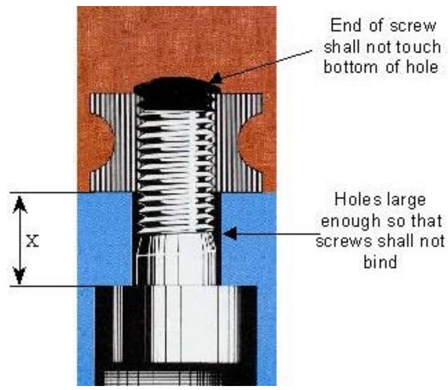
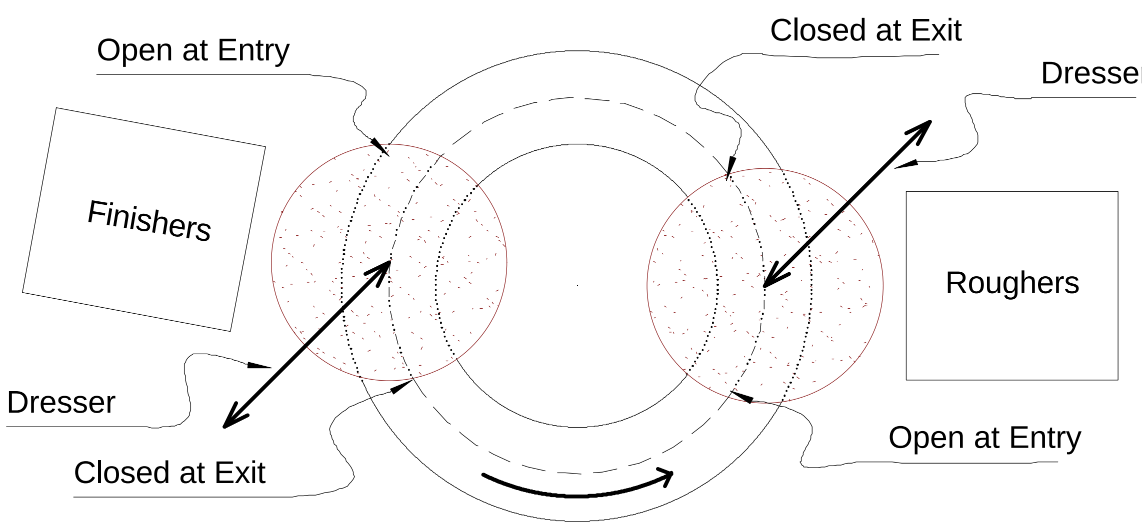
Prior to mounting the discs, check back plate. Run a straight edge across the plate to check for flatness. Insure that it is free of burrs and dirt and that the bolt holes are clean. Insure that the nut pattern in the abrasive disc matches that of the back plate.

Place grinding wheel on a flat surface and lower the mounting plate onto the wheel. Align the holes in the plate with those in the wheel and then secure the wheel to the plate with bolts of the appropriate length. It is very important that the bolts protrude deeply enough into the nuts to insure a tight grip, but do not touch the bottom of the nut hole. Most abrasive discs use 3/8 inch nuts. Bolts for these nuts should not penetrate the nut greater that 3/8 of an inch. Tighten the nuts firmly, but do not over tighten.



7. **Setup**

For downfeed grinders and lighter wire springs on crash grinders, the heads are often kept parallel to each other. For heavier wire springs on crash grinders, though, heads are normally set so that the wheels are slightly open at entrance and closed at exit so the springs are progressively ground as they pass between the wheels. A typical setting is to have the wheels set open roughly ¼ to ½ the wire diameter. Only the upper head is adjusted to set the opening. On a tandem grinder, usually ½ of the stock is removed on the first set of heads and the balance on the second set.



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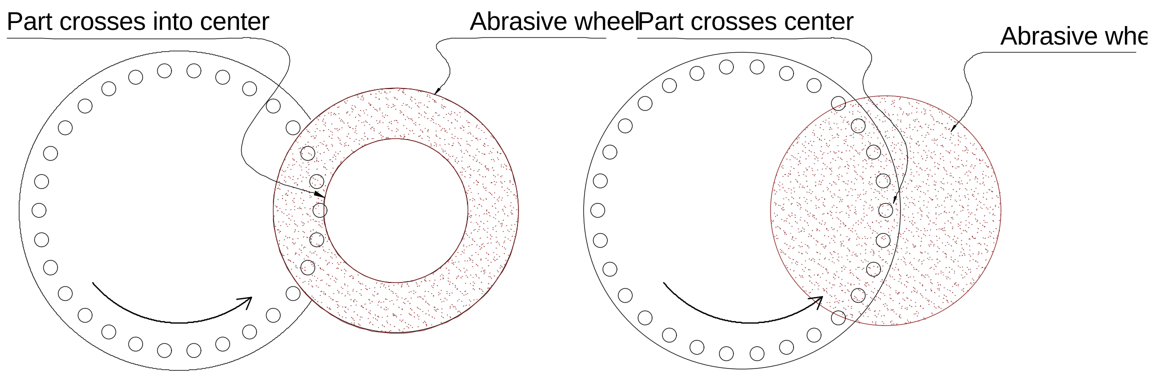
The path of the parts across the abrasives is important. First, it is important that the path crosses the entire face of the wheel. If the wheel has a center hole, then the part path should break into the center hole enough so that about ¼ diameter of the part is over the center hole. If the wheel has no center hole, then the parts should cross the center of the wheel. Taking the part across the entire wheel face will help the wheels to wear evenly and keep them flat. Often, the part path is moved behind the center on a no-hole wheel to elongate the part path to lengthen the abrasive contact.



Set up with a center hole

Set up w/o a center hole

The abrasive wheels are set so that they are equidistant from the feed wheel. The tube fixtures in the feed wheel are set to carry the springs equally exposed on both sides and they should be perpendicular to insure squareness. The springs should fit snugly in the tubes but should also be able to spin. The spinning action of the springs will help to sharpen the abrasive wheels and will prolong the dress life, as well as improve squareness of the grind. A sufficient gap is needed between the feed wheel and the abrasives to provide proper air flow. It is also important that the tube fixtures do not contact the abrasives. The tubes rubbing on the abrasives will produce a glaze on the abrasives and then create a burn on the springs.

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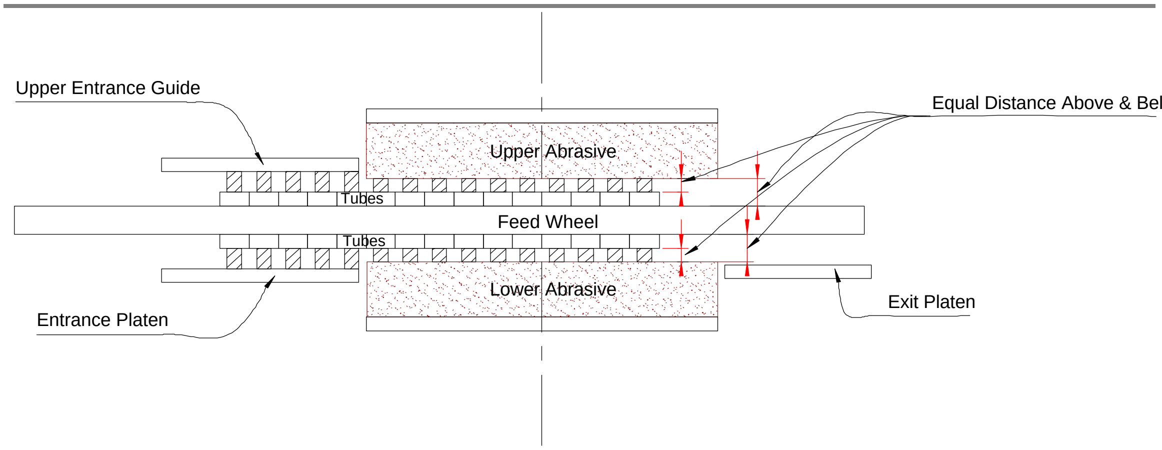

Airflow around the wheels helps to remove the dust and ground metal as well as provide cooling. It is important that there is sufficient airflow to accomplish all of these functions. Often, there may be enough exhaust air to keep the grinding area clean, but not enough to reduce the heat. The total volume of cooling air necessary can be estimated using the relations:

- ½ BTU is needed to raise 1 cu. ft. of air 30°F. and
- 1HP will add 42½ BTU/min. to the system.

Therefore, assuming that the cooling air will increase 30°F. during the operation, approximately 85 cu. ft. of air per minute is needed for each horsepower used by the grinder.

8. **Summary**

Spring grinding encompasses many different variables. In order to maximize the efficiency of the operation, all of the variables must be considered and accounted for:

- Spring material
- Spring dimensions
- Spring specifications
- Grinder type
- Grinder condition
- Coolant/exhaust air flow
- Abrasive

In many cases, there may be little that the spring manufacturer can do to adjust or optimize to some or many of the items on this list. Therefore, compromises will have to be made to at least get to a point that will result in the most efficient operation possible within the limitations. It also needs to be recognized that the status of many of these variables are not static, such as machine condition, and changes will have to be made over time to compensate for the variations.

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