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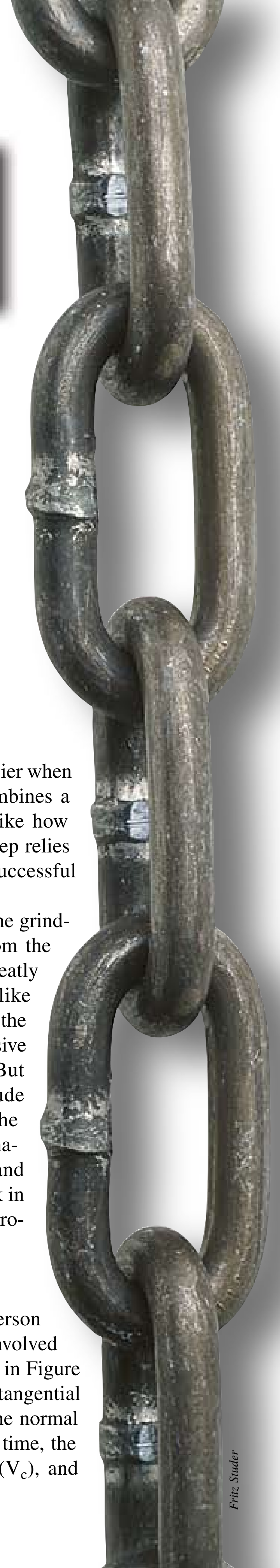
➤ BY JOHN RICHARD, FRITZ STUDER AG

Grind Right



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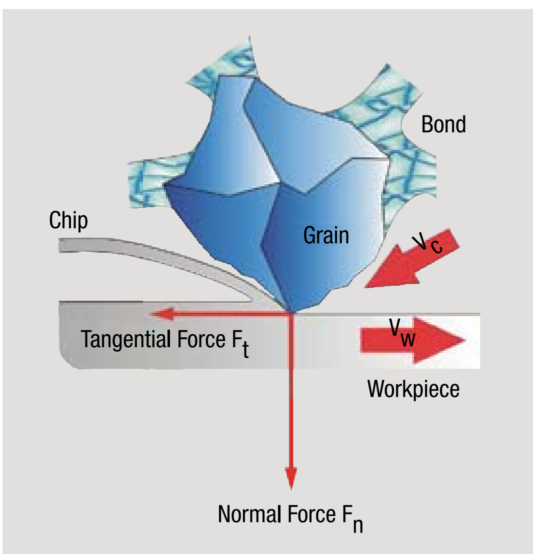
Once a grinding error is detected, machine shop personnel need to know how to troubleshoot the problem to minimize scrap and unproductive machining time.

The need to correct grinding errors is one of the most common, yet least understood, tasks in the metalworking industry. The results of an error are sometimes easily visible, such as chatter marks or those annoying comma shapes on a workpiece, sometimes called pickup marks. Others, like a slight out-of-roundness error, may be harder to detect.



Winterthur

Figure 1: Understanding the forces in the grinding process is key to understanding how to fix grinding problems.

Fixing any error, however, is easier when you understand that grinding combines a number of subprocesses, much like how a chain is linked together. Each step relies on the steps adjoining it for a successful outcome.

Grinding uses the abrasive on the grinding wheel to remove material from the workpiece, so wheel selection greatly influences the process. Factors like the abrasive, the bond holding it to the wheel and the density of the abrasive all affect the grinding process. But the process chain can also include the coolant, the dressing tool, the workpiece material, the grinding machine, the grinding parameters and the workholding. The weakest link in the process sets the limit of the process capability.

Grinding Forces

To fix grinding problems, a person must first understand the forces involved in the grinding process. As shown in Figure 1, chip removal involves both a tangential force as the wheel cuts (F_t) and the normal downward force (F_n) At the same time, the wheel rotation is exerting force (V_c), and the workpiece is creating a force as it moves along an axis (V_w). These forces and the links in the grinding process can lead to geometric grinding errors, such as dimensional or positional deviations, and physical or chemical errors, such as unwanted changes in the material characteristics of the workpiece's surface.

These errors should lead an operator to examine the grinding process to determine their sources. An operator should ask: Do the feeds or speeds need to be adjusted? Was the correct grinding wheel chosen? Was it dressed correctly? Is the coolant clean? Is the grinding machine set up correctly for the workpiece?

To answer some of these questions, look at the workpiece. Its ground surface texture should be consistent with a silky gloss. Marks, commas or scratches should not be visible.

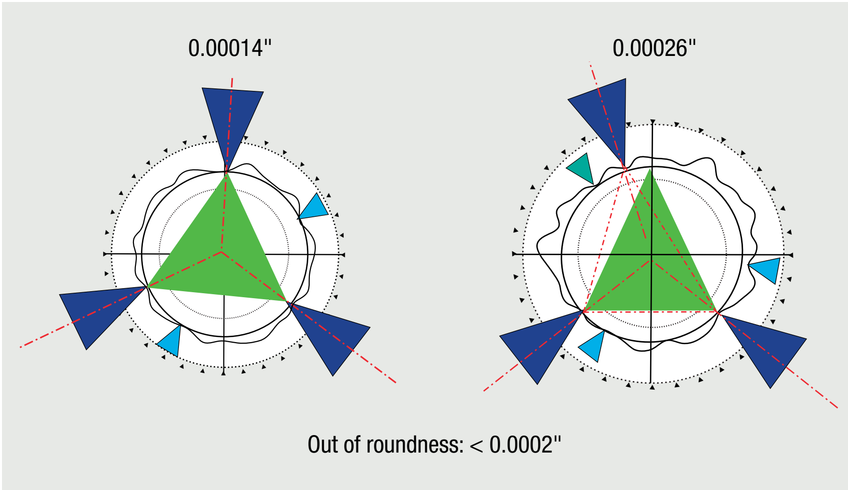


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Figure 2: Concentric distribution of the deviations improves the success rate of grinding.

Physical and Chemical

Reference the table (page 72) to help diagnose the most common grinding errors. In many cases, there can be more than one cause, so it may be necessary to check multiple scenarios to fix the problem.

Roundness or concentricity issues take more analysis and patience. The easy way is to say the machine builder created a lemon or call maintenance personnel and blame them for not maintaining the machine properly.

The honest way is to check the workpiece centers for nicks, burrs, dirt and premachining accuracy. The ideal center is within 0.0002" roundness, is not oval and has no burrs or nicks. It

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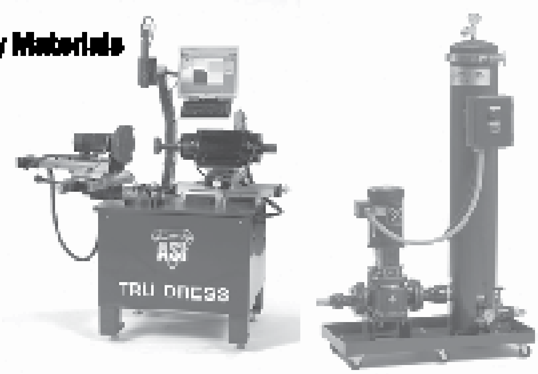


has an odd number of support points (Figure 2). Small deviations are acceptable if they are within tolerances and concentrically distributed.

The most apparent problems are when the deviations become unbalanced and the round becomes an oval (Figure 3). Such problems can occur if the workpiece moves in the workhead or tailstock centers when the grinding wheel is touching it. Cleaning the center with a center-hole sharpening wheel can sometimes be the answer to this problem. However, deviations or out-of-roundness errors may be so large that some workpieces can't be salvaged and must be scrapped.

Achieving workpiece straightness is a second geometric challenge. One unwanted outcome is a larger diameter in the middle of the workpiece than on the ends (Figure 4). Possible causes include:

- Bending forces during the grinding process,
- Incorrect infeed,
- Incorrect wheel overlapping,
- Too much coolant pressure on the workpiece (especially when working with thin parts),
- Tailstock or workhead misalignment, or
- Dressing issues, such as when the wheel isn't sharp and requires too much grinding force.

Bending forces can be overcome during grinding by using a steady rest. As a rule of thumb, use a steady rest if the workpiece is 10 times longer that its smallest diameter. Mount the steady

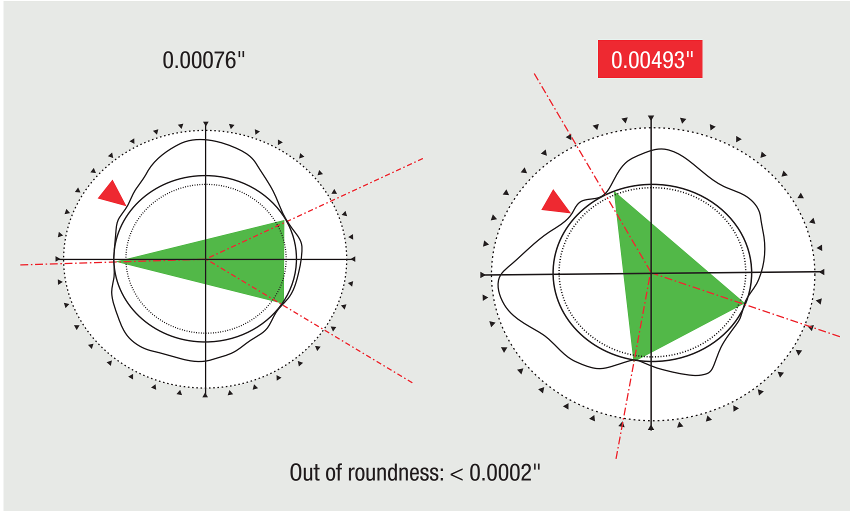
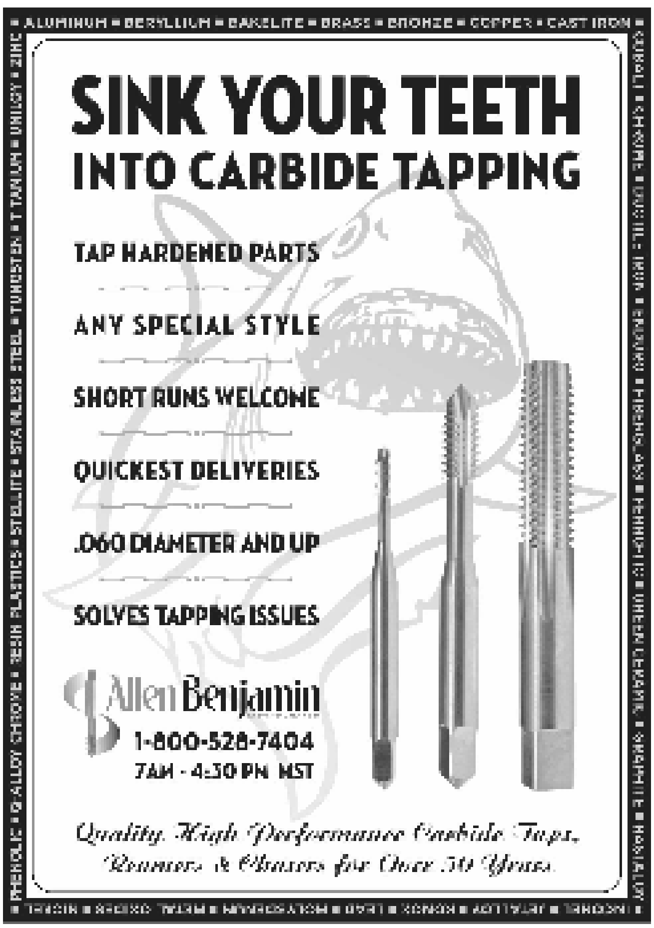


Figure 3: The unbalanced spread of the irregular centers may allow the workpiece to move in the workhead or tailstock centers during grinding.



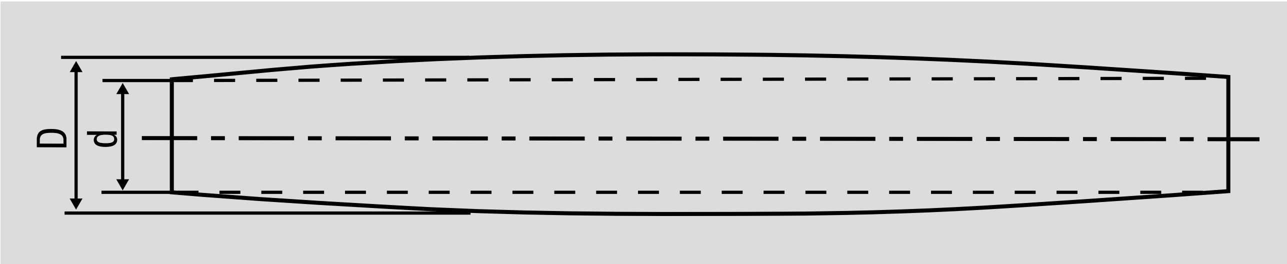


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Figure 4: Workpiece after grinding without a steady rest shows a larger diameter in the middle than on the ends.

rest on the smallest diameter. This rule can also be applied to determine if multiple steady rests are needed.

Infeed and wheel overlap create straightness issues when the wheel wears from traversing the workpiece. To fix this error when working on a single-diameter workpiece, plunge from the workpiece's two ends and traverse in both directions. To grind multiple diameters on a workpiece, always plunge the wheel on the larger diameter's shoulder and traverse out to the workpiece's end, which help ensure straightness and alignment of the two diameters. Make sure to overtravel a minimum of a third of the wheel width to help relieve the grinding pressure.

In many cases, a grinding error has more than one cause, so it would be necessary to check multiple scenarios to fix the problem.

Also, the spark-out time on the workpiece's ends may need to be changed, as well as the traverse speed. The wheel and workpiece speed may need to be changed, too. Finally, the dressing speed may need to be increased to ensure a sharp, open wheel. An operator may use a slow dressing speed thinking that it will create a fine wheel, but a speed that's too slow tends to close the wheel. A faster dressing speed can help open the wheel and make it sharp so it cuts properly and imparts a fine surface finish with correct geometrical values.

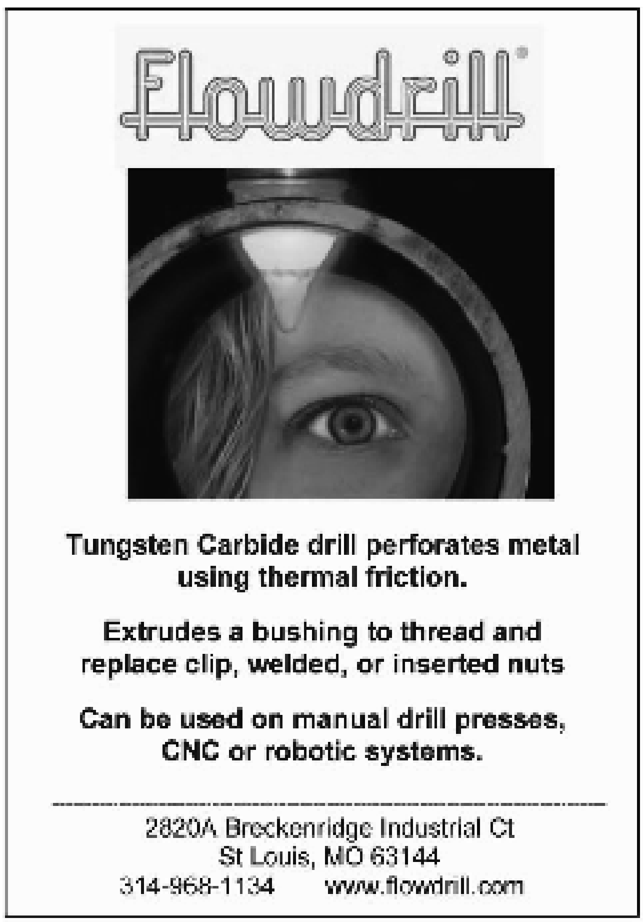
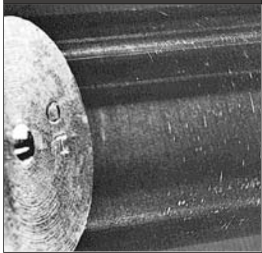
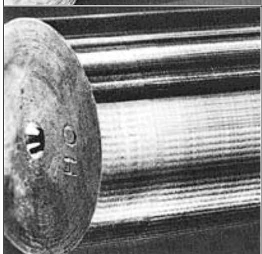
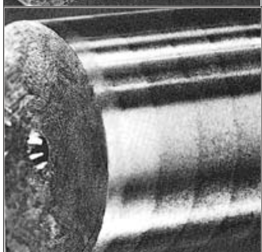
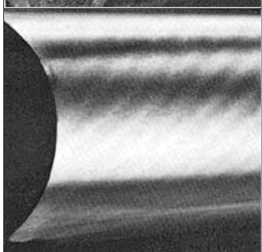
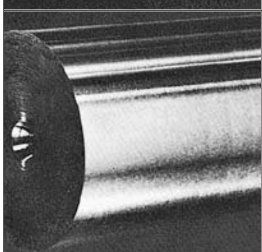
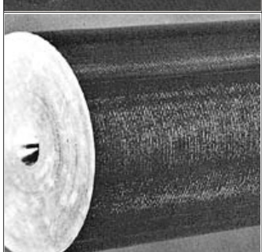
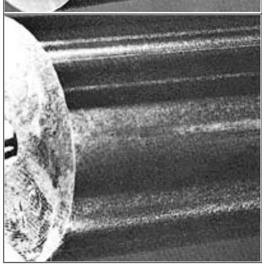


Table: Examples of grinding errors, their possible causes and their solutions.

Illustration	Visible grinding error	Possible cause(s)	Remedies
	Surface shows irregular, short "comma" scratches.	Abrasive grains in the coolant.	1) Check coolant filter, change if needed. 2) Clean wheel guard. 3) Clean the machine.
	Surface shows chatter marks that are distributed over the entire circumference and lie parallel to the workpiece axis.	1) Wheel not properly balanced. 2) Vibrations from an outside source. 3) Q_S (wheel-to-workpiece speed ratio) too low.	1) Never let coolant run onto a standing wheel (rebalance the wheel). 2) Use a steady rest. 3) Ensure machine is not next to a vibration source. 4) Check the Q_S ratio (wheel-to-workpiece speed ratio).
	Burning marks: Helical marks or local yellowish/brownish discoloration of the surface.	1) Overheating in the grinding process. 2) Insufficient coolant supply. 3) Wheel too finely dressed. 4) Wheel too hard.	1) Increase dressing feed speeds. 2) Check the Q_S ratio (wheel-to-workpiece speed ratio) 3) Increase coolant supply; use coolant with higher mineral oil percentage. 4) Use a softer grinding wheel. 5) Reduce material-removal rate.
	Grinding with angular marks.	A grinding wheel has been dressed too fast and transfers the error onto the part.	1) Reduce wheel dressing speed. 2) Always dress the wheel from one direction.
	Grinding with feed marks: The centerline of the grinding wheel is not parallel to the table.	Can be caused by a shifting dressing tool, thermal influence or wear during the dressing cycle.	1) Check dressing tool. 2) Check coolant. 3) Replace dressing tool if necessary.
	Mirrorlike gloss on the surface, original premachining surface finish still visible.	Grinding wheel too fine or dressed with dull dressing tool.	1) Increase dressing feed speed. 2) Replace the dressing tool.
	Grinding with source interference: Surface shows marks parallel to the workpiece axis that are on part or all of the workpiece circumference.	1) External influences, such as a forklift driving by or a punch press near the machine. 2) A ventilator fan or centrifuge may also be a cause; if so, the bevels will be spread over the entire workpiece.	1) Eliminate the interference. 2) Isolate the interference.

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Coolant Is Critical

Coolant plays a large part in proper grinding, and the wrong coolant or improper coolant application can cause various problems. With diamond wheels, always use coolant during dressing to increase diamond life and ensure proper wheel truing. Also, ensure an adequate coolant flow into the grinding zone because insufficient or incorrect coolant flow destroys the workpiece surface and increases wheel wear.

One sign of insufficient coolant is the presence of sparks. There shouldn't be any! Proper spark quenching may require additional coolant from beneath the workpiece or increased coolant pressure. The rules of thumb are:

- Use approximately 1 gpm of emulsion per 1 hp of spindle power.
- Use a flow of 6.5 to 20 gpm of emulsion per 1" of wheel width.
- Pump pressure should be at least 14.5 psi. (Normal is about 70 psi.)
- The oil's thermal conductivity is half that of the emulsion (4.2 joules/° K vs. 1.9 joules/° K), therefore the amount of oil should be doubled to dissipate the heat.

Grinding is an art that's perfected as a person gains experience. As this article shows, the process' components are linked, and each has an affect on the others. As with analyzing any other process, keep it simple. Begin with the obvious and proceed from there.

Editor's Note: This article first appeared in the summer 2007 issue of Grinding Journal*, published by United Grinding, Miamisburg, Ohio.* △

Keywords

tailstock:
A movable fixture mounted on a lathe or other machine tool used to support the free end of a workpiece.

workhead:
Also known as headstock. A machine tool component used to drive a workpiece, often by rotating it with a spindle.

—CTE Metalworking Glossary

About the Author

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