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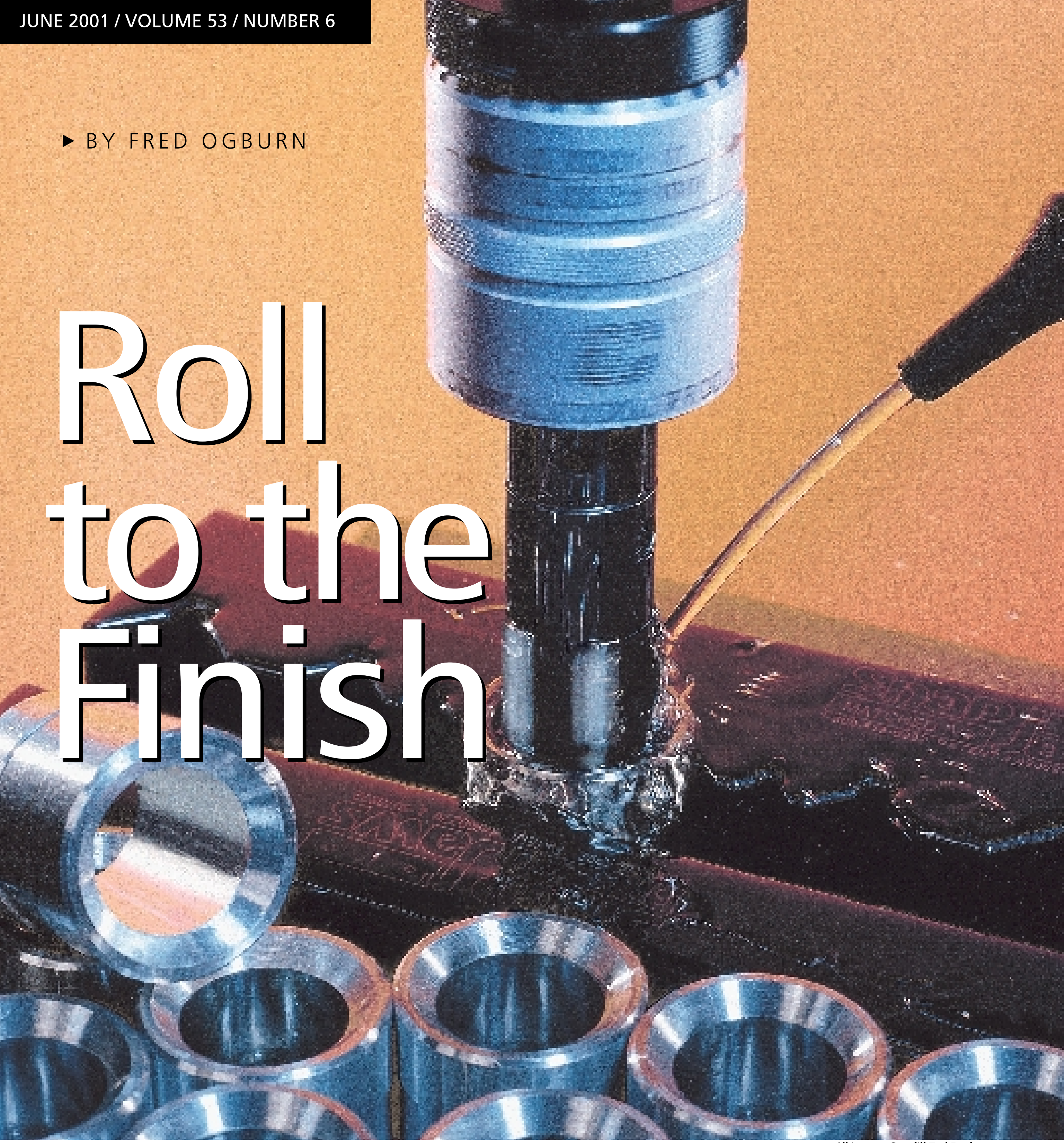
Roll to the Finish



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Although the concept of burnishing parts with rollers originated in Germany in the 1920s, it wasn't until the 1930s that the process was introduced in the U.S. The first applications of the new process were to improve the wear resistance of railroad car axles and rotating machinery shafts.

By the 1960s, roller burnishing had gained wider acceptance within manufacturing—particularly in the automotive industry—as additional process advantages were recognized. These include the ability to hold tolerances within 0.0005", typically impart surface finishes between 1µin. and 10µin. R_a, and boost surface hardness by 5 to 10 percent, or more.

Burnishing was also found to be a versatile process, since only one working spindle is needed to do the job. And because a burnishing tool can be operated on any rotating spindle, burnishing can often eliminate more costly secondary operations, such as grinding, honing or lapping.

In addition to imparting a consistent

Roller burnishing offers advantages over abrasive finishing processes.

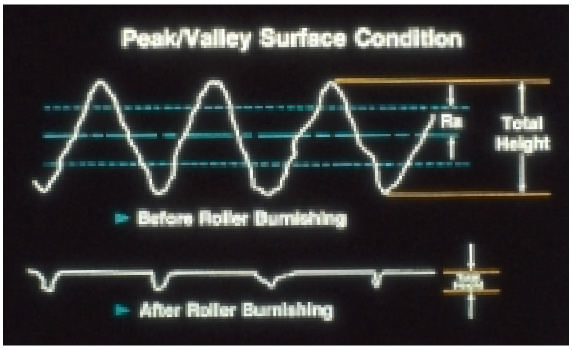

Figure 1: A comparison of a workpiece surface's peaks and valleys before and after roller burnishing.

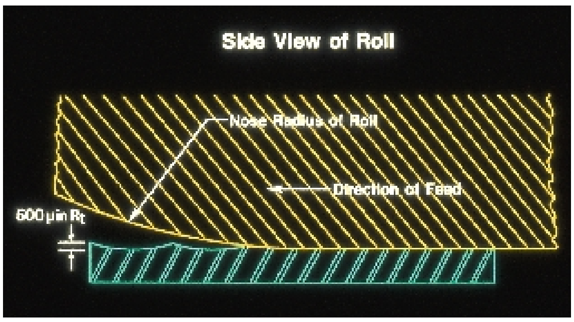

Figure 2: The radius on the burnishing roller presses down on the peaks of a workpiece surface and causes the material to cold-flow, thereby flattening the microscopic peaks into the valleys of the workpiece surface.

surface finish, burnishing can also sharply reduce cycle time compared to abrasive finishing processes. A 2"-long, 1½"-dia. surface on a torque converter can be burnished to a 5µin. R_a finish in 3 to 5 seconds. And since metal is displaced rather than removed, the process is cleaner than honing or other abrasive finishing methods.

What is Roller Burnishing?

Roller burnishing is a surface-finishing technique in which hardened, highly polished steel rollers are brought into pressure-contact with a softer workpiece. The tool incorporates a planetary system of tapered rolls that are evenly spaced by a retaining cage. When the tool engages the workpiece, a hardened mandrel, which is tapered inversely to the taper of the rolls, forces them against the surface of the workpiece.

As the pressure exerted exceeds the yield point of the workpiece material, the surface is plastically deformed by the cold flowing of subsurface material. This results in a very smooth, densely compacted surface with superior load-bearing characteristics.

When identical workpieces made of the same material are roller-burnished and abraded, a profilometer shows that the burnished surface is smoother and more wear-resistant than the abraded one. (A profilometer measures roughness height on workpiece surfaces at a microscopic level.)

The reason for this is that while an abrasive finishing process lowers the overall roughness height, it also leaves sharp projections in the contact plane of the machined surface.

Roller burnishing, on the other hand, displaces metal rather than removes it. Microscopic "peaks" on the workpiece surface cold-flow into the "valleys," creating a flattened profile in which sharp projections are reduced or eliminated (Figure 1).

A common misconception about roller burnishing is that the peaks on the machined surface are somehow "bent" or "folded over" into the valleys. Such an action would create occlusions or seams in the subsurface material, which could lead to stress fractures. The misconception probably stems from the way a profilometer readout represents the workpiece surface. The vertical gain on a profilometer reading is typically set at many times the horizontal gain, which exaggerates the peak/valley condition of the machined surface.

Rather than high, sharp peaks being folded over into the valleys, what actually occurs during burnishing is that the radius on the roller presses down upon the peaks and causes the material to cold-flow, thereby raising the valleys and lowering the peaks (Figure 2). There is no bending or folding over of the peaks into the valleys. The result is a smooth contact plane that provides a larger supporting area for a mating part than would be possible if the surface were abraded.

Preparing the Part

Roller burnishing is used to size, finish and/or workharden automotive and heavy-equipment components, including piston and connecting rod bores, transmission parts, torque converter hubs and brake system components.

Burnishing tools are also applied in nonautomotive applications to provide better and longer-lasting seal surfaces, reduce friction, improve wear life and enhance the cosmetic appearance of parts. Examples of these parts include valves, pump shafts, pistons for hydraulic or pneumatic cylinders, bearing bores, shafts running in bushings and plumbing fixtures.

Parts must be prepared carefully to maximize the finishing capabilities of the burnishing tool. Because metal isn't removed, a consistent, tear-free surface is critical for the peaks to flow uniformly into the valleys under roll pressure. Ideal applications for burnishing are bored or turned surfaces with a finish of 80µin. to 120µin. R_a (2µm to 3µm R_a).

This leads us to another common misconception about roller burnishing. One might assume that the smoother the preburnished surface, the better the resulting finish. In fact, a relatively rough, but uniform and tear-free, surface allows the burnishing tool to displace a greater amount of workpiece material, thereby enhancing the sizing capability of the tool. It also allows the prefinished tolerance to be much greater than the tolerance of a smoother prefinished surface.

Parts can be sized, finished and workhardened in one fast pass of the burnishing tool, provided proper attention is given to part preparation and tool adjustment.

Since the metal must be capable of cold flowing under roll pressure, hardness normally should not exceed 40 HRC, although somewhat harder materials have been successfully burnished. Generally, burnishing can increase surface hardness by 5 to 10 percent, with a surface penetration of 0.010" to 0.030".

Tool Designs

Standard tools are available to burnish IDs and ODs, and specialty tools are available for burnishing virtually any part configuration, including faces, internal and external tapers, contours, spheres and fillets.

The most common styles are rotary tools for finishing IDs or ODs. They have multiple, caged rollers that rotate and are in contact with a mandrel or race. Generally, each tool is intended for a specific hole or shaft size. These tools are adjustable, typically over a range of 0.040" for a given nominal size. Adjustments are made in 0.0001" increments by changing the position of the tapered rollers in relation to the inversely tapered mandrel so as to alter the effective tool diameter.

Special tool designs for burnishing flat surfaces or tapers feature rollers mounted parallel with, or at an angle to, the part surface.

Some designs incorporate a single roll so the tool can be more universally applied to burnish shafts, faces, tapers, contours or large IDs. Yet another burnishing tool design dispenses with the roller altogether. A replaceable, polished diamond insert mounted on a turning holder imparts a low-microinch surface finish on shafts or faces of any diameter.

A final tool combines roller burnishing with peening. Known as a "bearingizer," the rolls on the tool spin, rise and fall over a cam-equipped arbor delivering rapid-fire blows to the work surface. This action results in improved hole geometry in certain applications, extremely smooth surface finishes and an enhanced workhardening effect. A bearingizing tool is generally applied only to parts with thin walls or walls of varying thicknesses, or where very tight tolerances or ultrafine surface finishes are desired.

In almost all cases, speeds and feeds are not critical to the success of a roller burnishing operation. With regard to the proper coolant and lubricant, it is acceptable to use any standard grade, lightweight, low-viscosity lubricating oil, or any mineral, sulfur or soluble oil that's compatible with the metal to be burnished.

However, a mineral seal oil is ideal for burnishing cast iron. When burnish-

Attainable Results From Roller Burnishing

Material	Finish Range (Microinch Ra)
Cast Iron	10-15
Steel, Stainless Steel	4-8
Bronze, Aluminum	2-8

Table 1: Any ductile or malleable metal can be burnished. This table lists the resulting finishes that can be expected from burnishing different material types.

Roller Burnishing Troubleshooting Guide

Problem	Possible Cause	Solution
FINISH Scratches	Foreign material on workpiece surface Worn rolls	Clean and filter coolant Inspect rolls Replace if discolored or marred
Flaking	Too much interference Too much friction	Adjust tool to be smaller More lubricity needed in coolant
Spiral marks Residual tool marks	Premachining too smooth or not uniform	Replace or sharpen radius cutting tool Increase feed of cutting tool
	Not enough burnishing pressure	Increase tool diameter, support part wall if thin or consider bearingizer tool
	Roll stuck or foreign matter stuck in pocket Roll paths not overlapping Chips left in bore	Inspect and clean cage Replace cage if necessary Decrease feed rate Flush prior to burnishing
SIZE Too small or too large after burnishing	Incorrect stock allowance	Adjust cutting tool and burnishing tool
Bellmouth or taper	Premachining problem Misalignment Tool runout	Check before burnishing Correct or use floating toolholder Check mandrel with indicator, and repair or replace mandrel
	Part has thin wall, irregular geometry or no support	Support by fixturing or consider bearingizing tool
MISC. Rolls hit on entry	Misalignment	Correct alignment Chamfer part if possible
	Too much roll projection	Retain with O-ring if a short bore, use smaller cage or select tool with your part size on the higher end of the adjustment range
Can't burnish entire length of bore	Tool too short	Use R-style or consider special tool
	Mandrel hits bottom of bore or fixture	Grind mandrel tip off, use larger tool size or consider special tool

ing aluminum or magnesium alloys, a highly refined, low-viscosity, oil-based coolant is recommended. Regardless of the specific type of coolant used, adequate coolant filtration must be maintained so that metal particles or grit are not rolled into the part surface.

Economics of Burnishing

Roller burnishing is often viewed as an unusual or exotic process—an additional machining step to be considered as a last resort when ultrafine finishes cannot be obtained by conventional methods. In reality, though, roller burnishing is an effective and economical process that can be justified in terms of time and cost savings, as well as product improvement.

Burnishing is faster and, as a chipless finishing process, cleaner than abrasive finishing methods. And, finally, burnishing tools are more versatile in that they can be run on any spindle.

Roller burnishing tools come in many different styles, including (from top left moving clockwise): diamond insert; external; flat surface; internal taper; boring bar, single-roll style; indexable turning holder, single-roll style; and internal.

About the Author

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