By Dr. LaRoux K. Gillespie

Drag Race

It's kind of a drag when high-value parts knock into each other during finishing. Drag finishing prevents that and is also a lot faster than most other mass finishing processes.

Walther Trowal

A four-spindle M-TMD 4/1 mini drag machine from Walther Trowal. In this application, four parts are mounted on each of two spindles. Plastic abrasive media is being used in this wet process.

Traditional parts finishing usually involves tumbling or vibrating processes, but for expensive parts that cannot contact each other during the finishing process, drag finishing is a good alternative. Drag finishing—where parts are fixtured and dragged through abrasive media—is also an economical alternative to hand finishing. It's 10 to 40 times faster than some vibratory finishing processes and can be used as an edge preparation process for cutting tools (see sidebar on page 76).

Around the Track

Drag finishing—also known as flow or racetrack finishing—involves dragging parts through a bed of loose abrasive media combined with an abrasive or polishing compound. The abrasive compound adds more cutting ability to remove heavy flash or surface stock, rounds edges and removes burrs. Polishing compounds put the final finish or luster on the parts. Some compounds add lubricity to the mass, which helps suspend abraded particles and clean the media abrading surfaces.

Parts can be fixtured in groups or done singly. The motion through the media can be a straight line or can follow an oval "racetrack" system or a planetary motion. The abrasive media and compound rub against the part and its edges, as in other loose abrasive processes. The action is much like using a plow in the earth. The process can be run dry or wet with water and surfactants. The wet process provides a physical means to flush particles out of the processing mass.

Drag finishing can be used for large parts, such as castings and aluminum forgings, because it eliminates the possibility of impingement, and is not typically used for small parts. The process has comparatively higher labor costs than other finishing processes because parts must be fixtured. Also, drag finishing is a batch process, so it cannot be run continuously. Like all mass finishing operations, drag finishing

Drag Race *(continued)*

impregnates material into the part surface.

Many drag finishing machines use a rotating turret that also rotates spindles under the turret. There are two variations on this process. In the first, parts are placed on a nonrotating fixture and dragged through the media or the media is rotated past the parts. In the second, parts are placed on spindles that rotate while being dragged through the media or that rotate in a fixed tub of media.

Walther Trowal

A four-spindle M-TMD 4/1 machine. In this application, four scroll castings are mounted on the spindles and poised over abrasive ceramic media (wet process) composed of small angle-cut triangles.

Drag finishing media is similar to that used in other mass finishing processes. However, while over 4,000 media are used in vibratory processes, only 20 percent of those can be used in drag finishing due to the heavy weight and complex shapes of parts that are typically drag finished. Usually, bigger parts require bigger media. Mass finishing processes can use media larger than 1" in diameter, but more commonly they use shapes 3/16" in diameter and smaller. The loose abrasive grit comes in sizes of No. 00 to No. 24. A No. 00 size is roughly 2" in diameter and a No. 24 size is roughly 0.028" in diameter.

Three Applications

There are three distinct drag finishing applications:

- Heavy stock removal for loose-tolerance applications,
- Precision finishing to tight edge tolerances and fine finishes, and
- Jewelry polishing.

A typical drag finishing machine consists of a rubber-lined, annular steel bowl filled with loose abrasive media. Above the annular bowl is a turret that holds the fixtures for the parts. The fixtures rotate under power and can be raised and lowered relative to the media bowl (see photo on page 78).

Parts are loaded into the fixtures, which are attached to vertical shafts while the turret is in its raised position. The machine is then energized, the spindles begin rotating and the parts are lowered into the annular media bowl. When the parts are sufficiently immersed in the media, the lowering motion is stopped but the rotation of the spindles continues

Drag Race *(continued)*

until the parts are finished. The entire turret assembly is then raised, withdrawing the parts from the media.

While single spindles are available on some drag finishing machines, most machines have two, four or six spindles on each head. Multiple heads are possible but not typical. Some of the larger machines move spindle assemblies over two different tubs of media to provide rapid cutting action in the first tub followed by fine finishing in the second. The spindles' rotating speed is variable, and some machines rotate the spindle assembly as well, so it is possible to optimize the process—on a repeatable basis—for specific parts. Higher rotational speeds produce not only higher relative speeds between the media and workpiece, but also significantly higher media pressures as well, yielding impressive efficiencies as speeds are increased.

Drag finishing makes it possible to process even delicate workpieces until they are ready for plating, which improves appearance and protects against corrosion. Some of the

Fine finish for endmills

IN ADDITION TO PARTS finishing, drag finishing is being successfully used as an edge preparation process for cutting tools, such as endmills. The process can extend tool life by improving chip flow and reducing friction, according to Ken Raby, national sales manager for Walther Trowal, Grand Rapids, Mich. Walther Trowal is the U.S. division of Walther Trowal GmbH, Haan, Germany, a manufacturer of mass finishing equipment.

The Walther Trowal M-TMD 4/1 four-spindle drag finishing machine can provide four endmills with the desired cutting edge hone (radius) and flute polish in a 4-minute cycle, with 30 seconds of this cycle for loading the tools in the spindle fixtures and a process run time of 3.5 minutes, said Raby.

The machine can provide cutting edge radii from 15 to 60 microns, repeatable to ±0.5 microns. Ground flute surfaces can be smoothed to 4µin. R_a in the 4-minute cycle. Finer finishes, however, require longer run times, which increases edge radii. In addition to polishing after grinding, Walther Trowal has found that polishing with drag finishing after applying TiN or other coatings also extends tool life.

Raby noted that while the process is simple and the use of a CNC provides repeatability, drag finishing users must take care of the media by sieving out the undersize particles at least weekly in heavy use. Also, abrasive media selection is critical. Some media break down in a manner that helps the process, while others do not. The process can be used wet or dry, but for carbide applications it is important to run dry to prevent carbide embrittlement, said Raby. A collector is used to capture carbide or media dust. When used as a dry process, drag

Rough endmilling operation	Cutting edge preparation (drag finishing)	
	without	with
Tool price (euros)	23.00	25.00
Post-grinding costs (euros)	15.00	15.00
Edge preparation (euros)	0.00	5.00
Number of post-grinding actions	2	2
Part cycle costs (euros)	17.67	21.67
Diameter (mm)	8	8
Number of edges	2	3
Edge radius preparation (microns)	none	25 ±5
Length of blade (mm)	46.27	46.27
Block depth (mm)	32.25	32.25
Channel width (mm)	19.96	19.96
Chip volume per channel and tool (cm^3)	29.79	29.79
Number of chambers cut per tool	3	7
Number of tools per chamber	3	3
Number of channels per blisk	77	77
Number of tools per blisk	77	33
Tool cost per blisk (euros)	1,360.33	715.00
Savings per blisk (euros) Reduction in tool cost Monthly savings for 8 blisks (euros)		645.33 47 percent 5,163

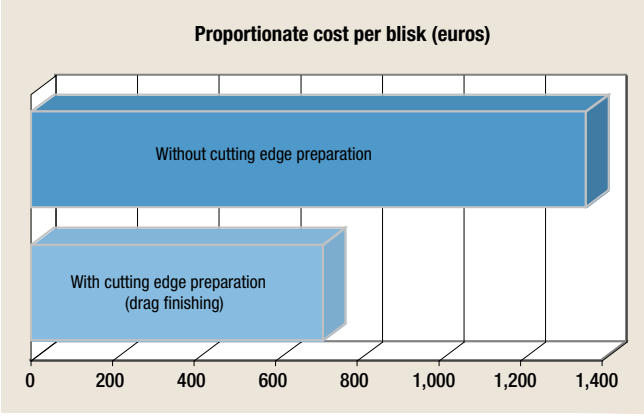
advantages enjoyed by drag finishing over some conventional parts finishing methods are:

- Fine finishes can be achieved on a repeatable basis,
- Many materials can be processed,
- Large workpieces can be processed easily, and
- Processing time is faster.

The lack of contact between parts in drag finishing is especially important for delicate or highly sensitive parts, such as turbine blades. The relative velocity and pressure between the media and workpiece in drag finishing are typically much higher than those for vibratory applications—even fixtured ones—so drag finishing cycle time can be 10 to 40 times quicker than in conventional circular vibratory systems.

Some drag finishing applications use a polishing paste dosed at regular intervals into the tub of media. When two different media are required, a mechanism moves the spindles over another tub or the tub is moved under the spindles. Some machines are built to pharmaceutical and food industry standards. If needed, water can cool finishing media.

A related process, spindle finishing, is similar to drag finishing. However, in spindle finishing, the media is rotated at high speeds around the spindle. A spindle finishing machine can develop high velocity that provides cutting as fast as seconds per part. Most of these machines use one or two spindles. Two-spindle machines have widely separated spindles that require travel from one position to the other. In contrast, drag finishing machines cluster the spindles and do not have to move large masses of media.



MTU Aero Engines

Endmill cost comparison in titanium machining application at MTU Aero Engines. The graph compares endmills that lack cutting edge preparation with endmills prepared by drag finishing.

Parts Applications

A typical drag finishing workpiece is a bathroom water faucet which, when processed in the conventional way, requires several belting and polishing operations. Using drag finishing, one machine (with two media) can finish the part prior to plating. Other appropriate parts include door handles, kitchen cabinet handles, fairleads, shackles, cleats, gears, boat propellers (up to 2' in diameter), compressor vanes and pumps, golf club heads, scissor blades and turbine finishing equipment can be placed in manufacturing cells. Wet mass finishing processes, including drag finishing, are typically confined to a separate area to avoid contaminating the work cell.

Some drag finishing equipment is capable of complex motion, which allows media to get in front of and in back of the part and into slots and cutouts. For example, overhead turrets can rotate in one direction while the spindles in the turrets rotate in the opposite direction. Some machine designs use planetary gearing that limits machine speed, while other designs provide a full range of speeds, including forward and backward for both turret and spindles. This feature provides maximum process flexibility, which is important when processing cutting tools, according to Raby. For example, the Walther Trowal M-TMD 4/1 has a turret speed range of 5 to 15 rpm, while the spindles can run from 2 to 20 rpm.

One manufacturer, MTU Aero Engines GmbH, Munich, Germany, was using an excessive number of endmills machining titanium blisks for an aerospace application. The company contacted Walther Trowal and, after extensive testing, began using Walther Trowal drag finishing machines as an edge preparation process for its endmills. As a result, MTU reduced the number of endmills used per blisk by 57 percent and reduced its tool cost by 47 percent (see table and graph).

—L. Gillespie

For more information about Walther Trowal's drag finishing machines, call (616) 455-8940, visit www.walther-trowal.com or **enter 330 on the IS card.**

Drag Race *(continued)*

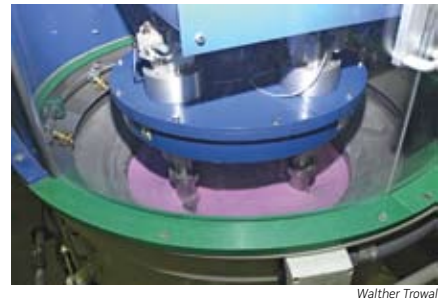
blades.

The drag finishing process is typically used for:

- high-value parts,
- complex geometries,
- parts with multiple contours, and
- very hard materials.

Because drag finishing can use small media, the process can efficiently deburr and radius very small breakthroughs. In vibratory finishing machines, it is very difficult to finish the inside passages of holes, ports or journals to the same degree as outside surfaces. This is especially true if the workpiece also has difficult-to-remove burrs around the hole because the smaller media required for the hole reduces the effective pressure between the media and the part. Small media sizes can be compensated for in drag finishing by increasing the spindle speed, thereby increasing media pressure on the workpiece.

Typical drag finishing applications are hand-size and larger parts. As in all loose abrasive processes, drag finishing works best on external edges of parts. The process does not lend itself well to deburring blind features because of media pileup, which prevents flow over part surfaces.



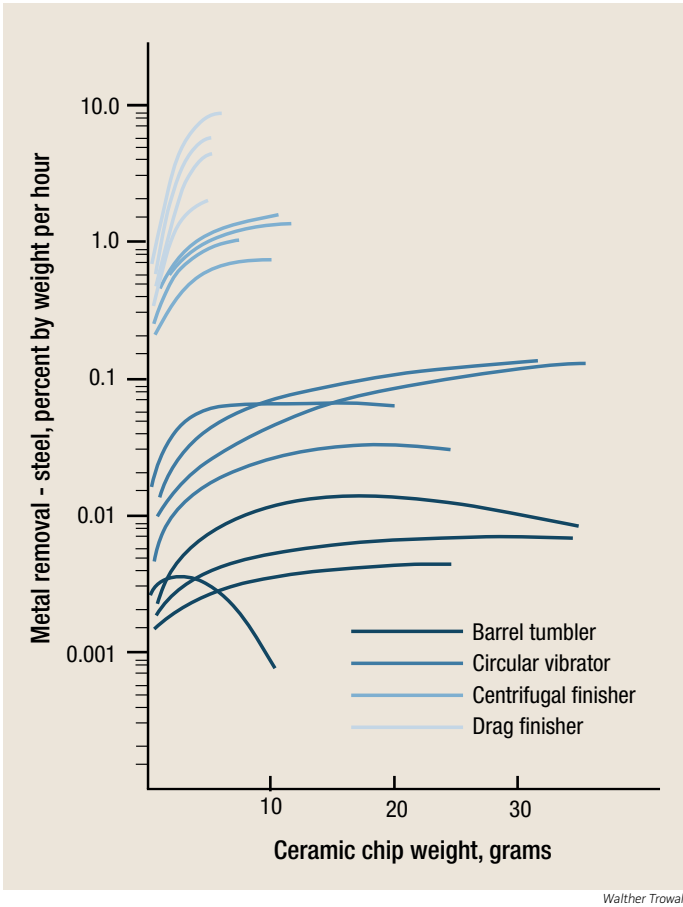
Walther Trowal

Fixtured endmills positioned over a specialized aluminum oxide media (dry process) in an M-TMD 4/1 machine. Below, endmills being processed.

Drag Finishing Machines

The original U.S. patent application for the drag finishing process, made in 1967 by Hisamine Kobayashi, indicates that for machines using circulating media and velocities of 70 to 500 m/min., deburring and smoothing will be complete within 10 seconds to 15 minutes. Today's machines finish parts in the midrange of these times without circulating the media.

There are several builders of drag finishing machines in the U.S., including Otec Precision Finish Inc., North Kingstown, R.I.; Rosler Metal Finishing USA, Battle Creek, Mich.; and Walther Trowal, Grand Rapids, Mich. Some companies produce large machines that can hold many parts on a single spindle and have several spindles to a turret. Large drag finishing machines can cost as much as $1 million, while jewelry drag finishing polishing machines cost as little as $12,000. Drag finishing machines used in typical metalworking shop applications range from $50,000 to $150,000. At least two U.S. job shops, Dynastar Finishing LLC, Fond



Walther Trowal

Figure 1: Material removal on steel workpiece with various media and machine types.

du Lac, Wis., and Engineered Finishing Corp., Minneapolis, specialize in drag finishing parts for other companies.

There appears to be little published process data on the drag finishing process. The author's "Mass Finishing Handbook," published by Industrial Press Inc., New York, contains some comparative data and applications, but that may not reflect all of today's capabilities. A continuous line variation called immersion lapping is used in Germany for small parts, but data for it is lacking.

For shops producing high-value contoured parts and parts with complex geometries, drag finishing may be a good choice. Figure 1 provides finishing efficiency for drag finishing compared with other mass finishing processes. Also, drag finishing is a highly repeatable process, eliminates part-to-part contact and can reduce costly hand labor, making it a sound alternative for some operations. CTE

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