Extrude Hone

FINISHING TECHNOLOGIES | FINISHING SOLUTIONS

Extrude Hone

KENNAMETAL®
EXTRUDE HONE®

“The most important aspects of a component are its surfaces and edges. The rest of the component is there merely to hold the surfaces and edges together!”

Kennametal Extrude Hone is dedicated to providing advanced manufacturing processes to produce the highest quality surfaces and edges on the planet.

Automotive | Die & Mold | Medical | Aerospace | Diesel | Fluid Power

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Programmed for Success

The success story of Extrude Hone, headquartered in Irwin, Pennsylvania, began with the development of our patented Abrasive Flow process in 1965. Today, Extrude Hone is recognized as a global leader, specializing in non-conventional technologies, including Abrasive Flow Machining (AFM), Electrolytic Machining (ECM), and Thermal Energy Method (TEM), for deburring, polishing, surface finishing, and edge conditioning.

Since our inception more than 40 years ago, one factor in Extrude Hone's history has remained constant: *We rely upon our innovation and deep understanding of our customers' needs*. In doing so, we continue to solve some of the most complex finishing and surface challenges faced by industry today.

Extrude Hone – Innovative Surface Finishing Technologies

Superior Quality

Wherever deburring, edge radiusing, and polishing of sophisticated man-made components are required, Extrude Hone's advanced processing technologies—Abrasive Flow Machining (AFM), Electrolytic Machining (ECM), and Thermal Energy Method (TEM)—provide a reliable and economic solution.

We are the leading supplier of advanced finishing technologies and contract finishing services, consistently solving some of the most complex deburring and surface finishing challenges faced by industry today. In fact, many of the world's largest manufacturers rely on our advanced solutions to deburr and polish the internal and external surfaces of critical components that have proven to be inaccessible by other means and technologies.

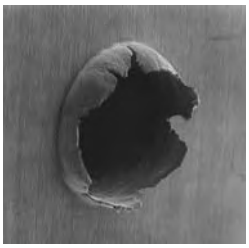
Moreover, Extrude Hone customers value our innovative finishing solutions for the significant competitive advantage they provide in the areas of increased productivity and profitability on the components they manufacture. Workpieces processed with Extrude Hone technologies enjoy improved functional stability, extended service life, and higher conformance to dimensional specifications.

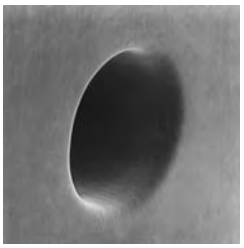
Contract Finishing Services—a Flexible Alternative

Perhaps the easiest way to discover all the benefits of Extrude Hone's precision finishing technologies is by using our global network of Contract Finishing Services. Today's worldwide manufacturing environments enable our customers to choose what parts of the production process they can and want to handle in-house.

At Extrude Hone, we satisfy our customers' needs by offering the flexibility to either provide custom capital equipment or access to our leading technologies through our global network of Contract Finishing Services (CFS) centers. Strategically located throughout the world, our CFS centers are available to machine, deburr, edge radius, polish, and finish your workpieces—economically, quickly, and conveniently.

KENNAMETAL®





before *after*

Think Global—Act Local

Our employees speak the language of our customers.Today, Extrude Hone has an extensive network of customer service centers and manufacturing facilities in the U.S., Brazil, China, Japan, Korea, Germany, United Kingdom, Ireland, France, Spain, and the Czech Republic.

Serving the customer is of major concern to us. We strive to deliver outstanding customer service 24/7. All of us at Extrude Hone are dedicated to meeting and exceeding the needs of our clients. In fact, our Technology Support Group, comprised of field service technicians, design and process engineers, and administrative personnel, is committed to supporting our customers and the operation of Extrude Hone equipment.

Throughout the world, we remain the preferred supplier to metalworking companies, including the global automotive industry and its first-tier suppliers, drive-train gear manufacturing, fluid power, medical, food processing, high purity, die & mold, aerospace, gas turbine, and other light engineering.

Complete Metal-cutting Solutions from Kennametal

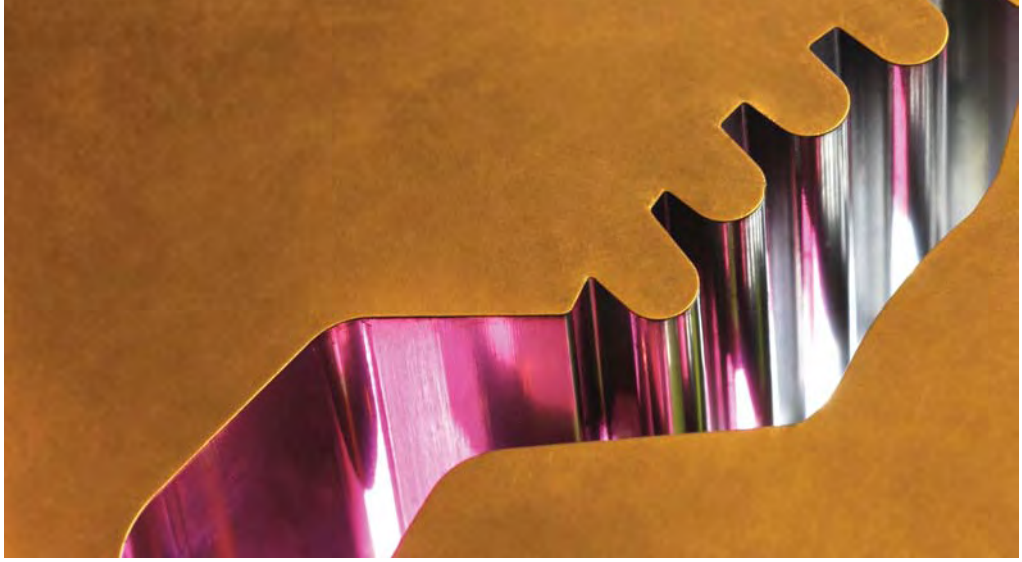
As part of the Kennametal Inc. family of companies, Extrude Hone leverages its direct relationship with Kennametal to further meet and exceed the needs of our customers. By combining Extrude Hone's advanced and innovative deburring and finishing technologies with Kennametal's state-of-the-art metal-cutting tools and systems, we are able to offer our customers a complete metal-cutting and finishing solution.

Together, Extrude Hone and Kennametal provide a breadth of technologically advanced products and services—from high-quality surface finishing of critical components to innovative tooling systems for metal-cutting—unmatched today in the marketplace.

AFM

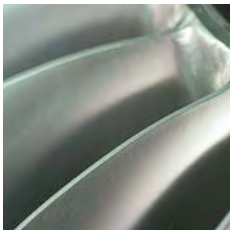
Abrasive Flow Machining

We deburr brilliantly.



Precision Deburring, Polishing, and Controlled Edge Radiusing Anywhere the Media Flows

before



after

AFM improves surfaces and edges created by a variety of manufacturing methods, including EDM, cast, forged, drilled, milled, and turned surfaces.

Process Features at a Glance:

- Offers high-precision deburring, radiusing and polishing
- Performs ideally in hard-to-reach areas
- Improves surface finish and integrity
- Increases life cycles and reduces wear rates of components
- Removes thermal recast layers and surface flaws
- Enables accurate process control and excellent repeatability
- Adapts readily to single parts, small lots or batch production

Abrasive Flow Machining (AFM)

The Extrude Hone AFM process defined a new level of quality and manufacturing productivity upon its introduction. As a result of ongoing advancements, AFM continues to be a leading and revolutionary process today.

AFM significantly improves the overall quality and product performance of cast, forged, and machined components at a reasonable and predictable cost. In fact, AFM is now recognized as one of the most cost-effective methods available for internal and external deburring and surface finishing of workpieces. As a standard practice, many manufacturers throughout a variety of industries now specify "Extrude Hone AFM processed surface" directly on original workpiece prints.

Our AFM process uniformly smoothes and blends in features, automatically and controllably, to a quality level and speed unachievable by hand or machine finishing. Plus, it finishes internal curved and complex surface locations previously unreachable by any other means.

Media with Brilliant Properties

At the heart of our AFM process is our unique, abrasive laden polymer—or, media—that changes its apparent viscosity when a shear stress is applied.

As the media is forced to flow over or through a restricted flow path, its molecules "cross link," transforming the media from a viscous fluid to an elastic—or even brittle—solid. Since our media sticks to little other than itself, it easily slips across edges and surfaces like elastic, abrasive "putty" with results similar to 3D flowable "sandpaper." Abrasive action is highest in the most restrictive passages with increased flow resistance.

Media Properties:

- **Life Cycle of the Media**
  The media provides a matrix for homogeneous suspension of the abrasive particles.
- **Consistent "Grinding Quality"**
  Stock removal can be controlled using a combination of pressure, flow rate and flow volume.
- **Universal Application Possibilities**
  We offer more than 200 media formulas, specifically developed to process a variety of workpiece materials and achieve precise surface and edge conditioning.

AFM media is reusable for extended periods although life expectancy is dependent on severity of use and application. Extrude Hone offers a wide selection of standard media formulations to service a broad range of customer applications. Custom engineered media formulations for special applications and process optimization also are available.

Our ISO 9000 certified manufacturing procedures assure you a dependable and repeatable AFM process every time.

Typical AFM Media abrasives include silicon carbide and diamond abrasives. Particle sizes range from 5 to 4,000 microns (1,000 to 8 mesh).

Abrasive Flow Machining

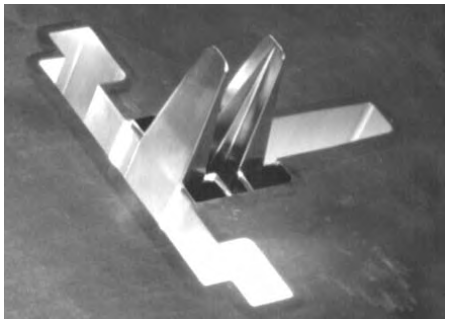
We deburr brilliantly.

before

after

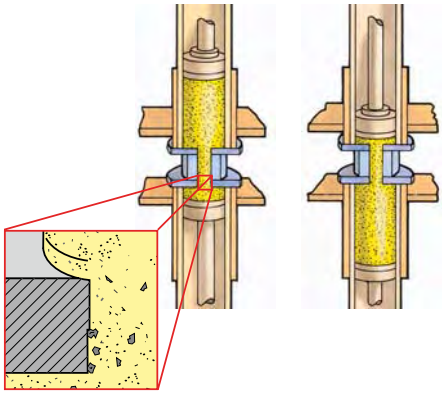
Internal passages within this turbine engine diffuser are polished to increase airflow to the combustion chamber of the engine by ±2 percent.

AFM produces dramatic improvements on a wide range of materials from drawn stainless steel elbows and fittings used by the semi-conductor industry (above) to turbo impellers (below).



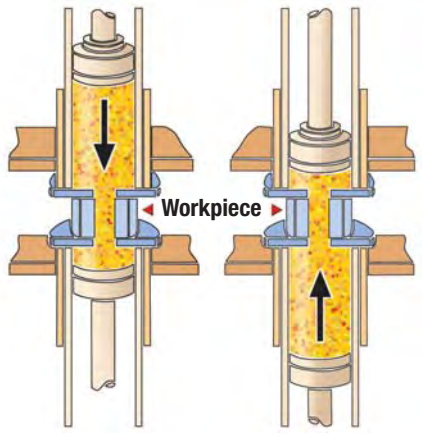
The surfaces of extrusion dies for the aluminum and plastic industries are polished accurately and uniformly in a fraction of the time when compared to hand finishing.

These delicate heart valves are finished using AFM, resulting in a superior, ultra-clean, smooth surface.



The rheological properties of AFM media constantly present abrasive particles to the workpiece surface in a continuous and uniform manner.

AFM removes as little as 2.5 µm (0.0001 inch) of material from a workpiece surface; however, the process can be used to remove virtually any amount required.



Two-Way Flow AFM

AFM is ideal for components with such features as…

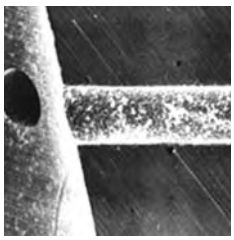
- Cross-drilled holes
- Steeped and intersecting bores
- Milled and broached slots
- Internal radii and chamfers
- Internal bends and curves
- Internal passageways
- Thousands of other applications

AFM VECTOR Series

AFM

MICROFLOW™

Precise Target Flow and Reduced Variability of Diesel Fuel Delivery Systems



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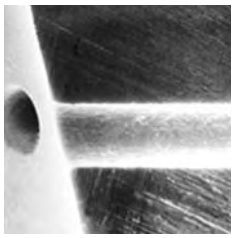
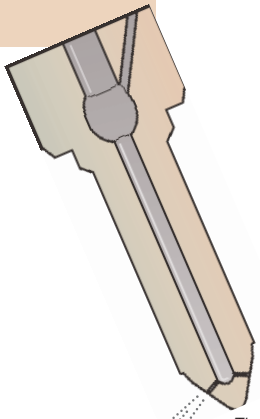


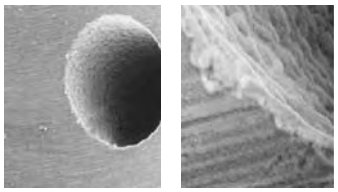
after

With our advanced control systems and unique MICROFLOW media, our precision MICROFLOW AFM assures high-quality, "right on target" holes that avoid the unfavorable asymmetric geometries produced by standard EDM processing.

MICROFLOW AFM achieves...

- Fine tuning spray nozzles to less than ±1 percent of targeted flow rate
- Smoother, more uniform orifice geometries
- Higher discharge coefficient than EDM
- Precise entrance radii for better atomization and fuel distribution
- Identical hole sizes every time





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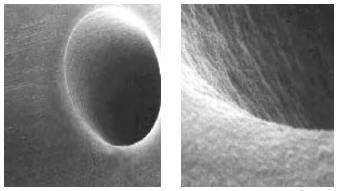


after

The MICROFLOW AFM process can be employed on virtually any precision nozzle or metering hole where gas, liquid or fine particles flow at a precise volumetric rate.

MICROFLOW™ AFM

When precision finishing and maximum performance matters most in your workpieces, our MICROFLOW AFM process delivers. While very similar to our standard AFM processing, our MICROFLOW AFM process is distinctive in three key areas. First, MICROFLOW AFM uses a much lower viscosity media. Second, the abrasive particle size within the media is much smaller. Lastly, MICROFLOW AFM features a more advanced and highly controlled feedback system.

MICROFLOW AFM is ideally suited for the diesel and automotive industries in the manufacturing of controlled or metered fuel/fluid delivery and distribution systems. This includes the sizing and flow tuning of advanced high-pressure diesel fuel spray injector nozzles. MICROFLOW AFM delivers unequaled manufacturing control over orifice surface finishes and entry edges. Our MICROFLOW AFM provides consistent hole quality and enhanced flow characteristics for improved atomization, deeper jet spray penetration and better fuel/air mixing, resulting in increased fuel economy, more horsepower and a cleaner burning engine.

MICROFLOW AFM Process

Prior to MICROFLOW AFM, precision orifices in fuel injectors and metering nozzles were first machined and then, in a separate process, flow tested. Now with our advanced MICROFLOW AFM, Extrude Hone has combined both critical and necessary steps into one process.

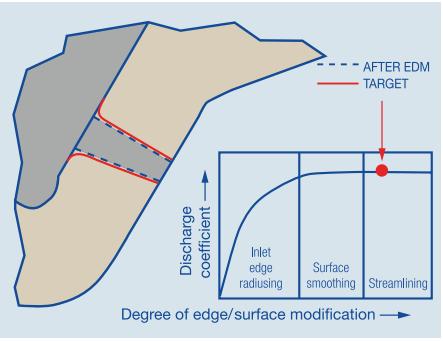
Workpieces are machined and tested as part of the same process run to provide tightly controlled volumetric flow rates that significantly enhance their discharge coefficient. This method of processing incorporates sophisticated sensing and precision algorithms in a closed-loop system that monitors and accurately maintains all aspects of the process—from media viscosity and media pressure to sheer force history and temperature. The result is virtually any spray nozzle can be fine tuned to less than ±1 percent of a targeted flow rate.

MICROFLOW AFM processing can be performed by either of two distinctly different methods, depending upon your needs. Each method has its own advantages.

- **High-Viscosity Media Processing**
  This method is suited to processing multiple parts simultaneously to achieve a superior hole geometry and greatly improved discharge coefficient (CD).

- **Low-Viscosity Media Processing**
  This method is ideal for achieving a target flow rate in a single step process.

Both methods achieve consistent and repeatable results.

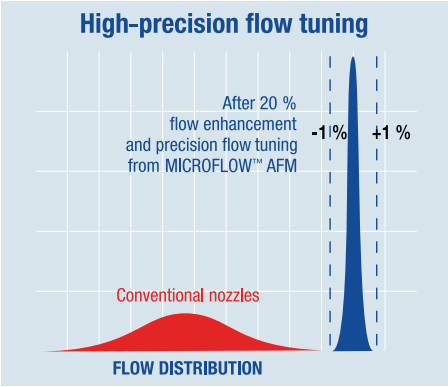


MICROFLOW AFM Optimize Flow Discharge Coefficient

A typical EDM orifice hole has a flow rate coefficient between 0.6 and 0.8 while a hole processed with MICROFLOW AFM has a typical flow coefficient in excess of 0.95, increasing flow velocity and improving atomization from an identical orifice diameter.

MICROFLOW AFM also is used to process high- and low-pressure atomization nozzles for:

- Oil heating systems
- Water and humidity systems
- Washing and cleaning systems
- Paint spraying systems
- Spray coating medical, pharmaceutical, and electronic devices



MICROFLOW AFM Machines

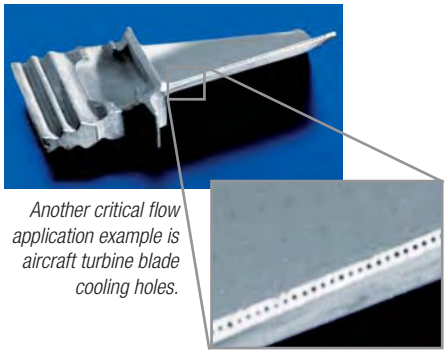
Extrude Hone is the world's leading producer of precision flow tuning equipment and testing systems for diesel fuel injectors, flow metering and fluid atomization devices. Extrude Hone offers two standard models of the MICROFLOW AFM machine: MICROFLOW LV and MICROFLOW HV.

Both models can be configured to suit your specific requirements—from laboratory development equipment to total turnkey production systems. Both systems can be designed to be semi-automated or fully automated with workpiece loading and unloading. MICROFLOW AFM systems are fully capable of providing the following:

- Sizing and flow tuning of hole diameters down to 50 µm (0.002")
- Different flow conditions—higher discharge coefficients
- Reduction of flow tolerance from ±6 percent total mass flow to less than ±1 percent—typical of EDM
- Nozzle pre-aging—purposely introduced wear at the spray hole entrance, resulting in high stability and consistency of the nozzle's performance throughout its operational life
- All nozzle geometries—conventional sac, VCO, minisac, etc.
- Total automation, including part handling, cleaning, testing, and sorting
- Process data records, storage and analysis

Visit www.extrudehone.com for complete technical specifications.

MICROFLOW AFM delivers unparalleled control over micro-hole surface finishes, providing consistent quality and enhanced atomization and flow characteristics.



Another critical flow application example is aircraft turbine blade cooling holes.

*AFM MICROFLOW™ **LV***

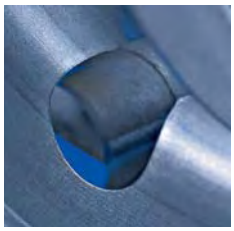
TEM

Thermal Energy Method

We deburr lightning fast.

Complete Internal and External Burr Removal in One Quick Operation

before



after

TEM is unique among material removal processes primarily because it removes burrs and flash simultaneously throughout the workpiece, including internal and external locations.

Process Features at a Glance:

- Offers the lowest overall burr removal cost
- Provides a highly controllable and repeatable process
- Removes all internal and external burrs simultaneously
- Requires only simple tooling
- Offers rapid process cycles
- Adapts well for both small lots and very high-volume production
- Performs particularly well on the flashings of die-cast parts

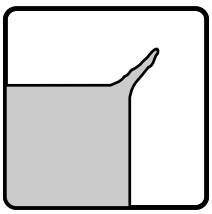
Thermal Energy Method

Today, manufacturers are improving workpiece performance with increasingly more complex designs, resulting in greater surface finishing challenges. Extrude Hone's Thermal Energy Method (TEM) uses intense heat to deburr and deflash workpieces accurately, quickly and cost-effectively.

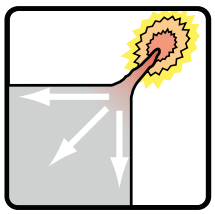
Our TEM process is distinctive in that it simultaneously removes internal and external burrs and flashings without affecting or compromising adjoining workpiece surfaces. The actual removal of burrs and flashings with TEM occurs in a flash with a mere 20 milliseconds completion time. Throughout hundreds of installations and continued refinement of our TEM equipment, one factor remains constant: TEM is a rapid, low-cost, high-production process that can process a million or more parts per year by a single machine.

before

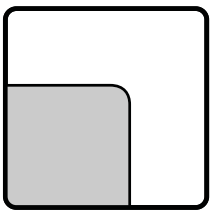
after



Burr before TEM...



burr is vaporized...



deburred part after TEM.

The TEM Process

First, workpieces are securely sealed in a bell-shaped combustion chamber. Depending upon the size of your TEM machine and the containment chamber, several to hundreds of workpieces can be processed at a time.

A pressurized mixture of a combustible gas—typically natural or methane gas and oxygen—is injected at 5 to 10 atmospheres of pressure, which is determined by the amount of material to be removed and the volume of parts in the chamber.

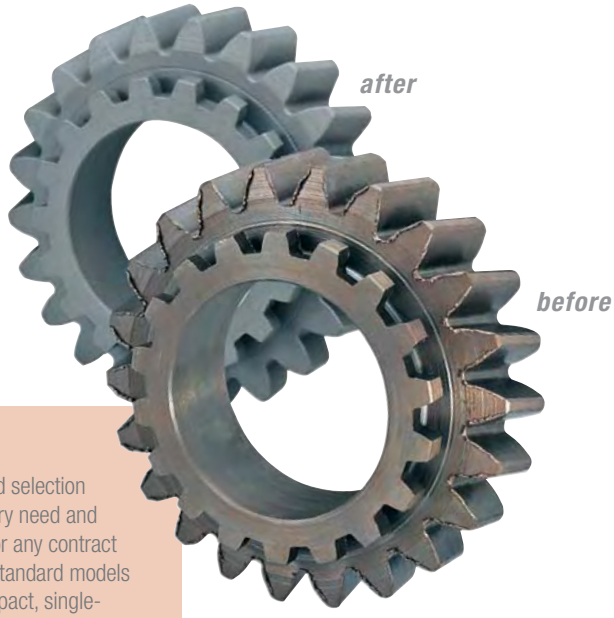
A spark plug ignition system ignites the gas mixture, releasing heat energy from the oxidation of fuel in a 20 millisecond, high-speed heat wave. The surface of the combustion chamber absorbs the majority of the heat.

With their raised surface areas and thin cross-section features, burrs and flashings burn away instantly. Depending upon the heat diffusivity of the workpiece material, most, if not all, burrs absorb the heat faster than the core of the workpiece. The burr becomes progressively hotter until it reaches the material's oxidation temperature and ignites.

Because the gas mixture engulfs the entire workpiece, all internal and external surfaces are exposed to the rapid oxidation. Internal cross-drilled holes and intersecting edges that are difficult or impossible to reach are instantly processed.

before

after



after

before

TEM

Thermal Energy Method

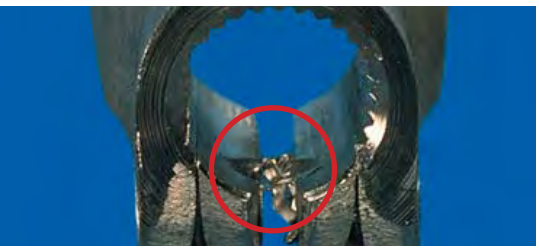
We deburr lightning fast.

A Low-cost Deburring and Finishing Solution

With its overall low processing costs, high-production rates, and repeatable results, TEM is used throughout many industries—large and small. From high-volume automotive parts and hardware fittings to one-off prototypes, TEM is the unanimous and preferable choice over the more erratic and often unpredictable media tumbling, vibratory, and manual deburring methods.

Hundreds of Extrude Hone TEM installations at major manufacturers throughout the world quickly and economically deburr and deflash billions of edges annually. These robust, field-proven systems are dependable, easy to operate and incorporate extensive safety features.

Tooling used in the process is generally simple, and often not required. As a result, TEM is quite flexible, allowing for the same system setup of different parts and different materials with only modest time required for changeover.



before

after

TEM Machines

Extrude Hone provides a broad selection of TEM machines to meet every need and budget. As an ideal solution for any contract or production shop, we offer standard models of TEM machines—from compact, single-station units to mid-size and larger machines that accommodate large parts, and higher production.

Our TEM machines are designed and constructed to operate 24/7, pausing only for routine maintenance and cleaning. Actual machine cycle time, including indexing, sealing, safety checks, gas injection and unclamping, typically requires only 30 to 60 seconds while the TEM processing itself takes a mere 20 milliseconds.

Visit www.extrudehone.com for complete technical specifications.

Our TEM processing is also available through our Contract Finishing Services.

TEM is ideal for such components as…

- Automotive parts
- Screw machine parts
- General hardware
- Gears and pinions
- Shafts with intersecting drilled holes
- Internal grooves and undercuts
- Die castings
- Hydraulic/pneumatic valves
- Thousands of other applications

A single Extrude Hone TEM machine is capable of processing millions of parts per year.

TEM S–250

ECM

Electrolytic Machining

We do more than just deburr.

Selective Deburring, Contouring, and Polishing for Superior Surface Quality

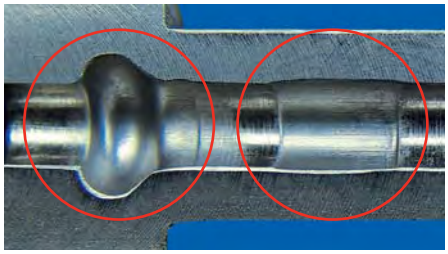
Electrolytic Machining, Deburring, and Polishing (ECM/ECD/ECP)

Extrude Hone's electrolytic technologies are highly cost-effective processes that provide fast, accurate and controllable surface finish improvements to your precision workpieces. Our electrolytic processes machine, deburr, and polish surface locations previously unreachable by other methods, including manual or handwork. They also boost productivity substantially—by up to 10 times compared to manual deburring methods. While ECM is a broad finishing category, ECM, ECD and ECP are essentially the same process. Each is used to achieve slightly different results or objectives depending upon component material and stock removal requirements of your workpieces:

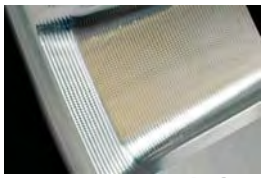
ECM is used to machine workpieces with unique contours or specific edge geometries that normally cannot be produced by conventional machining methods, such as the internal galleries of diesel fuel injector nozzles, recesses in gear teeth of synchronizers and rifling inside gun barrels.

ECD is used to deburr holes and edges in difficult to reach locations on such workpieces as drilled break-through holes on the interior surfaces of air bag propellant systems and cross-drilled holes inside manifold blocks.

ECP is used to provide high-quality polishing of complex 3D contour milled surfaces, such as those found on medical implants and biopharmaceutical diaphragm valves.



The fuel gallery of a diesel fuel injector is machined using ECM. The unique ability to precisely machine features to interior passages makes ECM a valuable tool for many industries.



before

after

ECM processing produces exceptional surface finishes on a wide variety of materials. This aluminum sample with low silicon (Si) content was machined on a multi-axis CNC mill and then finished using electrolytic polishing (ECP). The finish improved from 2.0 µm (80 µinch) Ra finish to 0.5 µm (21 µinch) in 35 seconds.

The Electrolytic Process

Our highly controllable electrolytic process employs a programmed pulse, low-voltage direct current (DC) while a conductive electrolyte solution passes between the tool and workpiece. The removal of metal occurs precisely from defined areas through the dissolution of surface atoms without direct contact between the tool and workpiece or exposure to mechanical or thermal stress. In adhering to Faraday's law of electrolysis, this selective metal removal process ensures that the amount of material removed is proportional to the time and intensity of an electrical current flowing between the tool and workpiece. Controlled material removal ranging from 0.0005" to 0.01" (0.01 mm to 0.25 mm) is realized on most applications. Typical electrolytic cycle times range from 15 seconds to 45 seconds for most applications.

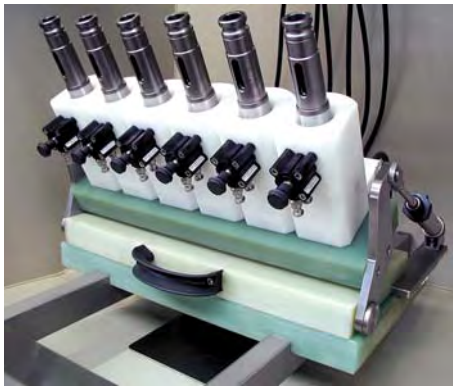
Since minimal tooling and setup time is required, Extrude Hone's electrolytic technology is ideally suited to both short- and long-production run applications.

Process Features at a Glance:

- Offers accurate, high-precision deburring and edge radiusing at pre-defined points
- Provides straightforward machining at hard-to-reach areas
- Combines deburring and contouring functions in a single operation
- Eliminates the formation of "secondary burrs"
- Offers rapid processing times (normally 10 to 30 seconds)
- Prevents mechanical or thermal stressing of workpieces
- Requires no special skills

Planet gear before...

...and after ECM



Use of multiple fixtures increases productivity.

Electrolytic Machining

We do more than just deburr.

Automated Systems—Tailored to Customer's Requirements

Extrude Hone's ECM equipment is very flexible and can easily be configured with robots and other automation equipment to achieve extremely high-production rates.

"SysLine" Series

For high-volume production, we also supply automated systems with integral process technology comprising pre-treatment EC processing, post-treatment and media conditioning in a totally enclosed system.

Auxiliary Equipment and Accessories

We provide our customers with everything they need from a single source: complete deburring and surface finishing systems with all the necessary peripherals, such as pre- and post-treatment systems, chamber filter presses, industrial coolers and chillers, gauging, workpiece handling and much more.

The ECM processing is also available through our Contract Finishing Services.

Electrolytic Systems

Extrude Hone offers a broad selection of ECM machines to address a full range of applications and customer needs:

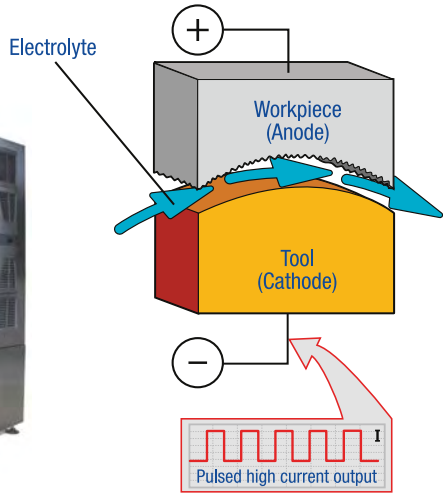
- **ECOLINE™ Series**—This series is equipped with all of the functions necessary for dependable deburring and profiling of precision metal components. Additionally, the series combines reliability with field-tested, proven technology at a lower price point for an outstanding cost-utilization ratio.
- **ECLINE™ Series**—This modular series is the perfect deburring solution for machining medium-to-large batch quantities of workpieces with burrs created from turning, milling, grinding, honing, or reaming operations, as well as edge rounding or contouring processes. The series is available with two working stations. Various automation configurations also make the system suitable for high-volume production.

Visit www.extrudehone.com for complete technical specifications.

ECM provides a highly controllable and cost-effective method of machining and polishing high-quality surface and edges.

Interior bore intersections can be perfectly EC-machined.

Fully automated ECM system, "SysLine" series, for high-volume production.



Extrude Hone developed Pulse Electrolytic Technology (PET) to produce fine surface finishes on materials, such as stainless steel, aluminum, and others, that meet or exceed electropolished finishes.

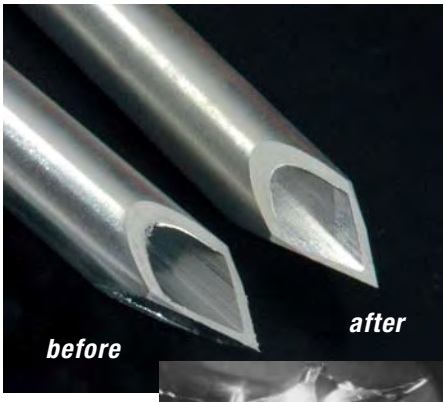
ECLINE

ECM

COOLPULSE™

We create perfection in detail.

Revolutionizes Deburring, Finishing, and Cleaning of Small, Delicate Components without Imparting Workpiece Integrity



before

after

Process Features at a Glance:

- Offers low operating costs—no conformal tooling required
- Enables safe operation—no harmful chemicals or acids
- Sets up quickly—typically in minutes
- Provides consistent production finishing—thousands of parts
- Enables repeatable and reliable results—easy-to-control process
- Requires no special skills

Perfect Finishing

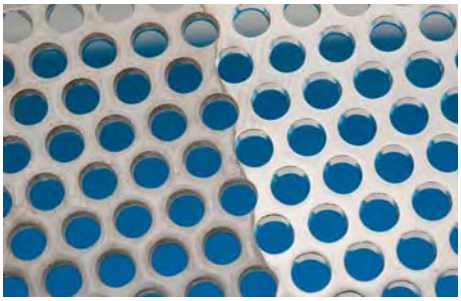
The more minute, fragile, or elaborate the component, the more inherently complex, and in some instances, more costly, it becomes to properly deburr, finish, and clean. With its distinctive pulse electrolytic technology, COOLPULSE™, Extrude Hone offers manufacturers of such complex, delicate, and high-precision components an innovative yet easy-to-manage and economical electrolytic process to deburr, finish, and clean.

COOLPULSE reliably produces higher quality, more precise and cleaner results without compromising or stressing the structural and functional integrity of the component.

The COOLPULSE Process

The Extrude Hone COOLPULSE process performs five key advanced finishing functions all in one process. It deburrs, polishes, stress relieves, cleans, and passivates. While COOLPULSE is optimized for edge effect, significant surface and cleanliness improvements are a natural by-product of the pulse electrolytic technology, enabling COOLPULSE to meet the stringent Ultra High Purity (UHP) standards of single-digit-ppb results.

The COOLPULSE process uses a specially formulated electrolyte solution with a computer-controlled, pulsed direct current (DC) power source. The electrolyte solution, which is chilled, non-fuming/odorless and near pH neutral, has a very high electrical resistance. When a machined component is immersed in the electrolyte solution, and a pulsed DC low-voltage charge is applied between the workpiece and a stationary cathode, an electrostatic charge is concentrated on the component's sharp features, i.e., the burrs and recast stress risers.



before *after*

COOLPULSE is ideal for devices and instruments used in…

- Medical and surgical
- Consumer electronics
- Food processing
- Laboratory and scientific
- Defense and communications
- Semi-conductor
- *and many other industries ...*

In areas of the concentrated electrical field, burrs and stress risers are dissolved and flushed away by the electrolyte. COOLPULSE is compatible with most metal materials, including mild steel, cast iron, and stainless steel, as well as nickel, aluminum, and magnesium alloys. Average cycle times range from 15 seconds up to 3 minutes. At these rates, a single COOLPULSE machine can process thousands of workpieces in a week.

The COOLPULSE ECM processing is also available through our Contract Finishing Services.

COOLPULSE

Extrude Hone Processes

Along with offering capital equipment, Extrude Hone maintains a global network of Contract Finishing Services. The following is a sampling of typical applications:	AFM	MICROFLOW™ AFM	TEM	ECM/ECD/ECP	COOLPULSE™ ECM
deburr internal/external surfaces (including intersecting holes)	●		●	●	●
deflash internal/external surfaces			●		
controlled corner and edge radius in hole sizes > 0.062" dia. (1.5 mm)	●			●	
controlled corner and edge radius in hole sizes < 0.062" dia. (1.5 mm)	●	●		●	
diesel fuel system components (common rails, runners), (improved high cycle fatigue resistance)	●			●	
diesel fuel injector nozzles (annulus, gallery, hole shaping, flow tuning)		●		●	
finishing hole sizes < 0.015" dia. (< 0.4 mm)		●			
finishing hole sizes > 0.015" dia. (> 0.4 mm)	●			●	
polishing and forming contoured surfaces				●	●
polishing die & mold (blind cavity)					
polishing die & mold (through cavity)	●				
polishing extrusion dies (aluminum & others)	●				
polishing internal surfaces & passages (ultra-high purity valves and medical components)	●			●	●
removal of thermal recast layer	●			●	
removal of EDM/spark erosion recast layer	●			●	
removal of laser erosion recast layer	●			●	
removal of sharp edges and burrs (elimination or radiusing)	●		●	●	●
smooth & blend internal surfaces & passages (automotive intake/exhaust manifolds, headers, etc.)	●			●	
surface finish improvements 0.05 µm R_a or lower				●	●
surface finish improvements 0.05 µm R_a and higher	●			●	●
surface machining, contouring and polishing				●	

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