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Thermal Energy Method: TEM

Extrude Hone C250 6 Station Thermal Deburr Machine

ATL Single Station Thermal Deburr Machine

Thermal Energy Deburring of Machined and Diecast Parts

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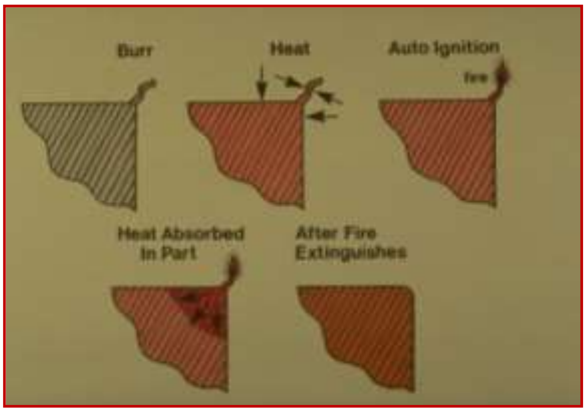
TEM: What Is It?

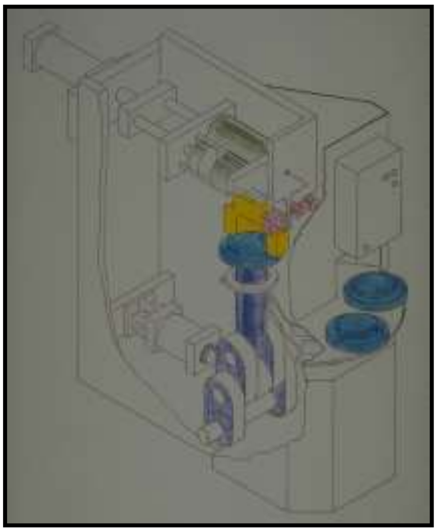
The intention of this paper is to provide an overview of a non-traditional deburring and deflashing method for machined and diecast components. TEM is an acronym for "Thermal Energy Method," a process that generates an intense but controlled burst of heat. With enough heat, low mass surfaces like burrs, flash and debris, ignite and burn away.

As mentioned, burrs from machined components, flash from diecast components, and even minor debris such as chips cannot withstand the heat that TEM generates, about 6,000ºF. Thin sections receive the brunt of the energy, burning toward the root and parent part and along this line the TEM process fades. The process is nearly instantaneous, about 20 milliseconds, and while burrs and flash burn away, parent material absorbs this energy and remains relatively cool, about 250°F. Too hot to handle without gloves, but not enough to change damage the part metallurgically. The process may in fact, relieve minor stress. TEM works uniformly on all part surfaces, we cannot selectively focus on any specific area. It is also repeatable, and consistent! The inconsistencies that occur are almost always attributable to incoming conditions, dull tools created larger burr, heavier flash etc.



How Does TEM Work?

The TEM process is an explosive one, so parameters controlling part contact and distortion are sometimes required. Precision and delicate parts can be ideal thermal deburring candidates, but they may need to be "fixtured" to prevent impingement. Often a simple "stacked" operation where parts are oriented proves acceptable. If parts may be "batched" together, TEM can provide exceptional throughput and quality. Even thin walled areas can be "masked" to absorb the heat energy. As long as parts physically fit within the machine, almost all material may be thermally deburred.



Fuel, compression and spark create an immensely capable combustion energy and TEM uses this energy to make undesirable features disappear. Briefly, parts are encapsulated in a chamber that is tightly clamped with 250 tons of hydraulic force and held closed by a ram and toggle system that goes beyond top-dead center by 2°. The combustion chamber is pressurized with a volatile mixture, usually natural gas and oxygen and after a slight dwell, ignited.

To begin the process, parts must be dry and free of oils, coolants, loose chips, debris, grease. Therefore, a simple alkaline wash and dry may be required. Clean, dry parts are poured, oriented, or fixtured onto a dished "lower closure" that rests on a turntable and is the bottom of the combustion chamber. Smaller parts can be bulk loaded into a coil so many may be processed at once. A coil shaped retainer, much like a coil spring, withstands the TEM process well and if necessary, perishable liners can be inserted to prevent parts from spilling between the coil rings. Maintenance personnel can manufacture most liners, however coils are usually purchased from the manufacturer and they should last thousands of hours.

Our thermal machines consists of six bottom “lowers” and a suspended upper combustion chamber visible in the picture to the right. The six stations rotate in a counter-clockwise direction and provide enough cooling time to prevent preignition.

For bulk processing, the operator manually empties the coil basket of completed parts into a tub, resets the coil and refills it with raw parts. As mentioned earlier some parts may require a fixture to hold them in place or operator orientation of individual parts to prevent delicate features from contacting an adjacent part.

The process itself is established for each part through trial and error. Both the amount and ratio of gas and oxygen can be varied. This allows some flexibility in chamber pressure and burn temperature. Zinc diecast parts require very little pressure to deflash them, aluminum a little more and carbon steel, quite a lot. These pressure changes usually vary from under 100 to over 300psi. Most machine owners set their machine and forget it, but these settings are easily adjusted with mechanical “stops.” If tooling is required it is usually a simple plate with pockets and a top disc to keep parts in place. Usually these are easy to fabricate, but they must be made from 17-4 stainless steel and a set of six or one for each “lower closure” is required. On a cautionary side, do not skimp on fixtures and cycle the turntable too quickly. The closures must have at least 3-minutes to cool, or they may prematurely ignite the chamber.

Operation of a thermal machine is straightforward. The operator loads parts and cycles the machine. The machine indexes the turntable so a lower closure with unprocessed parts is moved beneath the combustion chamber. A ram/toggle system lifts the lower from the turntable, presses it to the combustion chamber and firmly locks the chamber parts together. A charge system then draws gas and oxygen, where mechanical stops regulate the amount of gas each cylinder holds. This gas is injected into the combustion chamber and after a slight dwell, ignited. After another dwell, the ram/toggle system opens the chamber, venting exhaust and after lowering the parts to the turntable the cycle repeats. From start to start, cycles can be as fast as just over 30-seconds!

Completed thermally deburred parts usually present an oxide that can be removed in a post-process cleaning. These oxides appear as a white, chalk like substance on aluminum and zinc parts, or a rust colored oxide on most carbon steels. They can be wiped with a rag, but a simple immersion in a bath of a mildly acidic cleaner is much more effective. This bath can be conducted at the machine or parts can be collected and processed in a machine dedicated to this process. Often the post cleaning process involves a dip in a rust preventive and drying cycle too. Temperature, Agitation, Cleaner and Time (TACT) are key parameters to any successful cleaning and when developing and controlling your processes keep them in mind. Many parts can skip the post cleaning process entirely. They may look ugly, but if parts go to a plate, paint, vibratory, or heat treat operation, these processes may remove oxides.

Why Do We Use TEM?

With TEM, wherever gas flows, the burr goes! It is a process that is ideal for precision machined components where "hard to reach" burrs require probing or hand work. Burrs from internal cross-holes, ID breakouts, undercuts, interrupted cuts and flash from diecast components that are difficult to mass finish, are extremely easy for TEM. Additionally, minor chips and debris will vaporize presenting unrestricted mechanical motion of valves and spools or the removal of contamination in fuel, hydraulic and pneumatic components. Cut threads are another good thermal application, the parent thread absorbs the thermal energy, while lightly attached flakes and strings disappear. Gears too, are often cleaned up sufficiently in a thermal process as the root of the gear is processed along with both flats.

As a rule of thumb, if the burr can be wiggled with an unfolded paper clip, it will be removed in a TEM process. If the part cannot be deburred using traditional methods, it is probably a good TEM candidate. If hand deburring is the method of choice, TEM will probably excel from a through put, quality and cost standpoint.

Perhaps we should mention what TEM is NOT good at. While there are always exceptions to the rule, we have processed magnesium components, but never recommend or solicit them. Copper absorbs heat too easily and copper burrs or flash seem to be unfazed by even the most vicious TEM process.

Systems

Thermal equipment is expensive to purchase but has an extremely long useful life. Machines from the eighties and approaching 40-years in age are still desirable and I managed a thermal jobshop where all our machines were approaching or exceeding the million-shot marker. For this reason, rebuilt machines are desirable and hard to find.

Thermal machines involve many systems including, cooling, fuel, exhaust, electrical, hydraulic, lubrication, and safety. Generally, the combustion chamber is cooled adequately with simple line pressure water, but sometimes a chiller is added, or expanding to include cooling of the lower closures.

The line pressure of natural gas is too low for TEM so a gas compressor will be required if you plan on using this fuel. Additionally, a supply of oxygen is required. Bottled gases are frequently used, and consideration should be made regarding storage, handling and regulation. In addition to delivery, the machine has a "charging" system that consists of two very large pneumatic cylinders. These draw gas until prevented by mechanical stops, and then inject the gas through a "mixing block" manifold into the combustion chamber. This system will require periodic inspection and rebuild throughout the life of the machine.

Exhaust gasses are hot and contain an oxide that must be vented. An exhaust ring shrouds the combustion chamber and a standard industrial blower creates the negative pressure necessary to remove these particles and gasses. Roof or sidewall penetration of the building will be required, and you may want to consider where this is done from an external perspective too. The oxides may settle, and I have witnessed them depositing on parked cars. Don't exhaust over any VIP parking spaces!

Electrical systems are not overly complicated but older machines may have a manual hard-wired pushbutton for each stage of the process along with an automatic mode. Modern machines are PLC controlled but both involve numerous checks that can be troublesome to diagnose.

Thermal machines have their own dedicated hydraulic system that operates the ram-toggle chamber open/close and charging system. As with any hydraulic system it will require attention, maintenance and repair, usually pump, from time to time. It is a good idea to consider having drip tray made for the hydraulic system to sit in.

The ram and toggle system is a grease eating one and an automated injection system must be maintained. Usually the system gives a shot of grease every few cycles and the operator should notice consumption. Remember though that thermal machines generate grease melting heat and the while they have a grease tray, if it leaks you will wind up with a slippery and messy floor. For this reason and like the hydraulic system, I suggest setting the machine in a drip tray too.

Safety is a primary concern and to my knowledge no serious injury has ever occurred from the thermal process. The process takes place in a shrouded enclosure behind small fire proof doors that open and close as the turntable cycles. Don't operate this machine with shrouds open and safety switches bypassed. There is a chamber vent system to allow venting of the closed chamber should a misfire occur. Parts are hot, and the operator will wear hand, foot, and eye protection, but I found that due to the heat they often tried to ditch arm and leg protection. I allowed "cool off" breaks when desired but made long sleeve and long pants mandatory. Also, the machine is operated from a standing position and operators may need a platform to raise them to a comfortable height. Cushioned mats are appropriate too.

Chamber Options

The maximum amount of gas that a TEM charging system can deliver is the same for all equipment models, however the chamber size that this gas is delivered to is not. Typical chamber sizes are measured in diameters of 7”, 8” and 10” and between a 7” and 8” the area for parts increases over 50%; just over 100% between the 7” and 10”! Obviously, a larger chamber will process more parts, but it cannot generate the higher pressure your parts may require. Ferrous metals will require smaller chambers while non-ferrous parts may process in any size chamber.

New chambers may be purchased for old machines however they are expensive! Keep in mind you will need 6-mating lower closures too.

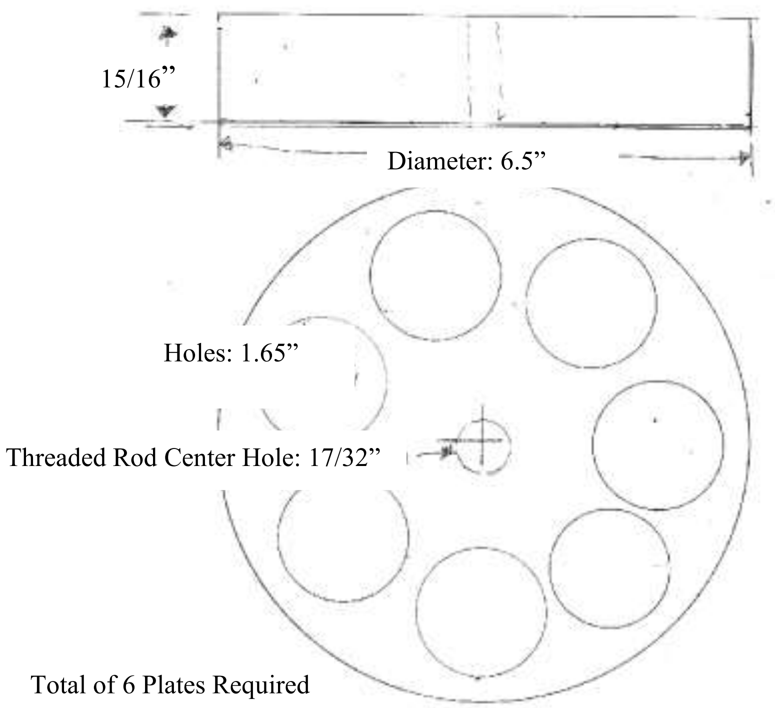
Maintenance, Repair, Operations Considerations

By now you should be familiar with expected MRO costs, fuel, oxygen, electricity, hydraulic oil, water, etc. but we would like to mention wear items that you will need to keep on hand too. The lower closure mates with the combustion chamber and is sealed with a dense plastic seal and bronze ring. These two items are visually apparent on each

lower and will require periodic replacement so a supply should be kept handy. They are removed with standard shop tools and the machine will seat them once it cycles. Additionally, the frame will flex slightly under pressure and this "preload" should be measured initially and monitored at annually.

A detachable "mixing block" mounted to the combustion chamber consists of the spark plug and valves which open allowing the charge system to inject gas, and then close prior to ignition. It also mates the water-cooling system to the chamber. These parts wear, foul, and collect combustion deposits and need to be rebuilt periodically. This is a simple rebuild and can be done inhouse, but you will want to purchase a spare block or two along with intake valves and keep a supply of spark plugs, O-rings, and bushings on hand.

Pictured below is a typical thermal fixture plate. Designed for a 7" chamber machine it will accommodate 7 parts. Cycle times are under a minute (32-35 seconds in automatic mode) so assuming a 45-second cycle this plate could run 80 cycles or 560 parts per hour. Even an 80% efficiency rate should yield 450 parts per hour. Sometimes a top plate is required to help confine parts to their compartment and any local tool and die or one-off shop should be able to fabricate these.



17-4 Stainless Steel material

Following are pictures of a typical Surftran C-250 thermal machine along with various parts before and after the thermal energy method. Thank you for your interest in the thermal energy method and the opportunity to review this process with you. We hope we have been helpful and look forward to working with you at your convenience.

Robert Schaeffer

President
Metal Form and Finish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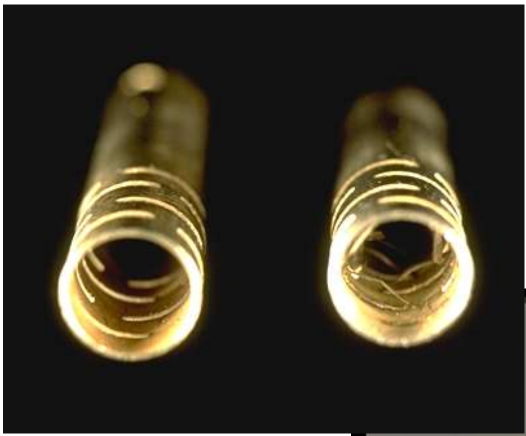
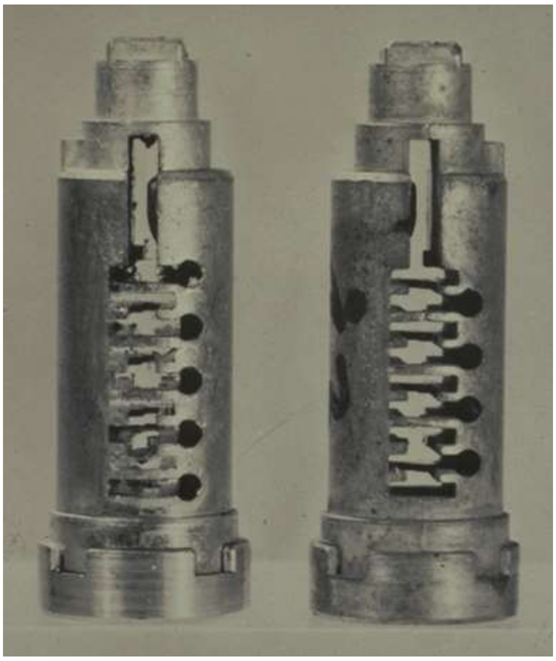
TEM: Before & After Parts

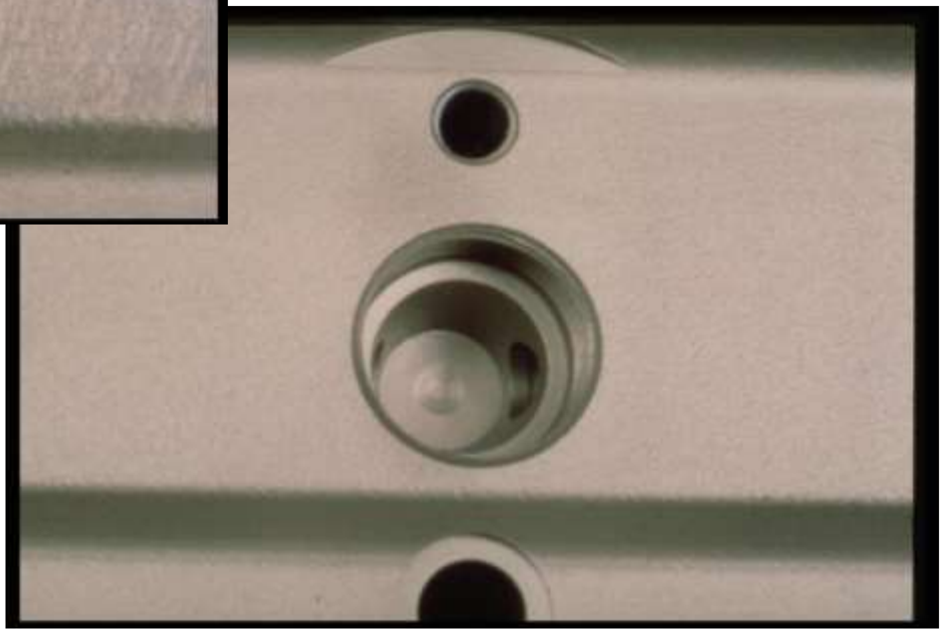
Small Parts



Die Cast Components



Internal Burrs



Machined Burrs

Transmission Banjo Bolt

Ugh! & Wow!