Practical Applications of Thermal Deburring and Electro-Chemical Deburring

Abstract

Many engineers will claim a part is produced "burr-free". This is a myth. The part may be burr free enough, but burrs will always be there! Burr removal on machined parts can be accomplished by a wide range of process. Described are Thermal Deburring and Electro-Chemical Deburring – practical applications and limitations of each.

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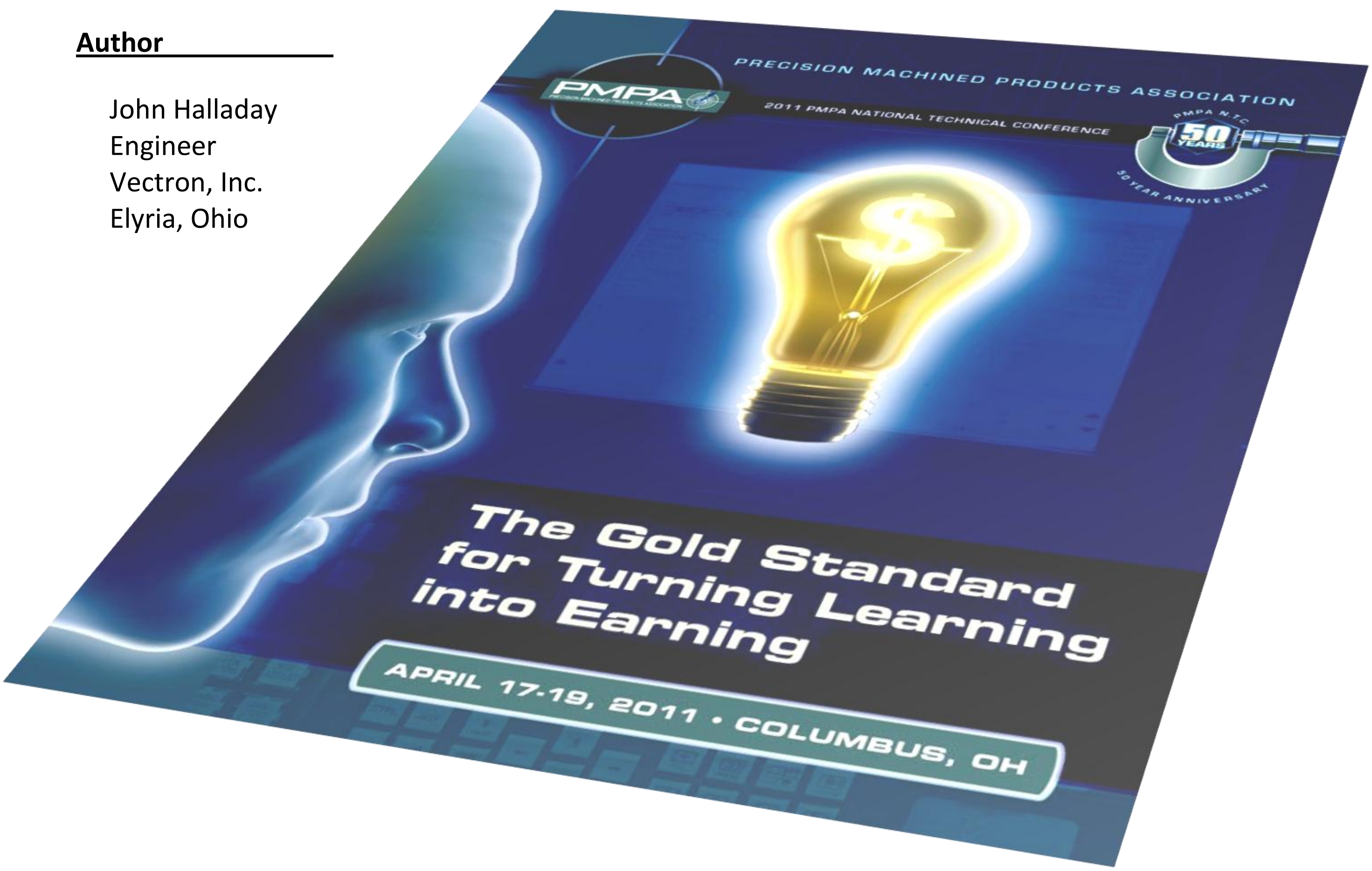

Introduction

Deburring is a consideration, and often a problem, for all manufacturing engineers. Many engineers will claim a part is produced “burr-free”; this is a myth. The burrs resulting from a manufacturing operation may be tolerable, however burrs are always present.

When the engineer determines a burr must be removed there are numerous manufacturing processes from which to choose. This paper deals with Thermal Deburring and Electro-Chemical Deburring - the practical applications and limitations of each. Although the scope of this paper is applications, a short description of each process is in order.

Thermal Deburring

Thermal Deburr (TD), as the name implies, is a manufacturing process utilizing heat energy to remove burrs. The parts to be deburred must be thoroughly cleaned removing all traces of cutting fluids, rust inhibitors, etc. They are placed inside a very thick walled steel chamber, about the size of a standard sauce pan. The chamber is closed and sealed with a toggle mechanism exerting 250 tons of force. The sealed chamber is pressurized with a mixture of combustible gas, typically methane and oxygen. The gaseous mixture is ignited with an electric ignition device creating a powerful explosion. The explosion creates a very intense heat approaching several thousand degrees Fahrenheit within fractions of a second. This intense heat energy will attack anything with a high surface area to mass ratio.

While this paper does not attempt to define a burr, it is generally accepted that a burr is an undesirable projection of material resulting from any of a number of manufacturing operations (ref. SME MR79-743), and burrs do have a high surface area to mass ratio.

With this definition in mind, the burr absorbs the heat from both sides. The heat cannot transfer from the burr to the parent material because the burr is very narrow at the root. The burr is rapidly oxidized, “burning” down to the parent material resulting in the elusive “burr-free” edge. An analogy often used is to imagine moving a lit propane torch rapidly down your arm; the hair would burn off without burning your skin.

One of the most unique aspects of TD is that the deburring “media” is a gaseous mixture. The word “media” is a reference to the abrasives or implements commonly used in other forms of deburring, such as mass finishing and hand deburring. Being a gas under pressure, the deburring “media” completely surrounds all burrs in the smallest and deepest holes, even if the burrs cannot be seen! This assures that all burrs are removed to the same consistent degree on every part, a goal of every manufacturing engineer involved with the usually inconsistent operation of deburring.

The blast of heat is accompanied by a shock wave. Most parts require fixturing to protect critical external surfaces and/or edges during processing. Fixturing is also used to heat sink very thin cross sections (high surface area to mass ratio) and/or to expose external burrs which may be heat sunk if the part were placed directly in the chamber. Some parts, such as large cast iron valve bodies and large aluminum manifolds, do not require fixtures. Small parts, with internal burrs only, can occasionally be batch processed. The restriction of “internal burrs only” is made because any external burrs can contact an adjacent part, heat sinking the burr causing insufficient deburring results.

Thermal Deburring will not change any dimensions, surface finishes, or material properties of the parent part when performed properly with adequate fixtures. The reason for this is that the parts are exposed to the intense heat for only a fraction of a second, with the actual part not exceeding a temperature of only a few hundred degrees Fahrenheit. Threads are also not affected because they are very wide at the root allowing the heat to transfer to the part.

As previously mentioned, the burrs are “burned” off of the part. The word “burning” is used in quotations because it is not technically correct. Burning is merely common terminology for rapid oxidation; therefore, to be technically correct, the burrs are rapidly oxidized. Because the burrs are rapidly oxidized an obvious by-product of the process is that an oxide of the parent material is formed on the part. Thermal Deburring aluminum generates an aluminum oxide, steel generates a ferrous oxide, zinc generates a zinc oxide, etc. The oxide formed by the burning of the burr is deposited on the part. This generally must be removed. Post TD processing operations can be difficult and generally require specialized equipment, rooms, waste water treatment, and dangerous chemicals. If parts are to be subsequently plated, anodized, heat treated, etc., often times the post TD processing can be eliminated.

Another important cleaning consideration can occur because it is very difficult to provide burrs or flash of a consistent nature after any manufacturing process. The TD process is likely the most forgiving as any deburring process can be; however, because not all burrs are consistent, very large burrs are occasionally not completely oxidized. When this occurs the burrs not totally burned take the form of small molten particles that are partially attached to surfaces of parts, especially internal surfaces. The partially oxidized burrs are very similar to weld spatter and must obviously be removed. Any deburring job shop specializing in TD will be able to provide all of the necessary processing required so that the parts will be prepared for the next manufacturing operation. The post TD processing is very important and is often the most critical factor in the success or failure of the TD operation.

Thermal Deburring Applications

Thermal Deburring is widely accepted in manufacturing. Some of the benefits common to all industries of having parts Thermal Deburred include:

- ✓ Fixed manufacturing costs with no variances.
- ✓ Eliminating costly and time consuming hand deburring.
- ✓ Assurance that all burrs are consistently removed on every part.
- ✓ Reduce personnel and labor costs.
- ✓ Increase quality levels and reliability.

Specific industries receive benefits from TD in addition to those just mentioned and are outlined in the following case studies.

TD is used extensively in the screw machine products industry. Many parts have secondary operations such as milling and drilling into or through I.D. and O.D. threads. TD will remove the burrs in and around the threads without damaging the thread form, as is often the case with hand deburring. Screw machine jobs are typically high production quantity jobs and the volume of parts further amplifies the inadequacies of hand deburring as the operator tends to tire form the monotony of the task. With TD the gas never “gets tired” - the last part of a lot will be deburred as consistently and reliably as the first. This holds true for brass, aluminum, steel, stainless steel, and plastic screw machine products.

Another industry with relatively high production quantities is the die casting industry; both aluminum and zinc die castings. Manufacturing engineers involved with die castings are concerned with deburring and deflashing. Often both operations are done by hand and then an additional vibratory or tumbling operation is used. TD can eliminate one or both of these operations in most cases (See Figure 1).

Figure 1

The fluid power industry, both hydraulic and pneumatic, is an industry in which TD is commonly utilized. With fluid under pressure passing through cross holes in components, it is critically important to remove all burrs. A loose burr in a system can result in costly and often times dangerous failures in the field. As previously mentioned, the gases surround all burrs, even in the proverbial “swiss cheese” manifold block assuring complete burr removal. TD is used to deburr spools, cartridges, valve bodies, manifolds, and other components (See Figures 2 and 3 on the next page). Valve bodies made of cast iron are excellent candidates for TD. Not only is the part deburred better than with any other method, the cast-in core sand and other impurities are “blasted out” during processing, resulting in a very clean part with no loose burrs, chips, or sand.

Figure 2

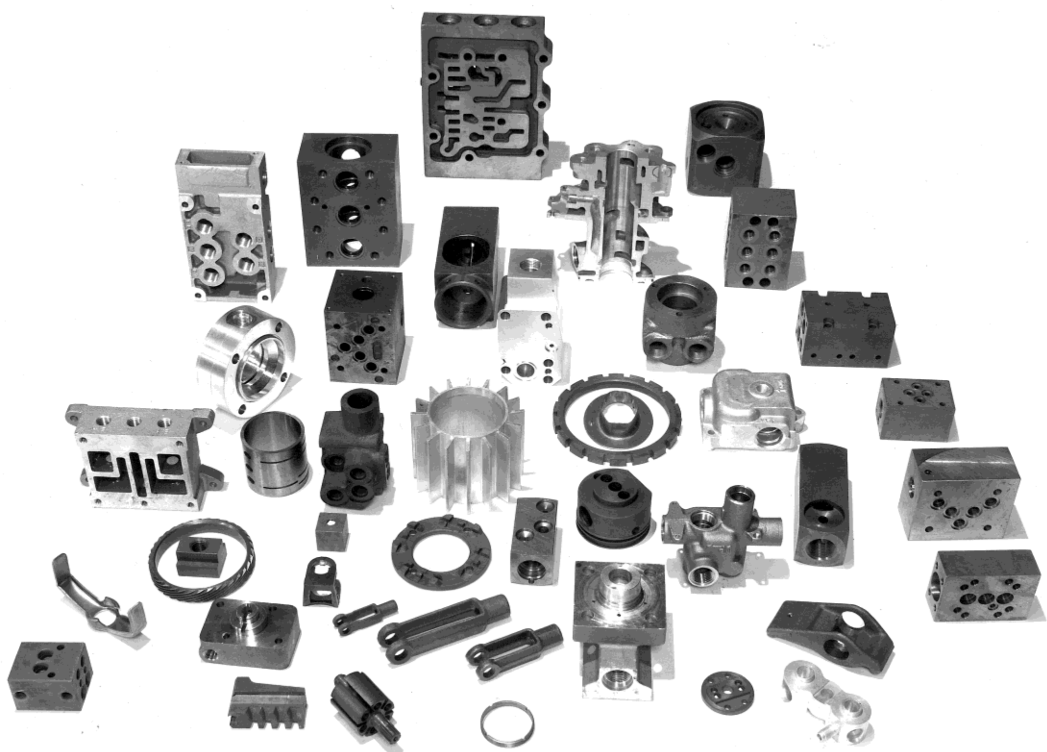

Figure 3

The list of industries served by TD goes on and on and grows as the knowledge of TD spreads. Recent advances include the processing of thermoplastics. TD will not replace all other forms of deburring, nor is it intended to. In fact, TD is sometimes used in conjunction with other methods to achieve the required results. TD is another manufacturing method at the disposal of today's manufacturing engineer to be used when the situation arises.

As a new product is designed, most design engineers attempt to utilize the manufacturing capabilities of the equipment available. Because TD is a manufacturing process, it is very important at the design stage for the engineer to take into consideration the capabilities of the process. If at the start of the design of a new part a Thermal Deburring specialist is consulted, quite often minor changes can be made to conceivably play an important role in the cost reduction on the finishing operation, without affecting the form, fit, or function of the part.

Limitations of Thermal Deburring

TD is effective on nearly all engineering materials, although as with any manufacturing operation, it is more suitable for some than others. As previously mentioned, the burr must absorb heat from both sides, reaching a high enough temperature to oxidize the burr. These two very critical steps in TD, heat absorption by the burr and oxidation of the burr, become difficult to achieve if the material resists oxidation and/or has a high heat transfer coefficient (the burr absorbs the heat but rapidly transfers it to the part). Occasionally higher energy levels can be used to provide excellent results and Vectron routinely processes stainless steel and copper alloy parts for many industries. These are traditionally two very difficult materials to process. A discussion on TD limitations would be sadly incomplete without mentioning magnesium. All that can be said for this particular engineering material is that regardless the size of the burrs, all of the burrs will be gone!

Electro-Chemical Deburring

Electro-Chemical Deburring (ECD) is a localized deburring process using electrical energy to remove burrs in a specific location as opposed to TD, which provides general burr removal. The part to be deburred is placed on a nonmetallic locator which locates an electrode in the exact vicinity of the burr(s). The work piece (anode) is charged positively, the electrode (cathode) is charged negatively, and an electrolyte solution is directed under pressure to the gap between the burr and the electrode. The flow of electrolyte precedes the application of the current to flush out any loose chips which may cause a short in the system damaging the part, the tooling, and/or the equipment. A controlled radius is generated as the burr is dissolved. The ECD process is extremely consistent from part-to-part and lot-to-lot.

Fixturing is always required for ECD. The typical fixture consists of a plastic locator to hold the part and to insulate or "mask" areas of the part not requiring ECD, and a highly conductive metallic electrode. The electrode is designed with a contour that conforms to the desired dimensional characteristics of the area to be deburred. The flow of electrolyte is directed by the locator and/or the electrode, depending largely on the specific techniques utilized by the fixture design engineer. The manufacturing engineer has precise control of the ECD process through the variables of voltage, electrolyte flow, and cycle time.

ECD will change the dimension of a part only to the extent of removing the burr, leaving a controlled radius. Thus the dimensional change is desirable and is generally required to make a part "to print". ECD will only affect areas of the part in the vicinity of the electrode if the fixture is properly designed and maintained. As previously mentioned, the locator can be designed to protect critical areas and/or surfaces, including threads, although ECD is extremely effective in removing burrs in threads from milling and drilling operations through the thread form (See Figure 4).

Figure 4

Electro-Chemical Deburring Applications

ECD is effective on all electrically conductive materials. The two materials noted in the limitations of TD section, copper alloys and stainless steel, are both excellent materials for ECD. Occasionally Vectron will use both ECD and TD in combination to provide a very high quality deburring job.

ECD, as with TD, is another manufacturing operation to be used as a tool by the manufacturing engineer. The benefits of having parts ECD'd include:

- ✓ Fixed manufacturing costs with no variances.
- ✓ Eliminating costly and time consuming hand deburring.
- ✓ Assurance that all burrs are consistently removed on every part.
- ✓ Reduce personnel and labor costs.
- ✓ Increase quality levels and reliability.

Additionally, another significant advantage is the fact that the radius generated during ECD is controllable. This can be a solution to functional problems such as removing burrs and/or sharp edges from the I.D. of valve bodies where cross holes intersect. The radius resulting from the ECD operation will eliminate the possibility of destroying elastomer seals during assembly and/or operation of the valve. This is also applicable to cast-in ports.

Another useful application of ECD is in the dial gage movement industry. The burrs created on the gear form of the movement during the hobbing operation must be removed without damaging the delicate involute gear form. ECD does an excellent job accomplishing this requirement. In additional to the deburring function, ECD actually improves the surface finish on the face of the gear form, reducing gage error and hysteresis. This also applies to gears used in other industries.

ECD and TD are often used in the ordnance industry to provide the exacting quality demanded by manufacturing engineers in the industry. The reason the quality is so important is the ordnance component only has to work once and there are no second chances! They must perform while being subjected to some of the highest forces that mechanical mechanisms can withstand. The forces from the incredible velocities, accelerations and RPM's that cause many of the components to function are the same forces that can cause disastrous malfunctions if the sliding, indexing, or rotating surfaces and edges are not properly deburred. Also, these same forces can cause a single loose burr or incompletely removed burr to become dislodged from a stationary component and jam or retard the critical movement of a precisely machined component. ECD and TD provide the manufacturing engineer the assurance that all burrs are removed every time providing the optimum in product reliability (See Figure 5).

Figure 5

ECD and TD are used in nearly all of the same industries. The decision of which process to use depends on the requirements of the part and the capabilities of the process, just as in specifying any other manufacturing operation.

Limitations of Electro-Chemical Deburring

As previously mentioned, ECD is effective on all electrically conductive engineering materials. Therefore, the major limitation of ECD is that plastics cannot be processed. There are other minor “limitations” which are not actual limitations, but rather practical limitations with regard to burr size and part size. There is not strict definition of either of these two limitations. Vectron routinely evaluates candidates for the ECD process. Only after a thorough evaluation by a qualified ECD engineer can a determination be made as to whether or not a part should be ECD’d.

One last consideration regarding ECD is fixture design. The designs can become elaborate and expensive to manufacture, therefore it is important that engineers experienced with the ECD process design and test the production fixtures.

Summary

ECD and TD, used alone or in combination, eliminate costly and time consuming hand deburring. These deburring operations are applicable to nearly all manufacturing processes, with no limits on how complex, or how simple, a part may be. The initial capital investment for TD and ECD units can be quite high and both require extensive maintenance. One alternative to purchasing machines is to take advantage of the contract deburring job shop specializing in both TD and ECD - (you betcha, Vectron!). Although “burr-free” machining is impossible, it is possible to remove burrs inexpensively and reliably with Thermal Deburring and/or Electro-Chemical Deburring.

Notes

For more information please call Vectron at 440-323-3369 and ask to speak with one of our experienced Deburring Engineers. Thank You!
www.vectron.cc