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# Thermal Energy Method of Deburring, A Game Changer in Fluid Power Industry

## Introduction:

Burr, an undesirable outcome of machining processes, is a common cause of concern to the manufacturing fraternity. Though conscious efforts are made at every step in the design, process planning and manufacturing, it is quite a challenge to ensure that finished parts are completely free from burrs, consistently. Burrs, if present in the component, ruin the design integrity of the part, require additional processes to fix it, cause safety hazards and result in malfunction of the product. All these side effects represent unnecessary cost to the industry in various forms such as additional manufacturing, warranty, service, recall and collateral damage on the company image. Therefore, in most cases, it is a must either to remove or to secure the burr in order to prevent it from being detached from the part

## Definitions & Characterization of Burrs:

Going by the dictionary, a burr is a raised edge or small pieces of material remaining attached to a work piece after a modification process. Deutsches Institut für Normung (DIN) defines an edge with a burr, a sharp edge and a burr free edge. The burr is described as "a work piece edge with overhang".

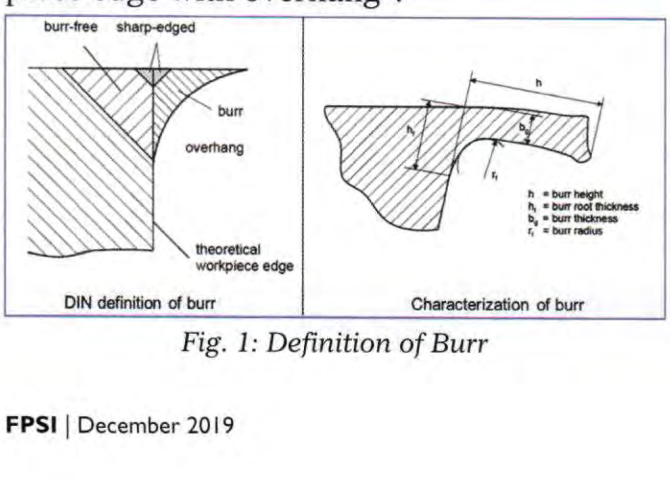



*Fig. 1: Definition of Burr*

Characterization of the burr depends on the application. In terms of deburring, how strongly the burr is attached to the work piece material may be the most important. Sharpness of the burr may be the most important criteria for safety concerns.

## Burr, An Unwelcome Element in Fluid Power:

In modern era, fluid power has found applications in many critical areas. From aviation to automotive to off-highway, fluid power has been entrusted with the most challenging tasks - control, manoeuvre, lift, dig, brake, steer, adjust and many more. Ever-increasing demand for higher power, faster response, finer control and compact sizes has driven modern day fluid power towards higher operating pressures, intricate designs and compact sizes. And that has brought a sea change in the perception of burrs.

Effect of presence of burrs in fluid power elements has always remained the same – anything from minor leakage to a complete breakdown. But, given the range of current widespread and demanding applications, the impact of such failures could be devastating.

## Conventional Deburring Methods

The most commonly deployed deburring method in industry is manual labour. Though manual deburring is flexible, low on initial investment and easily scalable; it is far from consistent. Skill and concentration being the requirements in manual deburring, it is almost impossible to ensure uniformity in output quality over a long period. Long working hours, absenteeism and manpower turnaround are some of the perennial challenges.

Typically, in any mass production environment, manual deburring creates bottleneck. Moreover, inaccessible areas in the component always remain suspect.

Other commonly deployed techniques are brushing, blasting, tumbling and vibratory. Though these processes are more productive and repeatable as compared to manual deburring, the chance of incomplete burr removal is high. Inaccessible areas still remain suspects. Undesirable side effect of these methods is cross-contamination - one part getting contaminated by burrs left over by previous parts. Hence, these processes do not guarantee burr free parts

Water jet, another commonly used deburring process, uses high pressure water to remove burrs. It works to the extent burrs are in the line of sight of water jet. Its effectiveness for ductile material is limited as burrs tend to fold instead of getting dislodged.

## Thermal Energy Deburring

Thermal Energy Method (TEM) of deburring utilizes energy generated in combustion of gases to oxidize burrs. This method differentiates burrs from the component by the ratio between surface area and mass. Burrs, which are high on this ratio absorb most of heat and get vaporized in oxidation. It is similar to a candle wick burning without lighting the surrounding wax.

TEM produces intense heat energy by igniting a pressurized mixture of combustible gas and oxygen within a sealed, specially controlled chamber. Due to sudden release of heat energy, high temperatures up to 2500° C – 3500°C is generated for few milliseconds. Because of this

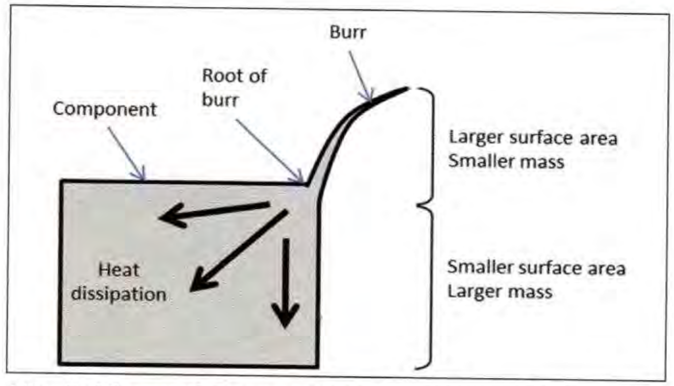



*Fig. 2: Thermal Energy Method (TEM) of Deburring*

intense heat, burrs & flashes catch fire, burn in excess oxygen and vaporize till heat gets dissipated into the body of the work piece. In the process, work piece also gets heated but to such a limited extent that there is no change in its metallurgical properties.

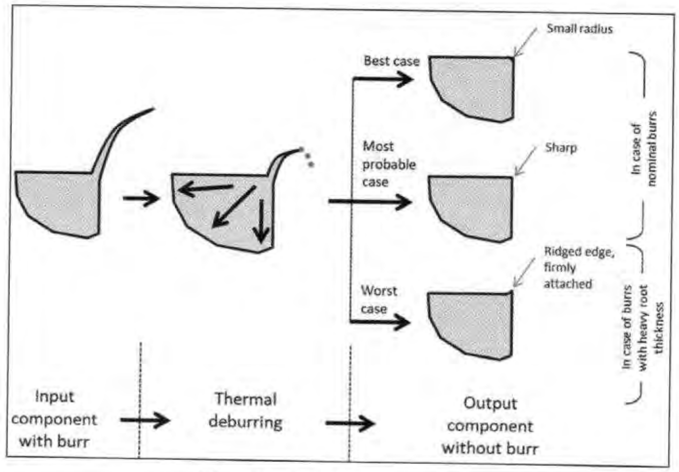



*Fig. 3: TEM Scenarios*

As gas covers all internal and external areas of component, TEM ensures overall deburring in one go. Deburring of multiple parts is a possibility as gas finds its way around them. Cycle time of the process, excluding component loading and unloading, is typically less than a minute.

The amount of burr that can be removed in TEM is determined by the volume of gas injected into the chamber, the thickness of the burrs, the heat transfer rate of the material being processed, and the ratio of fuel to oxygen.

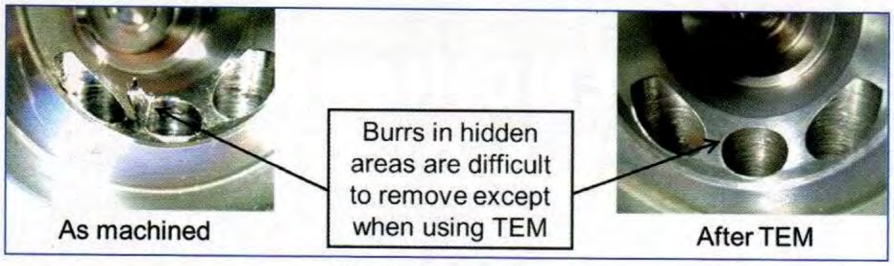



*Fig. 4: Comparison*

## Comparison Among Different Deburring Processes:

| | Manual | Vibratory | Blasting | TEM |
|---|---|---|---|---|
| Cycle time | Minutes | Hours | Minutes | 30-70 sec |
| Running Cost | Low | Low | Low | Lowest |
| Reliability | Moderate | Moderate | Moderate | High |
| Leaves contamination in surface | Maybe | Maybe | Yes | None |
| Can reach inaccessible locations | No | No | No | Yes |
| Meets demanding requirements | Risk | No | No | Yes |
| Reduces labor | No | Yes | No | Yes |
| Batch flexibility | None | Yes | Yes | Yes |
| Generates secondary burrs | Yes | No | No | No |
| Possibility to bend over flash/burr | Maybe | Yes | Yes | No |

## Process steps involved in TEM

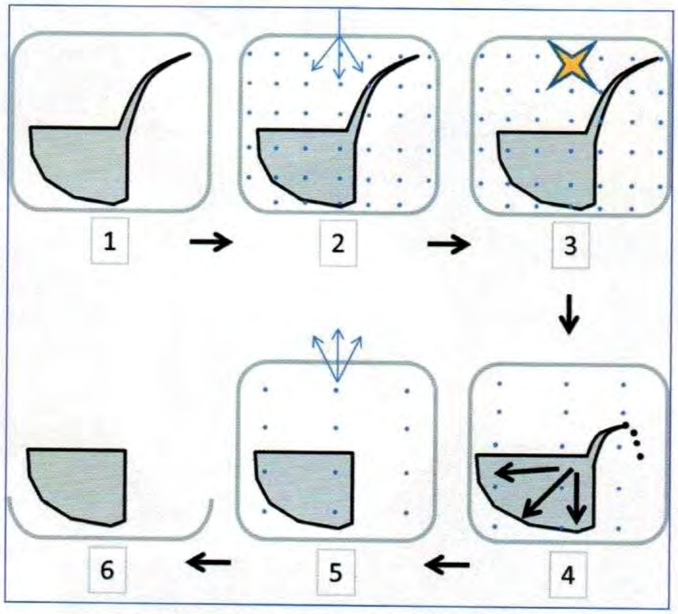



*Fig. 5: Process Steps in TEM*

1. Component to be deburred is loaded to TEM chamber and chamber is closed
2. Chamber is filled with pressurized mixture of gases
3. Gas is ignited
4. Burrs are oxidized, and component is deburred
5. Chamber is vented to de-pressurize
6. Chamber is opened, and component is unloaded

## Important Elements Involved in Thermal Energy Deburring:

- Chamber – a totally sealed, water cooled enclosure, resilient enough to withstand repeated thermal and mechanical shocks
- Mixing block – a metallic block where pressurized gases are mixed and ignited
- Spark plug – ignites the mixture of gases
- Fuel gas – any one of the fuel gases: hydrogen, compressed natural gas and methane to produce heat energy on combustion

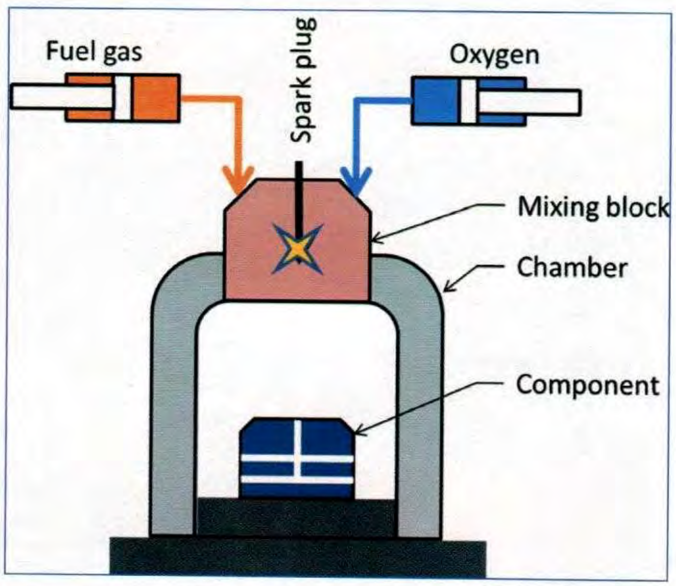



*Fig. 6: Elements Involved In TEM*

- Oxygen – aids in combustion, always supplied in excess to ensure oxidation of burrs and flashes
- Component – made out of commonly used materials: steel, cast iron, brass, aluminium, zinc, bronze and even some

plastics, firmly secured to a fixture to avoid damage due to thermal shock

## Applications:

TEM process of deburring and de-flashing is commonly used for:

- o Critical components which are to be absolutely burr free – fluid power, diesel fuel injection, and power transmission are a few of the major industry segments which demand burr free components for enhanced system reliability. TEM finds numerous applications in these fields. Most of these components have intricate shapes with a lot of inaccessible areas and intersecting holes. Given its ability of complete deburring, no other method of deburring has been as successful as TEM.
- o Mass produced components – short cycle time and possibility of accommodating multiple parts in a cycle make TEM a fast and economical process. Screw components, hydraulic fittings, automotive parts, lock cylinders, die cast components are some of the common TEM applications.

Intricate components with inaccessible areas – where other deburring methods have very limited success.

## Typical Components from Fluid Power Industry:

- Valve bodies – with lots of intersecting holes, grooves, threads and inaccessible areas, these components are a deburring nightmare. TEM is ideally suited for valve bodies. Efficient deburring makes assembly easy, spool movements free and entire system reliable

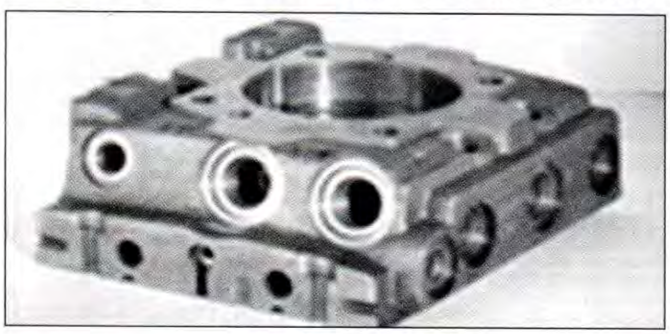


*Fig. 7: Valve Bodies*

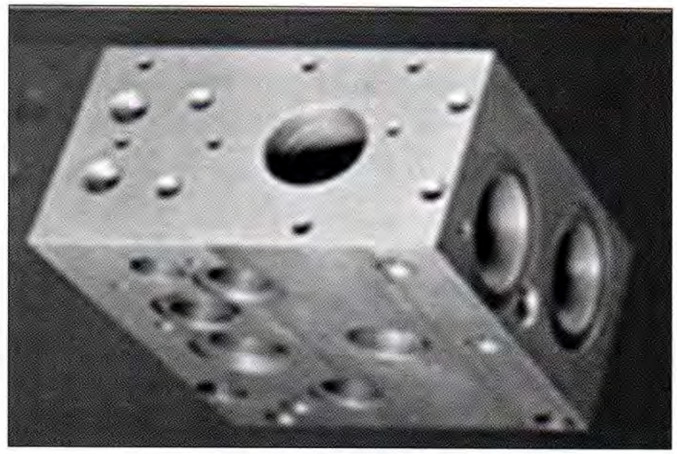


*Fig. 8: Manifold*

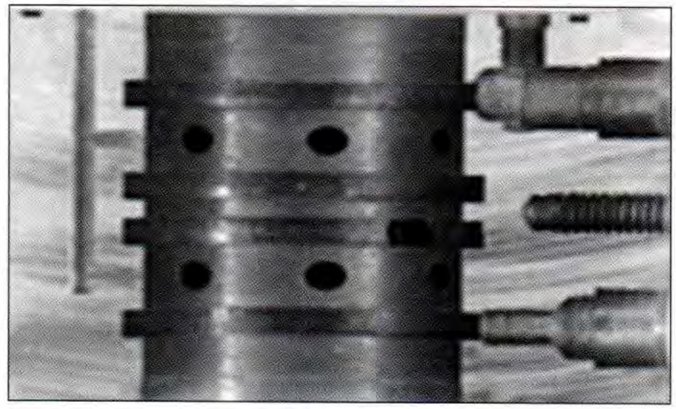
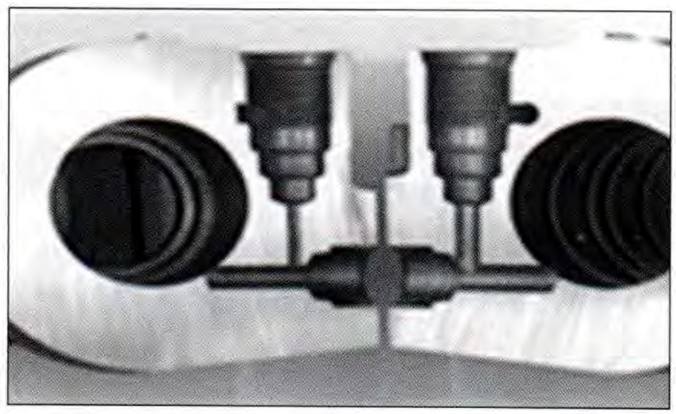


*Fig. 9: Spools*



- Manifolds – with challenges similar to valve bodies, manifolds are well suited to TEM deburring.

- Spools – precision grooves and intricate holes & notches make spool too intricate to be manually deburred. Ineffective deburring can cause inappropriate system functioning and even jamming.
- Pump and hydraulics motor elements – high pressure pumps and hydraulics motors, characterized by very small clearances between moving parts, are susceptible to failures if the elements are not deburred effectively.
- Cylinder components – cylinder porting blocks and end caps are common in TEM deburring
- Hydraulic fittings – often ignored, these are a common source of burrs. Once dislodged, burrs go to other critical areas in the circuit causing havoc.

Threads – a common source of contamination, yet they are not usually deburred at all. When connectors are fastened burrs get dislodged and get into the system. This leads to premature wear and failure. TEM does a perfect job to clear up the small particles along the thread major diameter.

## Limitations:

- o TEM is not suitable for magnesium, titanium and copper
- o TEM process cannot guarantee defined edge radius
- o After TEM deburring, a loose layer of metallic oxide is formed on the component making post-TEM cleaning a must in cases where parts are not heat treated, plated or anodized. Most plating and anodizing lines include a pre-cleaning step already designed to remove oxidation. Heat treating furnaces are the opposite of TEM. Their reduction atmospheres clean oxides after heat treatment.
- o TEM cannot handle thick (> 0.25 mm) and excessively long burrs – after TEM they form metallic balls
- o Incoming parts are to be free from oil, excess moisture and compacted chips

## Industry experience:

"Danfoss Power Solutions (Ames, Iowa USA) is a global company focused on fulfilling the needs of off-highway vehicle manufacturers with engineered hydraulic and electronic components. We manufacture hydraulic manifold for hydrostatic pump. They are high volume component. The main issue is burrs removal on intersected holes, cross-sectional holes from previous machining operations. We are using Extrude Hone solution. Combination of TEM and post washing process provided us more consistent and reliable process, significant improvement of productivity and increased safety of overall process.

All of this has been achieved with fully automated robotic integration. If machining process is under control (tool life management is very critical, and control of burr size is important too) TEM process with washing (machine also from Extrude Hone) will give you the best process reliability and repeatability.

High pressure water jet process did not provide this value."

Lubos Hanulik, Operations Manager at Danfoss Power Solutions October 9, 2012 edited March 2015.