

## COOLPULSE™ TECHNOLOGY

### **Enhanced finishing solution for metal 3D Printed, also referred to as Additive Manufactured (AM), components.**

COOLPULSE™ (CP) falls under the category of the Anodic Metal Dissolution Technologies, similar to Electro Chemical Machining (ECM) or Electro Polishing (EP).

The component is machined by utilizing tool that mimics the surface geometry of the 3D Printed component. The printed part is connected to a positive electric pole (anode), and the printed tool is connected to a negative electric pole (cathode). The surface of the printed part is machined by running an electrolytic solution between the parts, while driving a controlled DC current between the part and the tool.

Benefits of COOLPULSE™:

- COOLPULSE™ uses PH neutral, environmental friendly, electrolytes which do not have a strong edge rounding tendency. This is a large technological advancement over Electro Polishing.
- COOLPULSE™ will complete the component surface independent from resistance which is a technological advancement over Electro Chemical Machining process that get most of machining done always on the smallest resistance.
- Strong focus on machining peaks and edges of component due to higher Current density than in flat areas, to produce better surface finishes.
- Capable of machining larger surface areas by flowing exclusive electrolyte solutions that decelerated ions travel rate.
- Capable of producing COOLPULSE™ tooling rapidly, cost effectively, and with complex geometries through the utilization of 3D Printing.

Advancements in COOLPULSE™ technology over the years has produced an advanced product that now offers additional benefits over historic models:

- Improvements in microstructure of Metal 3D Printed Components ( $R_z < 4\mu\text{m}$ )
- Improvements in macrostructure of components
- Ability to complete internal & external finishing of components in one cycle
- Removal of remaining "pickles" from the support structures both internally & externally in the same stage of the process, similar to the surface finishing process.
- Multiple pieces can be done within one cycle
- Reasonable material removal, as well as reasonable edge rounding tendency

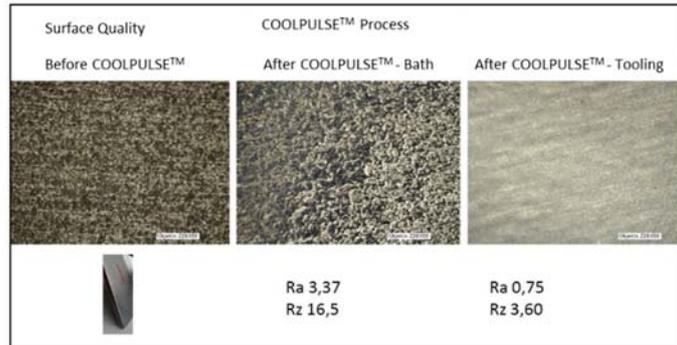
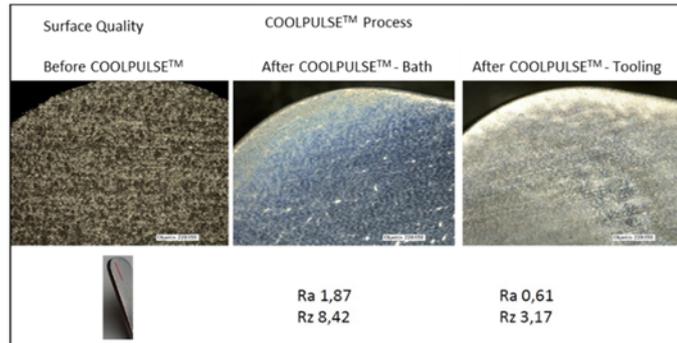
### Bath Technology :

- Able to improve micro finish, unable to improve macro finish drastically
- Micro finish Rz ~16 possible
- Strong effect on the edge !
- Outside finishing only

OR

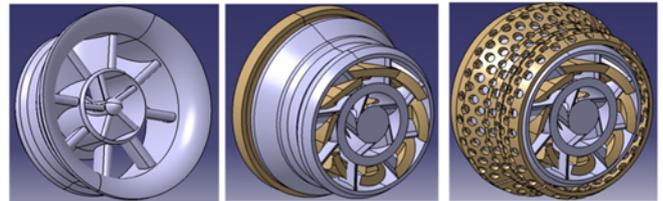
### Tooling Technology :

- Able to improve micro finish & macro finish of ALM part
- Micro finish with Rz < 4 possible
- Uniform results on edge & surface
- Outside & inside possible



### COOLPULSE™ Process:

1. Design part with Tooling according to our standards ( Supplied by EH )



2. ADD Anodic Contact Area to the Part



- A part design is intended for 3D Printing, it would be modified to also print a reference anode contact tab.

3. Print Cathode(s) with the Part & remove it from Baseplate



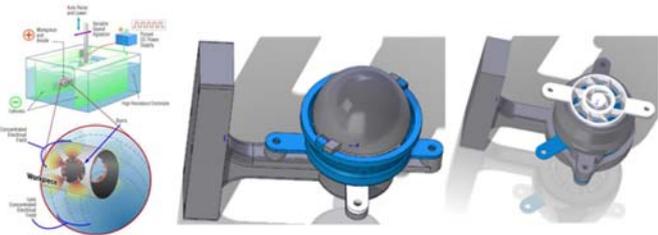
- Parts (with anode contact) and tools (cathodes) also coming with reference contact tab can be printed simultaneously, and can utilize the same 3D Printer materials. Mechanical finishing will be required like in any 3D printed manufacturing operation to remove construction structures.
- The part and tooling are assessed in a proprietary tool prior to part printing to ensure tolerances are met. Both components and tooling can be designed and optimized for the COOLPULSE™ process in less than 24 hours.
- In addition to part and tooling definition a set of parameters is also defined for the application. It will be directly uploaded in the COOLPULSE™ machine.

4. Assemble Tooling



- Reference tabs will ensure good contacting and mating between the cathode, the part and the patented Base Plate. Depending of the finishing requirement and complexity, several cycles might be required to cover the various finishing steps, while a Base Plate can also accommodate multiple cathode/part assemblies.

5. Run COOLPULSE Process



- Part and tooling components assembled on the Base Plate are run through a COOLPULSE™ machine to produce a finished component.
  - The tooling (cathode) does not see wear, and can be used for 1 or many components.

6. Remove Anodic contact

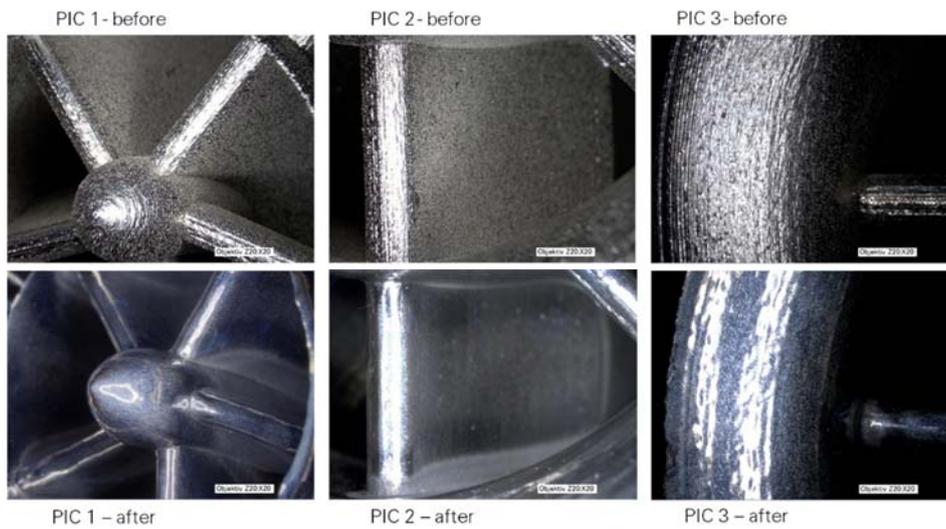


- After the COOLPULSE™ machining is done, the reference tab must be removed from the part.

**COOLPULSE™ Results,**

**Preliminary results, even better results can be achieved with advanced parameters an better incoming conditions.**





**COOLPULSE™ surface finishing benefits for 3D Printed components:**

- Attractive cost / benefit ratio
- Reasonable cost tooling
- Flexibility
- Short reaction times, utilizing 3D Printing technologies
- Easy to adapt, easy to implement, easy to understand
- High productivity
- Low material removal capabilities
- Reasonable Edge radiusing capacities