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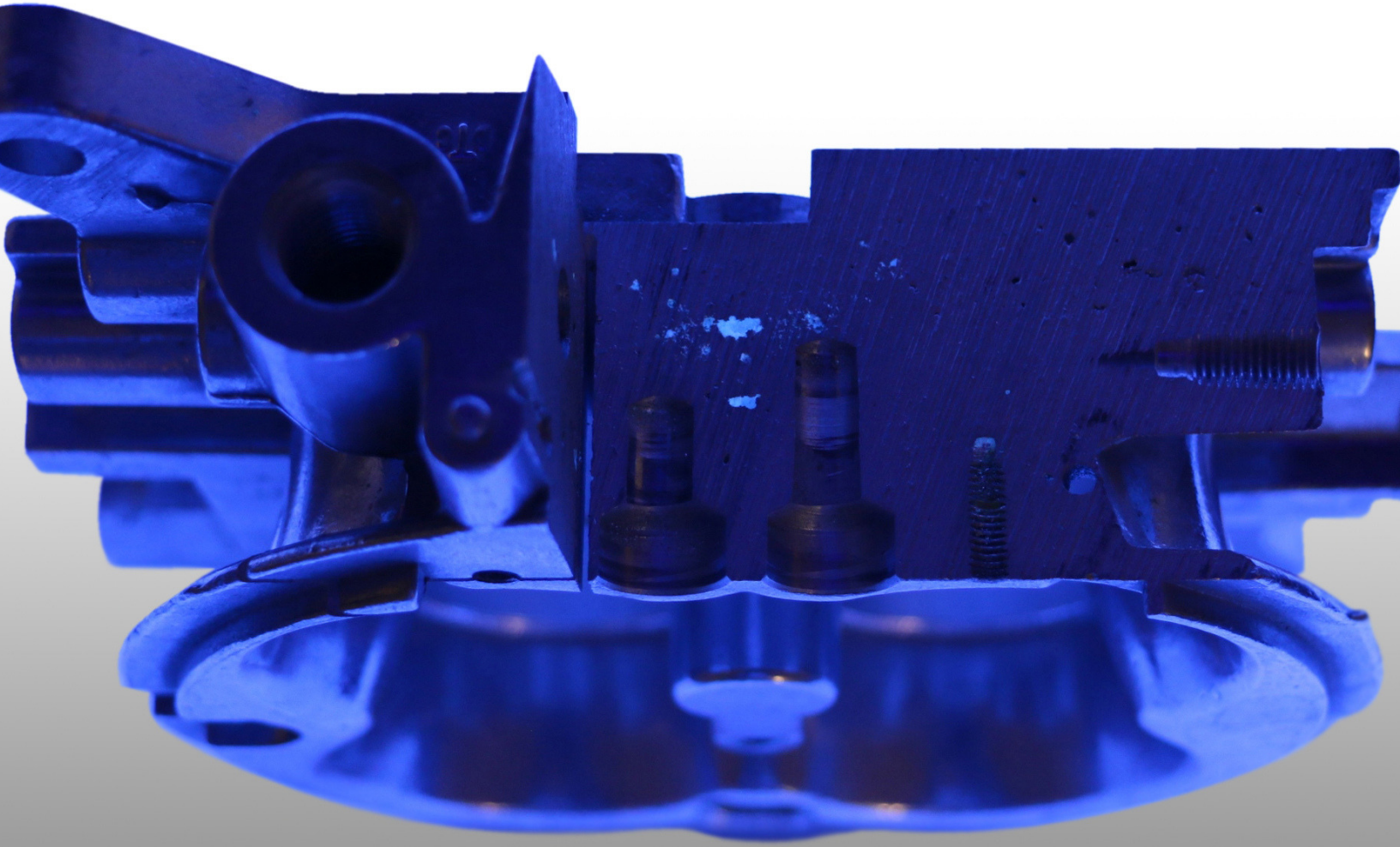
Understanding Porosity and Vacuum Impregnation



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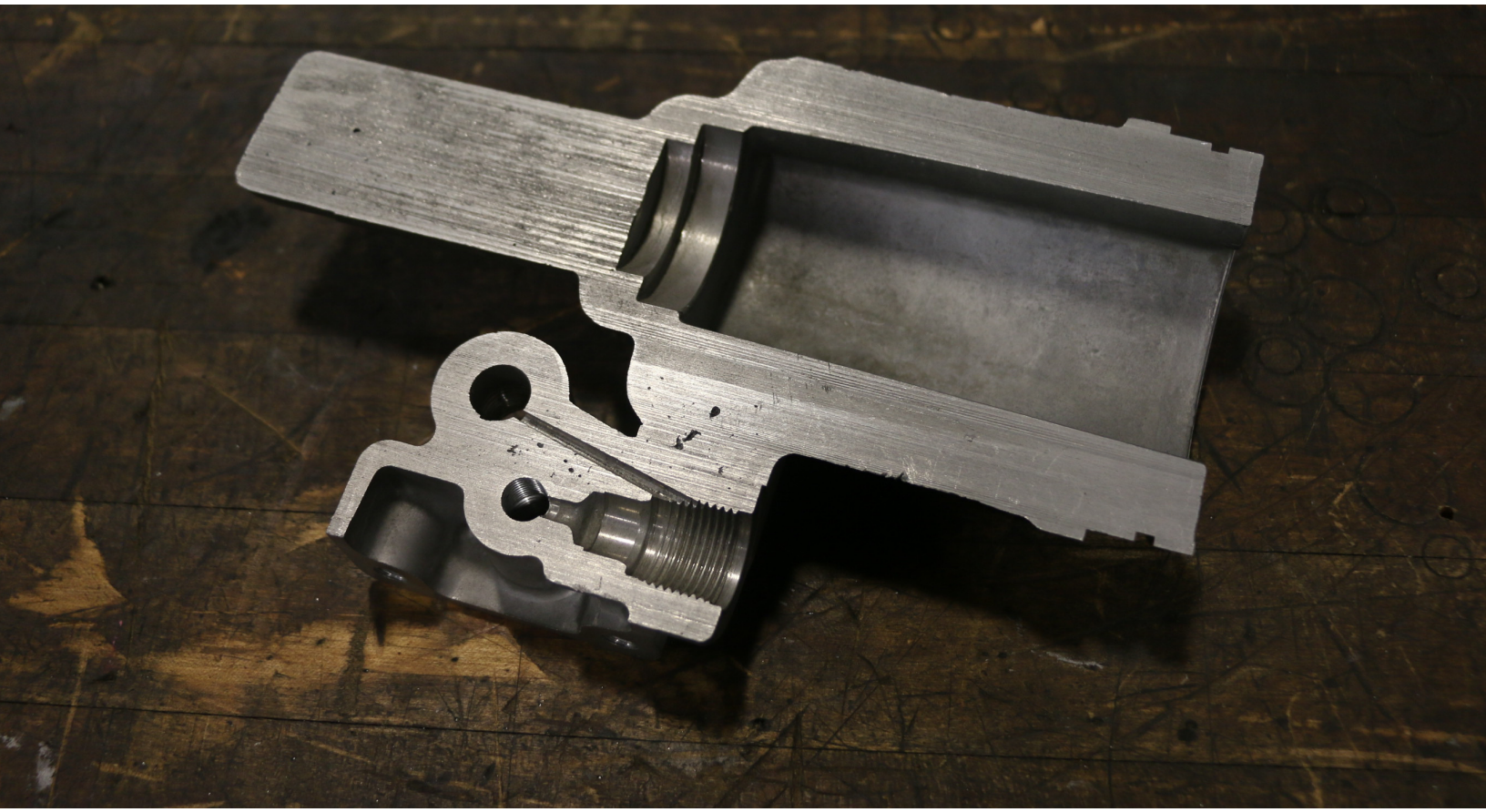

What is Porosity?

While some refer to porosity as a defect, it occurs naturally and is found in most materials, both man-made and in nature. In metal castings and plastic components, porosity is typically considered any void found in the part. Porosity can be caused by gas formation or solidification while the raw material is being moved from a liquid state to a solid state. This porosity can range in size, from sub-micron to voids greater than 10 mm wide, depending on the casting.

The result is that porosity can prevent the part from being pressure tight. This will impact functionality if the part is designed to hold gases or fluids.

In general, there are three casting porosity classifications:

Blind Porosity: From one surface only and therefore not forming a continuous passage for liquid (highlighted in blue in figure 1).

Through Porosity: Stretching from one side of a casting to another (highlighted in red in figure 1).

Fully Enclosed Porosity: Enclosed within the casting, and has no passage to the surface (highlighted in green in figure 1).

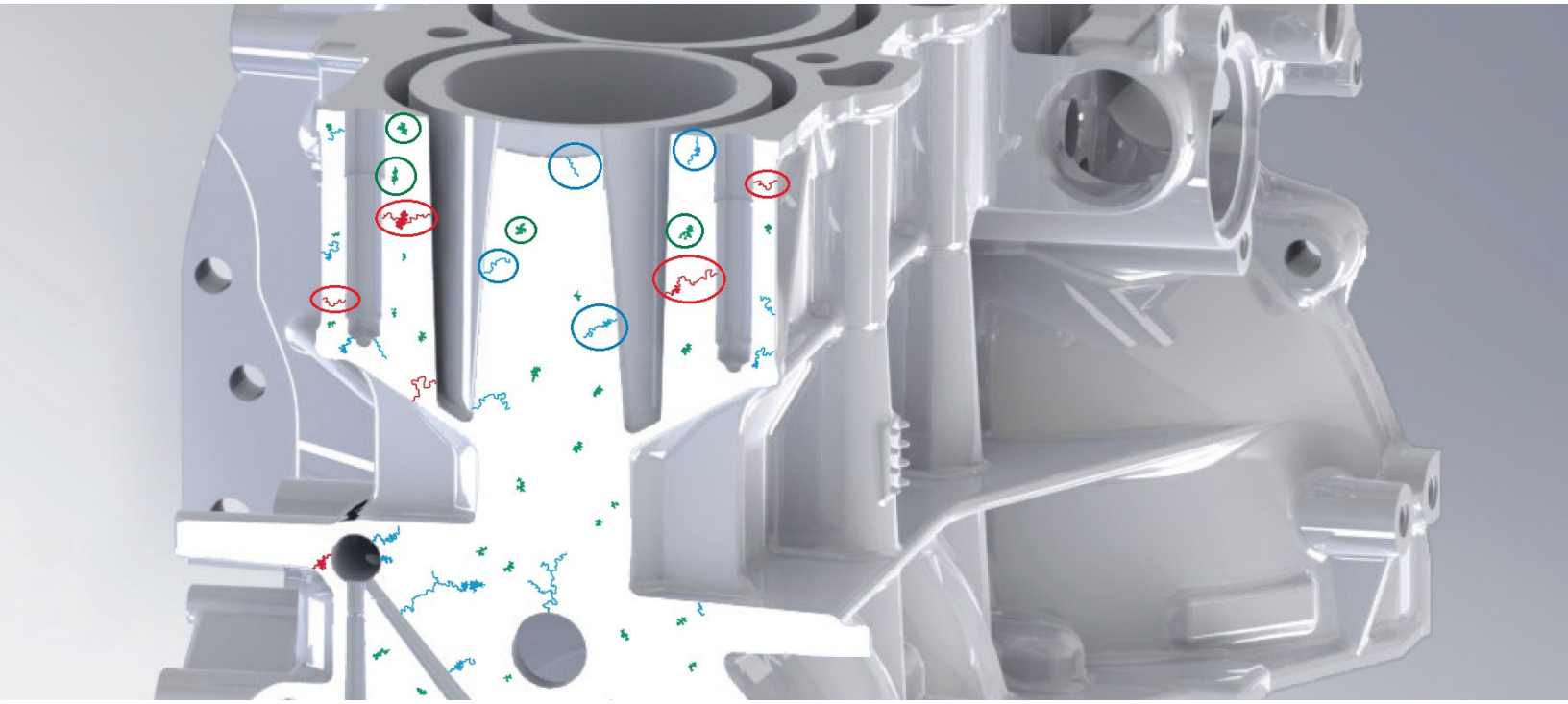

Figure 1: There are three types of porosity: blind porosity, through porosity, and fully enclosed porosity.

Blind and through porosity cause immediate problems. Blind porosity can cause internal corrosion in metal parts; while through porosity will create a leak path and allow gas and liquids to seep through the part (Figure 2). In addition, blind porosity can cause defects on the part surface when secondary treatments, like powder coating or anodizing, are done. This is because solutions used to clean the parts prior to the treatment will leech out of the voids during and after the surface finish process.

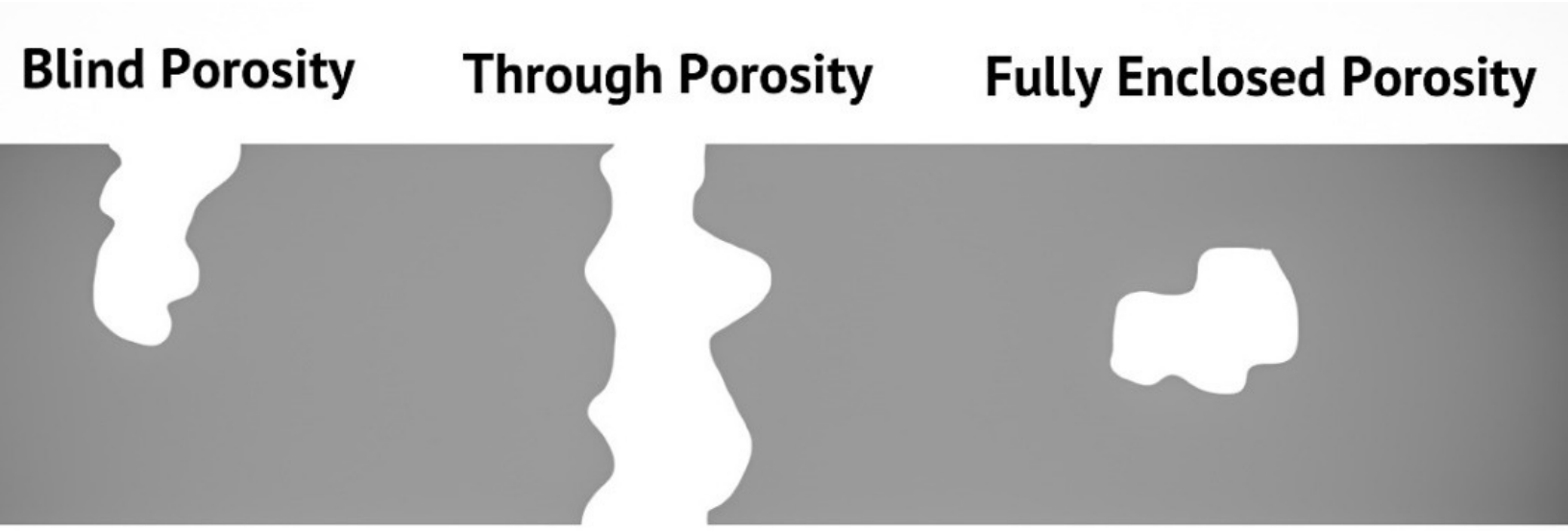

Figure 2: Blind porosity can cause internal corrosion; while through porosity will create a leak path and allow gas and liquids to seep through the casting.

Vacuum Impregnation

Vacuum Impregnation is a process that seals porosity without altering any other physical or functional properties of the part. Specifically, it seals the internal, interconnecting path of porosity, which breaches the part's wall. Vacuum impregnation allows manufacturers to use parts that would otherwise be scrapped. The process was developed in the 1940s and has evolved in recent years to be safer, more efficient and more effective. Vacuum impregnation is the preferred method to seal porosity in order to prevent fluids or gases from leaking under pressure.

Generally, the process occurs in the following four steps:

Step 1: The part is placed in an impregnation chamber, where a deep vacuum is created to evacuate air from the leak path.

Step 2: The evacuated leak path is filled with sealant by covering the part with the sealant while under vacuum and then applying pressure while the part is still covered.

Step 3: The part is moved to a wash/rinse station. Here, residual sealant is washed from the part's internal passages, taps, pockets and features where sealant is undesirable.

Step 4: The part is moved to a cure station. Here, the impregnated sealant is polymerized in the leak path with hot water.

Common Materials Vacuum Impregnation Seal

Vacuum impregnation is used in a variety of materials and processes where internal porosity is inevitable. Common materials sealed using vacuum impregnation are:

1. Die castings
2. Permanent mold castings
3. Semi-permanent mold castings
4. Sand castings
5. Lost-foam castings
6. Powdered metal parts
7. Over-molded electronics
8. 3D printed parts
9. Graphite and composite materials

What Size of Porosity Can Vacuum Impregnation Seal?

It's difficult to pinpoint a generic porosity range that vacuum impregnation seals because, generally speaking, one pore does not cause a leak path. A leak path is created through a series of interconnected pores. For example, a breach caused by a 5mm pore interconnected with a series of smaller pores will be easily sealed (Figure 3).

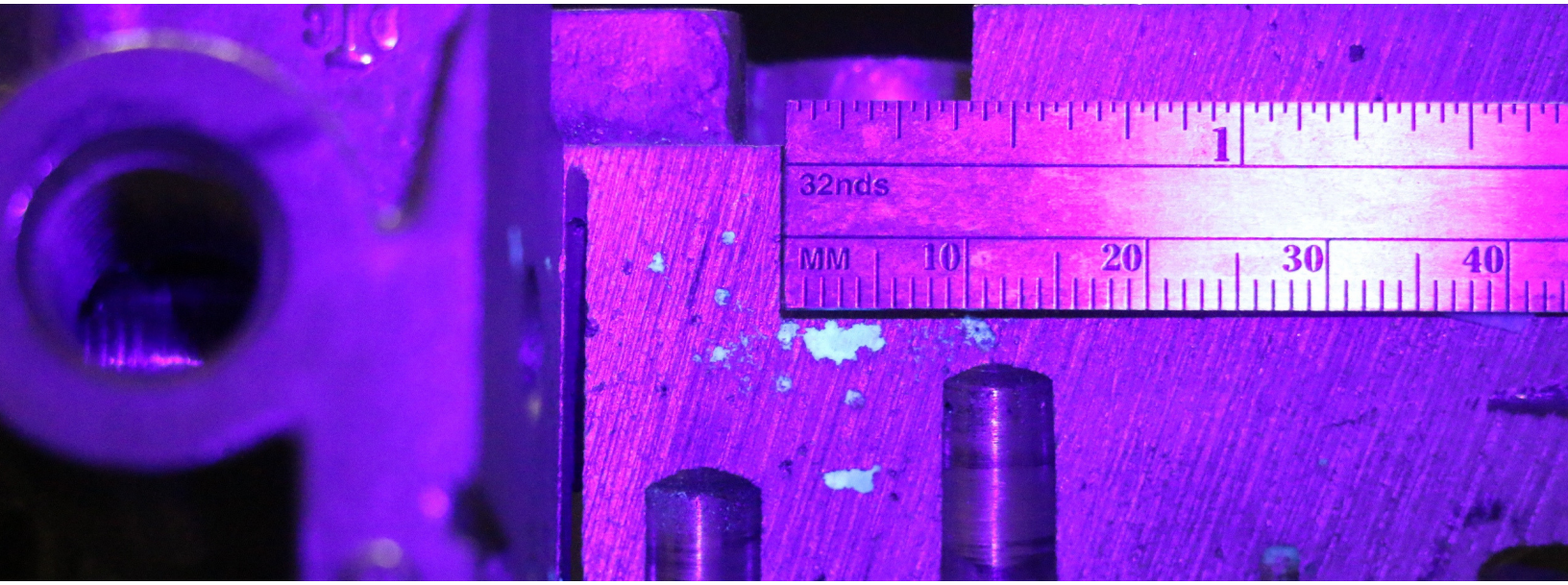

Figure 3: This sectioned casting shows a 5 mm pore that is interconnected to a series of smaller pores. Vacuum impregnation can seal this leak path.

Conversely, if the same 5mm pore breaches a 5mm wall it will be difficult, if not impossible, to seal as there is little casting material for the sealant to adhere (Figure 4). A pore of that nature has characteristics similar to surface porosity which is not a candidate for sealing through vacuum impregnation. One needs to view the porosity in three dimensions to see how it is interconnected, not simply analyze individual pores.

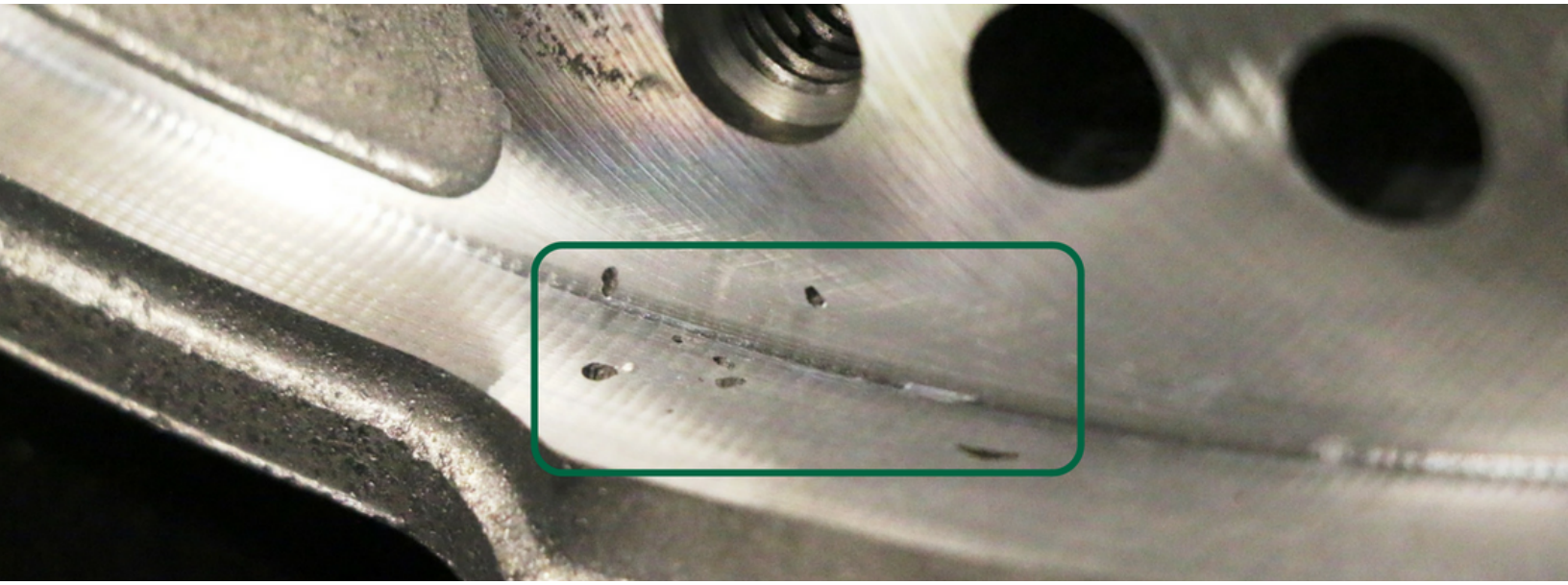

Figure 4: Vacuum impregnation will not seal this surface porosity. There is not enough casting material for the sealant to adhere.

The wide range of manufacturing parameters creates a limitless array of shapes and sizes of porosity possibilities. Despite this, vacuum impregnation can seal porosity of any size. While vacuum impregnation can seal porosity of any size, it is important to realize that the leak path is the key characteristic to evaluate and not pore size. A leak path is created through a series of interconnect pores, and not a single pore. Instead of asking "What size of porosity can vacuum impregnation seal?" one should ask "Can vacuum impregnation seal the leak path?"

When Should Vacuum Impregnation Be Performed?

Impregnating parts after final machining is the best way to insure leak free parts at build. Porosity can be opened during final machining, causing a previously undetected leak path to open (Figure 5).

Figure 5: Porosity can be opened during final machining, causing previously undetected leak paths.

The new inter-connected porosity (highlighted in green in Figure X) will create a leak path. The leak path will cause fluids and gases to leak from the part, causing it to be non-conforming, and in many cases unusable. Unfortunately, this occurs precisely at the wrong time, since the non-conforming part has already been cast, pre-machined, washed, tested, shipped, fully machined, washed and tested again. All the value has been added to the non-conforming part. In the worst-case scenario if the problem occurs frequently, the manufacturer may be at capacity and unable to replace the non-conforming castings with functional parts, delaying shipments and significantly increasing costs.

Figure 6: Machining can cause new inter-connected porosity

Vacuum Impregnation Misconceptions

To better understand how vacuum impregnation works, it is important to understand what the process does not do. Below are the three biggest misconceptions of the process.

1.Vacuum Impregnation is Not a Coating

Although parts are completely submerged and covered with sealant during the process, the sealant is completely emulsified and washed from all the surfaces prior to the final polymerization. Surfactants incorporated in the actual sealant promote the complete washing of the material from all surfaces. Only the sealant that has been drawn into the part's porosity by the force of the vacuum and pressure remains in the part.

Figure 7: Vacuum impregnation will not seal this surface porosity. There is not enough casting material for the sealant to adhere.

2. There are No Dimensional Changes to the Casting after Vacuum Impregnation

Vacuum impregnation allows engineers complete freedom to design and make parts to the actual net shapes. An engineer does not need to incorporate dimensional allowance for vacuum impregnation. In the final step of the process, the trapped sealant in the porosity polymerized with heat or absence of air (Figure 8).

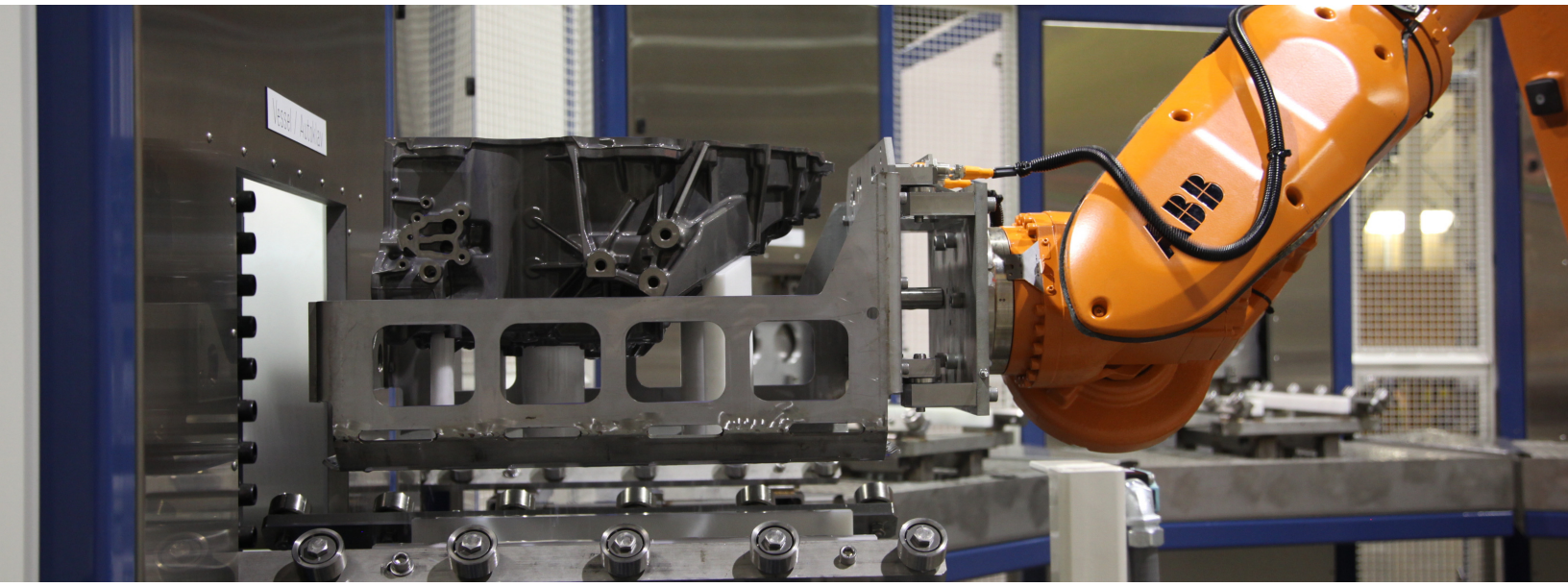

Figure 8: Vacuum impregnation allows the engineer to design the part to actual net shape.

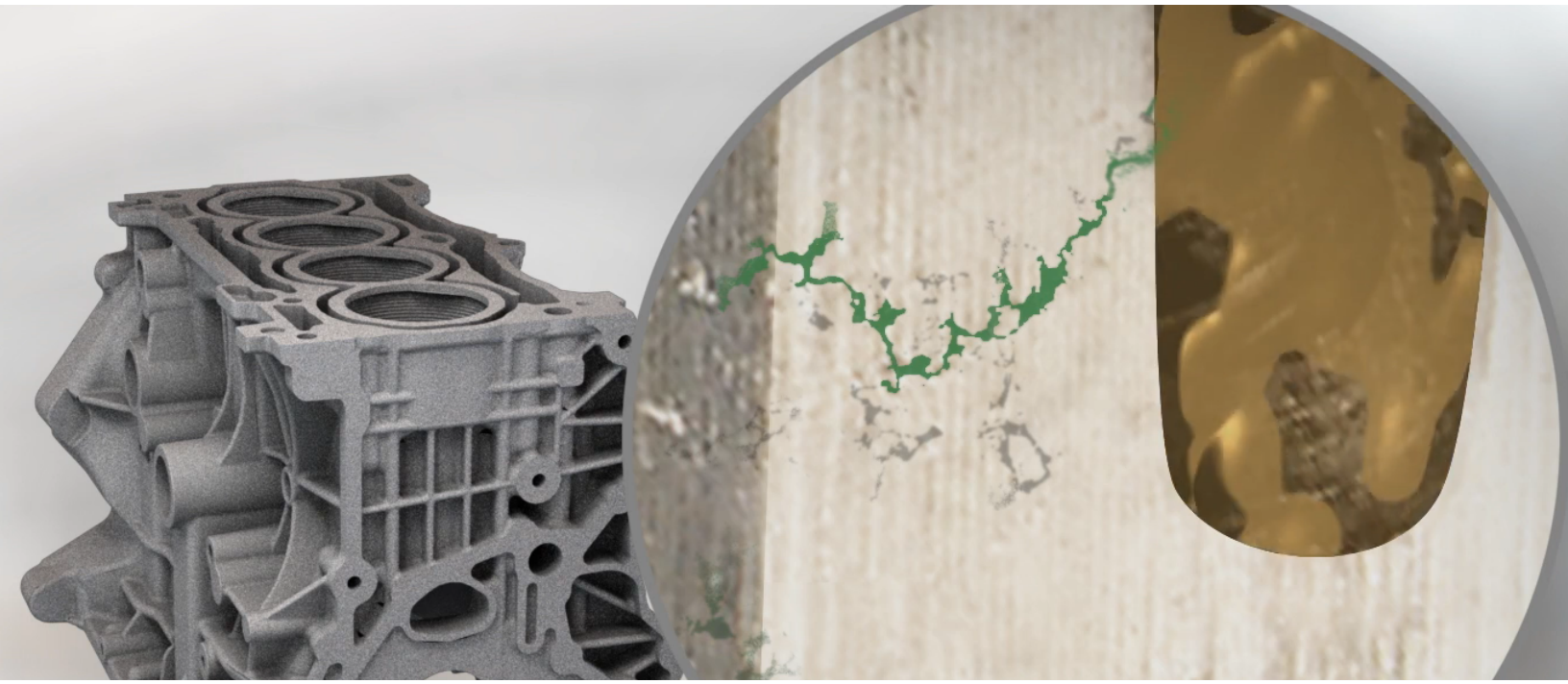

Figure 9: Vacuum impregnation seals the porosity, while any sealant on the surface are washed away.

3. Vacuum Impregnation Does Not Act Like a Cork or Plug

As mentioned before, the impregnation sealants are drawn into the open porosity and deep into the part's wall by the pressure used in the process (Figure 9). At the surface the sealants are washed away, because there is not enough material for the sealant to adhere. If there is visible or open porosity, the low viscosity sealants will most likely be washed out of any pits or holes.

A part with surface porosity or blemishes before the process will exhibit the same surface porosity and blemishes after the process. However, the porosity below the part's surface will be sealed.

Thank You For Reading

This condensed and simplified eBook is intended to provide a better understanding of porosity and vacuum impregnation. This information is a starting place to understand how vacuum impregnation can add value and eliminate unforeseen costs by sealing the internal, interconnecting porosity path. Vacuum impregnation will allow manufacturers to use parts that may otherwise be scrapped.

Why Godfrey & Wing

Godfrey & Wing brings simplification to a manufacturing world that has become increasingly complex. The Company has re-imagined and re-engineered vacuum impregnation, making it faster, safer, cleaner and easier to use than ever before. It's Simply Better.

Empowered by Godfrey & Wing's innovative process philosophy, manufacturers can take control of porosity sealing and integrate vacuum impregnation into their manufacturing flow. This eliminates the risk, waste and cost associated with outsourcing and creates a truly lean manufacturing environment.

With Godfrey & Wing technology, manufacturers can push engineering limits to meet challenging design standards, using fewer resources to manufacture robust, long-lasting products.