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Method for Capturing Binder Jet Binder Residue During the Sintering Process

Abstract

Metal Jet additive manufacturing uses a process of spreading a thin layer of powdered metal and then printing a binding agent (similar to an adhesive) in the locations that the final part is desired. This layering process is repeated many times to build up the final part. Once the build process is complete the loose powder is separate from the part and recycled for the next build. The part then goes through a heat treatment process to remove the binder and to sinter the particles into a solid functional piece.

The heating process is typically performed in a MIM (Metal Injection Molding) sinter furnace at several hundred degrees in an air, inert or hydrogen atmosphere at a slightly negative pressure. The binder in the part will thermally evaporate/decompose into gaseous products and mix with the process gasses as they are evacuated from the furnace. The MIM furnace will usually have a vacuum pump and valve that controls the atmospheric pressure and evacuates the gasses and binder residue. The furnace will also have a trap in the exhaust path to capture the binder used in the MIM process; however, the Metal Jet binder is chemically different enough that it is not efficiently trapped in the same manor that the MIM binder is. The binder can coat and foul furnace component causing failures if present in high enough volumes.

We report here a new approach of plumbing the exhaust gas path to capture the Metal Jet binder effectively.

Problem statement

When binder evaporates/decomposes from the 3D printed parts in the sinter furnace, different fractions of the chemical byproducts end up in different location: some are left inside the part itself, some deposit inside the main furnace chamber, some deposit on the exhaust piping between the main chamber and binder trap, some are captured in the binder trap, some in the piping after the trap and the throttle valve, some in the throttle valve, some in the vacuum pump, some pass thru the system and exit the tool as a gas and can be either burned or simply exhausted to the atmosphere.

The typical MIM sinter furnace has a trap in the exhaust path from the main furnace chamber to capture the majority of the MIM binder that is used to hold the parts together through the process. The trap works by being a larger volume that is cooled, typically with a water jacket. The binder residue crashes out of the gaseous phase into a liquid or solid that is stored in the trap until the process is complete and can be removed. The trap keeps most of the used binder from reaching critical valves, sensors, and the vacuum pump. If the binder does reach these components in high enough concentrations, it is possible, they would fail leaving the furnace in a potentially dangerous condition (with a large amount of hydrogen stuck in the furnace). By monitoring the electrical current that the vacuum pump is drawing as an indicator to how hard the pump needs to work to continue pumping the exhaust. As the pump accumulates more binder residue the current would increase until it reaches the maximum allowed and is shut down.

Since the Metal Jet binder is different than MIM binder it is not effectively captured in a traditional trap and routinely cause the furnace to fail. The user could compensate by putting smaller amount of parts inside the furnace limiting the amount of binder needing to be capture or depositing in the critical components, decreasing the efficiency of the furnace process and increases cost to operate. Once the furnace components have the used binder residue on them, they will need to be cleaned during a maintenance procedure, increasing the amount of cleaning waste and in lost production time. Not capturing the binder efficiently also can decrease the components lifetime from wear and tear.

Our solution

Addition of a length of exhaust piping that separates the throttle valve, that controls the pressure inside the furnace, from the vacuum pump. The piping is shaped as to form a trap or vesicle at the low point of the span between the components. As the binder residue deposits on the piping walls, it will migrate by gravity down to the low point of the piping, being captured and held without interfering with the process gas flow. See figure 1.

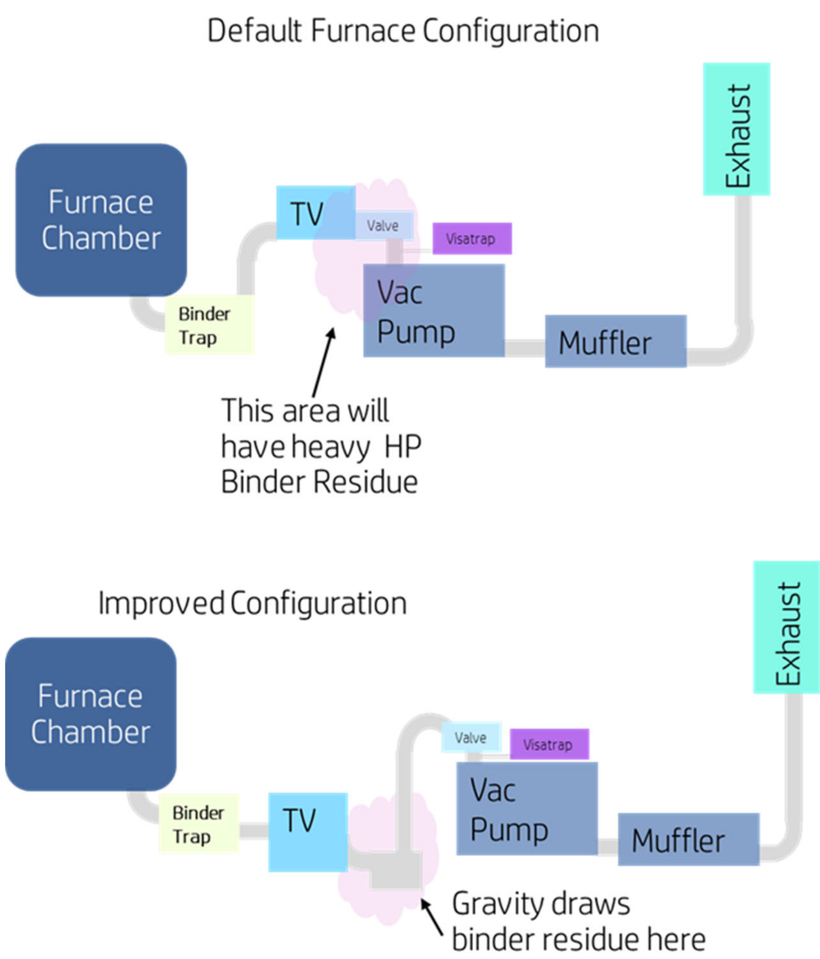

Figure 1: Exhaust piping path, default and the disclosed solution.

Results

With the default furnace piping configuration, it was common to have a vacuum pump increase more two times the value of the current from when no or a low volume of 3D parts was inside. A sustained increase of this level of pump current would cause the furnace to abort the process and stop the vacuum pump, resulting in either rework or loss of the parts inside. See figure 2.

When using the disclosed exhaust piping configuration, no vacuum pump current increase is seen even if overloading the furnace with Metal Jet parts. See figure 3.

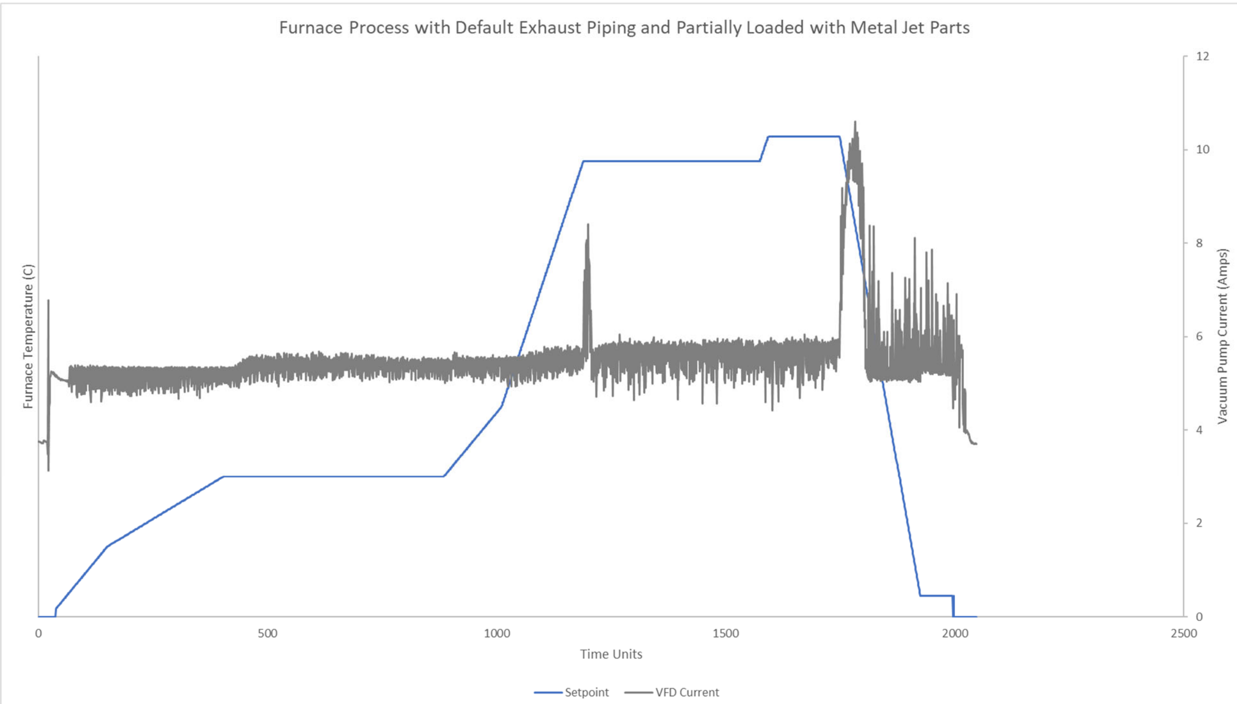

Figure 2: Vacuum pump current variability caused by binder residue in the pump.

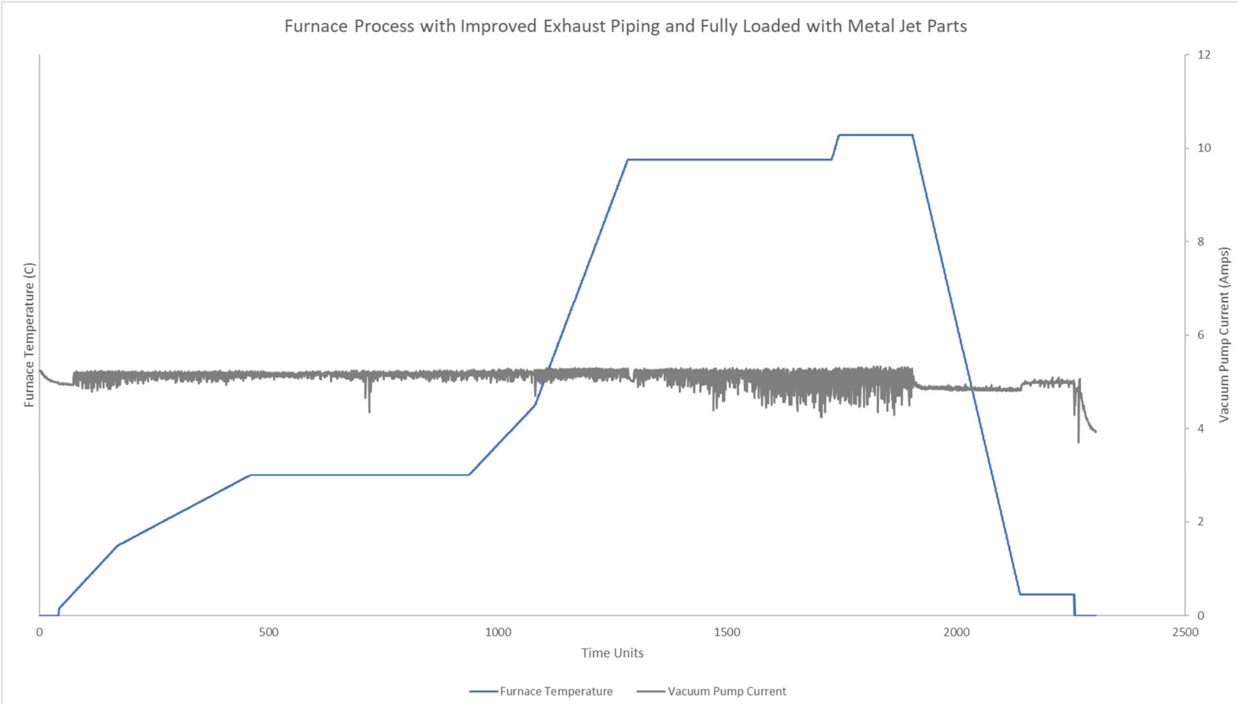

Figure 3: Vacuum pump current stable with improved exhaust piping solution.

Current status

The furnace manufacture is in process of creating options to include either exhaust piping path, this enables customers to process either conventional MIM or Metal Jet parts in the same furnace.

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