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## ALGORITHM TO ESTIMATE SUSPENDED METAL PARTICLES IN RECIRCULATION AGENT DELIVERY SYSTEM

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## *Algorithm to estimate suspended metal particles in Recirculation Agent Delivery System*

### Abstract

It is common for printers that use challenging agent or inks to include a Recirculation System through the printhead. This allows for the agent/ink to mix both in the Agent Delivery System and the Printhead.

This method is especially useful in 3D-metals printers, where printhead reliability is crucial and refreshing the printhead with new agent will increase the printhead life and achieve a better isothermal control in the firing chamber.

One risk of recirculating through the printhead is that particles in suspension in the air of the print zone might be ingested through the nozzles and end up in the agent recirculation system. As this recirculation is performed frequently, the quality of the agent could diminish and lead to problems both in printed part quality and reliability for the hardware of the printer.

This invention presents a new method to estimate the number of particles suspended in the agent by taking advantage of the conductivity of the agent. As more metal particles are present in the agent, its conductivity will increase. The method takes advantage of the conductivity sensors commonly used in agent/ink tanks to estimate their level. By checking its conductivity (based on a transmitter and a receptor), its value will be estimated and compared with the expected value of conductivity for a pure agent. If the value deviates from the nominal value, the system will report it so proper maintenance can occur (e.g., filter replacement).

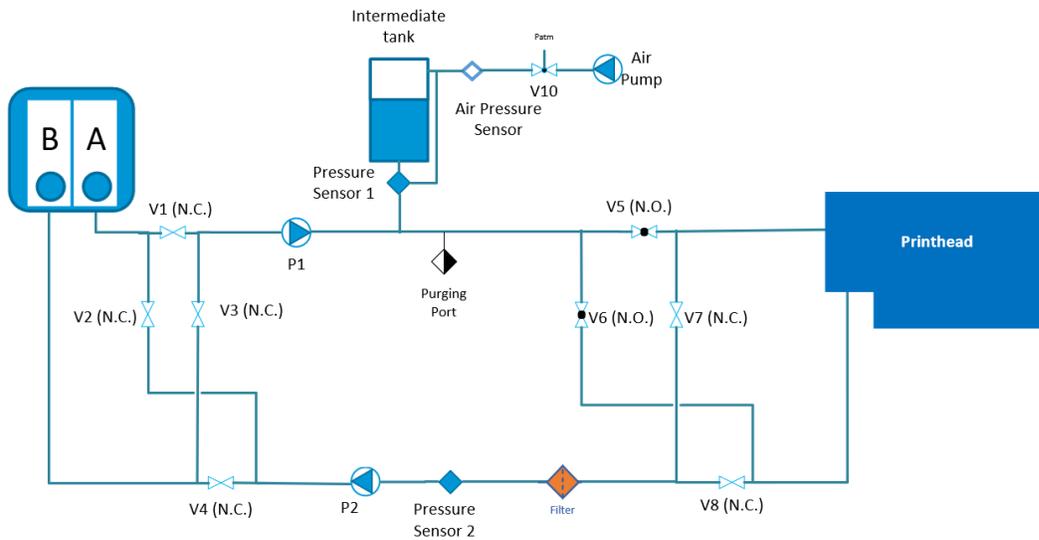
### Invention

This algorithm uses the level sensor that is commonly present in Agent Delivery Systems to detect the ink level in the ink reservoir.

Such readings can also be used to estimate the conductivity of the agent. Depending on the number of particles that has been ingested in the Recirculation Agent Delivery System, the sensor will report a different reading.



The general schematic of an Agent/Ink Delivery System with recirculation is the following:



Notice that the Intermediate Tank is the optimal location to include the conductivity sensors (because most of the times there is already one sensor installed), but such invention could be used with the sensor located in any other part of the agent circuit.

The particles content in the agent will affect the readings. By setting a threshold depending on the agent type, the readings will be monitored frequently (especially after a recirculation through the printhead event) and compared against the theoretical value. An alert will be reported to either the customer or the service engineer to replace the filter, as higher conductivity indicates that the filter is not able to remove the metal particles from the agent delivery system.

By monitoring the agent properties continuously, the system will be able to detect and act before it affects both the print part quality and the reliability of the hardware. Metal particles suspended in the agent could be detrimental to several components of the Agent Delivery System (pressure sensors, fluid pumps, etc.) and printer might be left inoperative if not corrected.

The method presented in this disclosure will trigger an alert (either via front panel to the customer or directly to the service engineer) to fix the filterability of the agent (in most of the times replacing the filter).

Prior solutions consist of triggering the filter replacement based on time or the amount of ink that has gone through the filter based on experimental data.

However, when it comes to recirculation through the printhead, several factors might affect the life and filter loading of a filter and having real data of the performance will avoid risks of damaging the printhead, the printer hardware and the quality of the job being performed.

Another approach has been to not recirculate the agent through the printhead, and only through the Agent Delivery System. However, this limits the agent space of fluids that can be printed, and the versatility of the printer gets reduced (only fewer demanding agents can be used, and this limits the performance across materials and productivity).

There are several advantages on monitoring the agent properties with this new method:

- It avoids premature filter or other hardware replacements because of the risk of filter loading. By monitoring the agent fluidic properties, the filter will only need to be replaced when really needed.
- It increases the reliability the system and protects the hardware (both the Agent Delivery System elements and the Printheads themselves).
- It allows for more challenging fluids to be jetted through the printheads. As recirculation through the printhead is enabled without any risk or limitation, more versatile agents are able to be developed for the same printer hardware.
- From a Big Data point of view, allowing to have more precise information on the agent properties and recirculation events.
- Enabling a variety of new diagnostics.

***Disclosed by David Butinya, Oscar Gomez & Cristian Diez, HP Inc.***