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CONSTANT PRESSURE VALVE TO COMPENSATE EXTRACTION SYSTEM PRESSURE VARIATIONS

HP INC

Constant pressure valve to compensate extraction system pressure variations

Abstract

Some 3D Printing technology heavily depends on the internal printing conditions in the Printing Chamber. One of the most important variables are temperature and pressure. The first permits to have temperature in a narrow range in order to have powder surface at constant conditions for printing process. Pressure and pressure distribution inside the chamber permits defined airflows within this cabinet.

Energy sources may include Fusing Lamps and Top Lamps. As the powder itself has a particular reflectance, not all the energy is absorbed, but reflected inside the printing chamber. Additionally, there are other heat sources in order to keep the powder in Print Bucket at the desired temperature, for instance. Globally, there is an excess of energy that needs to be removed from the Printing Chamber.

In terms of internal pressure, there are several objectives. The first is to have a defined over- or under pressure with respect to ambient conditions to obtain a global stray flow (due to lack of sealing) towards the Printing Chamber or from the Printing Chamber towards environment respectively. Second, the control of internal pressure distribution makes possible to have a preferred direction of airflow towards a desired area, which leads to higher thermal homogeneity if defined correctly.

In order to remove excess heat from the Printing Chamber, gas circulation is commonly used. It can be made with an open or closed circuit. When the gas is air, usually open circuit is used; contrarily, when the gas is for example an inerting gas, the circuit is closed.

Problems Solved

In an open system, Printing Chamber air renovation /cooling system, it is recommended to use a piping system towards the outside of the room where the 3D printing machine is located. This is mandatory if unsafe byproducts such as solvents, pigments, etc. are present inside the Printing Chamber, for example coming from the agents used during the printing process.

The system usually consists in an output tube in the machine where the customer connects his piping system to drive the gas towards outside of the building. For that purpose -as it is made in range hoods used in kitchens, the user installs an extractor to move the air outwards.

If this extractor has a power higher or lower than that recommended by 3D Printing machine manufacturer, there is a risk that this over- or under- suction influences the pressure inside the Printing Chamber, which brings as a consequence that the internal printing conditions are far from those recommended and the parts under manufacturing do not reach the required properties (dimensional, mechanical strength, look and feel, etc.).

At the same time, it is a growing tendency the installation of several machines in the same room -usually referred al “farms”-. In this configuration, exhaust pipes are

connected to a common duct of growing dimensions to receive their exhaust flows. It is compulsory that independently of the number of active machines simultaneously, each active machine must reach the appropriate internal working conditions. In particular, at the beginning of every plot, some calibrations are made regarding air flows; if -later- discharge conditions change, this calibration can become inaccurate with the same poor part properties result.

The use of a constant pressure valve permit to avoid the influence of the user extraction installation on the 3D Printing machine.

Even in the solution based on a servo-controlled fan presented in a previous disclosure, if customer installation is too big, this fan can be unable to compensate installation variations as the volume to be compressed/decompressed is too big.

Prior Solutions

Traditionally, manual valves to adjust gas flow / pressure are used with this objective. These valves are manually actuated what brings a very poor behavior when varying aspiration conditions occur.

An improvement of this system is the substitution of manual operation with servo operation of the valve.

The common solution of constant flow valve does not fit in this case, as the operating conditions of the 3D Printing machines vary along the printing process. For instance, in the starting process, there is a calibration sequence with constantly varying flows. The use of a constant flow valve causes wrong results in this calibration operation.

Description

The three main components of a constant pressure valve are:

1. Valve
2. Pressure sensor
3. Controller
4. Actuator

Quite often they are manufactured from a conventional valve with small modifications and the addition of components 2-4.

They are intended to keep at the input side of the valve a constant pressure with independence of the pressure in the extraction system within the working limits of the valve (usually from -50 Pa to -1 000 Pa). The declaration of the objective pressure can be made in several ways; in commercial constant pressure valves quite often this value is stated with a potentiometer which establishes a percentage of full scale value of pressure sensor. In other solutions, this objective pressure is directly set in the software of the servo which actuates the valve.

In some cases the valve can be part of the user installation and self-regulate in an autonomous way, while in some other the valve can be integrated in the printer and controlled by the printer own firmware.

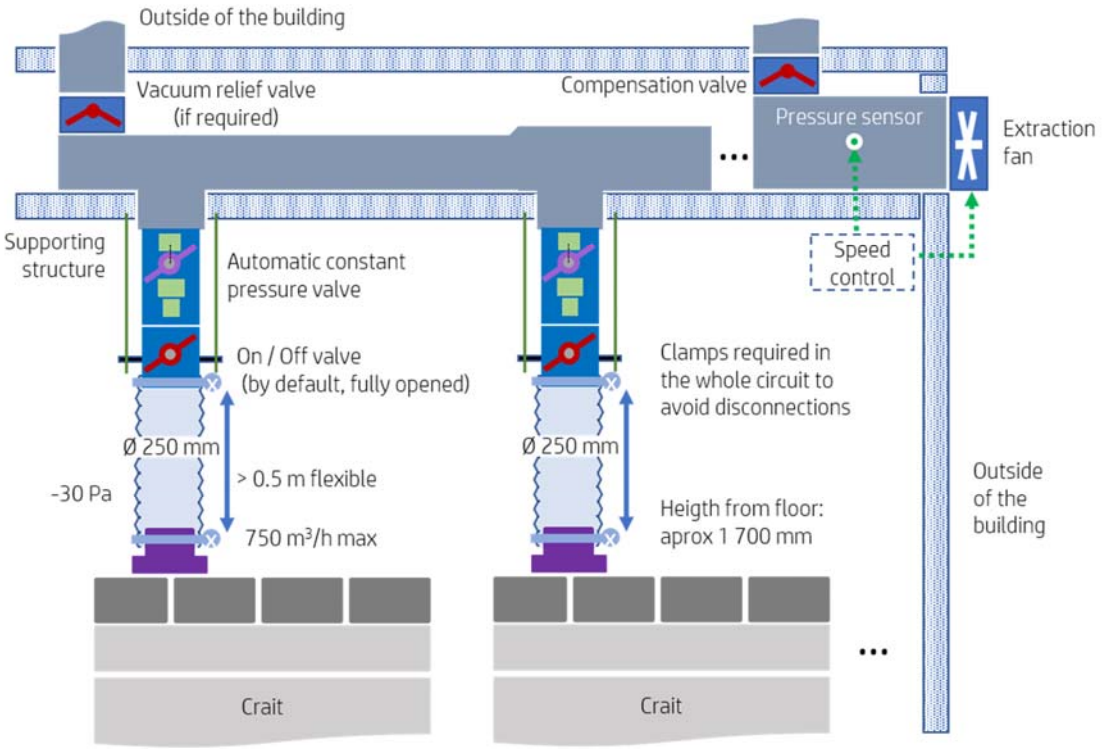
This constant pressure valve is located at the exhaust output of the 3D Printing Machine. Some machine designs include the valve in the machine itself, some other expects the user to include them in the Extraction System installation.

The objective pressure is mainly determined in such a way that the 3D Printing Machine operates in a similar way as working without Extraction System. In theory, could be set to a gauge pressure of 0 Pa, but in general some negative value is preferred to avoid local gauge pressures above 0 Pa which will lead to leaks towards the room.

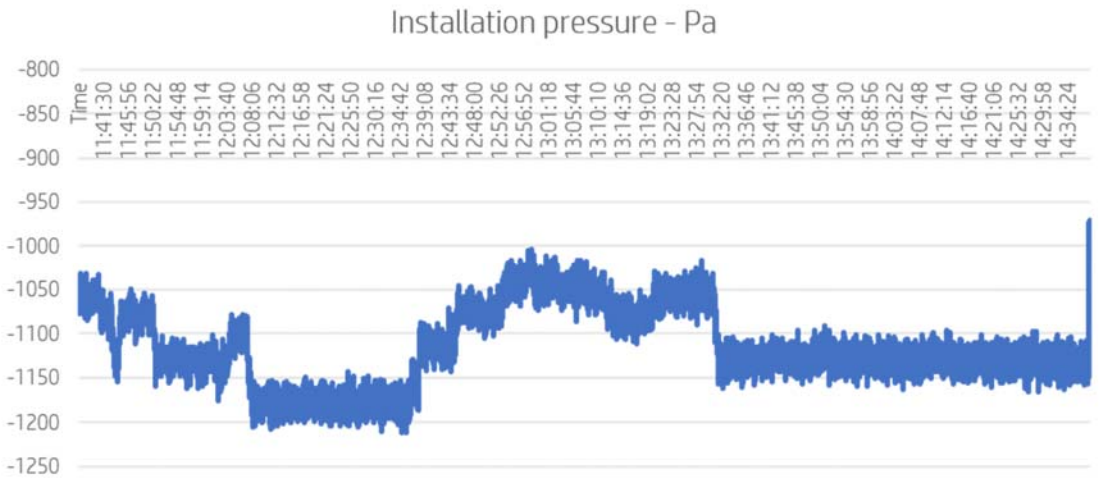
Tests have been done to analyze valve behavior with satisfactory results. The extraction pressure has been varied within the valve operation range and the valve has reacted to

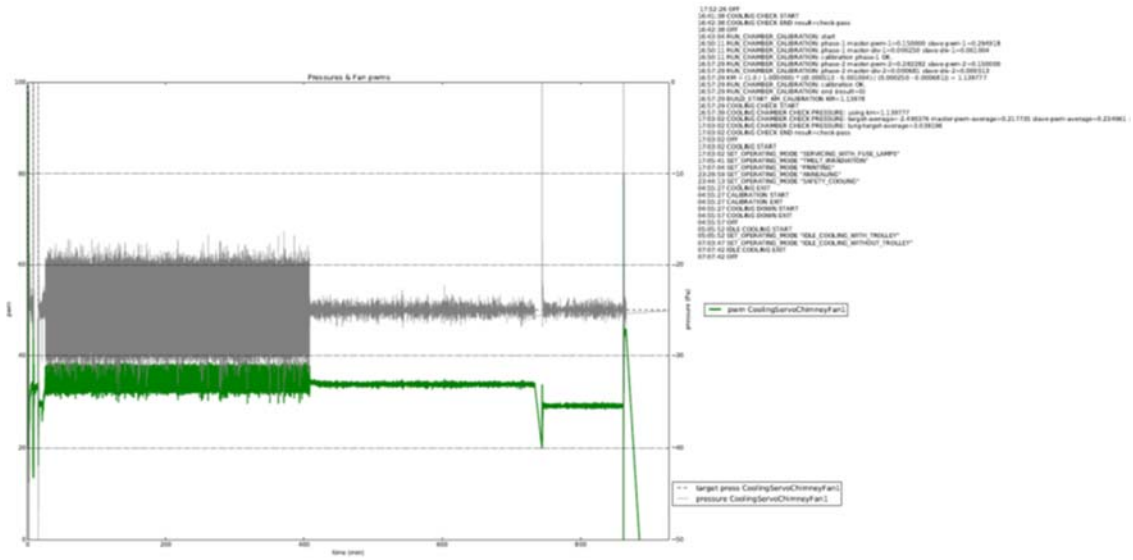
accommodate the new values. If Extraction pressure is increased, the valve closes whilst the Extraction pressure is decreased, the valve opens to keep the objective pressure (-30 Pa in this test).

For those 3D Printing machines in which constant pressure valve is not included in the machine itself, Site Preparation Guide specifies the compulsory use of these valves in installations where several machines can run simultaneously. In this way, when one machine stops printing, no other is affected as at that moment the valve in every machine rearranges its position to compensate the change.



As shown in the figure, although the installation pressures considerably vary, there is no effect on internal machine pressures, which are kept steadily reaching objective during the printing process. In the first graph, the values correspond to the pressures measured with an manometer in the extraction installation above the valve; in the second, the pressure in the exhaust manifold of the machine is represented, collected from the internal traces of the machine Firmware.





In a complete installation sharing a common extraction system, among others the valves react in the following situations:

1. Every time the user Extraction System changes its conditions.
2. Every time one machine changes the amount of gas discharged.
3. Every time one machine starts of stops.

Advantages

1. Improved part quality in terms of mechanical strength, dimensional and aesthetic properties with respect to a machine connected to an extraction system without regulation.
2. Fast response to extraction system aspiration conditions.

3. Straightforward system to avoid direct effect of customer extraction system on Printing Chamber conditions.
4. Constant pressure valve can be incorporated inside the machine, making it more autonomous (no need to request the user to install it).
5. Several machines can run connected to the same Extraction System without affecting each other.
6. Wide range of operation conditions regarding Extraction System under-pressure values.
7. Servo control, what automates the adjustment process to the printing varying conditions.

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