Air handling technologies in additive manufacturing

Utilization of extraction and filtration systems for air purification

Additive manufacturing offers many benefits compared to conventional production processes. This results in a special challenge with regards to extraction and filtration technology, particularly during metal 3D printing, i.e. selective laser melting (SLM), designated as direct laser metal sintering (DLMS) according to the new nomenclature.

The3D metal printing process is applied in an enclosed assembly area under inert gas atmosphere – mostly nitrogen or argon. Components are built up in layers in a powder bed by means of a laser jet. Results of the laser process are fume and fine dust, which partly consists of extremely tiny nanoparticles.

“To guarantee a stable construction process, the entire system must be designed to enable a uniform laminar flow over the powder bed, capturing fume and particulates but not the powder bed material. Finally, airborne pollutants are collected in a filter. This is definitely a technical challenge”, explains Boris Frühauf, Key Account

Manager Laser Technology with the company ULT. For quite a few years, ULT has been a vendor of fume extraction technology for additive manufacturing processes, providing a wide range of experience and technical expertise. “One can say, that we are the pioneers in this field, constantly enhancing our technology”, Frühauf adds.

Highly reactive dust must be disposed

In the ULT gas flow systems, specially developed cartridge filters come into utilization. Particles are retained on the surface of the filter elements. At programmable intervals and supported by sensors, the cartridges get cleaned with compressed air counter flush and the dust is completely gathered in dust collectors. Afterwards, the filters can resume their work. That guarantees, among others, long build jobs and filter life.

Cartridge filter solutions are commonly utilized in the industry because of their longer life, which is some months depending on processed materials.

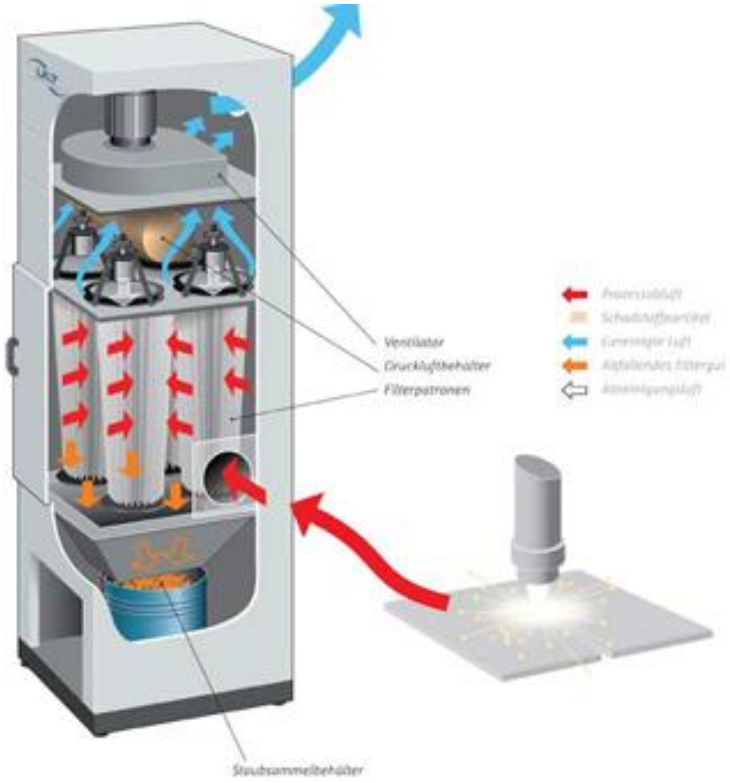

Image: basic principle of a cartridge filter system

Based on this challenge, ULT attaches great importance on occupational health and safety – for employees, machinery and products. Due to a small particle sizes, the dust itself can be highly reactive and inflammable. That is why safety precautions must be taken and safety guidelines are required.
It is also important that filters can be exchanged contamination-free, or at least, contamination-low.

However, currently there are no uniform standards or rules on correct dust disposal. That might be a reason why many additive producers struggle in finding the right disposal company that has sufficient experience in that area and knows how to deal with reactive materials. "ULT has compiled special passivation opportunities and disposal options", explains Boris Frühauf.

In filtration technology, there are two basic techniques: cartridge filter, which can be dedusted, and storage filters, which at some point in time are saturated and must be disposed. Storage filter disposal also requires correct handling, as dust may ignite through air or vibration. That can be prevented by passivation.

Furthermore, ULT fume extraction systems are equipped with differential pressure sensors. They measure pressure differences and recognize saturated or maximum loaded filters. Required filter exchanges are signaled in time to prevent system stops.

Post-processing and powder handling

Fume extraction technology is not only utilized in additive manufacturing systems. It is essential for the entire process. Solutions for post-processing (removing support structures) and for powder drying are also required. In addition to portable solutions, stationary units can be utilized.

"We are constantly striving to meet the requirements of additive manufacturing by continuously enhancing our modular systems. 'ULT – air quality' is ULT's corporate motto. In order to provide substantial ventilation solution, extensive knowledge on

the latest technologies, which we have successfully implemented in various solutions for laser processing, is required. That‘s the result of our high commitment to research and development“, explains Frühauf.

During material exchange, the entire construction chamber must be cleaned. For instance: if the production of a stainless steel component follows aluminum component manufacturing, the entire system must not contain any aluminum particles. Mobile fume extraction systems or wet separators are used to capture and bind residual material from the process. In the case of non-oxidized aluminum however, there is the danger of reaction with water. Thereby, hydrogen occurs. If it escapes and comes in contact with a spark, it may explode.

“So far, there is little experience with that matter. Yet, first additive manufacturing companies have begun to measure the hydrogen content. Their attempt is to determine the critical explosion magnitude and force ventilation or waste air outlet to the outside”, Frühauf explains.

However, the extraction of residual material is not the final link of the disposal chain, because the exhaust systems must also be cleaned. Usually, contaminated water is poured into containers, in which the particles slowly sediment. The remaining metal sludge must then be disposed of at regular intervals.
Today, these containers are partly positioned within the production facilities. The risk here is that hydrogen contents in these halls increases. Therefore, we recommend placing the containers outside to enable an outward degassing. At this point, much educational work is needed“, Frühauf comments.

Still, many situations in additive manufacturing are not determined. There are many technical challenges; and there are even more with new powder types and materials.

In summary, it must be stated that many standards in additive manufacturing are still in progress, e.g. the topics of health protection, emissions and powder

handling. There are no information on material mixture reactions on the nanoscale. Additionally, there are no numbers in explosion for nanoscale materials <0.5µm.

Material classification – whether it is hazardous goods or not – and disposal are hard to determine for system operators. Each disposal company values differently, moreover, hydrogen generation of powder in combination with water is dangerous as well as little studied.

“That is why ULT works on solutions together with other companies, institutions and associations within a large research network. Our goal is creating standards within additive manufacturing”, Boris Frühauf concludes.

Image: research and development network for additive manufacturing in Germany