UNDERSTANDING GAS REQUIREMENTS FOR Additive Manufacturing

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Understanding Gas Requirements for Additive Manufacturing

Additive manufacturing (AM) is a transformative method of industrial production, utilizing 3D printing technology to make functional components from digital models.

This innovative approach has undergone extensive development over the past three decades, evolving into a $16 billion dollar industry in 2023.[1]

Unlike “subtractive manufacturing” processes like machining, where parts are created by removing material, AM builds geometries by “adding” feedstock such as filament, wire or powder. This includes gas-critical processes, from powder bed fusion and binder jetting to directed energy deposition and metal material extrusion.

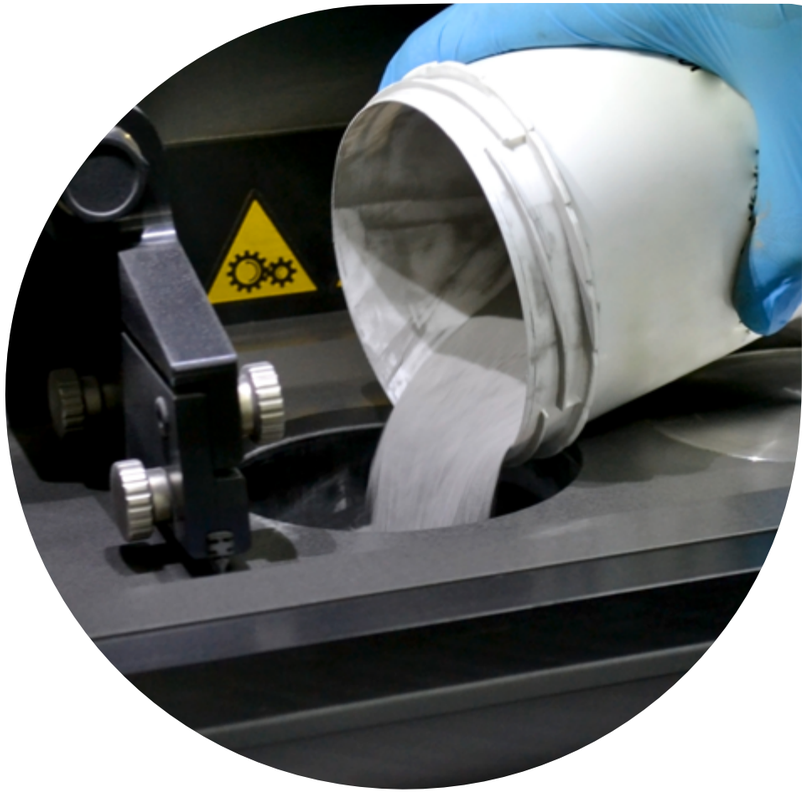
In this series, we’ll delve into the intricacies of additive manufacturing, breaking it down into three parts:

1. Introduction to AM Processes
2. Metal Powder Production
3. AM Post Processing

In this first eBook, we’ll provide an overview of key AM techniques, as well as critical aspects of quality control, such as gas purity, calculating gas consumption requirements, safe storage and more.

1. https://www.globenewswire.com/news-release/2023/06/21/2692058/0/en/Additive-Manufacturing-Global-Market-Report-2023.html

There are seven different AM processes that industry professionals use; choosing among them depends on the size, number, intricacy and material of the parts you intend to produce. These next pages will delve into the main processes that use gas: powder bed fusion (PBF), binder jetting, fused filament fabrication (FFF) and Directed Energy Deposition (DED).



Powder Bed Fusion

Powder bed fusion or PBF is a cornerstone of additive manufacturing, using a high-powered laser or electron beam to precisely melt and fuse material powder, layer by layer. This process is capable of building complex geometries from digital models.

While electron beam melting (EBM) requires a vacuum, PBF methods that use a laser heavily rely on the use of inert gases, such as argon or nitrogen, to create a controlled atmosphere. Not only does this prevent oxidation, it also ensures the integrity of the parts being produced.

These gases play multiple vital roles in PBF production by:

1. Removing by-products of the melting process to prevent contamination and ensure consistent properties through the build chamber
2. Preventing part oxidation by using argon or nitrogen gas to displace oxygen
3. Displacing oxygen so the laser heat source does not ignite the powder

One way to further ensure consistent material properties throughout the build chamber is to use a special diagnostic tool to measure and map gas velocity inside the chamber. This tool, available only from Airgas, can help to identify if the gas velocity distribution is uniform.

Sinter-based Technologies: Binder Jetting and Fused Filament Fabrication

Unlike other AM methods, which use energy to fuse materials, binder jetting does not require heat. Instead, the powder feedstock is “glued” or held together through the application of a liquid binding agent.

This process can produce parts much faster than laser powder bed methods, however, the printed parts are bonded together with the binder and do not have mechanical strength.

To make the parts dense and strong, a secondary step is required to remove the lubricant and sinter the powder particles together. During this step, the parts are heated in a gaseous atmosphere in either batch or continuous furnaces. It should be noted that because the density of the parts increases during sintering, shrinkage will occur.

While the printing process doesn’t typically require an inert environment, inerting the build chamber can be employed for processing combustible materials, such as titanium and aluminum powders.

Fused filament fabrication, or FFF, is an AM process that involves extruding a metal filament to create a component layer by layer. FFF is a sinter-based process like binder jetting in which parts are placed in a furnace to remove the binders and impart strength to them.

Gases like argon, nitrogen, hydrogen-argon non-flammable mixes and pure hydrogen can be used for the sintering gas.

Directed Energy Deposition

Directed energy deposition or DED is an AM technique that involves the precise melting of material using a focused energy source such as a laser, electron beam or plasma arc. This highly concentrated energy melts the powder or wire material to form layers or to weld beads of material.

Additive manufacturers often utilize DED for repairing components, adding materials to existing parts, and creating new structures from metal feedstock. This versatility lends itself to complex repair jobs and custom fabrications.

Gases play a crucial role in the DED process, primarily in shielding the melt pool from atmospheric conditions and contamination while stabilizing the deposition environment. Materials prone to oxygen pickup, such as titanium, can be processed by DED within an inert gas enclosure. This necessitates the use of argon as an inerting gas, as well as a shielding gas.

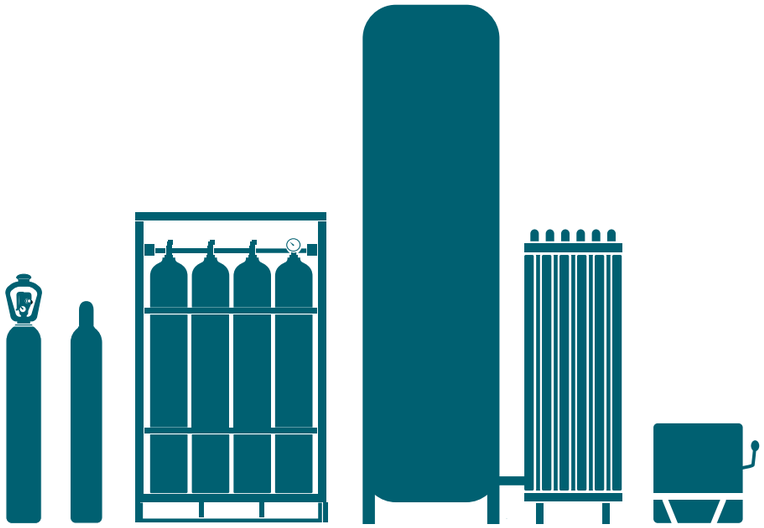
What Does Gas Purity Mean to Your Process?

Whether it's creating an inert environment or storing reactive materials, gas purity is of paramount importance when it comes to additive manufacturing processes.

Contaminants such as oxygen can have a direct impact on the mechanical properties and overall quality of parts produced. If the gas purity isn't high enough, it can degrade the parts, leading to poor characteristics like increased brittleness and, ultimately, wasted materials.

The industry standard for gas purity often hovers between 99.999 and 99.996 percent for most material applications. This level of purity helps avoid the introduction of oxygen and other reactive elements that could compromise the integrity and appearance of the finished product.

For materials that are particularly sensitive to contaminants, such as titanium or aluminum, gas purity requirements may be more stringent. However, most materials won't show a notable difference in AM outcomes whether purity is 99.996 or 99.999 percent, allowing for some flexibility and lower costs, without compromising quality.



How Much Gas Do You Need?

To understand the gas requirements for AM operations, it's first important to recognize the variability in gas usage across different machines and processes, coupled with the effect of materials being processed.

Each AM machine, depending on its size and the specific techniques it employs, consumes a certain volume of gas to create parts. For powder bed fusion-laser, initially, the process involves purging the machine's chamber of air by backfilling it with argon and nitrogen. After purging, the build process can be commenced.

The build process can take many hours; it's not unheard of for a build to take 100 hours to complete. If the operator runs out of gas during a build, the part would be ruined and the process has to be restarted.

Often overlooked are ancillary processes such as de-powdering, powder sieving, and heat treatments which require gas. These must be taken into account to be sure the gas supply is sufficient.

Continuous gas supply is critical for additive manufacturing. In terms of the gas needed for powder bed fusion-laser processes, purge volumes can range from roughly 3,000 to 22,000 liters, and the flow rate for producing parts can vary from 10 to 150 liters per minute, depending on the size of the machine.

Because of these wide ranges, it is important to work with a gas supplier who understands the gas requirements for 3D printing and is able to provide BOTH the purity needed and the uninterrupted gas supply to produce quality parts.

At Airgas, we have decades of experience assisting AM customers in navigating these gas requirements, providing solutions that ensure a continuous supply to suit their needs.

How to Protect Your Team and Process When Using Gas

While inert gases like argon or helium might not seem dangerous, all compressed gases are considered hazardous materials — whether through storage under pressure, intense reactions or oxygen displacement. It's imperative that manufacturers take the necessary steps to ensure the safe storage and handling of all compressed gases.

Fixed room oxygen monitors are required in storage areas where gas cylinders are kept, as overnight leaks can lead to dangerous, low-oxygen conditions.

At the same time, AM machines aren't completely gas-tight, and operations can run for extended periods. Installing fixed room oxygen monitoring systems with alarms is advised by equipment manufacturers to prevent the risk of asphyxiation. Airgas personnel can advise on the proper height for mounting monitors.

With over 50 QSSP- and OSHA-30 certified specialists and a full line of safety products and PPE — including oxygen sensors and respirators — Airgas has the expertise to keep you and your teams safe.

To learn more, download our three-part series on Compressed Gas Safety

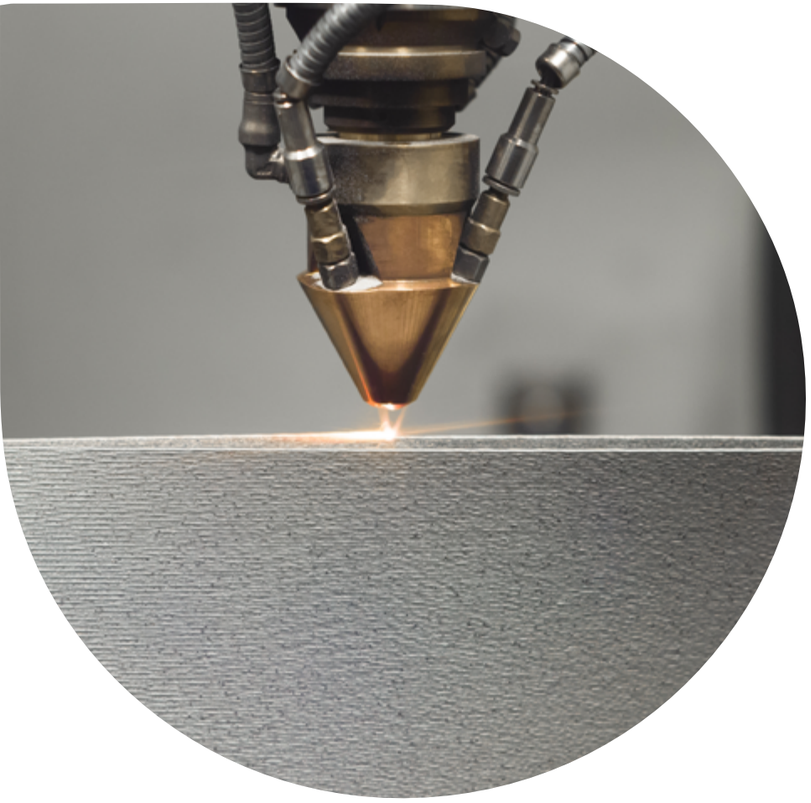
Addressing Common Challenges in Gas Management

Gas management poses several common challenges for additive manufacturers that can significantly impact production efficiency and part quality. One of the most critical issues is running out of gas in the middle of a build or during the sintering process, as this can ruin a part beyond repair.

If your machine does not track gas usage, flowmeters can be installed to track gas consumed for a build, enabling an estimation of manufacturing cost. This also allows quality documentation to show gas flow during the course of a print cycle. Monitoring gas flow can also assist in determining the optimum gas flow rate for a particular material system in DED processes.

EZ-GAZ™ can improve cylinder gas management. This digital cylinder pressure monitoring service provides real-time visibility and control over your gas supply, reducing the risk of run-outs and rush deliveries.

To mitigate these challenges, Airgas employs a comprehensive approach to gas management, including digital tools for managing the supply chain and ensuring the reliability of deliveries. By accurately sizing gas quantities needed and leveraging algorithms to predict when new deliveries will be required, we help our clients avoid running out of gas at crucial moments while optimizing usage to ensure cost-effectiveness.



How Can Airgas Help You Optimize Your Gas Use?

At Airgas, we are committed to helping our customers succeed in the additive manufacturing industry. We offer a suite of robust solutions designed to ensure operational efficiency, optimal gas purity and reliable supply.

We recognize the critical issues you face, whether it's ensuring the continuity of gas supply or sourcing products that meet high quality and purity standards. With a focus on optimizing usage and preventing supply interruptions, Airgas offers a powerful suite of digital tools to help manage your gas consumption. Our predictive algorithms use specific usage patterns and production schedules to alert you when it's time to reorder bulk gas — and our expansive footprint and local presence guarantee reliable, quick delivery.

We can even help you reduce the environmental impact of your operation with improved gas delivery via reliable, energy-efficient delivery routes. For gases used in bulk, ECO ORIGIN™ offers certified, low-carbon options for liquid argon and nitrogen.

Through our tailored solutions, Airgas not only addresses the immediate needs of AM operators but also contributes to a more efficient and cost-effective manufacturing environment.

Everything You Need for Additive Manufacturing

In the dynamic field of additive manufacturing, Airgas stands as one of the leading gas suppliers for companies navigating the complexities of gas management. Our commitment is to not only supply gases of the highest quality but also to ensure these critical molecules are delivered efficiently and reliably.

Leveraging expertise across all AM processes, we provide tailored solutions and a comprehensive range of gases to meet the unique needs of your operations.

Get in touch with the experts in additive manufacturing at Airgas to discover how to elevate your capabilities and succeed in this innovative industry.

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