



THE ROLE OF GAS WHEN
PRODUCING HIGH-QUALITY
Metal Powder for
Additive Manufacturing

Airgas[®]
an Air Liquide company

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Introduction

As additive manufacturing (AM) technologies continue to evolve, the demand for high-quality metal powder to produce AM parts is surging.

For instance, metal powders like aluminum and titanium are expected to see high annual growth rates as high as 40% as their use in powder bed, directed energy deposition and sinter-based processes increases. But with this rise in metal AM technologies comes a reliance on gas solutions.

Gases play a pivotal role in the fabrication of powders for additive manufacturing. Industrial gases such as argon, helium and nitrogen are essential for maintaining the purity and quality of these materials. Efficient gas management not only improves production outcomes, but also enhances sustainability and reduces environmental impacts.

In this Metal Powders edition of our Additive Manufacturing series, we'll explore the role of gas throughout the entire powder production cycle, along with techniques for safe gas storage, efficient transportation and effective management.

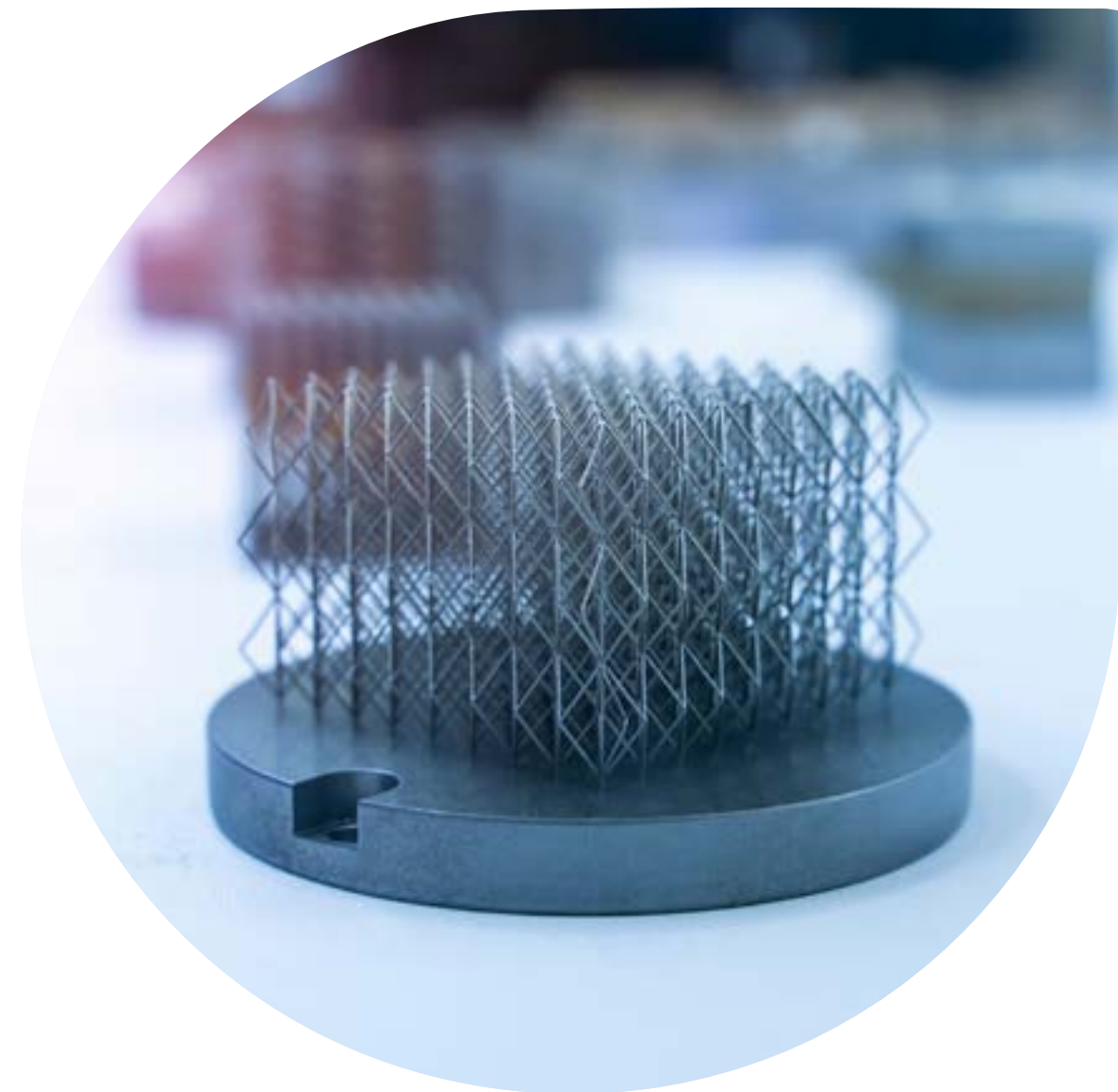
The Role of Gas in Metal Powder Fabrication

The role of gas varies depending on the fabrication process.

For instance, in gas atomization, inert gases such as argon and nitrogen create a protective atmosphere during the melting of raw materials, thus preventing oxidation and preserving quality. These gases are then used in high-velocity streams to atomize the molten material into fine, uniform powders critical for powder bed fusion and other AM applications.

In plasma atomization, helium is employed to generate a high-energy plasma arc that melts and atomizes metal feedstock, offering enhanced precision and consistency for advanced applications.

By tailoring gas parameters to the specific needs of each method, manufacturers can achieve high-performance powders that meet the rigorous demands of modern additive manufacturing. Let's look at some of the key methods used in metal powder fabrication.



1. Melting and Atomizing

Gas atomization is the most common method of producing powders for additive manufacturing. Gas atomization is actually a two-step process involving the melting and atomization of metal materials.

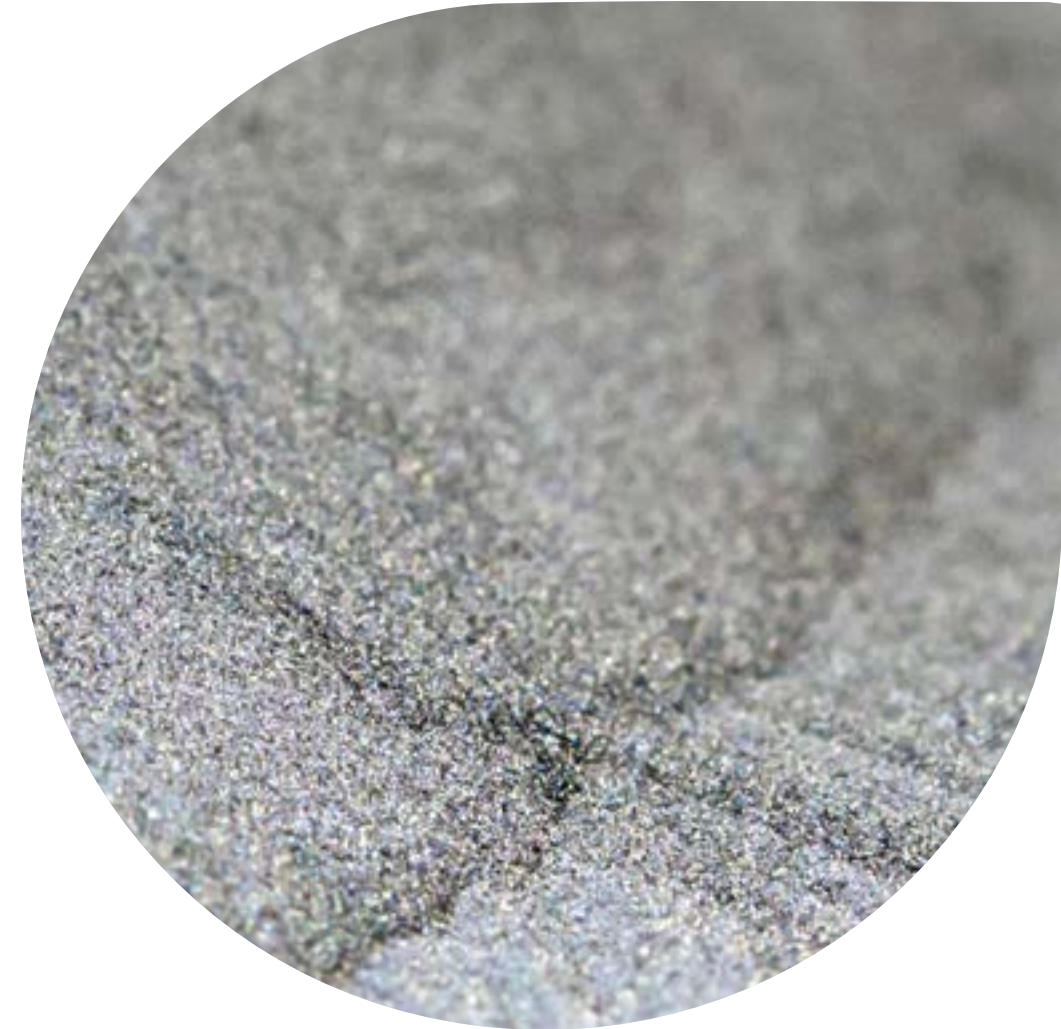
First, the melting process heats raw metal feedstock until it reaches its melting point and becomes a liquid. This molten metal is then subjected to a high-pressure stream of gas that breaks up the metal into tiny droplets that quickly solidify into fine powder particles.

During the initial melting process, gases such as argon and nitrogen are used to create a controlled atmosphere. Argon and nitrogen are particularly effective at displacing reactive atmospheric gases like oxygen. This inert environment is crucial for maintaining metal purity and preventing the formation of oxides, which would degrade the powder quality.

In atomization, a high-velocity stream of inert argon, nitrogen and occasionally helium are used to break molten metal into tiny droplets. These droplets then rapidly solidify into spherical powders, which are ideal for many powder bed fusion and other AM applications.

The type, pressure and flow rate of the gas used have a significant influence on the characteristics of the resulting powders. High pressures and optimized flow rates can produce finer powders with a narrow particle size distribution — which is crucial for achieving excellent flowability and packing density in AM applications.

Maintaining a specific gas temperature range throughout the year can help with powder quality and make it easier to achieve consistent powder properties. In addition, during periods of cold weather, it can be helpful to preheat the atomization gas to achieve a finer particle size.





2. Chemical Powder Processes

The chemical production of powders is another process for fabricating metal powders such as titanium and titanium alloys. This process is useful for applications requiring high purity and specific particle characteristics.

Unlike in mechanical milling or melting, chemical reactions are used to produce metal powders directly from their ores or other raw materials. This approach can be more efficient and environmentally friendly, reducing the energy required and minimizing the waste produced.

Reduction is the primary chemical process employed in this method. Here, manufacturers use reducing agents to reduce metal oxides to their metallic forms.

Powders fabricated using chemical processes have a tendency to deviate from a spherical shape. To correct this, argon and helium are used with a process called plasma spheroidization.

3. Mechanical Milling

Mechanical milling is a common method for producing metal powders. This technique involves the use of high-energy ball mills that grind metals and alloys into fine powder through mechanical forces.

When processing titanium, a hydride-dehydride (HDH) method can be used. First, titanium is hydrided, making it brittle and easier to mill into powder. Once milled, the hydrogen is carefully removed in the dehydriding phase, producing fine titanium powder with the ideal properties for additive manufacturing applications.

The milling process generates significant heat, which can lead to oxidation and contamination of the powders. To mitigate these risks, argon and nitrogen are often employed to create an inert atmosphere within the milling chamber. This displaces the oxygen and other reactive gases to prevent unwanted chemical reactions.





Powder Sizing

Following production, powder sizing is used to ensure that metal powders meet specific requirements for their applications. The size and distribution of powder particles have a direct impact on the performance of AM processes, influencing factors such as flowability, packing density and layer uniformity. Some processes will also require the use of powder particles that fall within a specific size range.

Powders are typically separated by size with screening. Fine particles can be removed using air and inert gas classification systems.

Gases play an essential role here by providing an inert atmosphere to minimize oxygen exposure. Keeping the oxygen level low preserves powder quality and enables more reuse cycles. Depending on the material, such as titanium, inert gas processing may even be required to reduce the risk of fires or an explosion.

Powder Passivation

Regardless of the production method used, passivation is a crucial step that enhances the stability and longevity of powders by creating a protective layer on the surface. This process involves introducing oxygen in a controlled manner to facilitate the formation of the oxide layer without causing excessive oxidation that could impact the overall quality.

This prevents the finished powder product from reacting with environmental elements, which can degrade its properties and reduce its performance in AM applications. Reactive powders such as titanium are combustible and regular powder handling could lead to a fire event if the powders are not passivated.

The passivation step not only enhances the performance of the powders in AM processes, but it also improves their storage stability, reducing the risk of degradation or waste.





Storage and Transportation

While passivation reduces the risk of powder degradation, it does not prevent it entirely. Eventually, all metal powders will degrade if not properly stored. Improper storage of highly reactive powders, such as aluminum, titanium and stainless steel, can also increase the risk of fire or explosions.

Limiting atmospheric contact is therefore essential.

Air and moisture can pass through thin plastics, container seams, or lids, compromising the integrity of the powder. To mitigate this, many manufacturers store powders in inert gases like argon or nitrogen immediately after packaging. Specialized containers that connect directly to the powder production machines can further enhance safety and efficiency by eliminating manual handling.

Maintaining stable temperatures and low humidity levels is equally important to avoid oxidation and contamination. Controlled storage and transportation environments ensure that powders retain their quality and reactivity, supporting consistent performance in additive manufacturing applications.

Gas Recovery

Some gas atomization processes may use over 20,000 liters per minute of gas in the atomizing process (in excess of 760 SCF per minute).

When argon is used, companies have an interest in recapturing and re-using the argon gas. Airgas can help companies measure the composition of the used or processed gas to understand how much purification will be required to get the gas back to the gas requirements for fabricating powders. The options for gas recovery will depend on these purification steps, along with gas flow rates and required gas pressure.



How Can Airgas Help You

Gas is used throughout metal powder production; the gas required and amounts needed depend on the process and size of the equipment. Fortunately, Airgas understands the different powder processes and the role of gas throughout the production process.

As a leading supplier of industrial gases with an unrivaled national distribution network, decades of experience and relationships with leading manufacturers of metal powder, Airgas can provide valuable support along the entire value stream, from chemical reduction processes and atomization to passivation and powder sizing, plus storage and transport. In addition, comprehensive solutions for gas management, including supply chain solutions like EZ-GAZ™ and advanced logistics support, simplifies gas delivery and management so you always have the right amount of gas when needed. We also offer sustainable solutions such as ECO ORIGIN™, which focuses on low-carbon gas production, and telemetry systems to monitor and eliminate gas waste.

Are you ready to see what the right gases and supplier can do for you? [Contact us now](#)

To learn more about gas usage during additive manufacturing, please continue reading this ebook series!

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