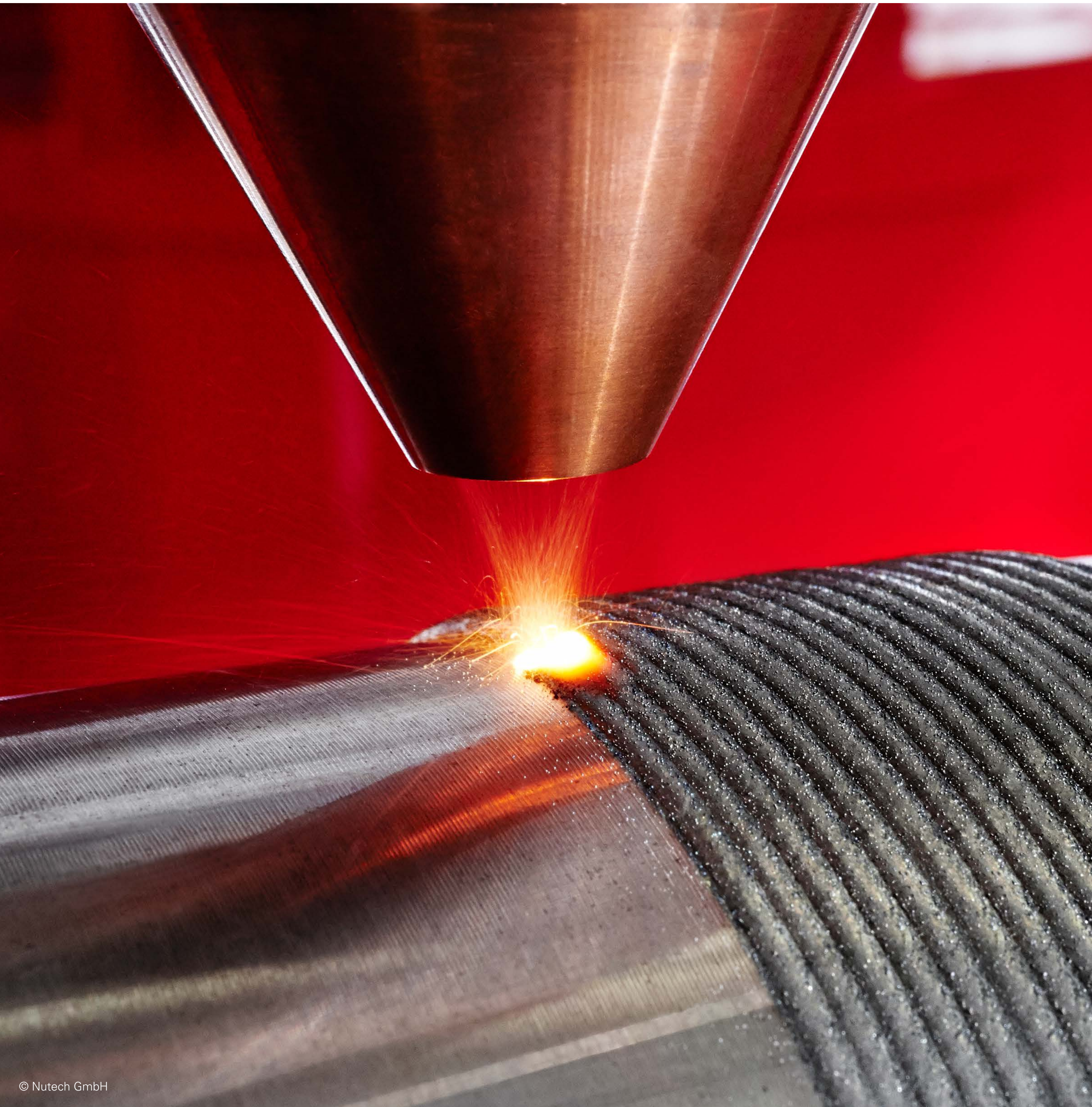
Addline

3D printing of metals



3D printing (also called additive manufacturing) of metals has only been developed in the last few years but is already seen as one of the technologies for the future. Many companies and research centres are investing in research and development with the aim of standardising 3D printing in production.

3D printing involves making components by adding layers of material one by one. This method differs from conventional production processes in that the component is produced directly by melting powder or wire feedstock. The process is well developed in the production of plastics and has been used in this segment for some time. 3D printing of metals is quite another matter: the units are fairly expensive by comparison and are used in industry or at research facilities.

In contrast to conventional manufacturing, 3D printing offers advantages in the production of complex components. The addition of layers one by one very effectively facilitates the production of complex structures that would be difficult or impossible to achieve using traditional manufacturing techniques. 3D printing is frequently used for the manufacture of individual items or small batches as it would be too expensive to set up a conventional production facility. Typical examples include hip or dental prostheses in medicine as well as turbine blades or turbochargers.

Messer has now introduced its new **"Addline"** product range especially for customers.

Addline - Gases for 3D printing

A variety of gases are used for 3D printing. There are gases for the actual printing of components as well as for their subsequent treatment. Depending on the specific process, printing a component involves the use of inert gases, carrier gases and/or cooling gases. In the majority of printing processes, the type of gas required – and its purity – depends on the material. The following table provides an overview of possible inert gases.

Gases are also needed for subsequent treatment of components. For instance, gases can be used for removing residual powders. Furthermore, in most cases, subsequent heat treatment is necessary after the printing process. This often involves stress relieving annealing, a process that requires the use of a protective gas. But other types of heat treatment may also be required.

Contact us and we will gladly provide advice about these gases

	Suitable inert gases			
Material	Argon	Helium	Nitrogen	Argon-hydrogen mixtures
Titanium	●	●		
Aluminium	●	●	●	
Austenitic steel, Nickel	●	●	●	●
Ferritic steel	●	●	●	

Aspects of the technique

Present-day methods for additive manufacturing with metals can be organised according to the aspects of material feed and energy sources:

Material feed	Energy source			
	Laser beam	Cathode ray	Arc/plasma beam	Furnace
Powder bed	x	x	–	–
Powder spray	x	–	x	–
Wire feed	x	x	x	–
Binder	–	–	–	x

Powder bed

The most common techniques nowadays involve a bed of powder. This means layering coats of powder onto the blank and melting the layers onto the existing component. The source of energy for this can be a laser or an electron beam. In the former case, the process is called Laser Powder Bed Fusion (L-PBF), whereas in the latter, it is referred to as Electron Beam Melting (EBM).

Powder spraying

Spraying powder requires the use of a carrier gas, meaning that electron beams cannot be used for the energy source. Powder spraying by lasers is already used for additive manufacturing and is known by the name laser metal deposition (LMD). Use of a welding arc in the form of a plasma beam has been known by the name plasma-arc welding for many years. Efforts are being made to adapt this method for additive manufacturing.

Wire feed

Additive manufacturing techniques using a wire feed can in principle be used with any kind of energy source. Use of these techniques is becoming increasingly widespread due to the relatively low cost of the filler material.

Binder

Metallic powders are mixed with a binder (often polymer). This binder is used to print a component layer by layer. The first step after printing is to burn out the binder. The next step involves sintering the component at a high temperature.

From powder to finished component

Carrier gas nozzle made of CrNi steel, developed by ifw Jena

Laser metal deposition

Common methods

Laser Powder Bed Fusion (L-PBF)
Laser Powder Bed Fusion is an additive technique for creating a 3D print in a powder bed. Apart from the actual hardware and metal powder for use as raw material, it is necessary to use a shielding gas. This protects the melted powder from atmospheric effects. Other proprietary names by which the process is known include the following:

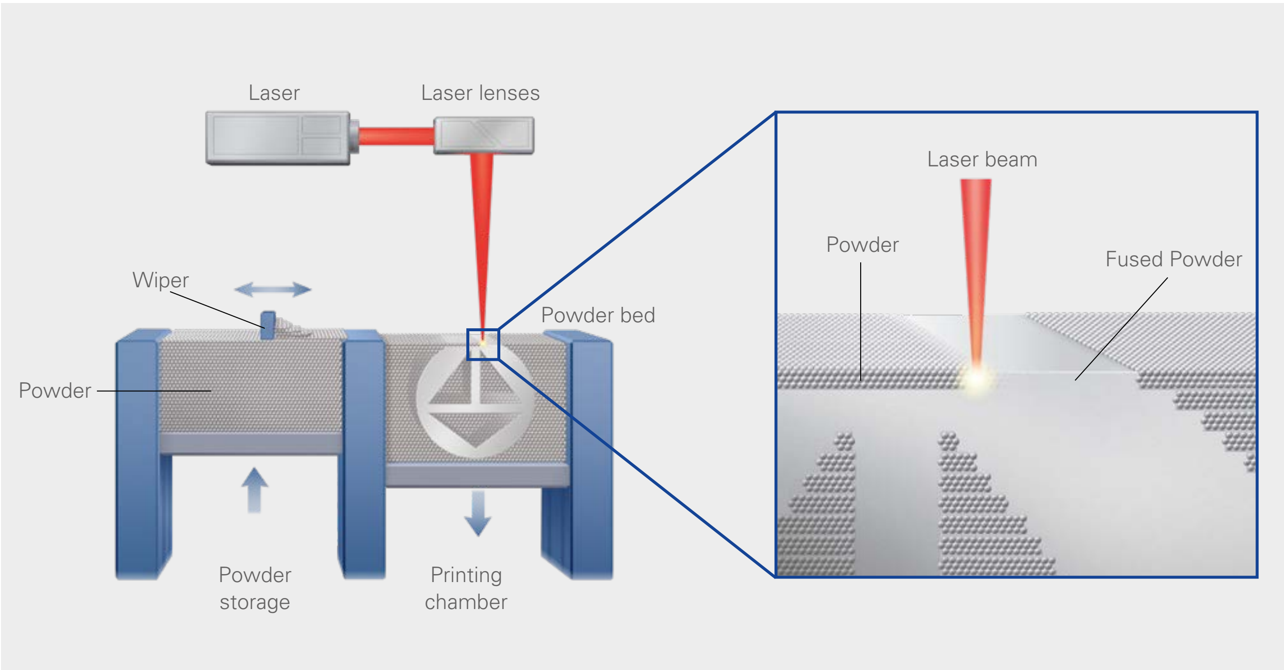
- Laser beam melting (LBM)
- Selective laser melting (SLM®)
- Direct metal laser sintering (DMLS)
- LaserCUSING®

Cooled welding nozzle made of CrNi steel, developed by ifw Jena

Features and benefits
By means of Laser Powder Bed Fusion it is possible to achieve high levels of precision. Precision is greater than with other methods because the layers can be tracked by the laser with high accuracy and safely. This high precision means that even very strict component tolerances can be met. The technique is slower than electron beam melting (EBM) as a laser beam is slower to respond for movement. Some suppliers of laser beam melting therefore offer systems with multiple laser beams.

Electron beam melting (EBM)
Electron beam melting is another additive technique in which the printed object is made in a powder bed. Unlike Laser Powder Bed Fusion, the procedure is carried out in a vacuum, meaning that there is optimum protection from atmospheric influences. However, it is not possible to modify the melting process through use of a shielding gas.

Features and benefits
Electron beam melting is not capable of achieving the same precision as Laser Powder Bed Fusion. This is due to the high energy density of electron beams. The printing process takes place at high temperature, meaning that the melted areas are larger. The accuracy which can be attained, however, is greater than any additive method other than LBM. One particular benefit is that the printing is very fast, since the electron beam can be deflected particularly quickly.

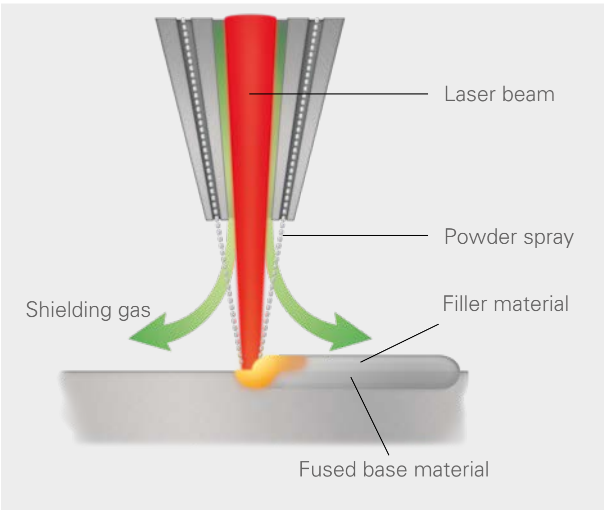


Laser Powder Bed Fusion (L-PBF)

Laser metal deposition (LMD)
Laser metal deposition is distinguished by the fact that powder is applied directly into the melt zone. The powder is fed to the laser head itself and then sprayed into the processing zone (printing zone) with the help of a carrier gas in the form of a beam which is concentric around the actual laser beam. A shielding gas is required in addition to the carrier gas.

LMD printed screw conveyor

Features and benefits
In the case of laser metal deposition, the laser head is usually guided by a robot. This means that the speed of the process is much slower than with powder bed techniques. Since the procedure is not confined to a bed of powder, it is possible for much larger objects to be printed. The precision and tolerances which can be attained are not as good as with powder bed methods. For many applications, though, it is quite sufficient and it may be possible to achieve the requirements through subsequent processing. It also presents no difficulty to print onto existing components. This may be performed due to the need for repairs or for combined manufacturing methods (conventional manufacture + 3D printing).

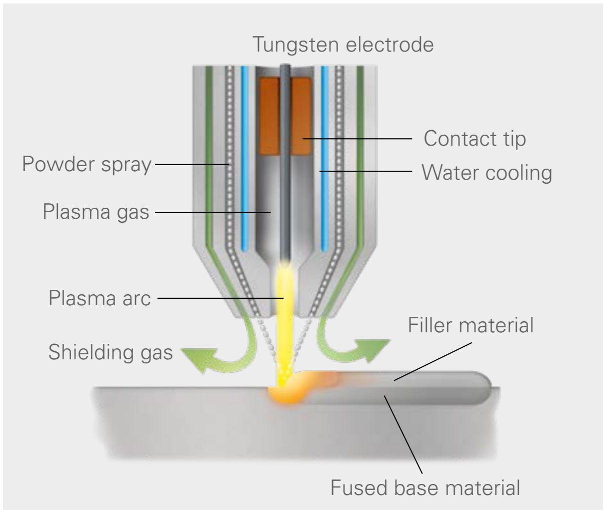


Laser metal deposition (LMD)

Plasma-arc deposition welding
Plasma-arc welding also involves metal powder being sprayed via the welding burner in a beam concentric around the plasma beam. This method requires a plasma gas, a carrier gas and a shielding gas. This technique is well known for building up coatings on components. For 3D printing the application requires building up multiple layers.

Plasma-arc deposition welding

Features and benefits
In the case of plasma-arc welding, the printing head or burner is also guided by robot. This again allows for the manufacture of especially large components. The method is also suitable for repair printing of damaged components.



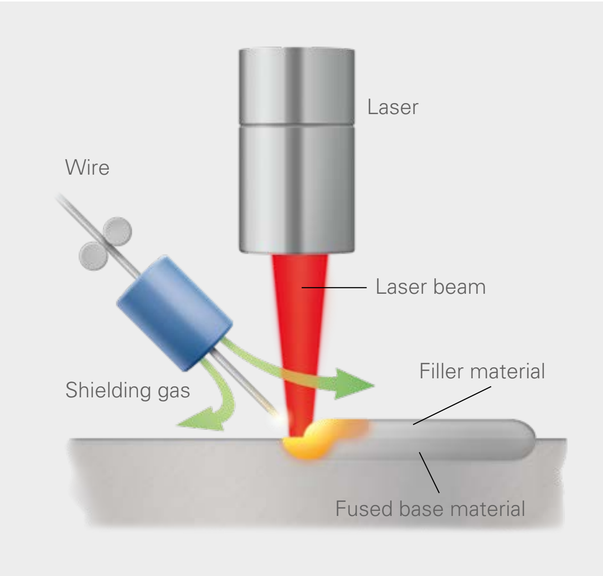
Plasma-arc deposition welding

Laser deposition welding with wire

Laser beam welding is a widespread joining process. Laser deposition welding is the application of this technique to 3D printing. The process involves a wire being used as filler material. A shielding gas is used to protect the printing process from atmospheric influences.

Features and benefits

In principle, laser deposition welding with wire is similar to the LMD process. Both techniques involve the use of a laser and a robot-controlled print head. The only difference is the supply of the filler material. The wire that is used in laser deposition welding has advantages as well as disadvantages compared with a powder. Wires are usually less expensive. In addition, there are far more wire materials than powder materials, which means that there is a bigger range of different materials to choose from for printing. The disadvantages are precision-related.



Laser deposition welding with wire

Arc welding process for printing

The MAG, MIG and TIG arc welding processes can also be used for 3D printing. Based on past practice, this application is also known as Rapid Prototyping.

Features and benefits

Using an arc welding process is the cheapest way of printing a metal component. The technique allows high deposition rates to be achieved. The torch or print head is usually controlled by a robot, enabling large components to be printed. A disadvantage is the relatively high degree of inaccuracy, which necessitates an oversize print outline. Additional machining is often carried out to achieve the required precision and surface quality.

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