# Technical report

Perfect Welding

Wire Arc Additive Manufacturing:

Economical 3D Printing for Metal

Wire Arc Additive Manufacturing is arousing a great deal of interest in several industries. Arc-based manufacturing by building up layers allows for a high degree of flexibility in component geometry. For prototypes and small-batch production runs in particular, it is a more cost-effective solution than other additive processes for metal. The key factor in determining the quality of components produced is the welding process. Cold Metal Transfer from Fronius effectively fulfills all the conditions for Wire Arc Additive Manufacturing.

Additive production methods generate components by building up material layer by layer. The most well-known example of an additive method is 3D printing. Wire Arc Additive Manufacturing, which is based on the arc welding process, also produces metal parts layer by layer, with the layers formed by the melting wire electrode. This generative method is particularly advantageous when complex component geometries have to be produced, as the design options are virtually limitless. In addition, parts can be manufactured at low cost and extremely quickly – which makes Wire Arc Additive Manufacturing a very attractive option for prototype construction and/or small production batches. Processing time, tool wear, and material loss during machining – especially with the conventional approach of milling out the workpiece from a solid block – all mean significant extra costs.

What is Wire Arc Additive Manufacturing?

There are a number of generative production methods for metal. Essentially these can be divided into two fundamental types: powder-based processes and wire-based processes. In powder-based processes, the layers are built up using molten metal powder. The most common method, the powder bed process, produces extremely precise results, but is somewhat slow in production. Wire-based processes, on the other hand, build up the component by melting a wire-shaped filler metal, requiring the use of a laser, electron beam, or arc. These processes have a high deposition rate and therefore help to cut production times.

Wire Arc Additive Manufacturing is a wire-based process, and uses the gas metal arc welding process (GMAW). Wire Arc Additive Manufacturing itself offers a number of advantages besides its high deposition rate (up to four kilograms per hour with steel materials). In the future, multi-wire solutions could give rise to even higher deposition rates. Equipment and material costs are also important criteria, which is another strength of Wire Arc Additive Manufacturing: all you need is a suitable welding system. There is no requirement for costly special equipment, such as the vacuum chambers needed for the faster electron beam process.

In comparison to powder-based processes, Wire Arc Additive Manufacturing benefits from the immediate availability of a range of certified wire types. There are relatively few powder-based materials to choose from, as it can take years to acquire the necessary certification and to produce data sheets, since the use of metal powder is a relatively new technology.

"Cold" Welding Process for Strong Layers

A stable welding process and effective heat dissipation are essential for large-scale 3D metal printing. The welding process needs to be sufficiently low energy such that when a new layer is applied, the existing layers do not melt again. In other words, the process needs to be as "cold" as possible. Furthermore, the weld layers need to be continuous, spatter-free, and consistent. If any flaws were to occur, these would be replicated in each subsequent layer.

The CMT GMAW process from Fronius and its process control variants meet these requirements. They produce a stable arc and a controlled short circuit with long short circuit times. This means that the heat input is lower and the material transfer is practically spatter-free, which helps to prevent flaws.

Two process control variants of CMT are particularly well suited to Wire Arc Additive Manufacturing. One is the CMT additive process characteristic, which has been optimized for large-scale 3D metal printing. It achieves high deposition rates while transferring very little heat into the component. The CMT Cycle Step variant reduces the arc power even further through the controlled deactivation of the arc during the process phase. However, this particularly "cold" process does need longer to build up the layers, as the deposition rate is lower.

Real World Wire Arc Additive Manufacturing Applications

Countless Wire Arc Additive Manufacturing components have already been produced using welding technology from Fronius in a variety of sectors. These include fan impellers for the electronics industry, which are made from high-grade materials. Milling the workpiece is very expensive due to the high rate of material consumption, while casting is not always able to meet the critical metallurgical properties required for walls just 1.5 mm thick. With Wire Arc Additive Manufacturing based on CMT Cycle Step, these fan impeller blades can be produced from a nickel-based alloy using an additive approach. It is even possible to repair components using Wire Arc Additive Manufacturing.

Fronius has also implemented another application with a partner in the aviation sector. Titanium is a frequently used material in aircraft construction thanks to its tensile strength, resilience, corrosion resistance, and low weight. The majority of the components are manufactured using subtractive methods, whereby up to 90 percent of the material is milled away. This causes high costs, long machining times, and costly tool wear. Components produced using Wire Arc Additive Manufacturing, on the other hand, only need reworking to produce a smooth surface. The titanium components produced using the CMT additive process do not exhibit any problems with lack of fusion and have impressive metallurgical properties. Tool costs, machining times, and wear can be reduced, meaning that overall machining costs can be brought down.

Wire Arc Additive Manufacturing: Economical and Flexible

This makes arc-based additive manufacturing a cost-effective and flexible alternative for component production. The additive process can be adopted with relative ease using welding technology from Fronius and the CMT solution.

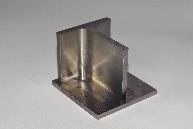
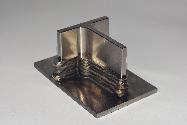
This press release, and the pictures, are available for download from: <https://www.fronius.com/en/welding-technology/info-centre/press>

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#### Images



Different filler metals can be used for Wire Arc Additive Manufacturing, such as steel, aluminum, chrome-nickel steel, or bronze.

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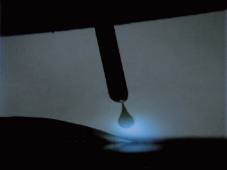
With Wire Arc Additive Manufacturing, components are "welded up" layer by layer before being mechanically reworked. In the example here, a component is being produced from titanium.

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Milling thin fan impellers from nickel-based alloys for the electronics industry is an expensive business, while casting is rarely an option. 3D metal printing is an economical alternative.



The key factors determining the quality of a component produced using Wire Arc Additive Manufacturing are the stability of the welding process and low heat input – the Cold Metal Transfer GMAW process from Fronius fulfills these requirements.



The reversible wire electrode used in the CMT welding process mechanically supports droplet detachment. This means that less energy is needed and long short circuit times are achieved – for a "cold" welding process.

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#### Business Unit Perfect Welding

Fronius Perfect Welding is an innovation leader for arc welding and a global market leader for robot-assisted welding. As a systems provider, the Fronius Welding Automation division also implements customized automated complete welding solutions, for the construction of containers or offshore cladding for example. The range is rounded off by power sources for manual applications, welding accessories, and a broad spectrum of services. With more than 1000 sales partners worldwide, Fronius Perfect Welding has great customer proximity.

#### Fronius International GmbH

Fronius International GmbH is an Austrian company with headquarters in Pettenbach and other sites in Wels, Thalheim, Steinhaus and Sattledt. With 6.100 employees worldwide, the company is active in the fields of welding technology, photovoltaics and battery charging technology. 89% of its products are exported through 36 international Fronius subsidiaries and sales partners/representatives in over 60 countries. With its innovative products and services and 1,366 granted patents, Fronius is the global innovation leader.

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