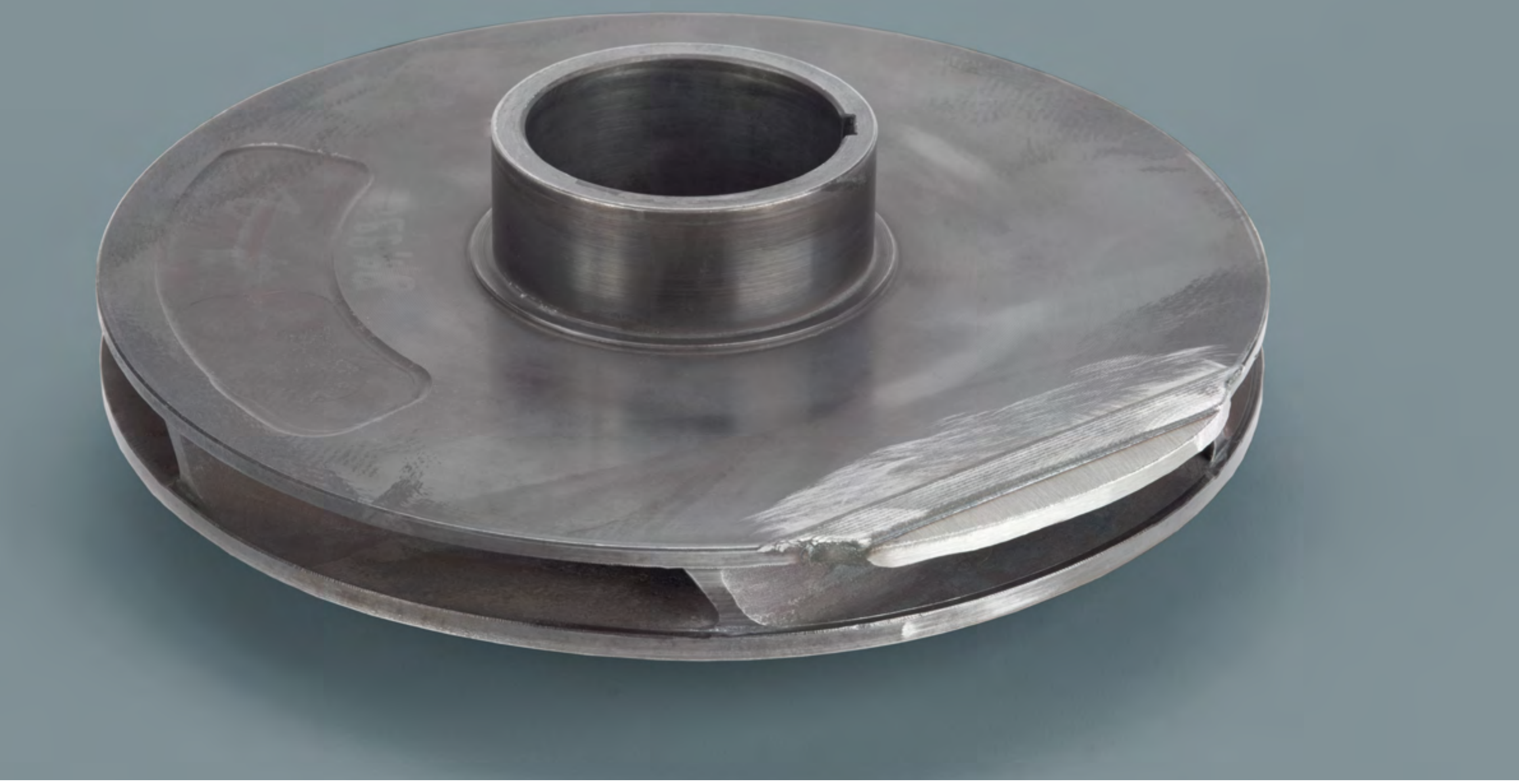
High-integrity rapid repair of pump parts



When the repair of damaged high-value castings and forgings is not possible using conventional methods, additive manufacturing offers solutions and shorter lead times.

Shafts and impellers are the most important parts with respect to pump integrity and operational reliability. Because of the high load during their operation, they have to be manufactured with high quality and fine tolerances.

> *“Laser metal deposition is speeding up repairs.*

Conventional repair methods are often insufficient

Current industry repair methods such as conventional welding or coatings will often result in unacceptable changes to material properties and design intent. For most of the cases, it is necessary to replace the whole component. Both forgings and cast parts can have lead times of more than six weeks. In the case of obsolete or third-party components, there is additional time needed for reverse engineering.

Additive manufacturing plus precise control

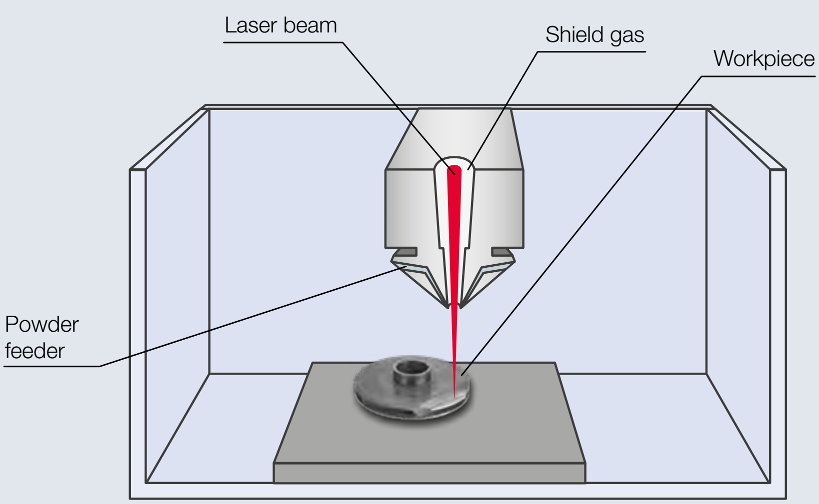
Conventional welding is not always a feasible solution. Welding has an impact on material properties, which require a post-weld heat treatment in some cases. Furthermore, the surface quality is not easy to control with welding.

In these cases, laser metal deposition (LMD) offers a viable repair solution. LMD combines the established additive technique of material buildup with the delicate control of laser power and the accuracy of CNC robotic control. In contrast to electric arc welding, LMD has low heat input to the base material as well as a comparatively small size and controllability of the weld pool.

LMD manufacturing repair offers several advantages, including:

- significantly reduced heat-affected zone (HAZ), which, for most common stainless steels used in pumps, can be considered insignificant due to low heat input
- precise control over weld deposition
- ability to create small, complex deposits
- equal or superior material properties to base material

Laser metal deposition (LMD) for repairs



LMD uses a laser (typically 2–10 kW) to generate a weld pool on a metallic component surface. Either powder or wire filler material is automatically added and simultaneously melted to form a deposit. The powder is inserted with an inert gas. Thus, the part is built up layer by layer on the substrate. Both the laser and nozzle from which the powder is delivered are manipulated using a robotic arm and CNC control.

Fig. 1 Working principle of laser metal deposition with powder.

Manufacturing settings for repairs

For this impeller repair using (Fig. 2) the LMD process, the material was deposited in layers 2–3 mm wide and approximately 1 mm high. The layer height and the surface structures are directly influenced by the particle size of the powder. A high-quality surface finish of LMD manufactured parts is necessary in many cases and can be done on conventional milling machines.

The first impeller repaired with this method took three working days. Tests have shown that the deposited material can achieve all required metallurgical properties, including hardness, strength, toughness, and interfacing with the base material. These properties are mainly influenced by the metal powder in use and by the LMD machine settings.

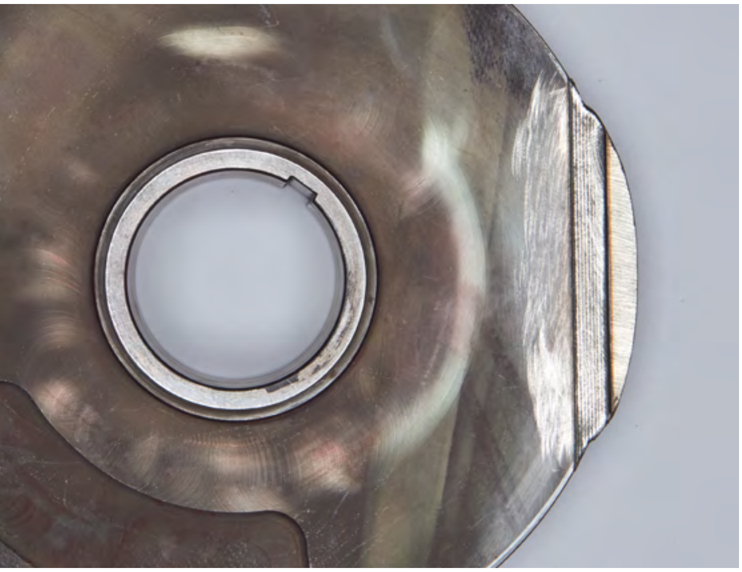


Fig. 2 Impeller with part added using LMD and partial surface finish.

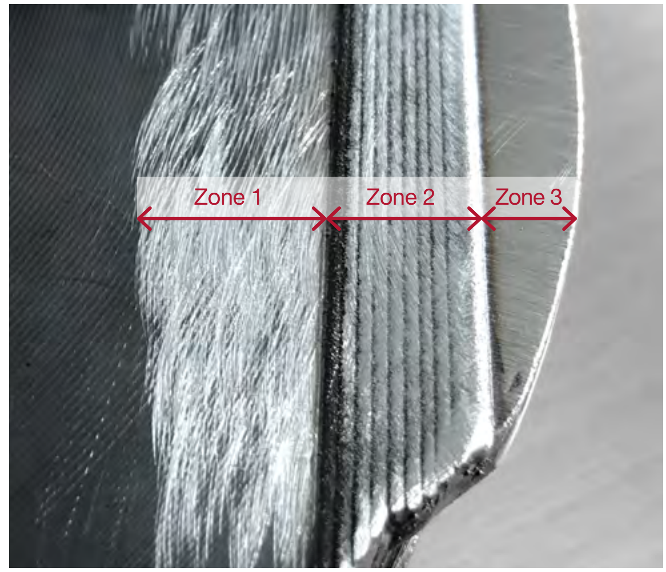


Fig. 3 Enlargement of the part added using LMD.
Zone 1 = Roughened impeller base material.
Zone 2 = Part added without the finish. The application of the metal in layer bands is visible.
Zone 3 = Part added with the final surface finish.

In the trial impeller shown in Figs. 2 and 3, a segment of the shroud was intentionally removed to permit the trial repair. Only the outer periphery of the repair deposit was dressed to show the quality of the weld material. The rest was left to make the weld layers visible for illustration purposes (Fig. 3, Zone 2). After final machining, there was almost no evidence of the repair (Fig. 3, Zone 3).

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High-integrity repair within days

Sulzer is currently working on a number of projects to qualify LMD processes for the repair of high-integrity duplex shafts as well as high-energy impellers. In the near future, Sulzer customers can benefit from high-integrity repairs in a matter of days.

For the future, Sulzer is working towards an integrated reverse engineering process through 3D scanning combined with CAD-CAM hybrid manufacturing for fast repairs.