Complete solutions under one roof

Whitepaper

MODERN REPAIRS OF MECHANICAL PARTS AND TOOLS

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1. INTRODUCTION

The latest standards in 3D printing are high-tech machines for additive manufacturing—metal production. The company MARSi group is offering 3D printing services for metals with one of the highest quality and most useful technologies for selective laser melting—SLM under the commercial label DMLS® (Direct Metal Laser Sintering), from the renowned manufacturer of industrial printers, EOS GmbH. By achieving uniform quality of laser-melted parts and material properties, DMLS technology is considered to be one of the most sophisticated in the industrial world of 3D metal printing and sets the highest standards in the industry.

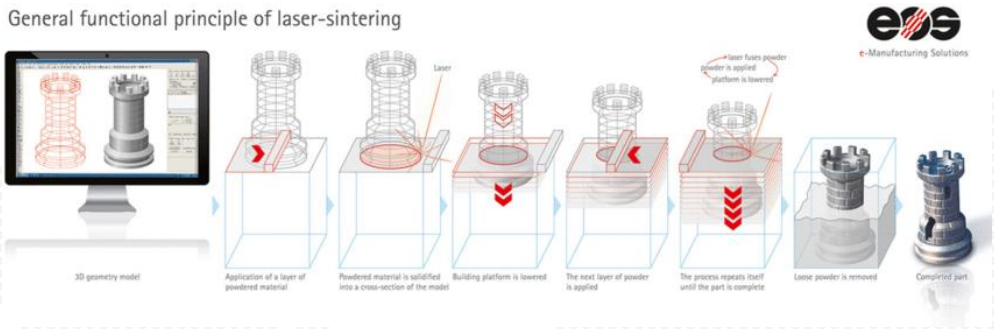

Figure 1: DMLS process [1]

2. REASONS WHY USE DMLS TECHNOLOGY

Given the needs of the industry for more economical and faster ways to repair tool inserts and mechanical parts, this technology has opened up completely new and more favourable repair options. Thanks to DMLS technology and the possibility of making hybrid parts with the "DirectTool" function, we can repair damages of a larger nature, which have been impossible to repair until now. This does not mean welding two or more broken parts together, but completely repairing the damaged area. The repair is carried out by adding a compatible material to the flat surface of the damaged area, which is completely removed and finally 3D printed, according to the 3D model. The process takes place in a closed, airtight process chamber, which operates in an inert gas atmosphere. Laser melting of powder material provides us with a completely homogeneous microstructure of printed parts, without visible weld lines at the place of repair. After the process, the printed parts can also be subsequently processed with conventional technologies and polished to a high gloss, if necessary.

Figure 2: Hybrid DMLS printed parts

Hybrid DMLS technology is not only used for repairs, but also when there are changes in construction or shape adjustments, as the existing, i.e. the unsuitable, part can be wire-cut and re-printed in the desired 3D shape. This usually significantly reduces costs and re-building time. When repairing mechanical and tool parts, besides the DMLS technology, we also use 3D chopping and reverse engineering. The latter allows us to repair and manufacture even in cases when technical documentation (in 2D and 3D formats) is not available.

With standard laser welding such repairs are not possible, as the process is manually controlled and does not allow us to apply material with such precision and high quality as we can with DMLS technology.

3. RESTRICTIONS

Regardless of the quality, practicality and convenience of DMLS technology, there are some additional limitations to its use, such as:

- *the size of the process chamber (250 x 250 x 325 mm) limits the size of repairable parts;*
- *the requirement for a properly prepared flat surface to start the layered 3D DMLS printing process;*
- *a relatively rough surface (Ra > 10 µm) requires additional conventional treatment to achieve lower roughness and tolerances.*

Figure 3: EOS M280 industrial printer [2]

The additive powder materials most commonly used to repair mechanical parts are: 316L Stainless Steel (W.Nr. 1.4404), Inconel® 625 Nickel Alloy (W.Nr. 2.4856) and Maraging Steel MS1 (W.Nr. 1.2709). The latter material is also most commonly used, as heat treatment can achieve a hardness of up to 54 HRc, or it can be manually set between 34 and 54 HRc. In addition, it is possible to combine different tool steels, which are limited only by the size of the laser melting surface and the weldability of the materials.

4. REPAIR METHOD ON THE ACTUAL PROJECT

4.1 Problem

Figure 4: Drive gear shaft breakage

The problem arose from the fracture of the "drive gear shaft" of the mechanical part of a classic conventional machine, due to its wear. The breakage occurred in the upper part of the mechanical part, i.e. in the gear area, where the maximum load forces are applied. This caused a lot of inconvenience for the customer's company, due to the age of the machine, and not the availability of the spare part. The company first applied for the service of 3D scanning and reverse engineering and we accommodated them by preparing the entire technical documentation, i.e. a 3D model and a workshop drawing with all of the required tolerances. After the documentation was prepared, they also asked for an offer on conventional production with the CNC turning and eroding process. The cost of production was unacceptable to them, as the shaft is a consumable material for them and it represents an enormous cost. Therefore they trusted us to urgently solve the problem and find the best solution.

4.2 Solution

In search of a quick and cost-effective solution, we offered them a hybrid DMLS printing service with additional conventional processing. The complete production of four "drive gear shafts" allows us to produce extremely fast in just two shifts. From an economic point of view, the rebuild cost was much more favourable, compared to conventional shaft manufacturing. The rebuild was about 1/3 of the production of the entire shaft, which would be made in a conventional way. At the same time, by repairing mechanical and tool parts, we are also much more economical in the use of material and energy.

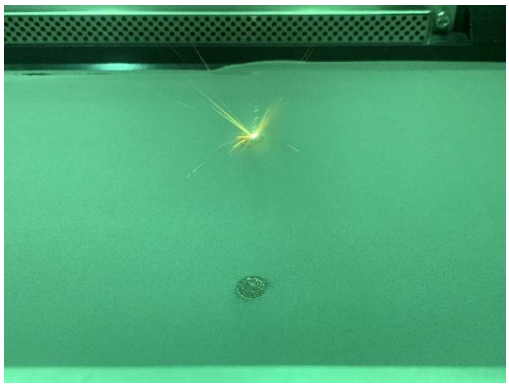

Figure 5: Hybrid DMLS printing process

The repair of the mechanical part took place in three stages, immediately after the delivery of the damaged positions. First, the damaged positions were conventionally treated by a milling process. This provided a flat, i.e. horizontal, surface, which is essential for the start of DMLS printing. We then inserted the machined and aligned positions onto the work surface of the EOS M280 machine, calibrated them, and began the 3D DMLS printing process, which was completed in one working shift.

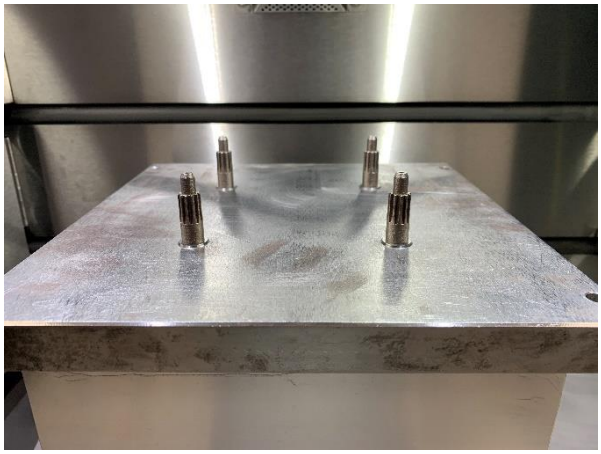

Figure 6: Gear shaft directly after the DMLS process

After the printing process was completed, the items were dusted, sandblasted in the printed area, and thoroughly cleaned in an ultrasonic cleaning bath. The final process in the manufacture of "drive gear shafts" was conventional machining with a turning process, to ensure that the repaired part met all the specified tolerances. The repair was completed within one working day and delivered to the customer the following working day.

4.2 Findings

Figure 7: Repaired drive gear shaft

The repaired "drive gear shaft" was functionally inserted into the machine in an extremely short time, as the repair process was reduced by two working days, compared to a full conventional production. According to the expert report and the customer's decision, the shafts, repaired with DMLS technology, fully satisfy all regulatory needs, tolerances, requirements and quality. According to the information received from the customer, the repaired shafts broke again in approximately the same time or even slightly later than the original conventionally crafted positions. The fact of the quality of the repair and the laser-melted material with DMLS technology left the customer speechless. The customer no longer doubted about the continuous repair of the displayed shafts with DMLS technology.

5. CONCLUSION

At MARSi group we are seeing an increase in the demand for the repair and refurbishment of mechanical and tool parts, as this speeds up and simplifies repair procedures. Due to its high quality and precision, additive DMLS technology is an ideal solution for the repair of various mechanical parts and tools for injection moulding of plastic products, as well as casting of light metals. Repaired tool parts that effectively extend tool life are a great example of that. Prior to the repair of tool parts, users of the presented services in the case of conventional, i.e. drilled cooling systems, often opt for model reconstruction, i.e. for the integration of conformal ducts. These allow them to have a more controlled heat dissipation, shorter cycle times and thus a more controlled process during injection moulding and light metal casting processes.

REFERENCES

[1] EOS GmbH – Electro Optical Systems [web]. Retrieved from: https://www.eos.info/en.

[2] MARSI GROUP d.o.o. [web]. Retrieved from: https://marsi.at/.

