3D printing propeller blades – towards remarkable high-quality, instant availability, increased sustainability, and lower costs

Ready to compete

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In the shipping industry, stagnation caused by wear, accidents, or other factors that put a ship out of service is a well-known expense driver. Often a repair service requires specialised and approved operations regulated by classification societies. Though costly, it makes perfect sense, as the best possible service should be applied to reduce the risks of failures outside the service intervals. The question is: can we do better?

We deal with three categories when viewing spare parts. First, the plug & play option, a ready-made spare part component (considered a consumable good to a certain extent). Second, there are high value and 'large' spare part components often manufactured when needed (in some cases, the piece is ready, just in case, due to insurance purposes). Here, refurbishment is possible if the timeline and expected quality allow it or the specified material isn't available. Third, extensive service that includes several parts of the two above.

Imagine

Highly skilled service companies take care of these categories. Although strategically placed worldwide, one still might find the locations 'too distant,' by which we mean service accessibility, material availability, costs, or timeline. Moreover, considering that the typically accepted manufacturing method is based on subtractive technologies, such as turning and milling, it also implies that a larger workpiece should be available. This setup will result in the 'production' of scrap. In other words, these solutions work; yet, there is room for fine-tuning.

Imagine a manufacturing world where all critical components and wear parts are stored as 3D files in the cloud. These blueprints can be downloaded by appointed and qualified additive manufacturing shops, printing the pieces on demand and precisely when the replacements are needed. Think of a print machine that only requires a 3D drawing and build material in the form of wire or powder, which you can shape according to your specific needs.

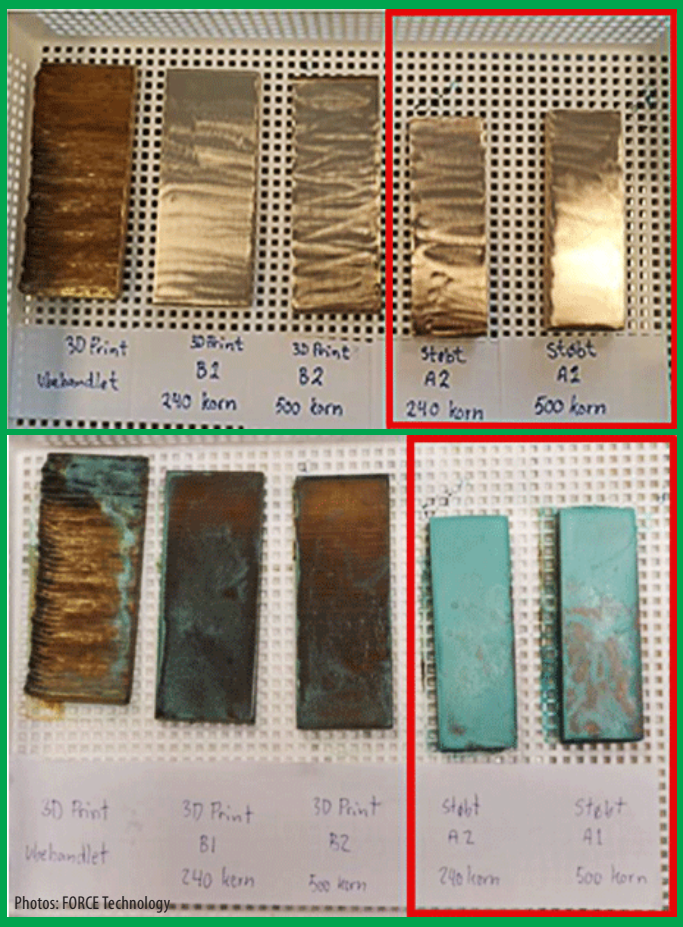
Additive manufacturing is not limited to polymer materials or space industry applications (or just for the fun of it). Thanks to its flexibility and efficiency (read: lower costs and lead times, plus local availability), 3D printing is a growing market. At FORCE Technology, we have scrutinised many different cases over the past couple of years. For example, print production of a 7.0 kg component for an F35 jet fighter showed reduced material consumption and time of production in the 90% parallel with acceptable quality.

3D printing vs traditional casting

Another study by FORCE Technology compared the wire arc additive manufacturing (WAAM) technology directly with traditional casting. As a production method, WAAM has been known since the 1920s. Today, the technique is utilised with CAD files and a robotic arm, quite a novel combination. WAAM is well-suited for large-scale components, meaning production isn't limited by space but by the robot's reach.

The work focused on propeller blade manufacturing in aluminium bronze (as propeller blades are already a subject of repairs). We included a bronze cast for direct quality comparison purposes. For casting, the requirements for processing propeller blades include raw material, a crucible, a mould, and post-processing. For 3D printing: wire material, a welding machine, a robot, and post-processing. Although casting has been used for thousands of years, while 3D printing is a new technology, the study delivered compelling findings favouring the 'newcomer.'

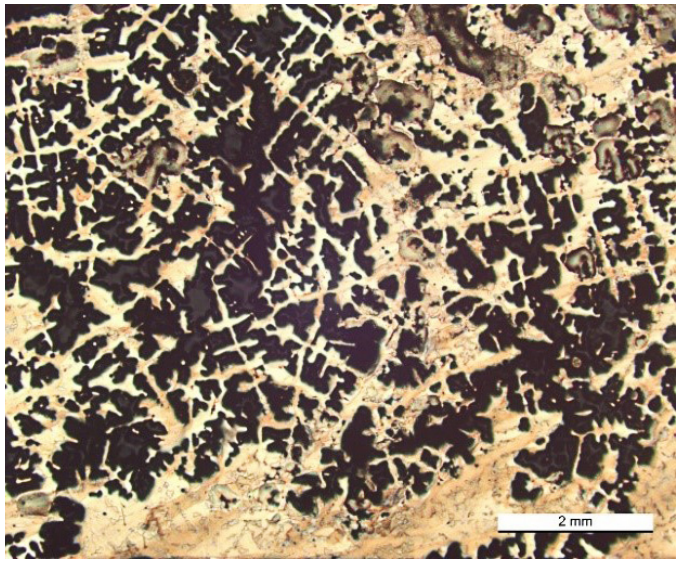
The images show three printed propeller blade samples (left) and two cast samples (right). The latter received some surface finishing, while the former set was taken right out of the 3D printer. Next, we exposed all samples to the same salt mist procedure. As can be seen in the bottom picture, the printed pieces experienced mild oxidation. The oxidation would have been even less if the samples had been subject to surface finishing. The cast samples experienced strong oxidation, independent of surface finishing.

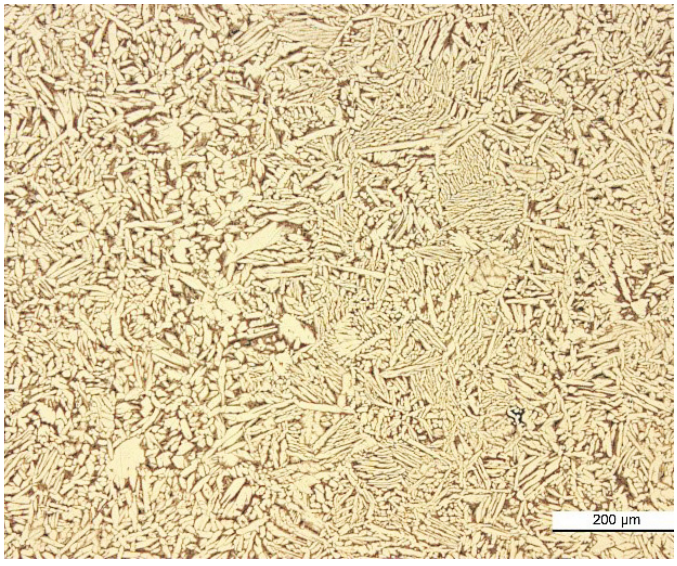


Photos: FORCE Technology









The mechanical properties of the cast and printed samples also showed remarkable differences. Due to defect formation during the casting process, the cast samples did not meet the mechanical properties stated in the standard for the material. The 3D-printed samples, to the contrary, obtained values that were very close to the standard material. The propeller blade samples' visual appearance and microstructure differed notably (left image – cast, right – 3D-printed).



Best of both worlds?

On top of the significant quality benefits, 3D printing is often a more cost-efficient alternative to casting. Additive manufacturing can yield direct production savings compared to casting since there is no need to create and maintain a mould. Furthermore, it can grant a higher degree of design freedom. Finally, 3D printing optimises resource use, with printing powder often made of recycled material.

Looking ahead, working with welding-based additive technologies, hybrid manufacturing – the combination of traditional and additive manufacturing – isn't something unthinkable. Mastering this method would allow for building special features on a turned shaft, saving heaps of material. ■

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