CASE STUDY

3D Printing Technology Dramatically Improves Manufacturing of Impellers

Xylem, the world-leading water technology company, simplifies production of impellers with ExOne binder jet 3D printing

ExOne™

Just two years ago, the impeller cores that Xylem used for casting water pump impellers were manufactured using a complex procedure where multiple parts were glued together. Today, they are 3D printed in one complete part and finished in a matter of hours. **To this end, the world's leading company in the field of efficient and sustainable water technology uses ExOne binder jet 3D printing, which meets all requirements for the printed impeller sand cores.**

At the end of 2017, the Swedish company Xylem Water Solutions Manufacturing AB installed the first 3D printer in its production hall, thereby solidifying a relationship with ExOne that had begun the previous year. As a company always fascinated by innovation, Xylem had contacted the global manufacturer of 3D printers at the International Foundry Trade Fair (GIFA) to help optimize its production process. Xylem supplies its innovative water technology solutions worldwide, covering areas ranging from water and wastewater transport, through water treatment, all the way up to quality analysis. These products are used by the energy sector, the food and beverage industry, construction or the municipal water supply. "We are always on the lookout for new technologies that enable us to optimize both our products and our own processes," explained Torbjörn Andersson, 3D Technician at Xylem. "This is why we have decided to use the possibilities of 3D printing for our production. However, as we had no prior experience with this technology, we selected ExOne to be our experienced partner."

By using the 3D printer from ExOne, Xylem was able to significantly simplify the manufacturing process for one of its key products: impeller cores. Since the new technology was introduced, the sand cores needed for casting water pump impellers have no longer been produced from four parts in a core shooting process – but from a single part in the 3D printer. "Our goal was to speed up production," commented Andersson. "Using the traditional method, it took seven days to manufacture impeller cores; with the 3D printer we can now do it within 48 hours."

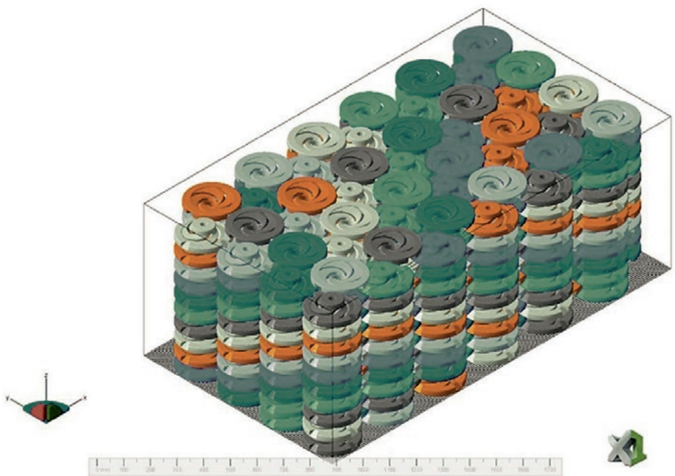

Figure 1
Up to 480 impeller cores can be printed in one jobbox per printing process. The illustration shows the ideal arrangement of the workpieces.

CUSTOMER
Xylem Water Solutions Manufacturing AB

INDUSTRY / PRODUCTS
Water treatment, pumps, filters, heat exchanger

HEADQUARTERS
Rye Brook, NY, USA

EMPLOYEES
16,200

CUSTOMER SPECTRUM
Municipal and urban water and waste water management, hotels, companies

WEBSITE
www.xylem.com

xylem
Let's Solve Water

“The quality of the impeller cores has improved significantly through the 3D printing process. At the same time, the ***production costs have decreased by around 30 %*** *for certain parts.”*

Torbjörn Andersson, 3D Technician at Xylem

3D printing technology reduces the number of steps in core manufacturing

The shorter production time is all down to the simplified process. When manufacturing water pump impellers using the conventional method, numerous work steps are necessary: First of all, the casting requirements are defined and a CAD model of the water pump impeller is developed. Corresponding to this, a core box is designed for the external shape of the cast part. In order to form the cavity in the interior of the workpiece, the core boxes are used for manufacturing the cores. Previously, these cores consisted of four parts, which had to be manufactured individually and glued together using core gum. Once the parts of the core had been put together and inserted in the mold, iron smelt could be poured. As soon as the cast part had set, the mold was emptied and the cast part removed.

Impeller core 3D printed as one piece in a CHP printer.

Conventionally manufactured impeller core produced from four parts in a cold box core shooting process; the parts are bonded together using core gum.

Figure 2

In the binder jetting printing process from ExOne, the core – with a diameter of 220 mm (8.7 in) and a height of 60 mm (2.4 in) – is produced in a single piece. To this end, the CAD model is digitally prepared and sent to the printer, which then prints the corresponding 3D mold. “Xylem uses the S-Max® CHP printer from ExOne,” explained Necip Cirakman, Regional Sales Manager at ExOne. “This uses cold-hardening phenol, or CHP, to bind the molding material.” CHP is especially well suited as a binder for these impeller cores. It is ideal for complex cast parts, retains its dimensional stability even at high casting temperatures and makes it easy to remove the core following casting thanks to its disintegration properties. As the binder hardens when cold, the printed components can be removed from the jobbox after just a few hours of curing. These components are stable in their form and only require a thermal post-treatment process before they reach their final hardness level.

Xylem uses a FS001-type silica sand as the molding material. Due to its fineness with an average grain size of 0.14 mm (0.006 in), printing with this sand results in a particularly high surface quality. “The quality of the impeller cores has improved significantly through the 3D printing process,” summarized Andersson. “At the same time, the production costs have decreased by around 30 % for certain parts.”

The core is produced layer by layer in the binder jetting printing process

The S-Max CHP printer from ExOne consists of a jobbox: a rectangular container with an open top and a height-adjustable base plate, known as the build platform. The jobbox is where the mold printing takes place: At the beginning of the process, it is automatically moved into the printer. First of all, the recoater of the printer covers the build platform, which at this point is positioned at the top edge of the jobbox, with several layers of sand. These are absolutely even, and the layer thickness is dependent on the material used. The printhead now distributes the liquid CHP on the sand layer – but only on the points which are to make up the impeller core. In doing so, the binder precisely binds every single grain of sand. The buildplatform is then lowered minimally so that the recoater can apply a new layer of sand. The printer applies the binder on the corresponding points of every new sand layer before the base plate is lowered again. This process – applying sand, printing with the binder, lowering the build platform – is repeated until enough sand layers have been bound. In doing so, the desired molded part – the impeller core – is created layer by layer.

The printer needs 27 seconds for each layer of sand. If the whole jobbox, which holds a build volume of 1,260 liters (76,890 in^3), is filled, up to 480 impeller cores can be printed at the same time. In this case, the entire printing process takes 24 hours. After printing, the jobbox automatically moves out of the printer. The excess sand that was not adhered is removed using a vacuum cleaner. Post-processing then begins: The impeller cores are removed from the jobbox, cleaned and then hardened in a thermal oven at around 160° C (320° F). After hardening, the cores are smoothed. They are then ready for casting.

Advantages of 3D core printing

Andersson was very happy with the print result: “The 3D printing process not only saves time, but also results in optimized core properties.” One of the advantages of the printed impeller core is that it is no longer necessary to adhere the core parts together. This rules out the formation of gas pockets when casting, which can form as a result of chemical reactions caused by the core gum when using the conventional procedure. As such, Xylem has reduced its defect costs from rejected parts. “The post-processing of the cast part also requires much less time and effort,” added Andersson. “Because the printed impeller core does not have any drafts, the amount of post-processing is reduced.”

A further advantage is that tool expenses for modifications and for maintaining the core boxes can be reduced by the 3D printing procedure. Even storage is no longer necessary, as no core boxes need to be held available for the foundry. A USB stick or another conventional data carrier is sufficient storage for 3D printing – and the impeller cores can be made in a “just-in-time” process.

Figure 3 (above)
The cast part made with a conventionally manufactured impeller core has deficiencies and requires laborious post-processing.

Figure 4 (below)
The cast part produced using a core from the 3D printer impresses with its high quality. No post-processing is necessary.

"We are now able to produce our impeller cores ***more quickly, at lower cost and in higher quality.*** *This is why we demonstrate this process to our visitors. We want to pass on our experiences and innovative spirit, as we see great potential for the future in 3D sand printing.*

Torbjörn Andersson, 3D Technician at Xylem

Xylem showcases 3D printing for visitors

Even though the 3D printer does not have any special space requirements, Xylem has decided to convert a production hall specially for the technology. During the course of this work, the company also installed an individual sand feeding solution. "We have laid new pipes and positioned the transport containers for the sand behind the hall," commented Andersson, summarizing the measures taken.

ExOne configured the printer for Xylem on the basis of the customer's specific requirements, adapting individual parameters for the printing process such as the angle of the recoater and the print speed. "Our customers were trained to use our printers in the ExOne Academy," reported Cirakman. "Therefore, if they notice that fine-tuning is necessary during the course of the process, they are able to do this themselves." The ExOne Academy provides users and engineers who will later work with the system with both the fundamentals of the sand printing procedure and information on the proper and safe operation of the printer.

A further advantage of the 3D printer is its simple operation, which offers the user greater freedom and flexibility. If the impeller core needs changing, for instance, all this requires is an adjustment to be made to the CAD model. There are virtually no limits when designing the cast part; the user has complete freedom when shaping the geometry. Even undercuts, which can only be achieved by changing the mold in the conventional method, can be realized without any problems in 3D printing.

There is another reason behind the decision to design the production hall specifically for the 3D printer, as Andersson explained: "We can welcome visitor groups here and give them the opportunity to observe this modern technology in practice." During the course of 2019, around 1,500 visitors, including school groups, students and young engineers, gained an insight into what is possible when two future-oriented companies such as Xylem and ExOne work together. "Switching over to ExOne's 3D printing technology has significantly improved our production process. We are now able to produce our impeller cores more quickly, at lower cost and in higher quality," summarized Andersson. "This is why we demonstrate this process to our visitors. We want to pass on our experiences and innovative spirit, as we see great potential for the future in 3D sand printing."

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