

# DuraForm Prototype Helps Kvaerner Test New Pump Design

Sector:	Industrial
Technology:	SLS® system/DuraForm™ material

Kvaerner is always trying to lower its electric bill. And who can blame them? Each month this Anglo-Norwegian engineering and construction company consumes massive amounts of electricity to power cooling pumps used at its gas and oil treatment installations on Norway's coast.

These pumps have power ratings of 1.5 megawatts and run 365 days a year as they draw massive amounts of sea water up from depths of 50 to 70 meters (164 to 230 feet). With these intense, ongoing workloads, even a slight improvement in pump efficiency can help shave a few kroner off Kvaerner's monthly power bill. Hence, company engineers are always on the alert for ways to improve pump efficiency.

Recently, Kvaerner relied on an SLS system located at the Oslo School of Architecture in Norway to create a testable DuraForm™ PA prototype of what it hoped would be a more efficient pump design. Computational data showed it would be more efficient. Functional testing would help Kvaerner be certain before it invested time and resources into producing the new pump.

## *More efficient, or not?*

In general, Kvaerner's water pumps should run at efficiencies of 85% or more. So Kvaerner engineers periodically review and evaluate new pump designs using computational fluid dynamic calculations and, when possible, functional testing with scaled-down functional prototypes.

"Flow dynamic principles rule the design of these pumps," explains Steinar Killi, assistant professor at the Institute of Industrial Design at the Oslo School of Architecture. "The equations modeling these processes are very sophisticated and have to run on advanced, high-throughput computer systems."

This type of virtual reality can depict real flow processes with a certain degree of reliability. However, these simulations can't compare with real functional testing. So when theoretical design reviews showed the potential for an increase in efficiency, Kvaerner approved the next step, performing functional tests using the scaled-down DuraForm PA prototypes.

To ensure an exact comparison, two prototypes were used, one representing the existing design and another exhibiting the new design.

*"The geometric accuracy of the laser-sintered parts met our expectation."*

*Cato Knutsen Moe, Kvaerner*

## *Creating functional prototypes*

"The first problem was finding a suitable material and processing method for the production of the pump prototypes," says Aage Bjerke, section leader in the foundry and pattern shop of Kvaerner Eureka's Manufacturing Division.

The method and materials had to successfully produce the intricate geometries typical of most pumps. These include long, curved inner flow channels. The method chosen would also be used to produce the rotor and diffuser ring.



*The Vanguard™ si2™ SLS system from 3D Systems utilizes a CO2 laser to fuse powder material into solid nylon parts. The finished parts can be used as prototypes for functional testing such as Kvaerner's water pump application.*

Rapid Prototyping

Kvaerner reviewed several solid imaging technologies and selected the SLS process for its ability to produce prototypes that can withstand harsh test conditions. The project team determined that milling would be too difficult and would require welding. It also explored plastic molding and ordered a plastic molded prototype rotor representing the existing design.

Polyurethane casting did not meet their needs. In addition, manufacturing the mold and cores this way was expensive, the cores were difficult to remove from the inner channels, and the material could not withstand the pressures exerted by the screws affixing it to the shaft of the motor. As a result, the core section of the flange had to be turned on a lathe and patched with a stronger material.

### *DuraForm prototypes created on SLS system*

"Kvaerner had heard about the good mechanical properties of the DuraForm prototypes produced on our SLS system and asked us to create two parts: the rotor itself and the stationary part of the pump, the so-called diffuser ring," recalls Killi.

A few challenges surfaced, but did not thwart the efforts. First, the pump rotor was a few millimeters too large to fit into the SLS system build chamber. This part had to withstand very high mechanical stresses, so it was downsized slightly. This allowed the part to be produced on the system as a one-piece rotor with a maximum outer diameter of 290 mm (11.4 inches).

The diffuser was also too large to fit into the build chamber, but since it would not sustain the high mechanical stresses of its rotating counterpart, the team agreed to produce it on the system in segments. These segments were produced in DuraForm PA material and glued together. As a finishing touch, an observation window was cut into one of the flow channel walls and fitted with a glued-in glass cover.

"The geometrical accuracy of the laser-sintered parts met our expectations," says Cato Knutsen Moe, design engineer in the Oil and Gas Division of Kvaerner Eureka.

### *Testing under intense conditions*

"The field trials were carried out on a test stand in our labs where the prototypes were mounted and operated in a closed-loop water circuit," says Moe.

The testing conditions were intense. Each test ran two to three hours. The power rating of the electric motor driving the pump shaft was 20 kW and the rotating speed of the prototype reached 1,500 RPM.

During testing, the water temperature in the closed circuit soared by 60° C (140° F) due to frictional power dissipation. The strain caused by this rise in temperature was so high, it blew out the observation window. Yet the DuraForm pump wheel and diffuser remained strong and withstood eight test cycles.

### *The results of the project*

"You can laugh or you can cry at these results," comments Professor Killi.

Contrary to computational data, functional test results revealed no significant efficiency improvements in the new design. The rotors of both the old and new pumps exhibited nearly identical performance. With no noteworthy changes, the new design was scrapped. This prevented Kvaerner from spending additional time and resources on a design that showed no significant improvement over its current pump.

Moe concludes, "In the future, when our ongoing research indicates that another new design is promising enough to test, we will certainly consider again using the laser-sintered DuraForm PA parts for the prototypes. Especially since we know we also can make them from the even more durable DuraForm GF, which includes glass beads."



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