

MEDICAL DEVICES AND PHARMACEUTICALS

B&W Engineering

Improving peristaltic pump efficiency to reduce prototype cycles

Products

Simcenter, NX

Business challenges

Improve the efficiency of the peristaltic pump

Account for stringent safety margins required in medical device applications

Achieve a constant flow rate within safety margins

Keys to success

Use Simcenter STAR-CCM+ to understand the fluid and thermal behavior

Use Simcenter STAR-CCM+ to solve fluid-structure-interaction problems with hyperplastic materials with stable and robust simulations

Select a software provider with comprehensive technical support

Results

Improved peristaltic pump efficiency to reduce prototype cycles

Used simulation to save time, reduce costs and bring a life-sustaining pump to market

Improved the drug delivery accuracy by 3 percent

Using simulation to save time, reduce costs and bring a life-sustaining pump to market

Consulting for complete medical devices

B&W Engineering is a consulting and service provider that develops complete medical devices. "Our know-how covers hardware, software and systems engineering," says Joachim Schütz, member of management for B&W Engineering. "Innovation is important to us. Our goal is to advance new technologies and efficient processes. Putting the needs of our customers comes first."

Designing a better life-sustaining pump

The design principles behind a peristaltic pump might seem deceptively simple.

Rollers compress a tube, resulting in the peristaltic forces delivering the fluid. For medical applications, there are extremely tight tolerances and regulatory requirements for operating conditions that make it challenging. The flow rate must be constant and accurate, with backflow limited to within acceptable safety margins. In one of its recent projects, B&W Engineering was tasked to improve the design of a life-sustaining peristaltic pump used for intravenous and parenteral infusions as well as enteral nutrition.

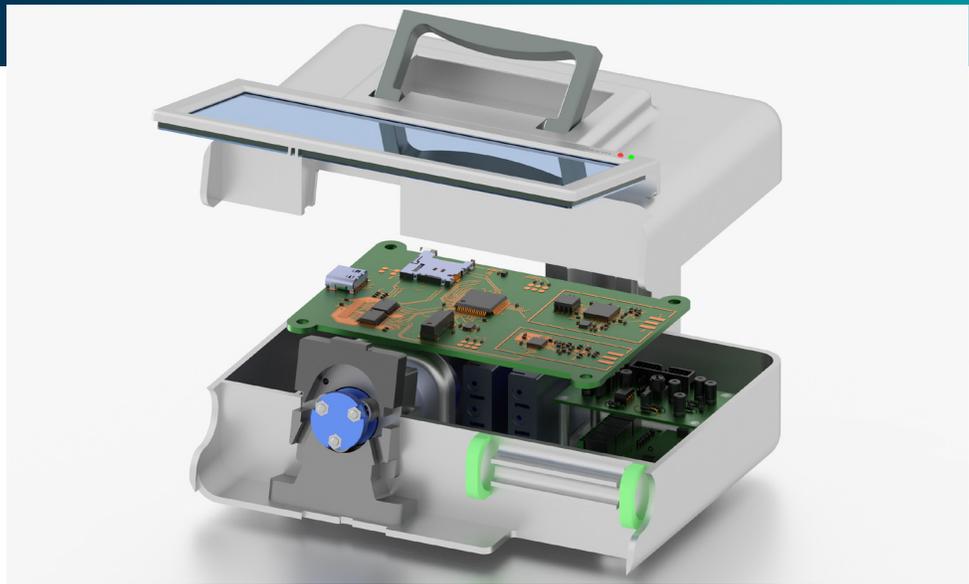
B&W Engineering had three objectives. First, it set out to develop a more precise drive compared to the previous model of this medical peristaltic pump. Second, it wanted to offer a lower drug delivery rate than the competition. This would require



Peristaltic pump for intravenous and parenteral infusions. The housing has smooth surfaces for easy cleaning. Several electronic components regulate fluid administration, battery charging cycles, and touch screen.

“Compared to other software, using Simcenter STAR-CCM+ has been a big advantage for us. Selecting a software provider with comprehensive technical support was also important for us and partnering with Siemens was the right choice.”

André Gasko
Simulation Engineer
B&W Engineering



Expanded view of the inner electronic components, which are sealed from the environment, to comply with the water ingress protection code.

integrating a new infusion pump system design focusing on higher conveying accuracy. The third goal was to deliver this to market faster than previous projects. “Using theoretical approaches and simulations, we wanted to complete this project in just one design cycle,” says Schütz. B&W Engineering used Simcenter™ STAR-CCM+™ software and NX™ software to gain critical insights into the pump design. The company was able to improve the pump design and performance accordingly. Simcenter STAR-CCM+ and NX are part of the Siemens Xcelerator business platform of software, hardware and services.

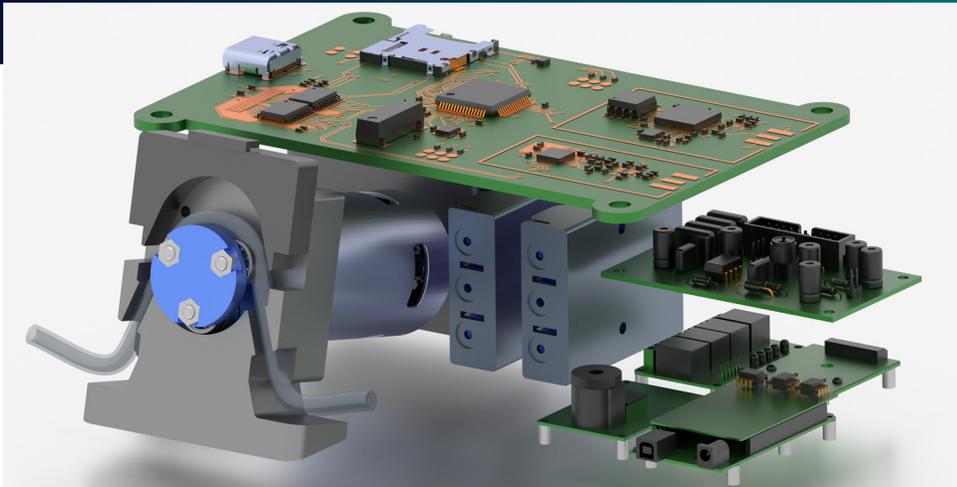
Temperature impacts battery recharge

The pump’s motor, along with other electronic components, produces heat and increases the temperature inside the device housing. The specifications limit the maximum internal temperature to 60°C, otherwise, the battery recharge capacity will be negatively impacted. In the event of a prolonged power interruption, the battery must sustain at least two hours of charge to operate at full capacity. Therefore, the recharging capacity of the batteries cannot be affected.

“Validating our design meant considering the worst-case scenario, in which we wanted to make sure the battery recharge

// Using Simcenter STAR-CCM+ provided us with all of the necessary tools to perform these challenging preloading processes and calculations.”

André Gasko
Simulation Engineer
B&W Engineering



“With this pump generation, we achieved the lowest drug delivery rate compared to other pumps in the market at the time and we have improved the delivery accuracy by 3 percent.”

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Simulation Engineer
B&W Engineering

View of the inner components showing the peristaltic mounting system that is integrated with the display mechanism and the main electronic components.

capacity would be unaffected to even the highest operating ambient temperature and power loss,” says André Gasko, simulation engineer for B&W Engineering.

Ingress protection keeps the heat in

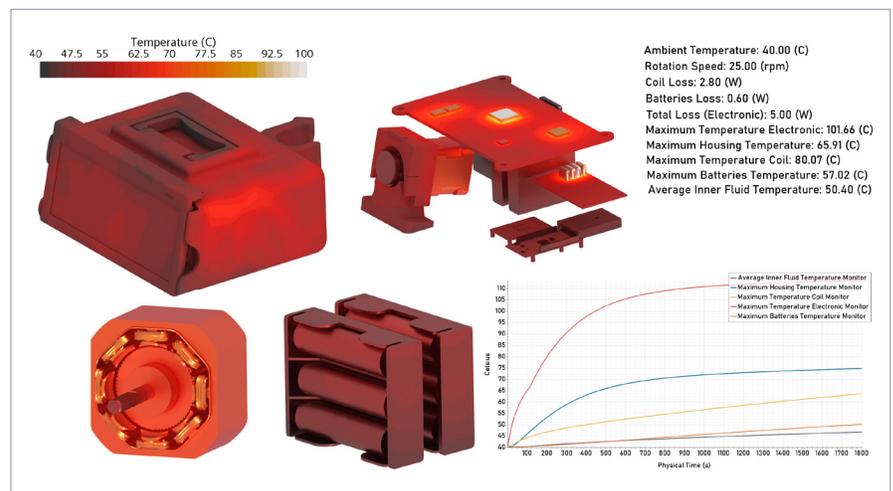
The device needs to be rated IPX4, an ingress protection (IP) code, as set by the International Electrotechnical Commission, (IEC) for which “water splashing against the enclosure from any direction shall have no harmful effect.” This requires the housing to be sealed from the ambient environment, making heat dissipation more difficult. “There are some challenges in keeping the temperature inside the housing below 60°C, especially if the pump is used to treat patients with burn injuries inside conditioned rooms where the temperature is set at 40°C,” says Gasko. Understanding the fluid and thermal behavior was key to achieving the improved design.

“Using Simcenter STAR-CCM+ provided us with all of the fluid, thermal and electromagnetics analysis required to simulate the pump,” says Gasko.

B&W Engineering used NX to develop the housing, display frame, holder and inner fixation regions. One design change to improve the heat dissipation rate was to reduce the housing thickness from 3 to 2.5 millimeters (mm). Using Simcenter STAR-CCM+ helped the team reduce the overall temperature when reexamined.

“We saved considerable time when we were changing properties or performing an optimization on our model since everything is in one module,” says Gasko.

“Compared to other software, using Simcenter STAR-CCM+ has been a big advantage for us. Selecting a software provider with comprehensive technical support was also important for us and partnering with Siemens was the right choice.”



Temperature results from Simcenter Star-CCM+. The maximum temperature reached by the batteries in this operation point is 57°C, which is under the maximum allowed value.

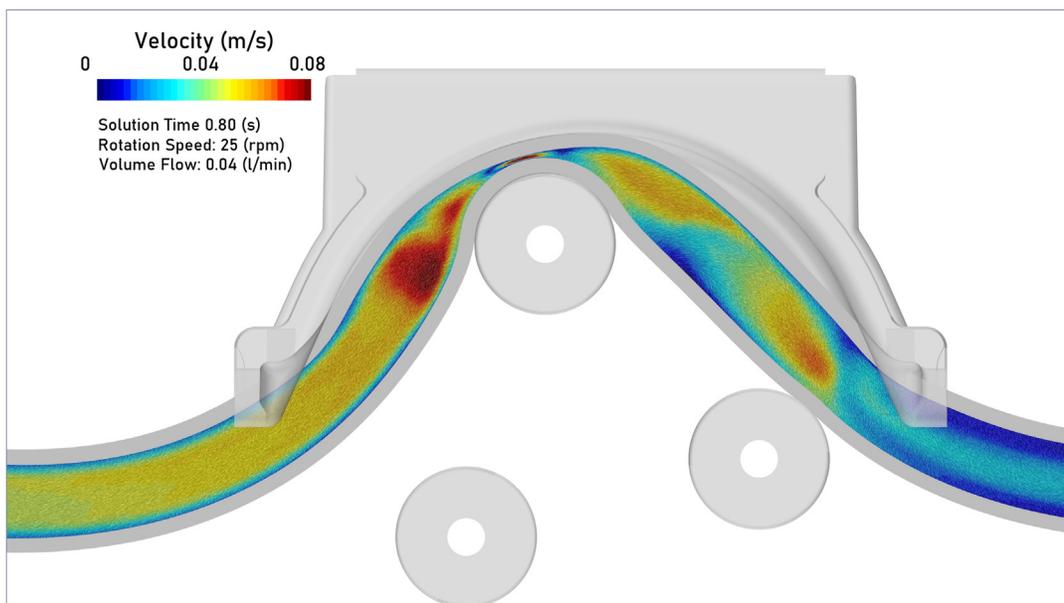
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Simulating the tubing

While the pump produces the forces to get it flowing, the tubing plays a significant role in the delivery of the drug. One challenge of the fluid-structure-interaction simulation is the preloading phase where the tubing has to be deformed from its original shape into the final state inside the peristaltic pump. At the end of the deformation when the tubing is pressed into the mount by the rolls, the time step has to be small enough to attain convergence.

Initially, this was done by trial and error. Using Simcenter STAR-CCM+ made it possible for the company to define a time step big enough to the highest deformation state when the tubing was completely pressed without causing convergence problems. Both ends of the tubing had to be displaced inwards, in the direction of the pump in the preloading process so there would be no pulling tension. The company also had to define the size of the displacement before it could start the calculation. This allowed for an accurate prediction of the drug delivery rate, which was an important design aspect of this project.



Fluid-structure-interaction simulation of the peristaltic pump at a rotation speed of 25 rpm. The analysis was made by accounting for the production tolerances of the closing mechanism that creates a gap inside the tubing allowing backflow, which was later on optimized.

Solutions/Services

Simcenter STAR-CCM+
[siemens.com/simcenterccm](https://www.siemens.com/simcenterccm)

NX
[siemens.com/nx](https://www.siemens.com/nx)

Customer's primary business

B&W Engineering specializes in developing complete medical devices, including hardware, software, mechanics and systems engineering.
www.buw-engineering.com

Customer location

Stuttgart
Germany

Another challenge with this calculation is the deformation of the small gap inside the fluid region when the tubing is pressed. The mesh had to be fine enough to capture the curvature of the rolls pressing the tubing yet still coarse enough to induce a higher iteration time.

"Using Simcenter STAR-CCM+ provided us with all of the necessary tools to perform these challenging preloading processes and calculations," says Gasko. "Using Simcenter STAR-CCM+ has been very stable to calculate fluid-structure-interaction problems with hyperplastic materials and multiphase calculations."

Reducing prototype cycles

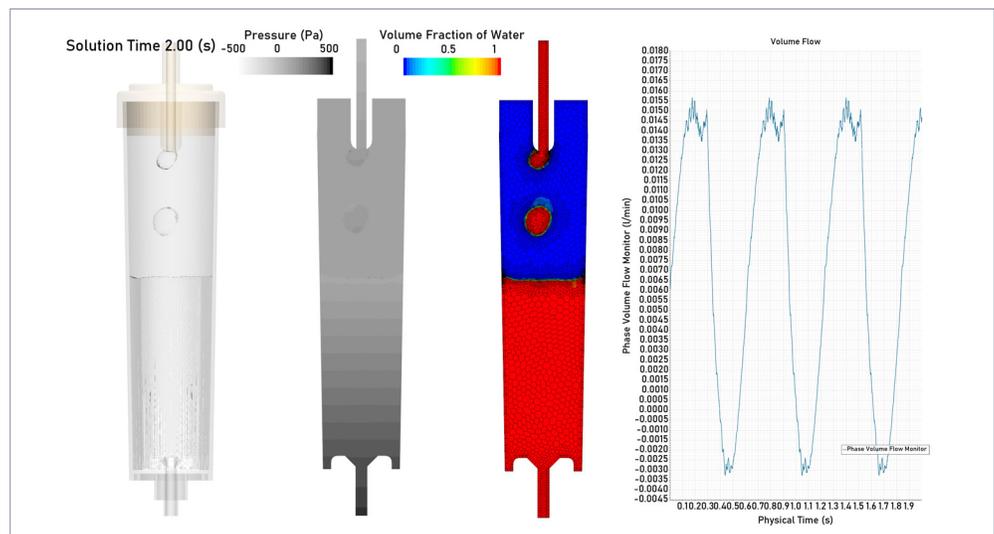
B&W Engineering was seeking to streamline the design process and leverage simulations to speed up the time to market and reduce cost. However, each prototype can cost upwards of 80,000 euros (€). Using NX and Simcenter STAR-CCM+ allowed B&W Engineering to do that.

"We needed fewer prototype cycles and coordination between the suppliers," says Schütz. "There was a higher precision because we could analyze important tolerances separately so there was more focus on the most relevant issues. All of this results in cost reduction and increase in precision."

"With this pump generation, we achieved the lowest drug delivery rate compared to other pumps in the market at the time and we have improved the delivery accuracy by 3 percent," says Gasko.

The demand for medical devices is continuously increasing. Delivering them to market faster, while keeping costs low and accuracy high, makes the challenge that much harder. By using Simcenter Star-CCM+, B&W Engineering can meet that challenge and engineer innovation for the lifesaving devices of tomorrow.

Because of confidentiality the pictures are modified.



Multiphase simulation of a study of the effects of the peristaltic movement to a drip chamber. The peristaltic behavior can affect the velocity rate of the droplet formation in the chamber. This can cause an inconsistency with the actual volume flow value shown in the pump.

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