The Latest Word in Pumps: Think Small!

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With increasing medical device miniaturization, micropumps are pressuring their way into portable and wound-care applications.

Compared with bioresorbable stents, 3-D printed tissues, or cancer-fighting nanobots, medical pumps are hardly the most ‘sexy’ technology on the block. But without them, doctors and nurses couldn’t dispense fluids or medications. They couldn’t remove tissue or foreign material from wounds. And they couldn’t monitor a patient’s vital signs. Sexy? Well, no. But trying living without them.

Medical pumps can be based on different technologies, such as diaphragms or pneumatic drives. They can come in a variety of different shapes, sizes, flow-rate capacities, and pressure and vacuum ratings. At bottom, the choice of pump type depends on the performance requirements of the application in question. However, with the trend toward smaller and smaller medical devices, one thing is certain: Pump manufacturers are shrinking their designs, leading to growing interest in micropumps.

Keeping a Low Profile

“With the trend toward miniaturization, today’s pumps have a very flat design and can be much less expensive than previous-generation pumps,” remarks Seta Davidian, marketing manager at Lexington, MA–based Servoflo Corp., which markets the mp6 diaphragm micropump from Dortmund, Germany–based Bartels Mikrotechnik GmbH. “The mp6 transports tiny amounts of gases or liquids in drug-delivery and infusion-pump applications. Aside from its size, the pump’s chief technological advantage is that it is easy to control. If an end-user needs to specify different variables, the pump can accommodate this.”

Because of its flat form factor, the mp6 piezoelectric diaphragm micropump can be designed into wearable medical devices.

The mp6 offers a range of advantages in medical device applications, according to Frank Bartels, founder of Bartels Mikrotechnik. “Because of its flat form factor, it can be designed into wearable medical devices. And because it is battery operated, it has low energy requirements. In addition, it exhibits material stability because only one material comes into contact with body fluids, ensuring a low reaction with blood, antibodies, or hormones.”

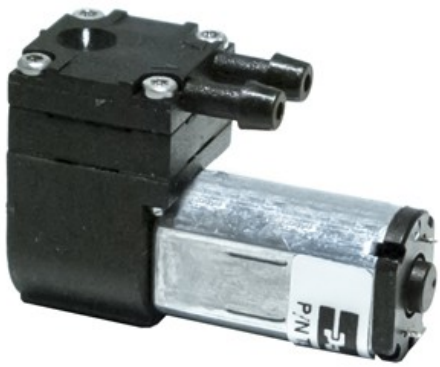
Incorporating a piezoelectric diaphragm in conjunction with passive check valves, the pump reacts to applied voltage by deforming a piezoceramic part mounted on a coated brass

membrane. The resulting downstroke displaces the medium in the chamber below. The check valves on both sides of the pump chamber define the flow direction. When the voltage decreases, the corresponding deformation of the piezo causes an upstroke of the membrane, causing the medium to be sucked into the chamber again. This design enables users to adapt it to specific flow rates or back pressure.

Unlike pumps that are equipped with magnetic electrical motors to drive the membrane-moving excenter, the piezoelectric diaphragm micropump is nonmagnetic, Bartels comments. “The advantage of the piezo approach is that it enables the incorporation of compact drives, membranes, and valves, which, in turn, enable complete pump functionality without any magnetic components. This feature allows the pump to be used in implantable medical device applications because it can be subjected to nuclear magnetic resonance and other magnet-based imaging procedures.”

Wound-Care Vacuum Cleaners

Medical device pumps are used in a diverse array of applications to provide pressure or a vacuum signal, remarks Abelardo Gonzalez, global product manager at Hollis, NH–based Precision Fluidics Division of Parker Hannifin. “When we look at the growing trend in the medical device sector toward getting devices into the hands of end-users, homecare—and hence, portability—are critical. This trend has led to device miniaturization and the proliferation of micropumps.” Meeting this demand is the company’s T2-05 micropump. Featuring flow rates up to 800 ml/min, the pump is a single-patient disposable-use pump that is used for treating small wounds.



Featuring flow rates up to 800 ml/min, the T2-05 diaphragm micropump is used for treating small wounds.

Like the Bartels mp6 micropump, the T2-05 is based on diaphragm technology. Such pumps, explains Leonard Prais, engineering manager at the Precision Fluidics Div., consist of a diaphragm that is driven up and down by such components as cams, creating displacement. Check valves manage the airflow in and out to create the pumping action. “One of the nice things about diaphragm pumps,” Prais says, “is that they are much better sealed than other technologies such as piston pumps, a feature that is important for preventing leakage.”

The T2-05 is used to draw a vacuum on a special bandage, creating negative pressure. When this vacuum is created over a certain amount of time, it brings the whole bandage down to a vacuum level of 75–125 mmHg, which is appropriate for the therapy. Then, when the pump shuts off, its check valves act as a load hold, preventing the vacuum from leaking out. While bandages are natural sources of leakage, the pump is able to hold the load in most cases. If it cannot, however, the OEM can incorporate an additional check valve to hold the vacuum when the pump shuts off. Once the pressure falls to a certain minimum level, the pump turns on again

and pumps the pressure back up to the required setpoint. The more efficiently the pump can perform these functions, the less battery power is required.

“Diaphragm pumps are an excellent technology when you’re trying to achieve a good tradeoff between performance, size, and lifespan,” Gonzalez comments. “While there are differences among them, all diaphragm pumps can be delivered in a smaller form factor than other pump types. And based on our own elastomer formulations, our diaphragm pumps can last up to 10,000 hours.”

OEMs, he adds, are doing a fantastic job applying diaphragm pump technology to treat injuries that traditionally were treated using passive technologies. “Thus, you can see something on the horizon like a high-tech band-aid. Wound-care technologies are moving in the direction of using pumps because they help improve safety and infection control while accelerating the healing process.”

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