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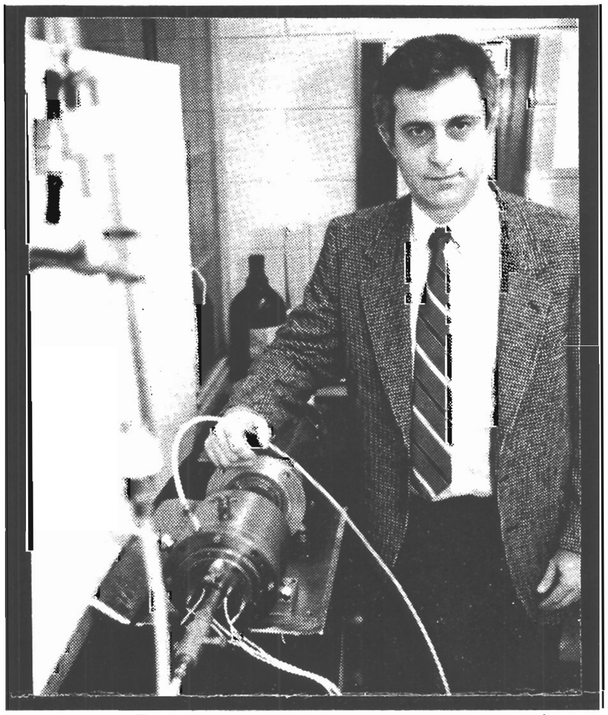
IMPROVING KIDNEY DIALYSIS: NEW BLOOD PUMP REDUCES CELL DAMAGE, BOOSTS EFFICIENCY

A pump that could reduce the damage dialysis treatment can do to red blood cells is even more efficient when one small component is modified, a Georgia Tech researcher's analysis shows.

Dr. Itzhak Green, who has spent the last two years working with colleagues in Israel to develop and test a prototype viscous pump, has demonstrated that designing it with V-shaped lobes instead of curved ones will improve performance.

"The circular lobes were the prototype, but they are not efficient," said Green, associate professor in Tech's School of Mechanical Engineering. "Straight, V-shaped lobes are up to three times more efficient than the circular lobes."

The pump holds potential for use in medical pumping applications because the fluid flowing through the pump does not come in contact with pump lubricants. In addition, the rotor and stator have no contact with each other in the flow path of the fluid, which reduces wear on pump components and allows red blood cells to flow freely without being damaged. The design might also be useful in printing technology and other uses that require small, controlled and highly accurate flows of viscous liquids, Green said.



Dr. Itzhak Green and a colleague developed a viscous pump that could improve dialysis treatments. Now Green has found a way to make the pump more efficient. Color Slides/B&W Prints Available

Dialysis treatment, the cleansing of the blood for those whose kidneys do not function, currently uses peristaltic pumps. Such pumps

FOR MORE INFORMATION:

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create a pulsating flow by letting blood fill plastic tubes and then squeezing the tubes with rollers, forcing the blood through a dialysis machine. That squeezing process can damage or destroy red blood cells -- vital, energy-supplying components that most dialysis patients have very few of.

The viscous pump that Green has collaborated on was developed in principle by his colleague Izhak Etsion, a faculty member in the Mechanical Engineering Department at Technion-Israel Institute of Technology. The pump's rotor, a flat disk, rotates above a stationary disk called a stator, from which the raised lobes protrude. The motion of the rotor creates a shear force between it and the stator, which propels liquid through the pump at a continuous rate. The lobes direct the process fluid to flow freely in one direction, and in the process are capable of building pressure. The stator and rotor are about 60 to 80 microns apart -- very close, but leaving a large enough gap for the average eight-micron diameter red blood cell to pass through.

Green and his colleagues demonstrated in 1989 that the original viscous pump with semicircular lobes provided a feasible pumping mechanism. They used the pump to move mineral oil, which closely resembles blood in terms of viscosity.

However, Green thought the pump might be more efficient if the lobes were composed of straight lines forming V shapes instead. With semicircular lobes, the number of lobes automatically determines their size; with V-shaped lobes, that constraint does not exist. Therefore, using V-shaped lobes adds yet another degree of freedom to the design, which improves the possibility of optimizing and designing a better pump.

Green used a theoretically optimized design of the semicircular-lobed pump prepared by Etsion, and created an analytical optimal design for the pump with V-shaped lobes. Both geometries were based on achieving maximum flow rate. Green verified the analytical model of the pump with V-shaped lobes using shape factors and finite element models.

He then compared the performance potentials of the two designs at different parameters using analytical and mathematical approaches. Green's findings showed that the pumping mechanism of the design with V-shaped lobes is superior to the one using semicircular lobes. Making the lobes V-shaped reduced pumping losses. In addition, increasing the number of V-shaped lobes, and their radial extent into the center of the rotor, increased the pumping capacity of the machine. Three V-shaped lobes perform almost 50 percent better than three semicircular lobes; eight V-shaped lobes perform three times better.

Green's analytical findings were published in the July 1992 JOURNAL OF TRIBOLOGY. Experimental results that confirm the analytical findings are being readied for publication.

In the future, Green would like to secure funding to design and test, at least theoretically, yet another pump configuration that he has developed and believes will provide improved performance. Other areas that need to be addressed are whether shear stress affects blood flowing through a viscous pump, and whether the flow pattern in the pump affects blood's clotting tendencies differently than pulsing flow does. Green would like to eventually test the efficiency of the newest designs by experimentally using them to pump whole blood.

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