New Principle for Fluid Flow Measurement

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During hemodialysis treatment is it important to measure an accurate and precise fluid flow, sensors that meet these specifications have a high manufacturing cost. The new principle is based on the principle of a rotameter, which is commonly used and cheap to manufacture.

In the treatment process of hemodialysis (HD), an important objective is to control the fluid level of the patient. It is important to avoid hypervolemia and hypovolemia[1]. Therefore, a precise measurement of the flow during the process is necessary. The current flow sensors, used in HD-machines, are expensive to manufacture. This article presents a new principle for fluid flow measurement. The purpose of the new principle is to provide an easier way to measure fluid flow.

The new principle is based on a conventional rotameter. The concept of a rotameter (Figure 1) uses a float placed inside a tapered, vertical tube. By changing its vertical position the float maintains a constant fluid velocity around it. This makes it possible to visually determine the flow rate by observing the vertical position of the float.

The new principle (Figure 1) uses a straight tube instead. With a straight tube the system only has one point of equilibrium. This point is chosen to be at a flow rate which is slightly lower than what is desired to measure. This results in an upward facing force on the float. A new force is introduced by putting a permanent magnet in the float and winding a solenoid around the tube. The float can be held in one place by applying a current through the solenoid. A relation between what current is needed to keep the float in place, and the flow rate of the fluid can then be found. Using the inverted model provides a flow measurement calculated from the measured current in the solenoid.

A prototype was designed by an iterative process and mounted in a test rig to measure and control the flow rate. The test were performed using the MathWorks softwares Simulink and Stateflow.

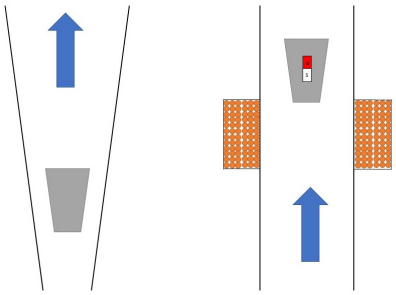

Figure 1: *Principle of rotameter to the left, new principle to the right*

The performed tests show that the new principle can be used to determine a fluid flow rate. At optimal conditions the new principle proved to be quite precise.

A few parameters were seen to reduce the accuracy of the measurement. The most significant parameter was the temperature. To get a reliable sensor operating with the new principle the temperature dependency needs to be considered. Some disturbances, from pressure changes, tilting of the sensor and introduction of air bubbles in the system, were found to have an impact. These disturbances appear to have solutions that can avoid errors in the measurement.

To get a more reliable result, and more thorough evaluation of the new principle, more experiments and tests need to be conducted. We believe that the new principle has potential, and that it in the future can be used as a commercial fluid flow sensor.

The new principle was investigated as a master thesis project for graduation from the mechanical engineering program at Lund University. The work was performed at the initiative of Baxter, Lund and the evaluation of the principle was made at the company. Baxter designs and manufactures hemodialysis machines.

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1. Hypervolemia is a condition of a too high fluid level in the blood. Effects of hypervolemia can be a pulmonary edema or heart failure. Hypovolemia is the reverse case with a too low fluid level in the blood and therefore leads too diminished blood pressure.