HALL EFFECT SENSORS IN PADDLEWHEEL FLOWMETERS

Hall effect technology has permitted dramatic changes in low-flow measurement. Although Hall effect sensors are relatively new to fluid velocity detection, they are replacing mechanical contacts, e.g., reed switches, and are being widely used in applications such as motor rpms that require relatively high frequency sensing. A commercial line of low-flow paddlewheel-type sensors features low initial cost, simplicity of design and operation, and negligible maintenance.

Paddlewheel flow sensors are insertion devices that use tee or saddle fittings for plastic pipe, and tee, saddle, or weldolets for metal pipe (see Photo 1). A simple but precise electromechanical principle governs their operation: Four permanent magnets, embedded in the rotor blades, rotate past a Honeywell Hall effect sensor in the sensor body (see Figure 1). Rotor rotation caused by the fluid flow produces an open-collector, square-wave pulse output that is directly proportional to flow rate. The patented "open cell" construction of the rotor in Figure 1 ensures a linear, repeatable output of ±1% of the full dynamic range. With only a modest intrusion into the flow stream, a paddlewheel configuration will deliver high accuracy with minimal head loss and no cavitation. If there is any pressure drop from the paddlewheel, it is too small to significantly affect the performance of the system. Because this sensor is available in several chemical-resistant, noncontaminating materials, it can handle a wide range of liquids including acids, solvents, and most corrosive fluids.

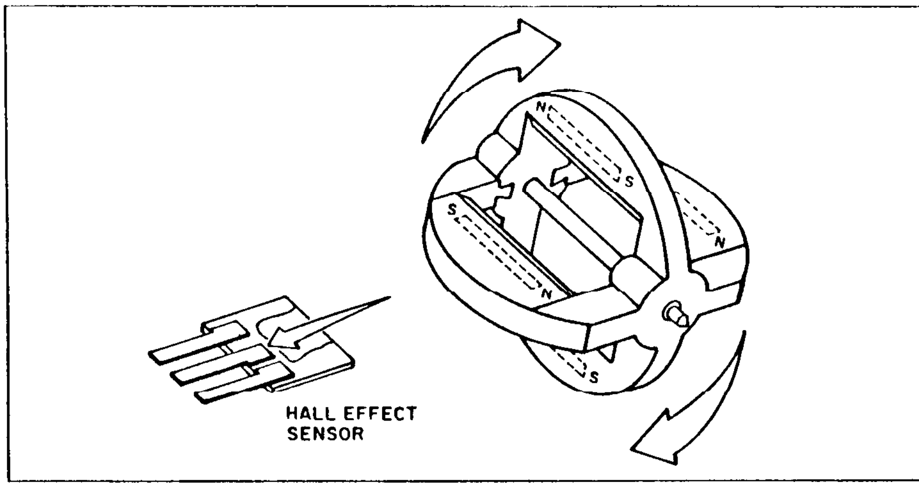


Figure 1. The Signet paddlewheel flow sensor incorporates four permanent magnets imbedded in the rotor blades. The magnets rotate past a Hall effect sensor in the body of the device. Fluid flow causes a rotor rotation that produces an open-collector, square-wave output directly proportional to the flow rate.

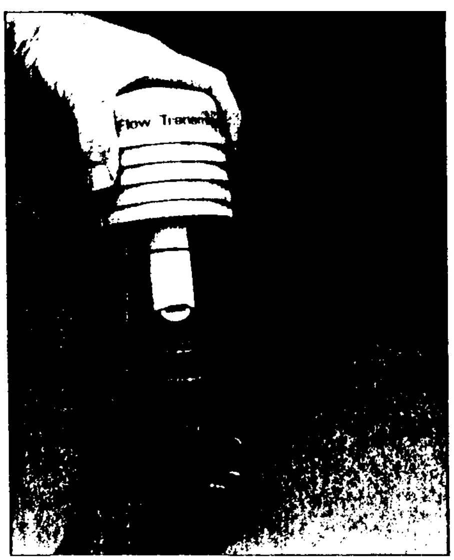


Photo 1. The Signet Model 3-2530 has a flow response from 0.3 fps to 10 fps in pipe sizes with diameters from .5 in. to 36 in. The output signal can be transmitted up to 500 ft to any device that will accept a square-wave pulse, e.g., flowmeters, DASs, PLCs, batch controllers, and computers.

Conventional insertion paddlewheel sensors incorporate a coil within the sensor body. As the rotor and magnets spin by the coil, they generate a signal proportional to the fluid velocity, i.e., to the rpm of the rotor. This type of sensor/generator requires the rotor magnets to have a relatively strong magnetism, which, together with the coil, creates magnetic stiction (an attraction of the rotor magnets to the sensor coil). In order to overcome the magnetic stiction, the rotor typically must be exposed to a minimum fluid velocity of 1 fps. By using a Hall effect sensor, however, the magnetic stiction can be eliminated, the magnet size and strength reduced, and the fluid velocity necessary to accurately spin the rotor decreased to 0.3 fps. Eliminating the coil within the sensor housing also reduces the potential for induced error in high-noise environments.

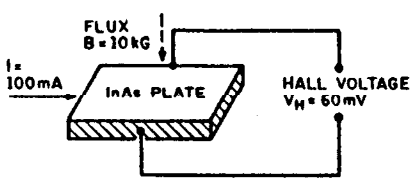
APPLICATIONS

Hall effect sensors are well suited to a wide variety of industrial, commercial, and liquid flow applications such as sensing gravity flow in a chemical additive system. In this example, output from the sensors is transmitted to a pair of controllers that keep track of the programmed mixture ratio through a host computer.

In another application, the sensors are used to accurately measure low-flow polymer added to an effluent line. The customer needed to add polymer proportionally to the flow line by using a feed pump; the problem was that the line flow ranged from 130 gpm to 400 gpm, which was too low for the standard paddlewheel to accommodate. The Signet 2530 low flow sensor, however, detects the flow rate

The Hall Effect

In 1879, E.H. Hall noted that a small voltage was generated across a conductor carrying current in an external magnetic field. This Hall voltage (or effect) was very small with typical conductors, and little was made of it at the time. With the development of semiconductors nearly a century later, however, it was found that larger values of Hall voltage could be generated. As shown in the figure, when a plate of indium arsenide (InAs) semiconductor material is inserted into a magnetic field, a voltage of 60 mV can be generated with a flux density (B) equal to 10 kG and a current equal to 100 mA. The applied flux must be perpendicular to the direction of current. For the example shown, the current is in the direction of the length of the conductor, and the generated voltage is developed across the width.



The voltage (V_H) generated across the element is proportional to the perpendicular flux density (B).

The amount of Hall voltage (V_H) is directly proportional to the value of flux density (B). This means that values of B can be measured by means of V_H, e.g., a gaussmeter will use an InAs probe in the magnetic field to generate a proportional Hall voltage V_H that is then read by the meter, which is calibrated in gauss. The original calibration is made in terms of a reference magnet with a specified flux density.

and signals the pump pulser, which controls the amount of polymer through the metering pump to the line.

For more information, contact Rick Hines, Flow Product Manager, George Fischer Signet, Inc., 2882 Dow Ave., Tustin, CA 92680; 714-731-8800, Fax 714-731-6201.

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