Design of a Sensor to Detect Conductivity Change

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Abstract

A sensor was designed to detect backmixing of vessel fluid into the feedpipe. The sensor was composed of electrodes and a designed electric circuit. The electrodes were installed inside the feedpipe and tap water was flowed into the feedpipe. When NaCl solution in the vessel penetrate into the feedpipe due to high agitator speed, the conductivity change is sensed by the electrodes and the resultant output signal is recorded by a pen-chart recorder. The electric circuit was designed to show maximum sensitivity. The resolution of this designed sensor was on the order of 10^{-5} mole/l.

1. Introduction

The yield of desired products for the fast competitive-consecutive reactions can be increased by introducing the feed into the highly turbulent region of the vessel. However, intense turbulence may cause backmigration of the vessel fluid into the feedpipe where the level of turbulence is lower than in the vessel and, consequently, decreases the yield of the desired products. Therefore, it is important for the reactor to be operated under the conditions on which the detrimental feedpipe backmixing can be eliminated. In order to do this, it is necessary to develop a technique which can detect backmigration of vessel fluid into the feedpipe.

Previous study developed a visual dye technique and determined operating conditions to eliminate feedpipe backmixing. However, the visual dye technique was limited to very low feedpipe flow conditions because the dye was dispersed very fast in highly turbulent flow conditions, and the naked eye could not follow the movement of the dye. Therefore, a more advanced detection technique is needed to be applied to high turbulent flow conditions.

In this study, a novel idea was applied to develop a sensor which can detect fast moving fluid into the feedpipe. The idea was to use the difference in the conductivity between the tap water in the feedpipe and NaCl solution in the vessel. An electric circuit was designed and connected to electrodes which was installed in the feedpipe. When NaCl solution in the vessel penetrates into the feedpipe, conductivity change is sensed by the electrode. The resulting signal is sent to the pen-chart recorder and is appeared in the form of peak. The resolution of this developed technique was determined with a minimum measurable peak on the strip-chart of the recorder.

2. Experimental

Platinum was chosen as the electrode material because of its low polarizability. 0.5 mm diameter platinum was inserted through a stainless steel tube which was installed inside the feedpipe. The stainless steel tube was used as the counter electrode. Epoxy was filled into the gap between the platinum and the stainless steel tube to electrically isolate each other. Both electrodes were connected to the pen-chart recorder through a designed electric circuit.

The electric circuit was composed of a 6V battery as the electromotive force and two resistance components. One was the resistance of an external resistor and another was the resistance of tap water between the electrodes. The resistance was hooked up across the pen-chart recorder. When the vessel electrolyte penetrates into the feedpipe to reach the electrodes, there will be increase in conductivity around the electrodes to cause a resistance drop in the electric circuit and subsequently, there will be a potential drop across the pen-chart recorder.

3. Results and Discussion

The electric circuit was analyzed by Ohmic relationship to get maximum sensitivity. From the mathematical analysis, it was found that sensor shows maximum sensitivity when the two resistances were identical. The resistance between the electrodes was measured by an ohmmeter and was about 16,000 Ω. Therefore, the external resistor was set at 16,000 Ω.

Minimum electrolyte concentration which the conductivity technique could detect was determined. The height of the minimum detectable peak on the strip-chart of the recorder was about 1/100 of the total span on the strip-chart. From the relationship between specific conductance and NaCl concentration, it was found that minimum detectable concentration of the conductive solution by this technique was on the order of 10^{-5} mole/l.

4. Conclusion

A sensor to detect backmixing of vessel fluid into the feedpipe was successfully designed using conductivity technique. The sensor was designed with maximum sensitivity by mathematical analysis of the electric circuit. The resolution of the sensor was on the order of 10^{-5} mole/l concentration of the conductive solution.