SMALL COMPUTER APPLICATION FOR INDUSTRIAL PROCESS CONTROL

LIQUID - LIQUID EXTRACTION

Research Thesis

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A B S T R A C T

Liquid - Liquid Extraction is a common industrial operation, in which solute is transferred from a solution of one solvent into another solvent, with favorable solubility characteristics for the solute. The industrial extraction operation is usually performed either in extraction columns or in mixer - settler units.

In this research an approach is made to the solution of the mixer - settler control problem. The usual feed-back control cannot answer the needs of such a process. As a result of the large volume of the settler, any disturbance that enters the system is felt at the outlet of the extraction battery only after long time delay. The Accepted procedure for dealing with process with large dead time is based on the assumption that this dead time or time delay is constant and to treat the measurements accordingly.

The approach proposed in this work is based on dynamic simulation which closely follows the events and updates the measurements while carrying out the control operation. To make the simulation possible and to determine the control possibilities, extraction processes were studied. A mathematical model was developed which describes the dynamic responses and physical parameters. The main assumptions of the model were that the streams leaving the mixer was at equilibrium and that a plug - flow regime was obtained in the settler.

A control strategy was choosen, based on the information available from the mathematical model, on the physical data and on the available sensors and control equipment. A computer program to execute this strategy was written.

The control program depends on the nature of the process and the way it is expressed in the model. It assumes the possibility of making a clear and pronounced distinction among the influences of the input streams, according to the state variables. The state variables selected were the interface level and the solute concentration in the light or heavy phase output stream. It was clear from the mathematical model that the heavy phase flow balance influences the interface level and that solute output concentration is influenced by the ratio of heavy to light inlet flow rates. It was necessary to filter signals in an appropriate way in order to make the feed - back control possible. The measurable variables were closely followed to permit the observation of the unmeasured variables which are important for the control performance.

Based on the plug - flow regime assumption simulation of the settler state is carried out batch - wise in accordance with the sampling periods. The expected concentration is compared with the measured one, and a decision is made for the valve state for the next step.

In order to check the control concept as well as the control program, a simulation was bulit on an analogue computer. This simulated the real process but without the time delay problem, which could not be readily simulated on the analogue system. The combination of the digital system with the analogue simulator yielded a hybrid system. The results obtained with the hybrid system showed that the control concept was correct.

The next stage involved the operation of the control program on an experimental set - up in the laboratory. The system chosen was Iso Amyl Alcohol - Water - Acetic Acid, for which equilibration were determined in order to enable meaningful execution of the experiments. The results obtained indicate that the assumption of a plug - plow regim within the settler is good, but is not accurate in some cases. For the Latter it is supposed that backmix factors should be employed. In general the control performance proved superior to those obtained by means of regular accepted algorithms.

It is evident from the above mentioned results that the quality of the control is tightly connected with the accuracy of the process simulation, i.e., a close to reality simulator enables tight control.

The concepts shown to treat a mixer settler unit is applicable to an extraction battery as well,with the main efforts invested in determining an appropriate expression for the time delay. The latter is obtained from a Dynamic simulation via a way similar to the one used for a single cell. The Simulation program will differ according to the equipment in use.

This work can be applied to extraction systems, industrial or others. For such units the typical characteristics should be identified and incorporated in the mathematical model and its expression within the simulation program. A specially important parameter is the hydrodynamic behaviour of the settler which should be carefully studied before expressed in the mathematical simulation.

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