Concentration of Brines by Removal of Water via Crystallization

Design Basis Memorandum and Engineering Data Sheet

Background

In the 1960's H.F. Wiegandt and other members of the Cornell Chemical Engineering Faculty proposed a method of producing potable water from brine by the production of ice crystals via direct contact with expanding refrigerant. As water freezes salt molecules are excluded from the crystal lattice leaving a fairly pure water crystal. When the crystals are washed and melted a very low salt content water suitable for human consumption is produced. Wiegandt and his colleagues felt that this could be very competitive with then commonly used flash evaporation method for producing low salt content water from brine in part because producing ice requires significantly less energy than the production of steam. Freeze concentration may be suitable for treating highly concentrated waste streams and supplying drinking water in areas where it is in short supply.

At present, low ion content water is produced from brines by either multi-stage flash evaporation or reverse osmosis. These methods are poorly suited to the concentration of water streams derived from agricultural or industrial waste water streams due to the surface fouling caused by both ionic and non-ionic materials in the water streams. Further, the cost of specialty steels required for corrosion resistance in evaporation systems and the cost of cleaning chemicals and replacement membranes in reverse osmosis systems make these approaches infeasible in many parts of the world.

A significant number of publications on freeze concentration, including much of Wiegandt's work, has been collected and will be made available to students working on this project.

Streams of interest include but are not limited to:

- Sea water
- Crop surface run-off
- Animal Farm waste
- Dairy product and other food processing waste
- Strip mine run-off
- Stack scrubber effluent
- Various kinds of chemical plant waste water
- Hydraulic fracturing return water

Our long term interest is in developing a stand-alone package system that could provide site specific effluent water concentration capability for water streams such as those cited above. This project will give students experience in process and plant design that will be of use to them in any later industrial career.

Scope of Work

Our intention is to ultimately produce a FEL 2 level feasibility study of this process to include a flow sheet, mass and energy balance, equipment sizing, equipment layout and from that work an estimate of capital and operating costs for various water streams. The first step in the FEL 2 study is the production of a Design Basis Memorandum (DBM) which will specify all expectations of the process and a Basic Engineering Design Data Sheet which will contain all information necessary to carry out the FEL 2 work.

This will include but not necessarily be limited to: information of compositions and physical properties of potential feed streams and refrigerants, crystallization temperatures and crystal growth kinetics,

information on interaction between the refrigerant and all relevant thermodynamic properties of materials involved in the process.

A literature search will be required to provide information specific to the formation of the ice crystals, the degree of salt exclusion to be expected, efficiency of washing operations and degree of concentration that can be expected.

The first step will be to develop a table of contents defining all the data that will be required to support the design solution. This will be reviewed by the oversight committee and then revised as necessary. The next step will be the acquisition of the data and also the highlighting of areas where the data is either sparse or non-existent. These cases will provide the basis for defining experimental work to be done to provide the requisite information. The third step will be the compilation of all of this information into the DBM and BEDD.

Schedule

This work is expected to require two terms to complete and is likely to require a team of several people to assure a reasonable work load for the participants. Initial milestones are as follows:

Project kick off meeting	1 week
Produce table of contents	3 weeks
Review by oversight committee	1 week
Complete table of contents	1 week
Accumulate requisite information	6 weeks
Review by oversight committee	1 week
Finalize data acquisition Recommend experimental work	1 week
Assemble final draft	2 weeks
Review by oversight committee	1 week
Publish final document	1 week

The first task of the project team will be to evaluate the work load for the team and the individual member and to provide a revised mile stone schedule based on their assessment of the scope of work.

Formation of the team and start of the work is expected to be no later than the middle of September.

Oversight Committee

M. A. Hurwitz
A. M. Center
A. S. Feitelberg
F. Q. You
Outside experts as available