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Process Integration Route For Water Conservation In Industrial Plants

G.Himabindu,

Department of Chemical Engineering,
Sri Venkateshwara College of Engineering, Sriperumbudur-602105,
Chennai, TamilNadu, India.

Phone No: +918754538434

Abstract: Process integration (PI) is a comprehensive approach towards to process design, retrofitting, and operation of industrial plants. Applications of process integration are focused on resource conservation, pollution prevention and energy management. Two main branches of PI are identified as energy integration which deals with exchange of energy throughout the process and mass integration that provides a fundamental understanding of the global flow of mass within the process and optimizing the allocation, separation, and generation of streams and species. This paper provides an overview of process integration design methodology, concentration interval diagram, resource conservation network that has been taken from different papers is preferred for the present study which outlines the major methodologies its ideas and objectives.
Keywords: Process integration (PI); Process integration design methodology; Concentration interval-diagram; Water pinch; Waste water minimization.

1. Introduction:

Limited supply of natural resources and the chemical industry quest for sustainability coupled with increasingly stringent environmental regulations are enough compelling factors for process industries to pursue more efficient means toward resource conservation. Process integration technology have been developed over the past two decades to achieve process improvement, productivity enhancement, conservation in mass and energy resources, reductions in the operating and capital costs of chemical processes[1]. This technique is used at the commencement of a project to screen out promising options to optimize the design and operation of a process plant. It can also often be employed in conjunction with simulation and mathematical optimization opportunities in order to better integrate a system[2].This paper presents a general idea of the developments in Process integration design tools and covers three papers which outlines about the system analysis tools, Process integration technology design tools for the first paper followed by second paper an automated target approach that was originally developed for mass exchange network synthesis is extended to locate the minimum flow rate for a resource conservation network with interception placement. In third paper the graphical approach problem is analyzed while determining the regeneration and reuse opportunities and select the treatment operations based on constraints.

2. Basics Concepts In Process Integration:

Generally speaking PI is concerned to the advanced management of material, energy and information flows in a production plant and the surrounding community (Fig.1.) based on the multi criteria optimization of the processing systems(Fig. 2.)[3].

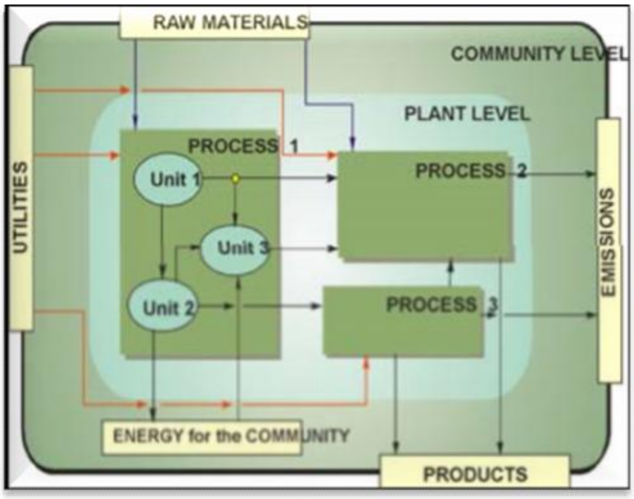

Figure.1: Process block diagram

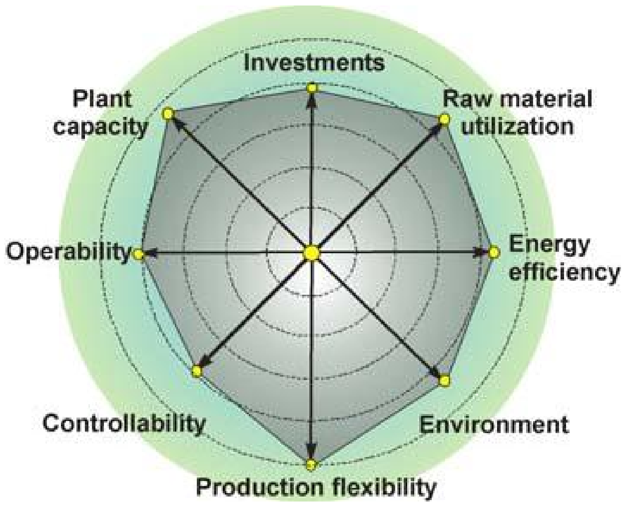

Figure.2: Pie diagram

PI can be used to : Minimize energy consumption (energy efficiency) and waste water reduction(water conservation) improve raw material utilization (improved heat recovery will allow increased recycling in the process and reduce equipment (investments), by identifying the optimal tradeoff between operating cost (raw materials and energy) and investment cost (equipment). Increase production volume (plant capacity) for plant debottlenecking. Increase plant controllability by selecting equipment parameters in a way that makes the control easier, irrespective of the actual control system. Minimize undesirable plant emissions, by reduced use of fossil fuels, switching to alternative energy sources, closing the processes (environment) which add to the efforts in the process industries and society for a sustainable development indicating the hierarchy of most processes[3].

Three papers dealing with this topic have been selected.

The first paper comes from Dunn RF, Gerg E.bush, Nylon Technology, Cantonment, USA, 2001.The basic task of MENs for Cleaner design strategy of waste reduction has been addressed as follows In fact there are specific steps that the designer should follow when applying this design strategy and these steps are summarized below[1,2].

3. Process Methodology

Step 1: Select the problem to be solved
Step 2: Collect data required for the generation of the systems analysis tools (source–sink stream representation diagram, stream mapping diagrams and the path diagram) needed to solve the specific problem.
Step 3: Identify the direct recycle and mixing and direct recycle designs using the systems analysis tools. Identify the interception technology design targets using the systems analysis tools.
Step 4: Brainstorm potential interception technologies (unit operations) Adsorption, Ionexchange, Reverse osmosis etc that could be employed for the specific problem to be addressed.
Step 5: Identify the process integration design methodology that includes the unit operations identified in step 4.
Step 6: Apply the process integration design methodology selected to determine the most cost effective waste reduction.

3.1. Discussion:

These process integration design methodologies tools streamline the identification of good cost effective solutions that result in waste reduction via recycle and reuse options and can also be used in a similar fashion for any waste reduction design task (gas, liquid or solid emission streams).

The second paper was written by Denny kok sum Ng,Dominic Chwan Yee Foo from the faculty of Chemical and environmental engineering, University of Nottingham in Malaysia, 2009. This paper presents an optimized based automated targeting to locate the minimum resource consumption targets for a resource conservation network with interception placement. This technique is formulated as a Linear Programming model for which the solution is framed[4,5].

4. Process Methodology

Step1: Collection of Data

a) A set of process streams (sources) i=1,2….n with flowrate F_i with constant concentration of single impurity C_i which could be recycled or discharged is considered.

b) A set of process streams (sinks) j=1,2….n with flowrate F_j accept sources with an inlet concentration lower than the impurity concentration $C_{jmax.}$ is also considered.

Step2: Arrangement of source and sink in ascending Order

In step2 construction of concentration interval diagram was prepared where impurity concentration of source and sink are arranged in ascending order from lowest concentration k=1 to k=n to which fresh resource and zero concentration are added if they don't persists in source and sinks. In addition final concentration level (10^6) ppm is added to allow the calculation of residue impurity level.

Step3: Calculation of flow rate and impurity load based on equation

The flow rate and impurity load cascade are across all concentration levels based on equation given below-

$$\delta_k = \delta_{k\text{-}1} + \left(\Sigma_i F_{\mathrm{SR}i} - \Sigma_j F_{\mathrm{SK}j} \right)_k$$

$$\varepsilon_k = \varepsilon_{k-1} + \delta_k \left(C_{k+1} - C_k\right)$$

The impurity load at each concentration level is given by the product of net material flow rate from level k and the difference between two adjacent concentration levels(C_{k+1}-C_k).

Step4: Flow chart representation of impurity load of all concentration levels from k=1 to k=n

Impurity load residue of each concentration level is cascaded down to the next concentration level and to be taken as a positive value.

Step5: Calculation of water pinch

When the residue impurity load is determined as zero in a model solution then a pinch concentration is observed which is a formulation of the Linear programming (LP).

4.1. Discussion:

This is a novel automated targeting approach for single component RCN that has the advantage of both pinch analysis and mathematical optimization including the flexibility in changing the objective function over conventional insight based techniques.

The third paper was authored by MihirDakwala, Bikash Mohanty, RavindraBhargava, Department of Chemical Engineering, Indian Institute of Technology, Roorkee, Uttrakhand, India, 2009. In this paper, the process integration approach is used to find out water conservation target for a Starch industry in the state of Gujarat, India. The aim of this study is to minimize the consumption of fresh and DM water and the production of wastewater to design optimal targets for water use so that the plant's outdated water network could be updated, while accounting for current economic and technological restrictions. The well known thoughts based on graphical analysis is chosen for solving waste water minimization in multicomponent systems.[6,7]

5. Process Methodology:

Step1: Data extraction

A set of i water-using processes involving a set of J contaminants data is taken and the problem is formulated with the inlet concentration limits C_{in} and outlet concentration limits C_{out}, with limiting water flow rate f_i.

Step2: Limiting water profile

Concentration interval diagram (CID) and concentration composite curve (CCC) is framed from a plot of concentrations of contaminant A at the inlet and outlet of each operation versus the total mass of A transferred. For two contaminants A, B, the water supply line uses the proportional mass transfer relationship for the concentration differences at inlet and outlet conditions. CID, CCC and water supply line is used to find the minimum fresh water flow rate in a multiple contaminant system.

Step3: Method of concentration shift

Now investigate whether feasibility of reusing water leaving one water using operation within another operation with respect to secondary contaminant is possible or not. This procedure involves shifting the inlet and outlet concentration. The necessary design equations and methodology has been adapted from Mann and Liu[8] in solving wastewater minimization involving multi contaminants.

Step4: Analysis of existing water network in a starch Plant.

The original network of the process flow sheet and the general data including inlet, outlet flow rates of stream along with concentrations of contaminants such as total organic content (TOC), total dissolved solids (TDS) and total suspended solids (TSS) as well as operational constraints are estimated and tabulated.

Step 5: Estimation of reusable water based on process constraints

The freshwater consumption and DM water consumption are 100 t/h and 51 t/h respectively. Due to process constraints, it has been found that it is not feasible to reuse water from any other water using operations to Reactor (R-1) and Separators (S) in the process flow sheet. These are constraints related to concentration of contaminants for each unit.

5.1. Discussion

The improved water using network consumes less DM water as well as freshwater. The reductions are of the tune of 27% and 69.6% for DM and fresh water respectively. The Process Integration approach described in the present paper can be used for planning of water conservation in different water using operations.

6. Conclusion:

We believe that the papers in this Special Issue under sustainable and clean technologies will be of interest and relevance to a broad range of the scientific and industrial community. The special thanks belong to all reviewers whose dedicated effort made this issue possible. This is an active research area that promises to lead to significant contributions on the engineering principles of integrated systems.

7. Acknowledgements:

We would like to thank Science Direct for giving us the opportunity to compile this special issue on process integration passage on energy efficiency and water conservation and wish to acknowledge God for guiding their path and for allowing them to use their knowledge and experience to be better stewards of the environmental resources that he has created.

8. References:

1. Dunn RF., Gerg E bush., Using process integration technology for CLEANER production, Journal of cleaner production,2001,9,1-23.
2. El-Halwagi MM., Pollution prevention through process integration, systematic design tools, San Diego, Academic Press,1997,675-680.
3. P.Raskovic., Process integration approach for energy saving and pollution prevention in industrial plants, University of Serbia,119-134.
4. Denny kok sum Ng., Dominic Chwan Yee Foo., Using Automated targeting for resource conservation network (RCN) with interception placement, Chemical engineering transtactions, 2009,18.
5. El-Halwagi MM., Manousiothakis V., Automatic Synthesis of mass exchange network with single component targets, Chem.Engg.Sci,1990, 9,2813-2831.
6. MihirDakwala.,BikashMohanty.,Ravindra Bhargava.,Journal of cleaner production 2009,17, 1654-1662.
7. Cao D., Feng X., Duan X., Design of water network with internal mains for multicontaminant wastewater regeneration recycle, Chemical Engineering Research and Design, 2004,82(10),1331–6.
8. Mann JG., Liu YA., Industrial water reuse and waste water minimization, NewYork, McGraw-Hill, 1999.

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