Minimizing Energy Losses in Ethyl dichloride Process Plant

Bhanvadiya Neqween
Department of Mechanical Engineering
School of Engineering, RK University, Rajkot, Gujarat, India

Falgun Adroja
Department of Mechanical Engineering
School of Engineering, RK University, Rajkot, Gujarat, India

Abstract- At present economy, chemical and process engineering should respond to the changing needs of the chemical processes and related industries in order to satisfy the increasing market requirements for the specific end-use properties of the product required by the customer, and the raw material and energy savings, and environmental constraints of the industrial scale process. Exergy wastes of the plant are investigated for the performance analysis and improvement, and are determined to be 39.75% and 32.24%, respectively. The present technique is an proposed as the useful tool for analysis of energy and exergy utilization, developing energy policies and providing energy conservation measures.

Keywords – Efficiency; Energy; Exergy; Exergy analysis; Material Balance

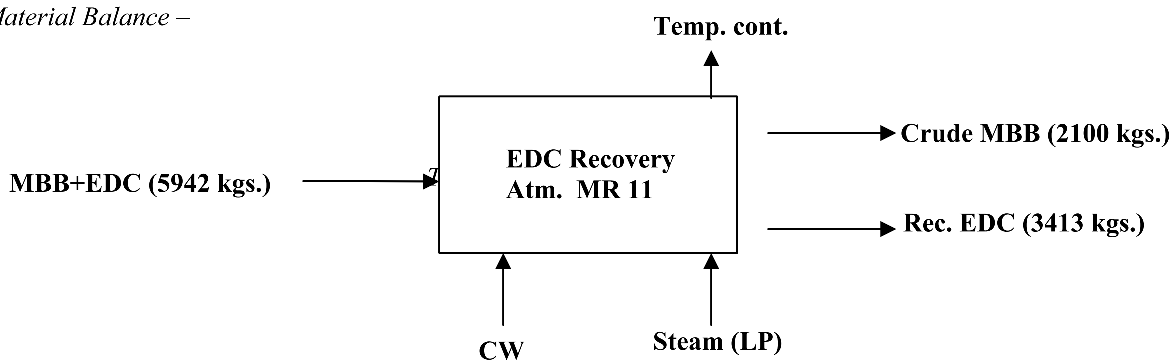
I. INTRODUCTION

The conservation of energy however differs from that of mass that energy can be generated or consumed in a chemical process. Material can change their form, and new molecular species are formed by the chemical reaction. The total mass flow into a process unit must be equal to the flow out at steady state. But the same is not true for energy. The total enthalpy of the outlet streams will not be to the equal that of the inlet streams if energy is generated or consumed in the entire processes. Exergy analysis helps in identifying the losses due to irresiveribility, which helps to make the improvement in order to reduce losses in the EDC process. Exergy analysis suggest that possible area where further improvement can possible.

The rest of the paper is organized as follows. Theoretical and practical calculations of energy in reactor used in EDC process are explained in section II. Exergy analyses of reactor are presented in section III. Proposed solution for minimizing energy losses in process plant are explained in section IV. Concluding remarks are given in section V.

II. THEORETICAL AND PRACTICAL CALCULATION OF ENERGY IN REACTOR USED IN EDC PROCESS

A. Material Balance –



INPUT	Kgs	OUTPUT	Kgs
MBB + EDC	5942	Atm. EDC	3363
		U/V EDC	50
		MBB Crude	2100
Total	5942	Total	5513

Table – 2 Theoretical calculation of energy required

EDC RECOVERY ATM :								
Reactant	**Kg**	**from °C**	**to °C**	**ΔT in °C**	**Cp in kcal/kg °C**	**Heat required Q = MCpΔT**	**Units**	**BCT hrs**
MBB	**2579**	**40**	**85**	**45**	**0.24**	**27853.20**		
EDC	**3363**	**40**	**85**	**45**	**0.22**	**33445.04**		
						61298.24	**Kcal**	
						15324.56	**Kcal/hr**	**4**
						28.38	**Kg/hr of Steam**	
EDC Recovery Atm	**3363**	**Kgs**						
Formula	M.λ			λ	heat of vaporization	85.75		
	288377.3	Kcal						
	72094.31	**Kcal/hr**						
	534.0	Kg of steam						
Steam required	**134**	**kg/hr**						**4**
					Total heat Required	**Q = MCpΔT + M.λ**		
					Total heat Required	**161.89**	**kg/hr**	

It has been seen that the energy which is calculated theoretically should be same as obtained practically. It happens only when there are no any losses. But our result shows that energy obtained practically which is condensate form has more than that of energy obtained theoretically. Hence we prove that there are some energy losses in the plant.. In order to minimize these losses we have carried out the exergy analysis. Hence from this exergy analysis we can find out the exergy destruction or exergy waste. These exergy lost would suggest the various improvement can be made in order to reduce losses.

Table – 3 Practically energy obtained

Steam condenset collected:	**Kgs.**	**Min**	**Steam/ hr**	
1	**13.50**	**5**	**162.00**	
2	**13.75**	**5**	**165.00**	
3	**13.85**	**5**	**166.20**	
		Average	**164.40**	**kg/hr**

Table – 4 Result

Total Steam Consumption :	161.89	kg/hr	688.02	kgs of steam
Steam condenset collected:	164.40	kg/hr	698.70	kgs of steam

III EXERGY ANALYSIS

For a real process the exergy input always exceeds that of exergy output and this imbalance is due to irreversibility, which is also called exergy destruction, $Ex_{destruction}$, and is represented as a function of entropy generation. The quality of energy that are dissipated into the environment is due to irreversibility which is clearly gets quantified in exergy analysis. Hence exergy analysis therefore allows the true magnitude of thermodynamic inefficiencies of industrial processes, the primary causes of their inefficiencies to be established.

The exergy value of steady stream of fluid which are entering or leaving part of a process is the minimum amount of energy or work that can be obtained from the stream in bringing it to equilibrium with the environment. With an enthalpy change of (H – Ho) and an entropy change of (S – So) at a reference temperature T_o = 30 ˚C, and T = 85 ˚C the physical exergy can be calculated by using Eq.

$$Ex_{ph} = (H - H_o) - T_o(S - S_o)$$
$$= (2651.9 - 125.8) - 303(6.410 - 0.437)$$
$$= 716.28 \text{ KW}$$

A. Exergy Calculation for Reactor –

Inlet Temperature (T1) = 40 ˚C + 273 = 313 K

Outlet Temperature (T2) = 85 ˚C + 273 = 358 K

Environment Temperature (T) = 40 ˚C + 273 = 313 K

Exergy input :

$$\dot{E}x_{in} = \frac{h_1 - h_o}{(h_1 - h_o) + T_o(S_1 - S_o)}$$
$$= \frac{2406.7 - 125.8}{(2406.7 - 125.8) + 303(0.573 - 0.437)}$$
$$= 0.98 = 98\ \%$$

Exergy Output:

$$\dot{E}x_{out} = \frac{h_2 - h_o}{(h_2 - h_o) + T_o(S_2 - S_o)}$$
$$= \frac{2651.9 - 125.8}{(2651.9 - 125.8) + 303(6.410 - 0.437)}$$
$$= 0.5825 = 58.25\ \%$$

There are many different ways of formulating exegetic efficiency proposed in literature. Often there is a part of output exergy that is unused, i.e. an exergy wasted, $\dot{E}x_{waste}$ to the environment. The exergy waste is also known exergy destruction.

$$\dot{E}x_{destruction} = \dot{E}x_{waste} = \dot{E}x_{in} - \dot{E}x_{out}$$

$= 0.98 – 0.5825 = 0.3975$

Hence exergy efficiency is:

$$\psi = \frac{\dot{E}x_{out} - \dot{E}x_{weste}}{\dot{E}x_{in}}$$

$$= \frac{0.5825 - 0.3975}{0.98}$$

$= 0.1887$

The maximum improvement in the exergy efficiency for a process or system is obviously achieved when the exergy loss or irreversibility ($\dot{E}x_{in}$ - $\dot{E}x_{out}$) is minimized. The improvement potential in rate form is denoted by IP.

$$IP = (1 - \psi)(\dot{E}x_{in} - \dot{E}x_{out})$$

$= (1 – 0.1887) (0.3975)$

$= 0.3224 = 32.24$ %

IV PROPOSED SOLUTION FOR MINIMIZING ENERGY LOSSES

1. Steam ejectors are used for vacuum generation at various recovery section Cost of steam is higher. Steam generation is not sufficient to provide nonstop high pressure for steam ejector. Hence Liquid jet ejector system should use instead of steam ejector.

2. Continuous low pressure steam is used in phenol storage tank to keep phenol in molten condition. Steam consumption is higher. Hence use auto control valve with RTD which is known as Cascade control.

Where two independent variables need to be controlled with one valve, a cascade control system may be used. Figure shows a steam jacketed vessel full of liquid product. The essential aspects of the process are quite rigorous:

• The product in the vessel must be heated to a certain temperature.
• The steam must not exceed a certain temperature or the product may be spoiled.
• The product temperature must not increase faster than a certain rate or the product may be spoiled

If a normal, single loop control was used with the sensor in the liquid, at the start of the process the sensor would detect a low temperature, and the controller would signal the valve to move to the fully open position. This would result in a problem caused by an excessive steam temperature in the jacket. The solution is to use a cascade control using two controllers and two sensors:

• A slave controller (Controller 2) and sensor monitoring the steam temperature in the jacket, and outputting a signal to the control valve.
• A master controller (Controller 1) and sensor monitoring the product temperature with the controller output directed to the slave controller.
• The output signal from the master controller is used to vary the set point in the slave controller, ensuring that the steam temperature is not exceeded.

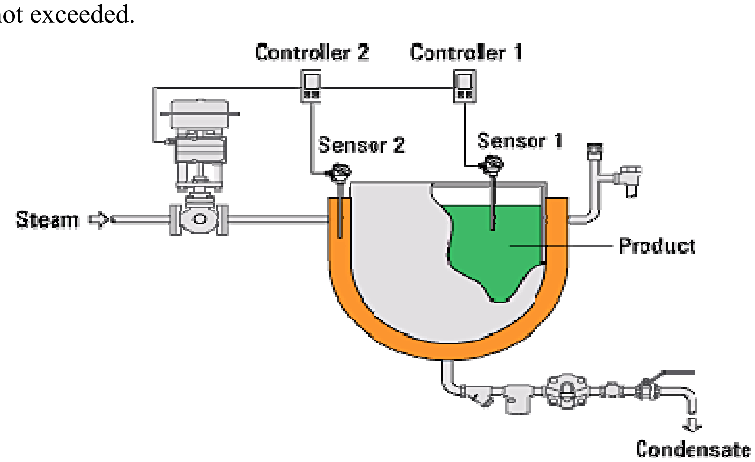


Figure1. Jacketed vessel

3. Steam leakage from packing joints and ejector system is higher. Radiation losses are due to poor insulation.
• Leakage from packing joints should be attended immediately.
• Steam supply to be stopped immediately in Ejectors when not in use.
• Proper insulation on steam line is required for stopping radiation loss.

4. Existing motor used in vessels and pumps are regular. Hence they are low efficient and high power consumption. So use energy efficient motor instead of regular motor. It has improved efficiency available from 60 % to 98 % load.

5. At present mild steel glass lined reactor are used in plant. 28.38 kg of steam is required per hour. But the entire reaction is completed in 24 hr. Hence, 28.38 x 24 hr = 681.12 kg of steam is required per day. The price of 1 kg steam is Rs. 15. Therefore, 681.12 x 15 Rs = 10216.8 Rs steam required per day to complete reaction. If stainless steel reactors are used than, 28.38 kg of steam is required per hour. But the entire reaction is completed in 18 hr. Hence, 28.38 x 18 hr = 510.84 kg of steam is required per day. But the price of 1 kg steam is Rs. 15. Therefore, 510.84 x 15 Rs = 7662.6 Rs steam required per day to complete reaction.

6. Cost Saving is Rs. 2554.2 saving per day.
Per month: Rs 2554.2 x 30 days = Rs 76626
Per year = Rs 76626 x 12 month = Rs 919512

V.CONCLUSION

The aim of these studies is to determine the energy and exergy utilization efficiencies for ethyl dichloride plant. Mass balance and heat losses, energy and exergy utilization efficiencies were analyzed by using the actual plant operational data. Exergy analysis is a powerful tool, which is successfully and effectively used in the design and performance evaluation of energy related systems. The waste energy that leaving temperature could be recovered by means of a heat recovery system in which efficiency of the system would be increased. Hence above proposed solution would definitely helpful for reducing the energy losses. The stainless steel reactor has more heat transfer coefficient than that of mild steel reactor. Hence replacement of mild steel glass lined reactor by stainless steel reactor would result in cost saving, i.e. less energy is required. It is also very helpful in establishing the energy conservation policies.

REFERENCES

[1] David L. Eidredge, Bob Holdman, "A Cost Minimization Production Planning Model for Continuous Process Chemical Plant Operations", JOURNAL OF OPERATIONS MANAGEMENT Vol.2. No.3, May 1982.

[2] T.J. Kotas, "The exergy method of thermal plant analysis", Tiptree, Essex:Anchor Brendon Ltd., 1985.

[3] I. Dincer, "The role of exergy in energy policy making", Energy Policy 30 (2002) 137–149.

[4] Dincer I, Hussain M, Al-Zaharnah I. "Energy and exergy utilization in transportation sector of Saudi Arabia". Appl Therm Eng 2004;24:525–38.

[5] Rosen M. "Evaluation of energy utilization efficiency in Canada using energy and exergy analysis". Energy 1992;17:339–50.

[6] Hannsjörg Freund, Kai Sundmacher, "Towards a methodology for the systematic analysis and design of efficient chemical processes Part 1. From unit operations to elementary process functions".

[7] Brodyansky, V.M., Sorin, M.V.and Le Goff P., 1994, "The eficiency of industrialprocesses: exergy analysis and optimization".

[8] Anonymous. (1995). "Guidelines for safe process operations and maintenance". NewYork: American Institute of Chemical Engineers. (pp. 245-269).

[9] Sauar, E., Kjelstrup Ratkje, S., Lien, K.M.,1996, Equipartitioning of Forces: A New Principle for Process Design and optimization. Ind. Eng. Chem. Res.,35,(no.l1),4147-4153.

[10] Sorin, M. and Paris, J., 1997, "Combined exergy and pinch approach to process analysis", Comput Chem Eng, 21(suppl): S23-S28

[11] R.L. Cornelissen, Thermodynamics and sustainable development: The use of exergy analysis and the reduction of irreversibility, PhD thesis, University of Twente, The Netherlands, 1997.

[12] Szargut, J., Morris, D. and Stewart, F., 1988, "Exergy Analysis of Thermal, Chemical and Metallurgical Processes" (Hemisphere Publ Co, NY).

[13] E.A. Torres, W.L.R. Gallo, Exergetic evaluation of a cogeneration system in a petrochemical complex, Energy Conversion and Management 16–18 (1998) 1845–1852.

[14] Rosen M, Dincer I. "Sectoral energy and exergy modeling of Turkey". ASME – J Energy Resour Technol 1997;119:200–4.

[15] Moran M, Shapiro H. "Fundamentals of engineering thermodynamics". NewYork: John Willey & Sons, Inc.; 2000

[16] Petchers N. "Combined heating, cooling and power handbook: technologies and application". Lilburn (GA): The Fairmont Press, Inc.; 2003.

[17] G. Wall, "Exergy tools, in: Proceedings of the Institution of Mechanical Engineers", Wilson Applied Science and Technology Abstracts Plus Text, 2003, pp. 125–136.

[18] Al-Ghandoor A, ALSalaymeh M, Al-Abdallat Y. "Energy and exergy utilixations of the Jordanian SMEs industries". In: Conference proceedings GCREEDER, Jordan University, Amman (Jordan), April 26–28th; 2011.