BTX SEPARATION CHAIN

INTRODUCTION :

Benzene-Toluene-Xylene (BTX) are major feedstock for a large number of intermediates which are used in the production of synthetic fibres. Styrene, linear alkyl benzene and cumene are the major consumer of benzene. As per CMAI, demand for benzene is forecast to grow at an average annual rate of 2.8% per year through 2020 resulting in nearly 57 million tonnes of demand by 2020. Major application of toluene is as solvent, raw material in manufacture of benzoic acid, chloro derivatives, nitro toluenes, benzaldehyde. Amongst the xylenes, about 80% of the production is of para xylene; used in the manufacture of terephthalic acid.

Catalytic reforming is a refining process that uses selected operating conditions and selected catalysts to convert high value aromatic hydro carbon into BTX. The process of aromatic BTX separation from the reformates of the catalytic cracking of naphtha and heavy oil has for a long time utilized a series of extraction and distillation. When the solvent is regenerated for its recycled use, distillation is applied using high-pressure steam due to high boiling point of the solvents. In addition, the amount of solvent used in the extraction is large, about 2.5times the feed amount which makes the process costly.

PROCESS OVERVIEW:

Separation processes in many industries are by far the most dominating energy users to an extent that the operating costs of chemical productive processes are highly influenced by the downstream separation units. Over half of a plant's energy demand for either process is used in full operational distillation columns; optimizing the process with maximum energy recovery through more engineering time given to the design phase and retrofitting older operating plants to save or recover even minuscule amount of energy used can significantly affect the economic efficiency.

The conventional procedure for a simple separation can begin by introducing feed to a flash drum where light component(s) are vaporised and discharged off from the top and the liquid exiting the bottom. The bottom product will then be preheated either with the warm products of the tower using several heat exchangers or just by using a furnace (heater). The top product of the flash drum will meet up again with the preheated liquid upon entrance to the tower where they are inserted as one single stream

An equi-molar mixture of BTX is sent to a 20 staged distillation column operating at 1 atmospheric pressure. The overhead is pure benzene (60-90^{o}C) with the bottom containing a mixture of Toluene (90-110^{o}C)and Xylenes (110-140^{o}C)which are further distilled in a 30 stage column to yield pure products respectively. The emphasis is on optimisation of feed tray & vapour fraction in feed that reduces reboiler load and a portion of energy that might be recovered through a condenser.

RESULTS:

	XYLENE-RICH	TOLUENE RICH	EQUI-MIX	BENZENE RICH	
Temperature	411.522	382.86	298.15	353.589	K
Molar Flow	3.34958	3.34972	10.049	3.34976	mol/s
Mol Frac (Benzene)	1.55135E-10	0.0208596	0.333333	0.979119	
Mol Frac (Toluene)	0.000784	0.97833	0.333333	0.020876	
Mol Frac(P-xylene)	0.999216	0.00081043	0.333333	4.98486E-06	

CONCLUSIONS AND RECOMMENDATIONS:

1. Click on the "Chem-Sep" custom unit operation. Go for "Tools--->Parametric study".
2. On selecting the feed tray plate as the independent; Reboiler, Condenser duty as the response variables. The following table can be obtained,

Step Units	Feed1 stage	Condenser duty MW	Reboiler duty (MW) MW	Net Flow MW
1	1	-0.00891129	0.152217	0.14330571
2	2	-3.981267	4.135437	0.15417
3	3	-1.440924	1.595139	0.154215
4	4	-0.670395	0.824633	0.154238
5	5	-0.422122	0.576369	0.154247
6	6	-0.33158	0.485831	0.154251
7	7	-0.292731	0.446985	0.154254
8	8	-0.274883	0.429138	0.154255
9	9	-0.268242	0.422497	0.154255
10	10	-0.269792	0.424047	0.154255
11	11	-0.279571	0.433827	0.154256
12	12	-0.299958	0.454214	0.154256
13	13	-0.336462	0.490717	0.154255
14	14	-0.40041	0.554665	0.154255
15	15	-0.516224	0.67048	0.154256
16	16	-0.742648	0.896903	0.154255
17	17	-1.239692	1.393948	0.154256
18	18	-2.489901	2.644156	0.154255
19	19	-6.037883	6.192139	0.154256
20	20	-27.05455	27.20928	0.15473

The net energy supplied to the reboiler(Steam...) can be obtained as heat input to the condenser process fluid (Cold water...); the energy recovery is similiar to feed input on 2-19th stage. Since the economics also depends on the reboiler load, minimum energy that the cold water can take before reaching saturation; 7 or 8th stage allows recovery with a minimum heat input.

3. Methods as feed splitting and heating part of the feed have also been suggested. Through preheating by part of the feed and inserting the other part as cold to maintain low reflux ratio, however requires additional equipments, but will yield a significant reduction in energy consumption of approximately 38%.
4. The usual topology will actually result in a higher reboiler heat duty as it requires additional elevation of light components to higher stage. The proposal is to insert the top product of the flash drum in upper trays of the column separately instead of mixing it with the liquid exiting the bottom of the flash drum upon insertion to the distillation column .
5. Being composed of light hydrocarbons corresponding more to higher stages of the column, inserting this feed to upper trays results in an increase of purity of side stream products (if any exists) or column's main products (Distillate and Bottom). This is due to less contact of the vapour entering and the liquid falling down from upper trays. Eventually the rising vapour is less likely to experience condensation and be detected in the side stream products. Therefore the reboiler duty would decrease as no further boiling of light components would occur, consequently maintain the same purity of products with a lower reboiler duty.

REFERENCES:

1.Image Source: Chem.-Sep Custom Unit Operation.
2. Flash Zone Optimization of Benzene-Toluene-Xylene Fractionation Unit by M.Arjmand, K.Kotari
3.Flowsheeting :Chem. Sep Separation book http://www.chemsep.com/downloads/index.html