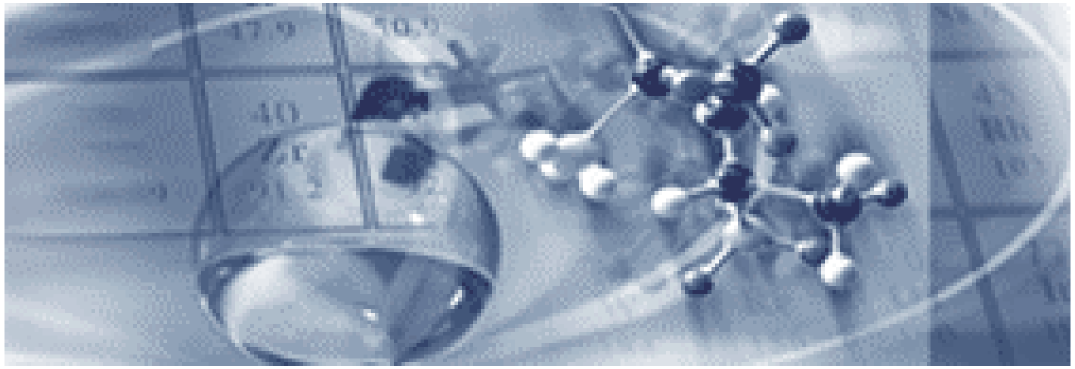
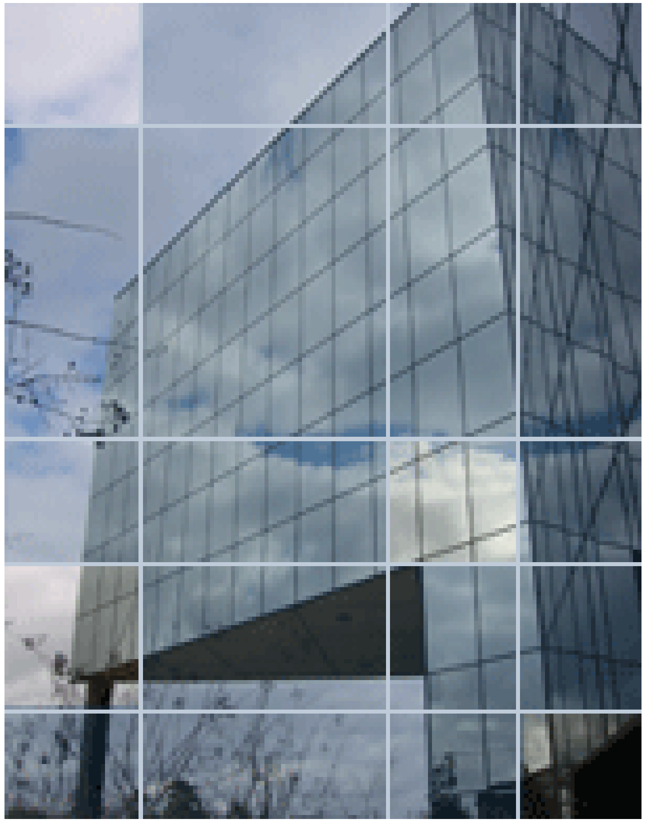
Guidelines For BTX Distillation Revamps

Proprietary Licensed Technologies





Guidelines For BTX Distillation Revamps

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Introduction

There are many reasons to revamp a process unit. These include;

1. Increased purities,
2. Increased recoveries,
3. Decreased environmental impacts
4. And increased capacity.

The best revamps will include each of the listed items.

Introduction

Steps of A Revamp – Papers by Karl Kolmetz

- The High Load Test (AIChE 2005)
- Process Simulation (Thailand PROII Users Conference 2005)
- Rate the Existing Equipment
- Equipment Design (AIChE 2002)
- Equipment Inspection (AIChE 2007)
- Tower Commissioning

Introduction

With the current environmental mandates to reduce the benzene in the gasoline pool, the production of benzene for use in other products is increasing.

In the United States the benzene in the gasoline pool is regulated to very low levels, whereas in other parts of the world the standard is 1.0 weight percent.

As this world standard is lowered this benzene will need to be purified for downstream reprocessing.

Introduction

Currently many of the benzene separation units are utilizing liquid-liquid extraction which can be revamped to extractive distillation for all of the previous mentioned goals of a revamp.

Processing Schemes

Benzene, Toluene and Xylenes (BTX) contained in the olefin plant pyrolysis gasoline, refinery catalytic reformer products, or other hydrocarbons streams cannot be used directly in the downstream processes due to the impurities in the raw reactor products.

Solvent-based extractive techniques which utilize the polar nature of benzene and its preferential solubility in polar solvents are required to separate the aromatics from the non-polar non-aromatics.

Processing Schemes

Since heavier aromatics such as toluene and xylenes are co-produced with the benzene-containing streams, it is sensible to purify the heavier aromatics along with benzene.

There are two main processes than are used for this purpose: liquid-liquid extraction and extractive distillation.

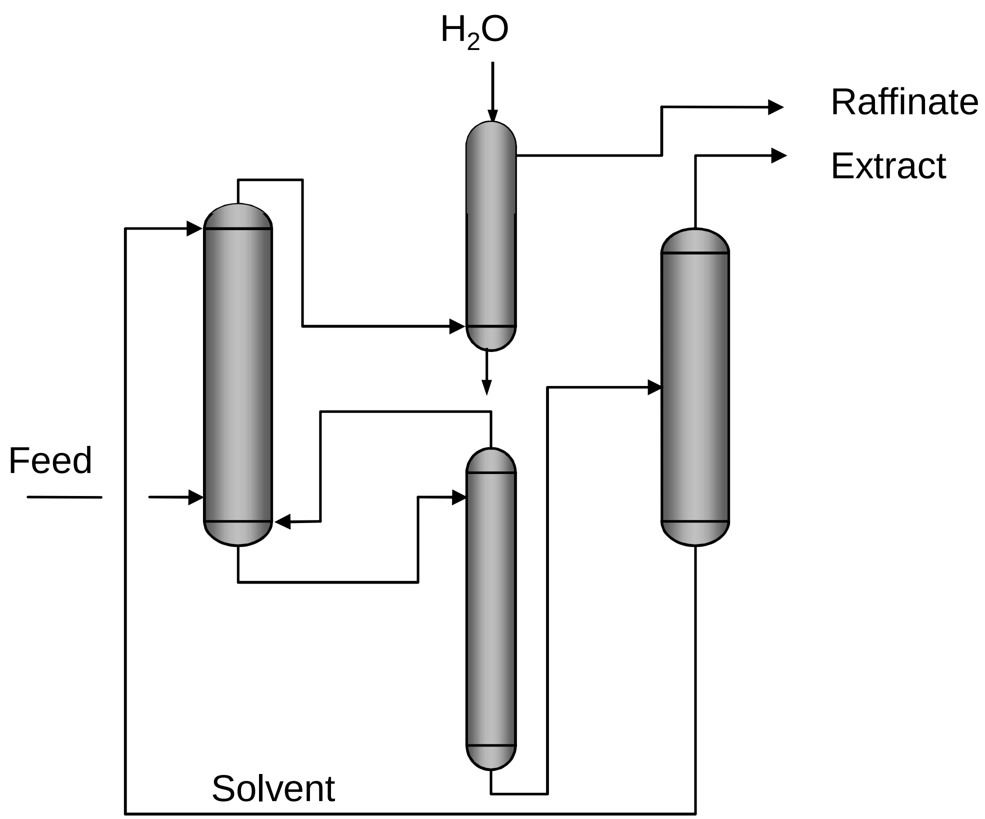
Processing Schemes

Liquid-liquid extraction processes, although reliable and prevalent in the industry for a long period of time, have not been able to offer improvements that make them competitive against the current extractive distillation process.

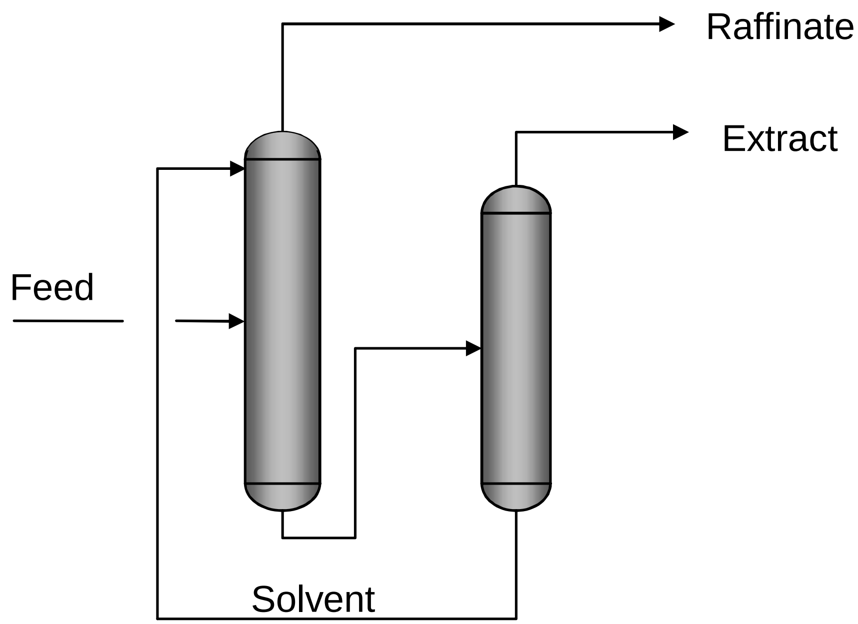
The configurations for the two processes are compared next.

Processing Schemes

Liquid-liquid Extraction



Extractive Distillation



Processing Schemes

In the liquid-liquid extraction systems, the solvent makes an incomplete separation of the components at both ends of the extraction column, thus requiring the additional steps of extractive stripping and water washing of the raffinate.

A particular problem for liquid-liquid systems is methyl-cyclopentane which has a polar moment.

MCP can component trap in the bottom of the extractor and recycle back from the flash drum and stripper column.

Processing Schemes

Extractive distillation, which is the use of a solvent in distillation to enhance the separation efficiency, is recognized as a useful means to separate close-boiling mixtures.

Extractive distillation is a vapor-liquid process unit operation.

The extractive solvent creates or enhances the relative volatility difference between the components to be separated.

Processing Schemes

In BTX extractive distillation, the polar aromatics and the polar solvent combine to from a heavy boiling species.

The extractive solvent and the now lower volatile component flow to the bottom of the distillation column as a liquid.

Processing Schemes

The liquid is the recovered by a subsequent downstream vacuum distillation, where the vacuum separates the polar compounds.

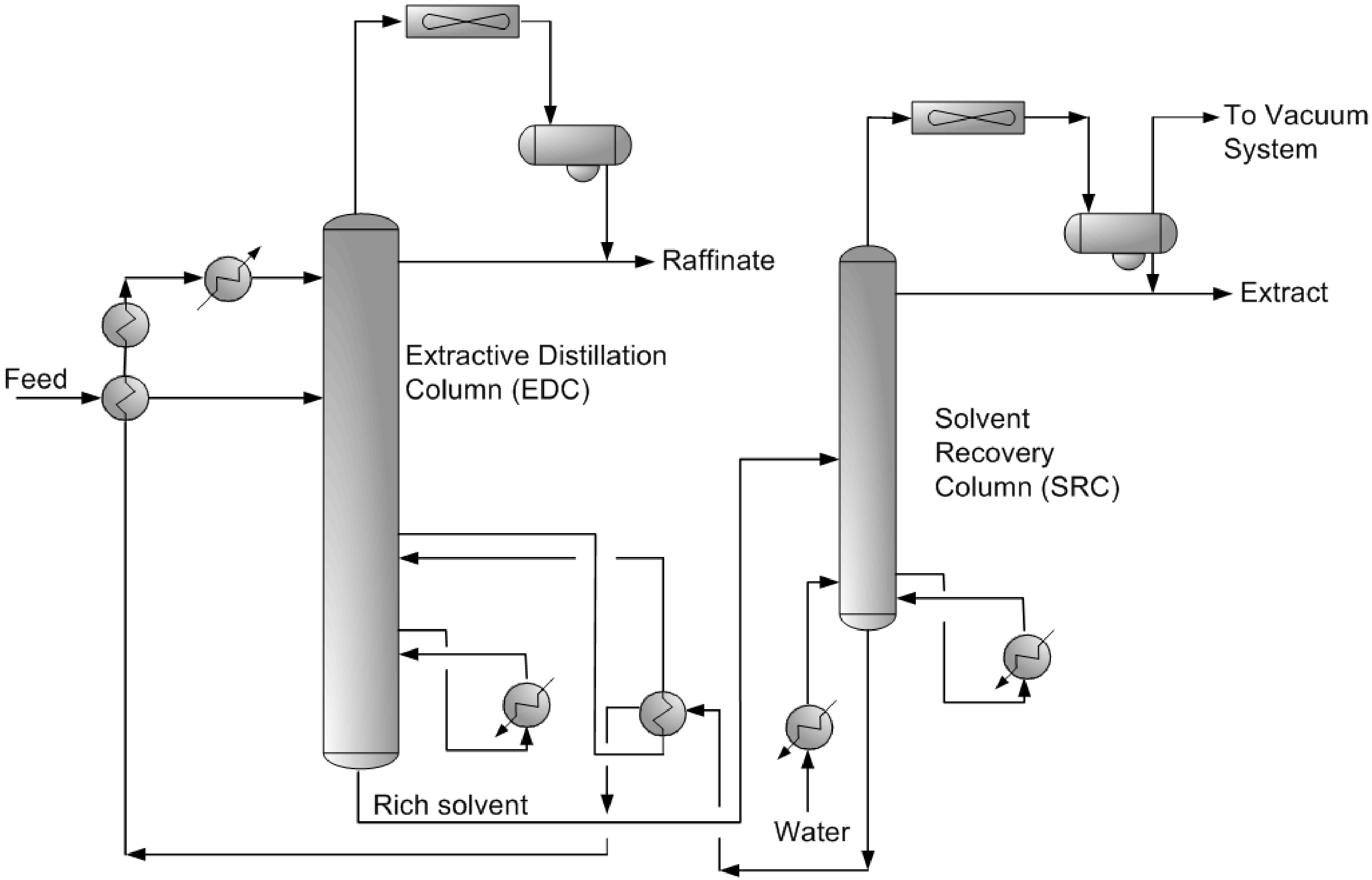
The non-extracted non-polar species are distilled as a vapor to the top of the extractive distillation tower.

Processing Schemes

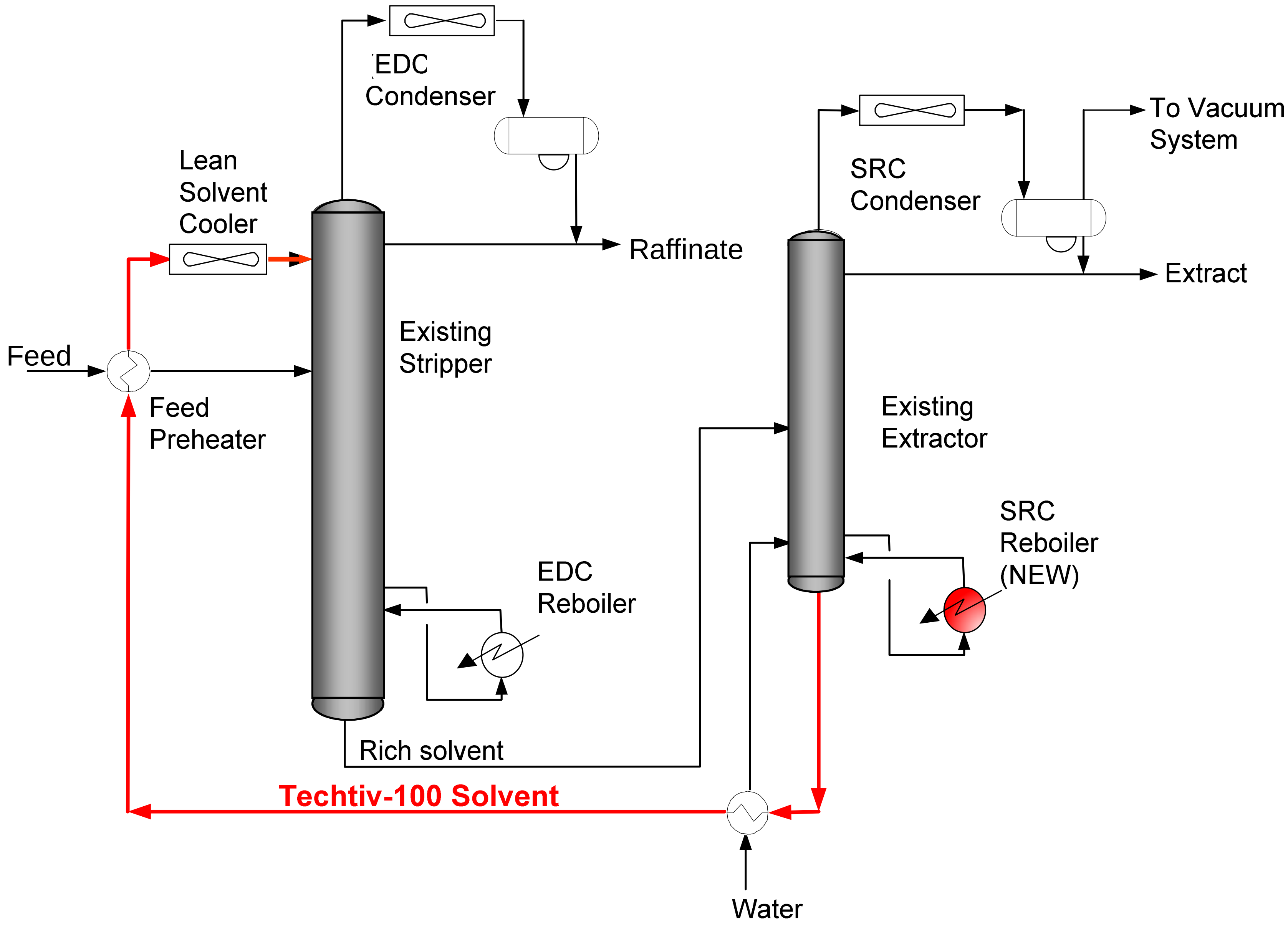
In the extractive distillation system, the extractive distillation column cleanly removes the non-aromatics from the aromatics; and the aromatics and solvent from the raffinate in a single column operation.

Therefore, the extractive distillation design require fewer pieces of equipment and a much lower capital cost than a liquid-liquid system or other extractive distillation systems that require washing of products, or reprocessing of the raffinate.

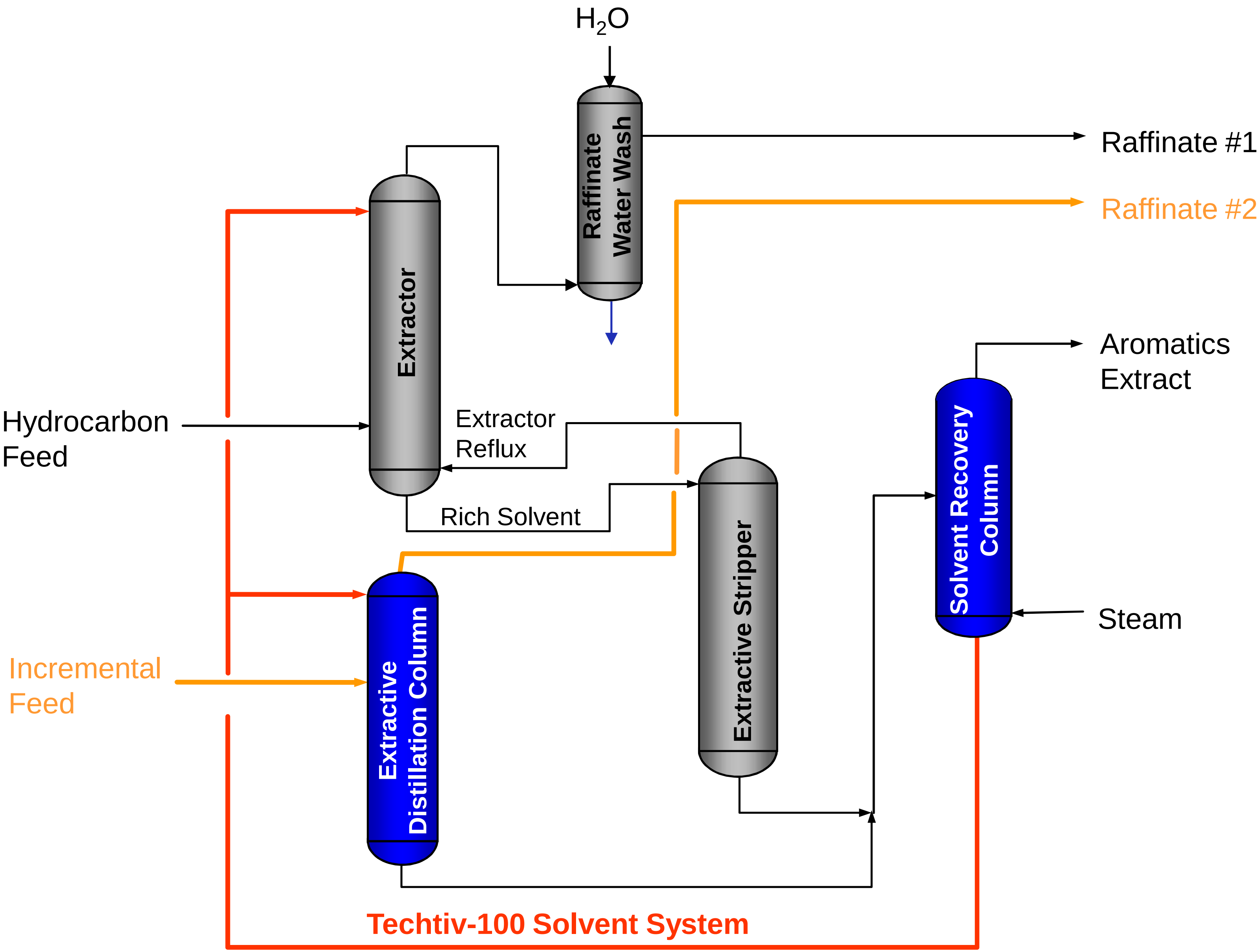
Processing Schemes



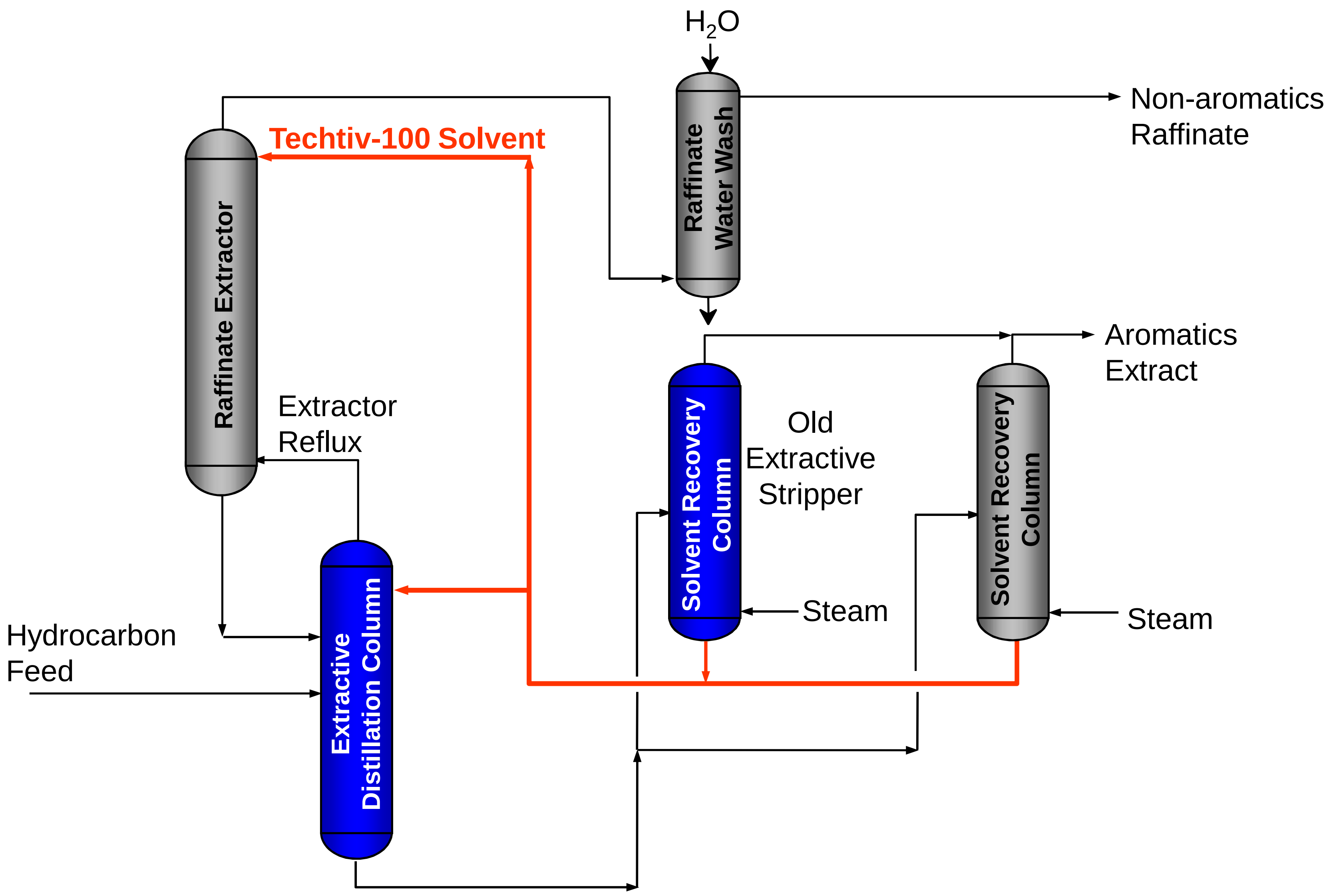
Revamp of Glycol Extraction Units



Hybrid Design for Incremental Feed



Hybrid Design to Double Unit Capacity



Critical Success Factors

In each type of revamp there are some critical success factors.

Some are consistence from revamp to revamp – others are revamp specific.

Critical Success Factors

For BTX Revamps there are three critical success factors.

1. Solvent Selection
2. Equipment Design
3. Equipment Inspection

Solvent Selection

Traditionally, unit operators have relied on liquid-liquid extraction technologies for aromatics recovery.

This is because the older generations of extractive distillation solvent could not produce acceptable performance of product recovery and purity across multiple carbon numbers.

The first generation of solvents was glycol based and was utilized in liquid-liquid extraction.

Solvent Selection

The second generation of solvents were sulfur and nitrogen based and commissioned in extractive distillation with limited success.

The second generations of extractive distillation solvents was not selective enough to cleanly separate more than one aromatic species at a time, and were plagued by ineffective performance due to 3-phase distillation foaming issues.

Solvent Selection

Some of the second generation processes used nitrogen based solvents which are poisons in many downstream benzene consuming units.

Some nitrogen based solvents are an environmental and safety hazard as they easily hydrolyze with water to toxic compounds – i.e. morpholine which is toxic to humans in ppm levels

Solvent Selection

These concerns are no longer an issue with the third generation of blended solvents, which are commercially used to recover BTX at higher efficiencies, with no product contamination or toxic hazards because non nitrogen based solvents are compatible with water.

The selectivity of the third generation of blended solvents has a large advantage over the first and second generation of solvents.

Solvent Selection

The third generation blended solvent is 40% more selective than the first generation solvents and 20% more selective than the second generation of solvents and is foaming resistant.

Comparison of Different Solvent Systems for Aromatics Recovery

Solvent	S/F	Relative volatility (α) n-C_7/benzene
Techtiv-100 (GT-BTX®)	3.0	2.44
Sulfolane	3.0	2.00
N-methyl pyrrolidone	3.0	1.95
N-formyl morpholine	3.0	1.89
Tri-ethylene glycol	3.0	1.44
Tetra-ethylene glycol	3.0	1.39
Glycol blends (CAROM)	3.0	1.35
No solvent	0	0.57

Equipment Design

It is important to review each design to conform to distillation fundamentals.

Even though a design has been successful in the past, a review of each new application needs to be completed.

Some small deviation could restrict the column from obtaining design goals