

## **A Method for Reducing Energy Consumption by Thermal Coupling**

### **CROSS-REFERENCES TO RELATED APPLICATIONS**

[0001] This Application claims the benefit under 35 U.S.C. § 119(e) of U.S. Provisional Patent Application Ser. No. 61/763,326 filed February 11, 2013, which is  
5 incorporated herein by reference in its entirety as if fully set forth herein.

### **FIELD OF THE INVENTION**

[0002] The claimed invention relates to a method for reducing energy consumption in a distillation process by using thermal coupling. Embodiments of the claimed invention are directed to the inclusion of a side reboiler and a partial condenser in the prefractionation  
10 section of a first column, which in turn helps to uniformly distribute the vapor liquid traffic between a first column and a second column.

### **BACKGROUND OF THE INVENTION**

[0003] Distillation is the most common separation process used in the chemical, petrochemical, refining and related process industries. It consumes a large amount of energy  
15 due to the heating and cooling steps involved through the reboiler and condenser respectively. The major cost overhead for the process industries comes from operating costs which includes raw materials cost, energy cost and labor cost. It would be desirable to reduce the energy cost in the interest of economy as well as society.

[0004] There are complex distillation configurations available which offer substantial  
20 reduction in energy and capital expenditures. These options include, but are not limited to, dividing wall columns and thermally coupled columns.

[0005] Although thermally coupled columns require 20-30% less energy, they have serious drawbacks that make them ineffective for commercial installations. For example, thermally coupled arrangements are realized by setting up two-way vapor/liquid flow  
25 between different columns of a distillation sequence. One of the drawbacks of thermal coupling is non-uniform vapor liquid traffic in the column. As shown in FIG. 1, the top and bottom section of the column sees heavy vapor liquid traffic, whereas in prefractionation and

main section, of the column the traffic is low. The heavy traffic puts a restriction on column capacity and in many cases existing column shells cannot be utilized.

[0006] There is therefore a need to develop and implement a thermal coupling system that has superior energy conservation properties, while at the same time having a uniform  
5 vapor liquid traffic in the column.

### SUMMARY OF THE INVENTION

[0007] An embodiment of the invention is directed to a distillation system comprising a first distillation column and a second distillation column wherein said system is used to separate benzene, toluene and xylenes via thermal coupling. In an embodiment of the  
10 invention, the prefractionation section of a first distillation column includes a partial condenser and a side reboiler.

[0008] In an embodiment of the invention, the benefits of the thermal coupling scheme of claimed invention is used in a benzene-toluene distillation sequence.

### BRIEF DESCRIPTION OF THE DRAWINGS

15 [0009] FIG. 1 is directed to a prior art process and system for distillation; and

[00010] FIG. 2 shows a thermal process in accordance with an embodiment of the invention.

### DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[00011] An embodiment of the invention is directed to a distillation system  
20 comprising a first distillation column and a second distillation column wherein said system is used to separate benzene, toluene and xylenes via thermal coupling. In an embodiment of the invention, the prefractionation section of the first distillation column includes a partial condenser.

[00012] In certain embodiments of the invention, the partial condenser has a  
25 high condensing temperature and can generate low pressure (LLP) steam. In an embodiment of the invention, the partial condenser offers steam generating capability in the

prefractionation section overhead. This overhead vapor serves as the feed for the top section of the second distillation column.

[00013] In certain embodiments of the invention, a side reboiler is connected to the prefractionation section of the first distillation column. In certain embodiments of the invention, the prefractionation section of the first distillation column has a vapor side draw. This vapor side draw serves as the feed to the main section of the second distillation column.

[00014] In an embodiment of the invention, the main section of the second distillation column comprises a reboiler. In certain embodiments, this reboiler is a waste heat recovery reboiler. The reboiler of the main section of the second distillation column runs on low temperature heat. The reboiler reduces the overall steam consumption and can run on flash steam recovered from steam condensates.

[00015] In certain embodiments of the invention, the vapor side draw of the prefractionation section of the first distillation column also feeds into the reboiler of the main section of the second distillation column. Thus, the reboiler stabilizes the operation of the second distillation column by absorbing any fluctuations of vapor feed flow from the first distillation column.

[00016] In an embodiment of the invention, the addition of use of a side reboiler and a partial condenser in the prefractionation section helps in uniformly distributing the vapor liquid traffic in the two columns. Additionally, the addition of the side reboiler and the partial condenser increases plant capacity and reduces energy consumption.

[00017] In an embodiment of the invention, the benefits of the thermal coupling scheme of claimed invention is used in a benzene-toluene distillation sequence.

[00018] As set forth in FIG. 2, the aromatics feed is flow controlled and is sent to a first column that is designated in certain embodiments as the toluene column. The first column overhead vapors are partially condensed in the partial condenser. The condensed liquid is collected in the first column overhead receiver. The overhead condensed liquid from the first column overhead receiver is sent back to the first column as reflux. The uncondensed vapor stream from the overhead receiver is sent to a second column that is designated in

certain embodiments as benzene column. Thus, the first column overhead pressure floats on the second column pressure.

[00019] In certain embodiments of the invention, the first column includes a bottoms reboiler. In certain embodiments, this reboiler is a steam reboiler that uses steam as a heating medium. The heat input to the bottoms reboiler of the first column is regulated by controlling the steam / condensate flow cascaded to the bottom tray temperature of the first column. Thus, the first column's bottom temperature is controlled.

[00020] In certain embodiments of the invention, the first column side reboiler is a steam reboiler that uses steam heating medium. The heat input to the first column side reboiler is regulated by controlling the condensate flow.

[00021] In an embodiment of the invention, the thermal coupling effect in the column is generated by interaction between 3 streams:

- a. The vapor sides draw from prefractionation section of the first column is sent to second column bottom section. This stream is flow controlled.
- b. The bottoms liquid from second column is sent back to the prefractionation section of the first column. This stream is flow controlled cascaded to level control of the second column bottoms.
- c. The overhead vapor from the first column overhead receiver is sent to top section of the second column.

[00022] In an embodiment of the invention, the second column is provided with two feed streams. The first feed stream is the vapor stream from the overhead receiver of the first column. The second feed stream to the second column is the vapor stream from the prefractionation section of the first distillation column. The second column pressure is maintained by controlling the pressure of second column overhead receiver. The liquid from the second column overhead receiver is sent back to the top of the second column as reflux. This stream is flow controlled cascaded to the level control of second column overhead receiver.

[00023] In certain embodiments of the invention, a highly pure benzene product is drawn off as a liquid side draw near the top of the second column. The benzene product purity is maintained by controlling the flow of benzene product cascaded to a differential temperature controller between two trays in the top section of the second column.

5 [00024] In certain embodiments of the invention, a highly pure toluene product is drawn off as a liquid side draw of the second column near the bottom of the column. The toluene product purity is maintained by controlling the flow of the toluene product cascaded to a temperature controller maintain the temperature of a tray near bottom tray of the second column.

10 [00025] In certain embodiment of the invention, The second column reboiler duty is controlled by controlling the flow of the heating medium to the reboiler.

[00026] Overall aspects of the invention relate to methods for increasing the energy efficiency of a distillation process using a thermal coupling process. Those having skill in the art, with the knowledge gained from the present disclosure, will recognize that  
15 various changes could be made to the methods disclosed herein without departing from the scope of the present invention. Mechanisms used to explain theoretical or observed phenomena or results, shall be interpreted as illustrative only and not limiting in any way the scope of the appended claims.

## **CLAIMS**

1. A distillation system comprising:

a first distillation column having a top section and a bottom section, wherein the top section is a prefractionation section;

a second distillation column having a top section and a bottom section, wherein the bottom section is a main section of the second distillation column;

a first overhead receiver in fluid communication with the prefractionation section of the first distillation column and the top section of the second distillation column;

a partial condenser in fluid communication with the prefractionation section of the first distillation column and the first overhead receiver;

a side reboiler in fluid communication with the prefractionation section of the first distillation column;

a vapor side draw feed in fluid communication with the prefractionation section of the first distillation column and the main section and a reboiler of the second distillation column; and

a bottom liquid feed in fluid communication with the main section of the second distillation column and the prefractionation section of the first distillation column,

wherein the said distillation system is used to separate benzene, toluene and xylene.

2. The distillation system of claim 1, wherein the partial condenser has high condensing temperature and can generate LLP steam.

3. The distillation system of claim 1, further comprising a second overhead receiver in fluid communication with the second distillation column, and wherein a liquid product is drawn off near a top of the second column as a liquid side draw.
4. The distillation system of claim 1, wherein the vapor side draw feed is the feed from the prefractionation section of the first distillation column to the main section and the reboiler of the second distillation column.
5. The distillation system of claim 1, wherein the reboiler of the second distillation column is in fluid communication with the main section of the second distillation column, wherein the reboiler of the second distillation column runs on low temperature heat.
6. The distillation system of claim 1, wherein the reboiler of the second distillation column stabilizes the operation of the second distillation column by absorbing any fluctuations of vapor feed flow from the first distillation column.
7. The distillation system of claim 1, wherein the first overhead receiver comprises a first outlet and a second outlet, the first outlet feeds condensed liquid back to the first distillation column, and the second outlet feeds uncondensed vapors to the second distillation column.
8. The distillation system of claim 1, wherein the bottom liquid feed is the feed from the main section of the second distillation column to the prefractionation section of the first distillation column.