International Journal of Mechanical, Industrial and Aerospace Sciences
ISSN: 2517-9950
Vol:3, No:3, 2009

Automated Separation of Organic Liquids through Their Boiling Points

Muhammad Tahir Qadri, Syed Shafi-Uddin Qadri, Faizan Farid, and Nabeel Abid

***Abstract*—**This paper discuss the separation of the miscible liquids by means of fractional distillation. For complete separation of liquids, the process of heating, condensation, separation and storage is done automatically to achieve the objective. PIC micro-controller has been used to control each and every process of the work. The controller also controls the storage process by activating and de-activating the conveyors. The liquids are heated which on reaching their respective boiling points evaporate and enter the condensation chamber where they convert into liquid. The liquids are then directed to their respective tanks by means of stepper motor which moves in three directions, each movement into different tank. The tank on filling sends the signal to controller which then opens the solenoid valves. The tank is emptied into the beakers below the nozzle. As the beaker filled, the nozzle closes and the conveyors come into operation. The filled beaker is replaced by an empty beaker from behind. The work can be used in oil industries, chemical industries and paint industries.

***Keywords*—**Miscible Liquid Separation Unit, Distillation, Waste Water Treatment, Organic Liquids Collection.

I. Introduction

LIQUID evaporation and condensation processes have been observed and studied for a long time, with the first systematic investigations on the evaporation process of water by Dalton in 1803 [1]. Small quantities of one or more liquids having a high boiling point dispersed with a large quantity of one or more immiscible liquids having lower boiling points can be separated [2].

The designed system has a wide range of uses. It can be used in Oil industries, for separation of different liquids into their respective chambers. It can also be used in the Paint industries, Chemical industries and widely in the sugar industries. Especially in sugar industries, the work can be used to extract molasses. Molasses is a left over of sugarcane from which sugar is already extracted [3]. Molasses is being seriously considered as a bio fuel. This work can make it a profitable product for the industrialists which they usually throw away. The work can be divided into four tasks, Boiling of liquids, Condensation, Separation and Storage.

Boiling of the liquid takes place in a manner so that liquid with a low boiling point separated first. This process is called fractional distillation. The miscible liquids in the flask are heated, when liquid reaches their respective boiling point, the temperature is noted and is stored in the PIC micro-controller. The liquid evaporates and enters into the condensation chamber. The temperature raises more and each liquid reach their boiling points and evaporate and go to condensation chamber for second phase.

The second task is of condensation. Different liquids reach the condensation chamber, the condenser cools the vapors and converts them into liquid. The condenser used in the work is called the Liebig condenser. The condenser tubes are winded around the inlet tube. The vapors enter from one side and after passing through the tube condense into liquid form. The temperature of the condenser is constantly maintained by the ice in the copper tubes.

The third task consists of separation. As the liquid leaves the condensation chamber it has to be sent to the storage tank. A stepper motor is placed to direct the liquid into its desired destination. The stepper motor has three movements. Each movement directs the liquid into different tank; three liquids of different boiling points are separated and sent into different tanks.

The fourth task is of storage. When the first liquid is filled in the storage tank, as it reaches the desired level the IR sensors send signals to PIC micro-controller. The PIC directs the solenoid valves to be opened. The tank is emptied into the beaker stationed below. The solenoid valve closes and then the conveyor starts, so as to bring an empty beaker in place of the filled one. An IR sensor is placed on the conveyor so as to properly position the beaker beneath the nozzle. The conveyor starts for 10 seconds, so that the filled beaker is replaced. In case, no beaker arrives within the stipulated time, it runs for further 10 seconds. After this time, it generates the message "Conveyor Empty".

The rest of the paper is organized as follows: section 2 will present the system model. Section 3 will discuss the simulation results and finally section 4 will end the paper with conclusion.

II. System Model

The PIC micro-controller controls all the operations of of the system. Whether its temperature monitoring or stepper motor control, tank emptying or conveyor control, each and every component is subservient to the micro-controller. The LCD is also used for multiple messages and update the user with the various ongoing activities.

Authors are with Department of Electronics Engineering, Sir Syed University of Engineering & Technology, Karachi, Pakistan (e-mail: mtahirq@hotmail.com, shqadri_s@hotmail.com, fayzan786@hotmail.com, nabeelabid@gmail.com).

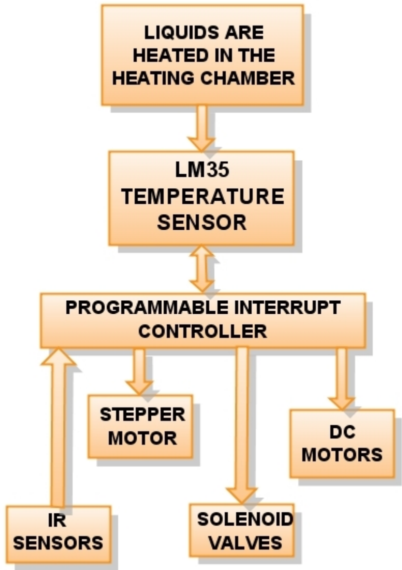

Fig. 1 System block diagram

A. Boiling of Liquids

The liquids are poured into the flask and then heated, as the temperature starts increasing gradually, liquid with the lowest boiling point boils and converts into vapor form. The temperature sensors constantly monitor the temperature and update the PIC micro-controller. As the first liquid starts to boil, its boiling point is noted and is stored in the PIC micro-controller. After the first liquid evaporates, the temperature increases till the boiling point of second liquid is achieved. Temperature will keep on increasing till the liquid with the highest boiling point evaporated.

Fig. 2 Heating flask

B. Condensation Of Liquids

Vapors from boiler enter into the condensation chamber. Temperature of the chamber is always below the respective boiling point of liquid so pure liquid can be achieved microcontroller is responsible of controlling different temperature for the respective liquid to achieve condensation. The condensation tubes are winded around the tube carrying the vapors. The vapors cool down and hence convert into liquid form. The temperature of water in the condensation unit is constantly kept down by passing the water through the copper tubes enclosing the ice.

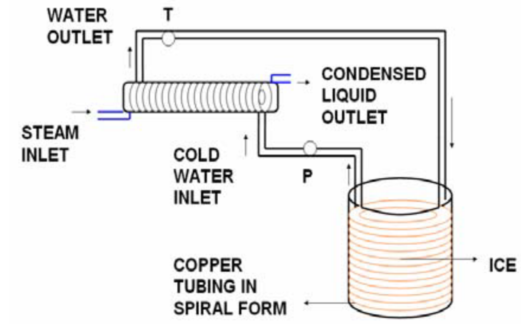

Fig. 3 Condensation setup

C. Separation Of Liquids

From condensation unit, the liquids are directed into its dedicated tank. The PIC micro-controller directs the stepper motor to the tank where liquid is to be sent. Each movement of the stepper motor corresponds to a different tank. After the first liquid has been sent to the first tank, the controller directs the stepper to move the outlet tube in different directions. As the direction changes, the output tube corresponds with the next tank and the second liquid is then stored in the tank. Hence the process continues.

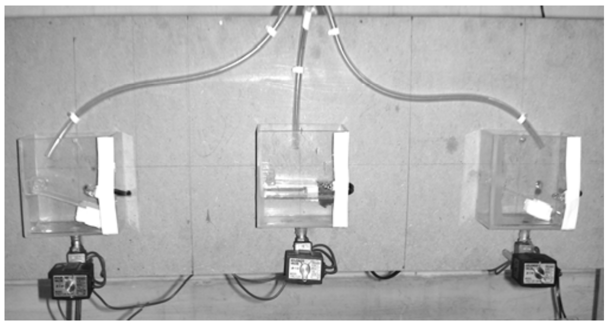

Fig. 4 Three beakers

D. Storage of Liquids

Liquids separated through stepper motor are filled into respective tanks. As the tanks are filled, the IR sensors notify the controller that it needs to be emptied. The controller sends signals to the solenoid valves to open. All the liquids are drained out into the beakers which are placed exactly beneath the nozzle. When all the liquids are emptied into the beaker, conveyor comes into operation and runs for 10 seconds. The filled beaker is replaced by an empty one. If no beaker replaces the filled one, the conveyor runs for another 10 seconds. If still no beaker replaces it, the LCD will generate the message of empty conveyor.

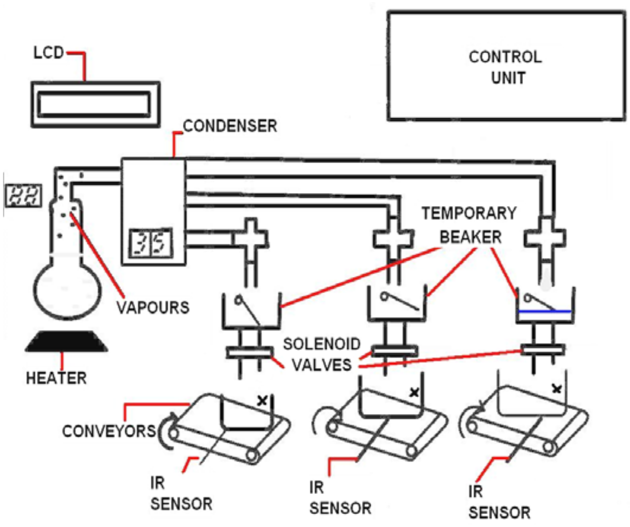

Fig. 5 Diagrammatic representation of the process

III. Discussion and Results

Energy crisis is major issue for industries all over the world. Preserving energy and recycling raw materials is the major priority of every industry. This work will help industries in bringing down the product cost and at the same time will increase their profits exponentially. The reusability of liquids will decrease the cost of working units.

We used three liquids benzene, toluene and xylene. These liquids have the property to be mixed into each other. After they form a miscible liquid it is very difficult to separate them and the only method is to separate them using their boiling points.

The first liquid to be collected was benzene. Its boiling point is 80^o C. Until the whole sample of benzene was collected the overall temperature of the system remained constant. After benzene, toluene was the next to be collected. Its boiling point was 110^o C. Next, Xylene was collected at its boiling point of 140^o C.

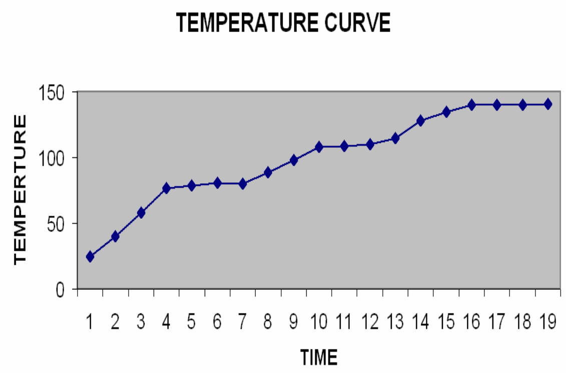

Fig. 6 Temperature curve of the three liquids

As the system starts PIC micro-controller starts the first conveyor until the IR sensor detects it. The first sensor sends the signal to the PIC micro-controller the second conveyor starts and then the third. If there is no empty bottle on the conveyor the conveyor will stop after 10 seconds. Then a message will appear on the LCD to refill that conveyor.

After that the heating process will take place and the temperature will rise. LM35 sensor will detect the temperature changes after every 10 seconds to check the stability point. At this point the first liquid will start to evaporate and condensed later on.

Now the stepper motor will guide the tubing towards the first beaker. After the first liquid is totally boiled the temperature will rise again and similarly same procedure will be repeated with toluene and xylene.

This process has large number of applications. It can be used in paint industries, chemical industries, oil refineries and sugar industries. Paint and chemical industries can reuse their waste water which they usually throw away in canals or rivers which results in increasing of pollution and very harm full to marine life, and by reusing the same chemicals cost per production can be decrease.

In sugar industries it can play a vital role. Back in the days the by-product formed after the processing the sugar from sugar canes was thrown away. This by-product is commonly known as “MOLASSES”. Now research has proven that this by-product contains 90% of Ethanol by volume. The system can be used with this by-product to extract ethanol. Ethanol has proved to be the alternate fuel source of the future.

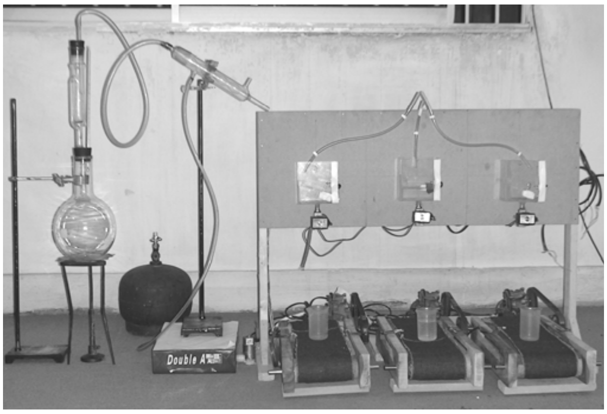

Fig. 7 Actual mechanical structure

IV. Conclusion

The work has a wide array of applications. Its strength is the purity of the product incredibly low cost. Various industrial sectors like oil refineries, Paint industries, Dyeing industries, Chemical industries and Sugar industries can benefit from this. It can be used to separate multiple liquids easily. Prototype has been built to determine the accuracy and purity of the product it has been concluded that this application can be used from the lower scale simple process to high scale industrial application. Bio fuel can also be extracted in the suger mills after extracting sugar from the sugarcane left over is Molasses. Scientific research in the field of bio fuel proved that Ethanol can replace conventional fuel, has a higher efficiency and cleaner then crude oil. Especially in third world countries who can not accommodate the fluctuating price of oil in the market. Countries like Pakistan which are rich in the production of sugarcane they can develop bio fuel from sugarcane which can support its economy and they will not depend on external resources and also saves the foreign exchange which then can be used for public welfare. Obtaining the clean water is major issue in many underdeveloped countries. This work can serve for the betterment of the well being by purifying water clean water can be extracted by using this system on large scale as it is very cheap and provides high quality product in case of pure.

References

[1] Ting Kang Xia and Uzi Landman, "Molecular Evaporation and Condensation of liquid", School of Physics, Georgia Institute of Technology, April 1994.

[2] Poland E. Weber, Lawrence K. Wang, John J. Pavlovich, "Separation of Liquids with Different Boiling Points with Nebulizing Chamber" , United States Patent, October 1992.

[3] An Overview on Biofuels by Júlio F.M. de Castro (May 2007). Available at: *www.hedon.info/docs/BiofuelsOverviewMay2007-JdeCastro.pdf*

[4] NatcoGroup Liquid/Liquid Separation Filter Element. Available at: *http://www.natcogroup.com/PDFContent/Cartridge-Filtration/FluidSep-Liquid-Liquid-Separation-Filter-Element.pdf*

[5] Teaching Resources for Science. Available at: *http://fcit.usf.edu/florida/teacher/science/mod2/resources/cyclones.experiments.pdf*