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Implementation of a Cooling System in a Distillation Tower for the Obtaining of a High Concentration Alcohol

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Abstract

The implementation of a cooling system increased the efficiency of the distillation tower of the industrial process laboratory, as well as reducing the environmental impacts caused by the discharge of the process water at temperatures higher than those established in the environmental regulations. this began with the identification of the process variables: temperature (T), gay degrees Lussac (GL), distillate flow ($\dot{D}$), heat extracted (q), in which, it was determined that the cooling system is not adequate, because it does not extract enough heat from the distillate flow, which results in low distillation efficiency and performance, which is why we work with the optimization of the process variables described initially and with the design of a refrigeration system. To the requirement of the necessary heat to be able to improve the refrigeration, it was determined that the design of the cooling system requires the following characteristics: Surface area of heat transfer = 0.192 m ^ 2; Ø_i = 0.012 m; length of the refrigerant system = 5.09 m; Tank capacity = 60 L / h; Tank height = 90 cm; Cooling Unit = 0.75 Hp; Pump = 0.75 Hp. Through the design, it was verified that the cooling system had an increase in the efficiency of the equipment of 63% and a yield of 33%.

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Keywords

Heat removal,
Distillation tower,
Alcohol distillation,
Distillation performance,
Engineering

Introduction

When implementing the cooling system in the distillation tower of the Industrial Processes Laboratory of the Faculty of Sciences-ESPOCH with the purpose of increasing the efficiency of it, it is necessary to identify its initial process variables (Brito *et al.*, 2017) having the following values: temperature difference = (305 – 348) K; alcoholic strength = 85 ° GL; $\dot{D}$ = 0,164 kg / h; q = 337, 824 kJ / h. After identifying the initial process variables of the distillation tower (Brito *et al.*, 2001) it was determined that the heat transfer to the distillate flow in the cooling system is not adequate since not enough heat is extracted producing the efficiency and performance of the equipment have low values: ε = 30%; r = 33%, which is why we opted to implement the refrigeration system with which it was possible to extract enough heat to optimize the process variables and improve the alcohol content (Carrera *et al.*, 2017). To obtain a better result in the cooling of the distillate flow (Brito, y otros, 2016), it is determined that it is necessary to improve the heat removal, a cooling system is implemented with the following design characteristics: Surface area of heat transfer = 0,192 m ^ 2; Ø_i = 0,012 m being the copper material; length of the refrigerant system = 5,09 m; Tank capacity = 60 L / h with a safety factor of 2 for sizing; Tank height = 90 cm up to its maximum capacity; Cooling Unit = 0,75 Hp that was worked with 404 th refrigerant; Pump = 0.75 Hp. Obtaining that the cooling system has a heat removal of 41.28 watts in the distillate flow and 65,75 watts in the equipment, resulting in an alcohol of 95 ° GL, improving the efficiency of the distillation equipment in a 63 %.

Materials and Methods

The present investigation allows to increase the efficiency in the distillation tower of the Industrial Processes laboratory of the Faculty of Sciences - ESPOCH, aiming at the implementation of a cooling system, which indicates that the variables of the process to be corrected are: temperature (T), gay grades Lussac (GL), distillate flow ($\dot{D}$), heat extracted (q). Once the variables have been delimited, it is obtained that in the distillation column, the cooling supply was directly and without a pressure system. Due to the temperature of the gaseous phase inside the column, it does not generate the correct condensation of said flow, thus giving the equipment no adequate distillation purification.

The distillation tower (Brito *et al.*, 2017) initially presents the following values: temperature difference = (305-348); alcoholic degree 85 ° GL; $\dot{D}$ = 0,164 Kg/h; q = 337,824 Kj/h, ε = 30%; r = 33%, considering the values previously mentioned, we tried to solve the problem in the refrigeration system, for this we chose alternatives that improve the efficiency in the condensation zone, the implementation of a cooling system with water recirculation is considered with temperature of exit to 4 °C and its recirculation of 18 °C after having extracted the necessary heat in the condensation, to verify these values we proceed to the design of the cooling system having the following: Surface area of heat transfer = 0,192 m ^ 2; Ø_i = 0,012 m; length of the refrigerant system = 5,09 m; Tank capacity = 60 L / h; Tank height = 90 cm; Cooling Unit = 0,75 Hp; Pump = 0,75 Hp. The present data is oriented in calculations basically of heat removal, distillate flow, contact with the heat transfer section, lengths, heat removal capacities that allow knowing the amount of energy to be extracted. Implemented the design is known the amount of energy extracted being this 41, 28 watts from the distillate flow due to a better energy transfer, which allows to increase the concentration of the alcoholic degree resulting in a distillation of alcohol at 95 ° G, this alcoholic strength is within the norm NTE INEN 375 (for alcoholic beverages, rectified ethyl alcohol) and its alcoholic strength was verified with the norm NTE INEN 340 (for alcoholic drinks) (Normalizacion, 2015). Determination of ethyl alcohol content was done by Alcoholmetric method (Gay-Lussac). The cooling system took into account the amount of cooling, the heat of condensation, the recirculation temperatures, providing an improvement in the distillate flow, trying to extract 65,75 watts from the cooling equipment, obtaining the amount of energy needed to that this flow in the condensate improves its efficiency up to 63%.

Results and Discussion

When carrying out the investigation in the laboratory of Industrial Processes Faculty of Sciences-ESPOCH, high concentration alcohol was obtained in the distillation tower, it was started with an alcohol supply at 30°GL and when it reached a temperature of 75°C in the distillation column the distillate goes to the condensers in which, when the cooling system is implemented, there is a change in temperature so that the phase change occurs (18 – 75)°C, reaching an alcoholic degree of 95°GL, and thus obtain that alcoholic degree that improves the efficiency of the tower.

The present investigation without the implementation of the cooling system the alcohol resulting from the distillation reaches around 85 ° GL with an operation time of 72 hours, with an efficiency in the distillation of 34% and the performance of the equipment of 33%. With the implemented cooling system, an alcoholic degree of 95 ° GL was obtained, with a heat removal in the condensation of 148,595 kJ / h with an operation time of 44 hours, increasing the distillation efficiency to 63% with a yield of 33% team. In order to reach higher alcohol content, it is necessary to solve the design limitation of the feed tank jacket, which causes the heat transfer to be inadequate. For this, in the distillation section, the performance of the equipment must be improved. an alcoholic strength at most for its condensation.

This indicates that by calculating the variables obtained by comparing them with the initial values, they contribute a decrease in time, flows and quantities of heat to be removed, which resulted in an energy saving of 43% that gives greater efficiency to the distillation. When implementing the Cooling System it was determined that the initial conditions of the distillation process are: q = 93,84 W; $\dot{D}$ = 0,164 kg / h with an operating time of 72 h, obtaining a distillate flow of 0,07 kg / h with an alcoholic degree of 85 ° GL.

Without the cooling system			With the cooling system		
Variable	**Value**	**Unity**	**Variable**	**Value**	**Unity**
q	93,84	Watts	q	41,28	Watts
QS refrigeration	61,83	Watts	QS refrigeration	65,75	Watts
m. refrigeration	5,91	Kg/h	m. refrigeration	5,65	Kg/h
D.	0,164	Kg/h	D.	0,07	Kg/h
T	72	H	T	44	H

SOURCE: Moreno A. / Toscano C., 2017.

For the cooling system, the calculated dimensions are: Surface area of heat transfer = 0,192 m ^ 2; Ø_i = 0,012 m and length of the refrigerant system = 5,09 m; Tank capacity = 60 L / h; Tank height = 90 cm; Pump = 0,75 Hp; Cooling Unit = 0,75 Hp.

The operation variables of the cooling system in the distillation tower is the cooling mass equal to 5.65 Kg / h, the temperature change for the phase change to occur being (18-75) ° C and the amount of heat removed by condensing the refrigerant = 148,595 kJ / h. With the validation of the equipment by means of the artisanal alcohol distillation operation implementing the cooling system, an alcohol of 95 °GL was obtained, which indicates an increase in the efficiency of the equipment of 63 %, the yield of 33 % and an optimization of the Operating time from 72 to 44 hours.

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