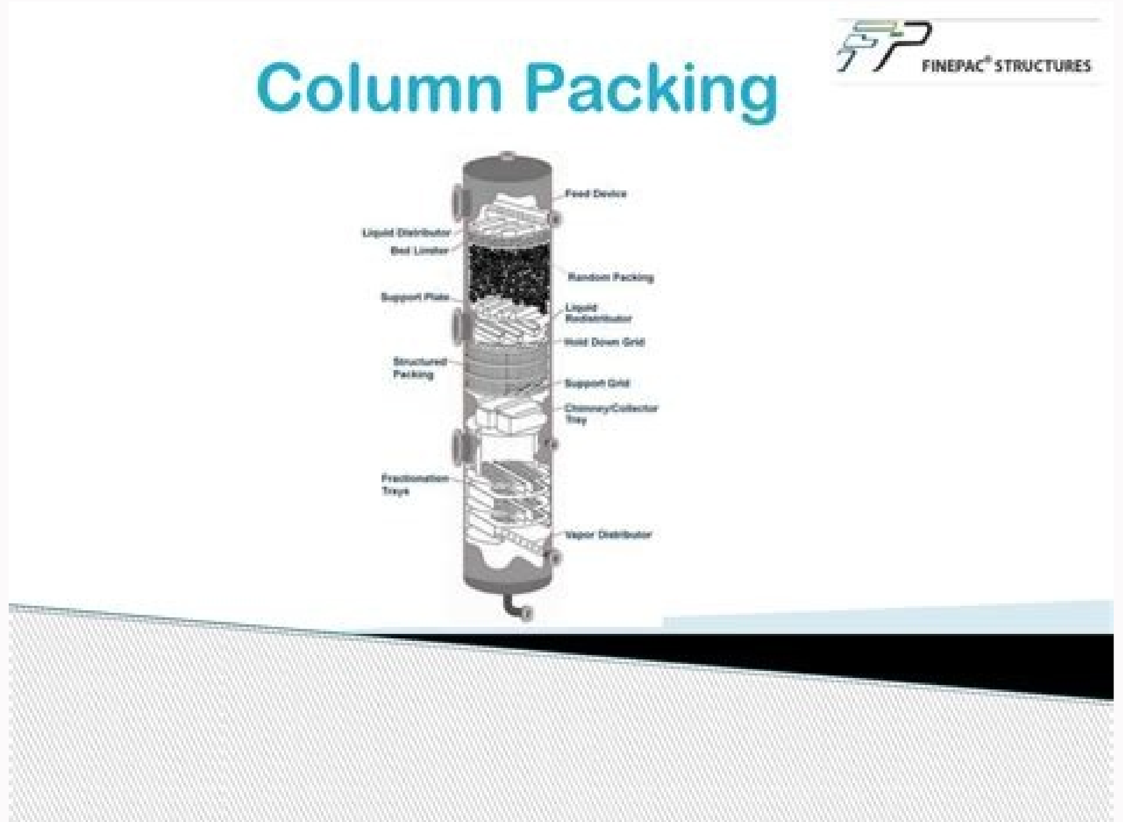
Packed bed distillation column lab report

HAZOP for the Packed Column
Intention: Provide mixing column for the separation of [illegible]

Guide Word	Parameter	Cause	Consequence	Action
No	No flow of water to pump	Valve from water tank is closed	No water entering column. No extraction occurs	Open the valve
No	No flow of water to pump	The pump is off	No water entering column. No extraction occurs	Turn the pump on
Less	Less flow of water to column	The tubing is pinched	[illegible] extraction rate due to insufficient flow of water	Change the tubing
More	More flow of water to column	The operator accidentally increases the pump speed	The column may overflow with water. All the oil will be drained.	[illegible] the speed of the pump in order to [illegible] flow of water
More	More flow of water to column	A power surge may increase the speed of the pump	The column may overflow with water. All the oil will be drained.	Restore normal power to the pump to restore the original pump speed



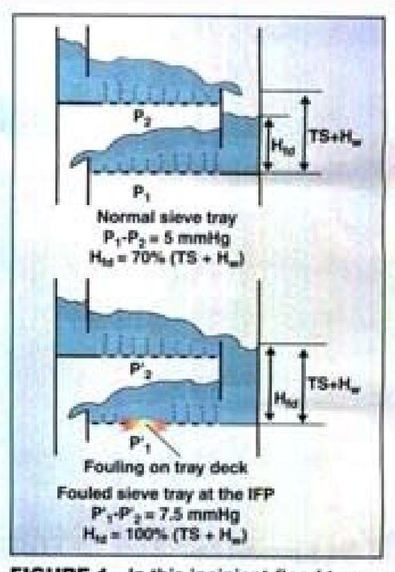
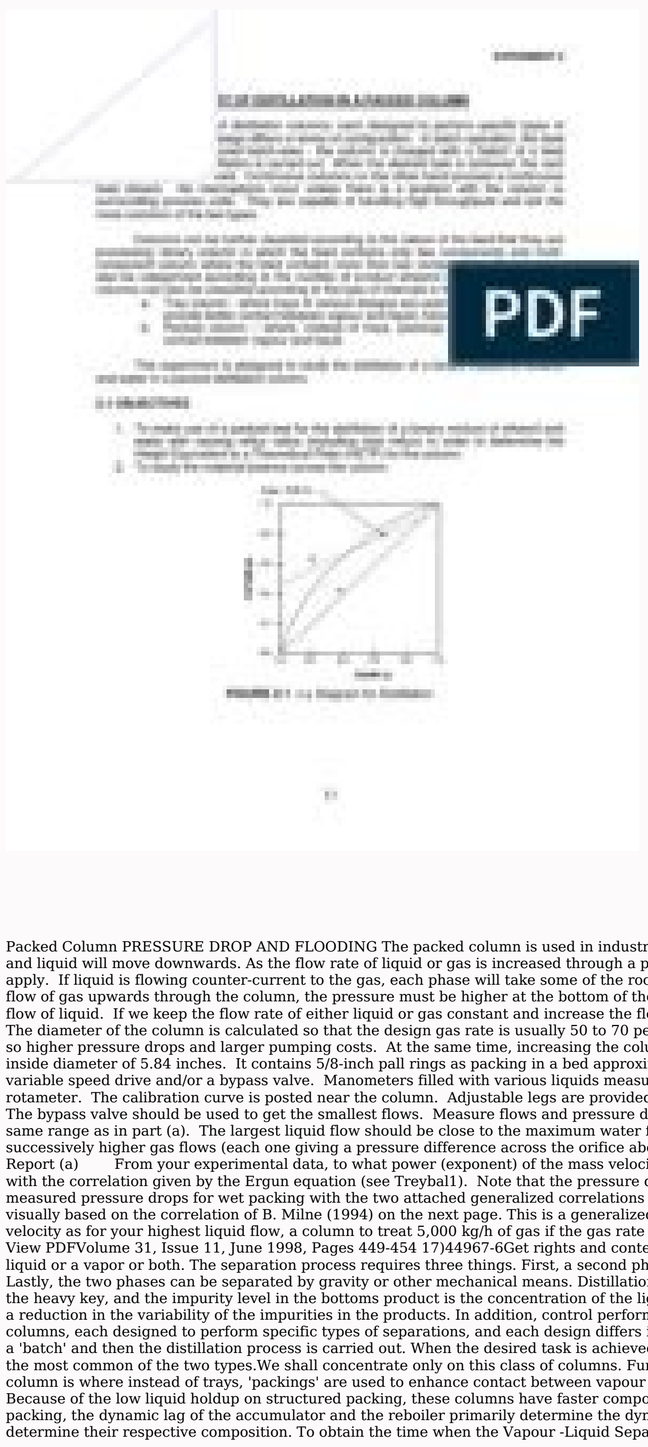


FIGURE 1. In this incipient-flood tray, fouling has caused an increase in pressure drop and downcomer liquid backup (P = pressure, mmHg; H_{fd} = downcomer backup, mm; TS = tray spacing, mm; H_w = outlet weir height, mm)



Distillation column example. Distillation column capacity. Distillation column inspection procedure. How does a packed distillation column work.

Packed Column PRESSURE DROP AND FLOODING The packed column is used in industry to produce mass transfer, i.e. gas absorption, distillation, and liquid extraction. This experiment is intended to study the factors affecting the capacity of a packed column to handle liquid and gas flows. The flow will be counter-current: gas will move upwards and liquid will move downwards. As the flow rate of liquid or gas is increased through a packed column of constant diameter, the pressure drop per foot of packing increases. If there is no liquid, so that the column is dry, we have a case of gas flowing through a packed bed. In that case we might expect the Ergun equation (Treybal1, p. 200) to apply. If liquid is flowing counter-current to the gas, each phase will take some of the room in the column, so each will have an effect on the pressure drop. We can get some idea of the accuracy of an empirical correlation in the literature by comparing measured pressure drops with values predicted by the correlation for the same conditions. To have flow of gas upwards through the column, the pressure must be higher at the bottom of the column than at the top. The liquid flows downward through the packing against the pressure and the flowing gas phase because the liquid is appreciably denser than the gas and so is pulled down by gravity. The pressure gradient in the column opposes the flow of liquid. If we keep the flow rate of either liquid or gas constant and increase the flow rate of the other phase, we will eventually come to a limiting condition in which counter-current flow cannot be maintained. This limiting condition is called flooding. In practice, the diameter of a packed column is designed for a certain approach to flooding. The diameter of the column is calculated so that the design gas rate is usually 50 to 70 percent of the flooding rate. This percentage approach is determined by economics and by the uncertainty of predicting the flooding point. Decreasing the column diameter for constant mass rates of flow gives higher flow rates of liquid and gas per unit area, and so higher pressure drops and larger pumping costs. At the same time, increasing the column diameter gives larger equipment costs. Thus there will be an economic optimum diameter depending upon relative costs and the relation between pressure drop and flow rates. Experimental Apparatus The packed column is a 9-foot QVF glass tower with an inside diameter of 5.84 inches. It contains 5/8-inch pall rings as packing in a bed approximately 5 feet deep (measure more exactly). It is fitted with a small gas saturator upstream of the tower to minimize evaporation of water in the main column during as absorption A Roots blower supplies air to the system. Gas flow can be controlled with the variable speed drive and/or a bypass valve. Manometers filled with various liquids measure blower exhaust pressure, pressure drop across the orifice, and pressure drop across the column. The orifice is of diameter 1.501 inches in a pipe of diameter 2.067 inches, and the orifice coefficient can be taken as 0.61 Water flow rates are determined with a rotameter. The calibration curve is posted near the column. Adjustable legs are provided to adjust water levels while maintaining liquid seals to prevent leakage of gas. Procedure (a) With dry packing (no water) use four widely different gas flows, with the highest flow giving a pressure drop over the packed column of about 10 cm. of methanol. The bypass valve should be used to get the smallest flows. Measure flows and pressure drops. Remember that gas temperature and absolute pressure will be needed. (b) Pressure drops for wet packing should be measured for a minimum of four different gas flows for each of three different liquid flows. The gas flows should be over about the same range as in part (a). The largest liquid flow should be close to the maximum water flow posted on the control panel, and the range should be as wide as practical. Note that water flows above the posted maximum may force water into the manometer containing fluid. (c) At the highest liquid flow of part (b), further runs should be done at successively higher gas flows (each one giving a pressure difference across the orifice about 20% larger than the one before). For each run, besides measurements of flows and pressure drops the appearance of the system at all points should be noted. The gas flow should be increased until signs of flooding are observed. Calculations and Technical Report (a) From your experimental data, to what power (exponent) of the mass velocity is the pressure drop for dry packing proportional? Does this indicate that the flow is laminar or turbulent? Is this result consistent with the relative size of the two terms of the Ergun equation? (b) Compare the measured pressure drops for dry packing with the correlation given by the Ergun equation (see Treybal1). Note that the pressure difference across the orifice can be related algebraically to G, the superficial mass velocity of gas in the packed column. Thus it is not necessary to calculate intermediate quantities such as the superficial linear velocity in the column. (c) Compare your measured pressure drops for wet packing with the two attached generalized correlations (due to Eckert et al.) which are found in Treybal (Figure 6.34)1 and Bennett and Myers (p. 613)2. (d) Plot log (DP) vs log G for each value of L, the mass velocity of the liquid. Compare the flooding point indicated by this plot with the flooding point observed visually based on the correlation of B. Milne (1994) on the next page. This is a generalized correlation of the form equivalent to the graphic in Treybal(1980) Figure 6.34. (e) Design, on the basis of your measurements rather than the correlations in the literature, packed with the same packing as in the laboratory and at the same liquid mass velocity as for your highest liquid flow, a column to treat 5,000 kg/h of gas if the gas rate is to be 65% of the flooding rate? What pressure drop per foot of packing would be expected? Technical Letter Give a Brief comparison between your experiment results and those in the literature and then present the results of your design study.
View PDFVolume 31, Issue 11, June 1998, Pages 449-454 17)44967-6Get rights and contentpacked batch distillation columnPI overhead composition controlView Abstract Distillation is a process that separates two or more components into an overhead distillate and bottoms. The bottoms product is almost exclusively liquid, while the distillate may be liquid or a vapor or both. The separation process requires three things. First, a second phase must be formed so that both liquid and vapor phases are present and can contact each other on each stage within a separation column. Secondly, the components have different volatilities so that they will partition between the two phases to different extent. Lastly, the two phases can be separated by gravity or other mechanical means. Distillation differs from absorption and stripping in that the second phase is created by thermal means Distillation columns exhibit static nonlinearity because impurity levels asymptotically approach zero. The impurity level in the overhead product is the concentration of the heavy key, and the impurity level in the bottoms product is the concentration of the light key. . Coupling is significant when the composition of both overhead and bottoms products are being controlled. Columns are affected by a variety of disturbances, particularly feed composition and flow upsets. Improved distillation control is characterized by a reduction in the variability of the impurities in the products. In addition, control performance can affect plant processing rates and utility usage. After the variability of a product has been reduced, the set point for the impurity in the product can be increased, moving the set point closer to the specification limit.There are many types of distillation columns, each designed to perform specific types of separations, and each design differs in terms of complexity. One way of classifying distillation column type is to look at how they are operated. Thus they are batch process and continuous column. In batch operation, the feed to the column is introduced batch-wise. That is, the column is charged with a 'batch' and then the distillation process is carried out. When the desired task is achieved, a next batch of feed is introduced.While in contrast, continuous columns process a continuous feed stream. No interruptions occur unless there is a problem with the column or surrounding process units.They are capable of handling high throughputs and are the most common of the two types.We shall concentrate only on this class of columns. Furthermore, the column interval has two types which are tray column and packed column. Tray column is where trays of various designs are used to hold up the liquid to provide better contact between vapour and liquid, hence better separation while for packed column is where instead of trays, 'packings' are used to enhance contact between vapour and liquid. Columns that use sections of structured packing offer significant efficiency advantages over trayed columns for low-pressure applications because there is less pressure drop across the structured packing than across a corresponding set of trays. Because of the low liquid holdup on structured packing, these columns have faster composition dynamics than trayed columns. The liquid holdup on the structured packing is low enough that the composition profile through the packing reaches its steady-state profile much more quickly than the reboiler and accumulator. For a column with structured packing, the dynamic lag of the accumulator and the reboiler primarily determine the dynamic response of the product compositions . Operate Vapour -Liquid Separation Experiment using a Packed Column Distillation Process Unit. Analyze the sample for the Top and Bottom Product by Refractometer to obtain the Refractive Index (RI) in order to determine their respective composition. To obtain the time when the Vapour -Liquid Separation is nearly finish.• Should familiarized with each item such as the Reboiler, Condenser, Distillation Unit and the flow paths and apparatus before conducting of the experiment. This distillation operation usually deals with very hot and highly flammable

materials. Extreme care should be taken when handling the apparatus, in taking readings and collecting samples. • The Flow Meters should be operated smoothly in order to avoid pressure surges within the equipment. • The equipment was inspected visually for any damaged components or glass breakage.If any such defects were noticed, please report to technician. • Goggles must be worn at all times in the laboratory.• Worn an appropriate rubber gloves must be when handled Organic Solvents.• Avoided by wearing clothes which could easily caught by the fire. • The flow rates of liquids should not exceed the maximum of the rates that showed in the flow meter. • The water supply pressure to the Condenser and the Coolers should not exceed 2 bar gauge. • The equipment was inspected visually for glass breakage and leakage. • The water pressure did not allowed to exceed 2.0 bar maximum as indicated by PI.2. • V8 was always maintained in the open position during atmospheric operation (avoid system pressurizing). • The cooling water did not isolated until the heating has been shut down (at least 10 minutes). • The immersion heater did not switch on the level in the reboiler below the heater elements or when the reboiler is empty. • Don't return the product distillate collected to the reboiler vessel when the equipment is in operation. • Do not allow the liquid level to raise much above the top graduation on the tube before the stop valves V2 and V3 were opened.• 3 litres mixture of ethanol in 27 litres of water ware prepared by mixing appropriates quantities. • The valves V1, RCV1, V3, V4, V5, V6, V7, V9 and FCV2 were ensured close while V2, V8 and V10 were opened. • The ethanol and water mixture were started to fill up to the desired level. • The cooling water was slowly opened to the condenser and was made sure the water was indeed flowing through it. • Water flows to the drain from cooling water outlets was checked.• The experiment could not started until the cooling water flowed was visible in the outlets to the drain. • The bottom product sampling V5 and top product sampling valve V4 were ensured close. • A reboiler vessel was ensured already being charged with the ethanol-water mixture through the charge port. • The liquid level was check either satisfactory or not, otherwise, top up with the ethanol-water mixture through the charge port. • The concentration of feed in the reboiler vessel was ensured being corrected and that the liquid level is at the vessel equator • The Reboiler Vessel should never be filled with liquid above the maximum level indicated. • While on operation the level, it should never recede below the minimum level. • The Reflux Adjustment Valve RCV1 and valve below Product Cooler V2 were closed. • A sample of Ethanol -Water mixture from the Reboiler through the Sampling Port wars obtained and tested its composition using Refractometer. • The main power control switch and the power switch of the heater ware turned on. • Electrical supply was switched on (green 'heater on' button). • Heater controller was set HC.4 to maximum setting. (About 200 V) • A period of 15 minutes was allowed for the equipment to maintain thermal equilibrium with surroundings. • The temperature readings of all Temperature Indicator (TI) were observed and the temperature reading was recorded every 5 minutes. • When distillate liquid was seen to flow through RI.A1, the heat input was reduced and HC.4 was set to roughly 170V. • During this period, HC.4 was observed.The unit was ready to be used for an experiment.• The valve for Reflux Ratio RCV 1 was ensured that the adjustment was opened.• Both valve for Reflux Ratio RCV 1 and valve below Product Cooler V2 were adjusted so that both readings on R1 and R2 provided a Reflux Ratio of 1.0 for the operation. • Waited for about 15 minutes until the flow rate was shown by R1 and the temperature readings at the top and bottom of the columns were steady. • Samples from the Reboiler and the overhead from the Sampling Port were collected for every 5 minutes. • The Temperature of the Reboiler TI4 was observed. If the temperature was already 90ºC, the current of the Reboiler was reduced to between 170V to 180V. • The flow rate at R1 was observed and the valve for Reflux Ratio adjustment was adjusted to ensure that the Reflux Ratio is maintained at 1.0. • The concentration of the samples drawn was measured using the Refractive Index method. • The reading of temperatures was continued recorded for every 5 minutes.• Readings were recorded in the provided table of results.• Heater controller HC.4 was adjusted to minimum setting. • Electrical supply was switched off (red 'heater off' button), turned off the power switch of the Reboiler and turned off the main power control switch. • Hot liquid from the Reboiler could not be drain. If necessary, the liquid within the system could be drained only when the liquid was already cooled. • The Cooling Water was allowed to run for some time. Distillation is a method of separating mixtures based on differences in volatility of components in a boiling liquid mixture. It is one of the most common equipment in industry for vapour-liquid separation process. It can be run in a continuous or batch system. The compound that has higher volatility will vapourize and condensed before collected while the compound that has lower volatility will remain in the column. Batch distillation plant was used in this experiment, it refer to a mixture is distilled to separate it into its component fractions before the distillation still is again charged with more mixture and the process is repeated.In this experiment, packed column distillation was used for vapour-liquid separation.It has pack tower contain layer of device called packing. The tower of the packed column have section filled with cylindrical ring known as raschig ring. The packing breaks up the liquid so that it flows over a large amount of surface area. This exposes more liquid to the vapor and increase heat transfer from the vapor to the liquid. The mixture of Ethanol and distilled water was used as the sample, it was prepared by mixing 3L of Ethanol with 27 L of distilled water and then it was boiled. The temperature readings was observed and recorded for every 5 minutes after the equipment achieve thermal equilibrium. During record the temperature, the sample of bottom product and top product was take and being analyzed using spectrometer to obtain the refractive index of both samples.Based on the result it was found that, the temperature readings for TI 1, TI 2, TI 3, AND TI 4 were increased with time while TI 5 and TI 6 were constant. because each time it revaporizes it will be slightly more low boiler then high boiler. In this experiment it use raschig ring or cylindrical ring, It breaks up the liquid so that it flows over a large amount of surface area. The more theoretical plates the better the separation.Vapour-liquid separation through distillation was studied using packed column distillation process unit. Packed column consists of small shape of solids that are inserted in the column to provide high interfacial area for mass transfer between liquid and vapour.Based on the data obtained, it was found that the refractive index for top product is 1.361 and for bottom product is 1.333 thus, the top product was Ethanol while the bottom product was water. The time obtained for the vapourliquid separation is nearly finish was 30 minute. It can be concluded that this method used for the separation of Ethanol-water mixture can be considered a reasonably reliable method. This experiment can be improved by taking the data more than once and calculate the average mean value. Other than that, the condition of machine should be checked thoroughly so that no damages or leakages occur in this experiment in order to achieve more accurate result. Besides that, lab manual also should be read properly before entering the laboratory to avoid any misunderstanding, misconception in order to run the experiment smoothly.

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