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Enhancement of Heat Transfer in the Separation Process of Ethanol from the Ethanol-Water Mixture by Using Surfactant: A Review

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----------ABSTRACT----------
Tostudythevariousseparationprocessofmixedliquids.Theproductionofbioethanolhasgainedattentionrecently becauseoftwomainreasons.First,itisusedgraduallyasanoxygenatedfuelinsteadofmethylt-butylether(MTBE). The second reason is related to its potential to be used as an alternative fuel. The economic competitiveness of the ethanol production process depends to a large extent on the amount of heat and energy used. To maximize the effectivenessofethanolmonetarilyasaliquidfuel,theethanolpurificationhasbeenproposedseveraloptimization steps related to purification of ethanol have been proposed because it requires more amount of thermal energy for distillation. Half of the creation of vitality is devoured by refining. To manage this high vitality request and improvementoftheprocess,theconceptofpolygenerationand hydrothermaltreatment, particularlyinthecase of small-scale ethanol plants, is generating more and more attention. In any case, the investigation of the bioethanol cycleshowsthatrefiningis as yetthemostutilized.Thermalintegrationofdistillationandrectificationisknownto provide the greatestreductioninheatdemand.Theaimofthispaperisatrytopresentareviewoftheexperimental study of heat transfer enhancement, the time required, and energy consumption in the distillation or separation process of an ethanol-water mixture by the addition of surface-active agents(Surfactants).
KEYWORDS: *Ethanol water separation, Distillation, Heat transfer, Surfactant*

I. INTRODUCTION

According to the current energy scenario worldwide, the most demand is fuel energy, as an increase in the costs of fuels and increasingtherequirementofenergyandalsotheglobalwarmingeffectsontheenvironment.Thesearethemainkeyfactors to produce renewable energy sources. So taking this aspect in mind, Biofuels are the better choice for the substitution of non-sustainablepowersources.Biofuelsareasfluidorgasesandtheyareproducedusing(sugar,vegetableoil,creaturefats,wood, sawdust, grass, and horticultural waste). The two most broadly utilized biofuels are ethanol and biodiesel which is fluid- structure.Ethanolorethylliquor(C2H5OH)isthefluidhaving noshadinginthiswayfueldeliveredbythematurationofsugar found in sugarcane, rice, potato skins, it is normally produced using wheat, corn, sorghum. The creation of ethanol utilizing a cyclelikefermentinglager, wherestarchcropsarechangedoverintosugars.Thesugarisagedintoethanolandethanolisthen refined to its last shape which can be utilized as fuel. These days ethanol creation the most significant factor as of late as a result of two reasons. Initially, it is utilized as oxygenated fuel on account of methyl t-butyl ether(MTBE).
Thesecondreasonitisusedasfuelinsteadofpetrolthatmeansitisanalternativefuel.Ethanol isanecologicalfueloflesstoxic and it causes an impact on the environment when spilling occurs. If the fuel or ethanol isburned then there is the production of water. Hence because of this carbon dioxide and water, the reduction in pollution from petroleum products which is harmful to the environment are SO_X and No_X. The solution for non-renewable energy sources, Petroleum products is to produce alternative fuels because the stocks of the crude oils are limited. Therefore, taking this aspect in mind the production of more amount of renewable energy sources is to be produced worldwide. Thus, the bioethanol gives more attention as a renewable fuel and having eventually maximum growing potential. However, the main task in the production of bioethanol is the separationofthehighlypureformofethanol,becauseitcontainssomeamountofwater.Hencetheseparatingtheethanolfrom water is difficult due to the presence of azeotrope in the mixture. Therefore, for those kinds of obstructions, it is necessary to studytheimpactsoreffectswhenmixingofsurfactantsintothewater-ethanolconcentrationtoproducepureethanol.Nowthe surfactants (surface active agents) are used to reduce the surface tension of the liquidmixture.

What is mean by surfactant?

It is also known as a surface-active agent. It is a reducing agent that reduces the surface tension between two or more mixed liquids. This reduction of surface tension gives the better heat transfer rate to boil the liquids also consumes time taken for the boiling process

II. LITERATUREREVIEW

Yang et al. [1] studied the impacts of surfactant used in the pool boiling process in which they used two sets of apparatus one is for pool boiling process in which how the boiling occurs by mixing of surfactant of a dilute solutionandanotherisonlyfordeterminingcriticalheatfluxes byaddingsurfactant.Thedifferencebetweenthat two apparatus is the heat transfer surface. They used sodium lauryl benzene sulfate (SLBS)**,** and sodium lauryl sulfate (SLS). Finally, they studied that the addition of surfactant in pool boiling gives better results inboiling.

Tzan et al. [2] investigated and studied that in pool boiling heat transfer, effects on the boiling process using surfactantwhileperformingexperiments.Theyperformtheirexperimentsintwowaysinthissodiumlaurylsulfate and n-propanol is used as a surfactant**.** The first way is by using more amount of surfactant (SLS) does not give a betterboilingprocess.Ithasbeenobservedthatusinglessamountconcentrationofsurfactantgivesbetternucleate boilingandhighheattransfercoefficientandheatfluxes.Thesecondwayistheuseofthesamesetupbutadifferent mixture that is water and n-Propanol add (SLS) surfactant and the author conclude that SLS and n- propanol reducesthesurfacetensionofwaterandalsostudiedtheimportanceofmassdiffusioneffectonthebinarymixtures added withsurfactant.

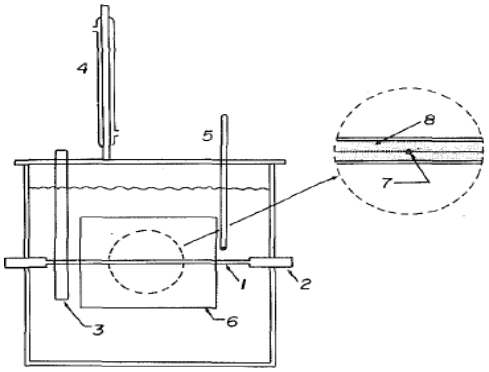

Fig1. Pool boiling apparatus. (1 Heating wire, 2 Nickel coated copper bar, 3 Glass tube, 4 reflux condenser, 5 Thermometer, 6 View window, 7 Thermocouple, 8 Silicon powder [1][2]

The above apparatus is an old technique used in past years for better and proper boiling of liquids using a surfactant.

TsannWuetal.[3]studiedheattransferinnucleateboilingofwatermixedwithanionicandnon-ionicsurfactants inwhich99%SDS(anionic)andTritonX-100(non-ionic)areusedforpoolboilingprocess.Inwhichtheystudied theimpactofsurfactantintheprocessofboilinginwhichtheformationofvaporbubblesandtheirgrowth,butwe cannotdecidetheircapability.Byexperimenting,theygotslightvariationsinthesizeofbubblesandtheirgrowth. thepoolboilingoccursbecauseofSDS95%, SDS99%isbettercomparedwithTritonX-100.Also,thewarmmove ofsoakednucleatepoolboilingoffluidarrangementsofthreesurfactantsonalevelcylindricalradiatorwasexaminedtentativelyand usingphotographicviewexaminationisverysimplertostudy.

Hetsroni et al. [4] investigated the impact on properties like surface tension and kinematicviscosity on the heat transfer coefficient in the nucleate pool boiling of water and pure water using a cationic surfactant. At less concentration below 530 ppm, the coefficient of heat transfer increases because of the reduction in surface tension.Elsewhereformaximumconcentrationlike1060ppm,adecreaseincoefficientofheattransferbecause the kinematic viscosity gets increased. Also studied the variation in boiling behavior, the thermal pattern on heating surface, the effect on bubble growth in pool boiling heat transfer. For all these operations he uses pool boiling apparatus. For better understanding highspeed camera is kept to visualize the growth of the bubbles. Following is the apparatus were they used to performexperimentation.

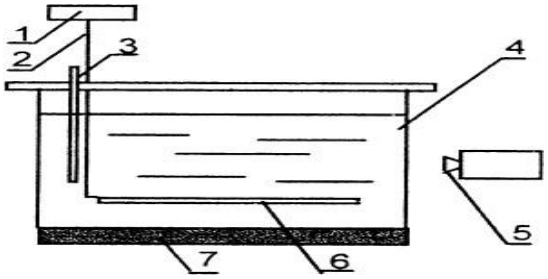

Fig2. Apparatus of pool boiling on a tube. (1 temperature measurements, 2 Thermocouple, 3 supplementary heaters, 4 Window 5 High-speed camera 6 heating tube 7 Insulation. [4]

Wasekar et al. [5] experimented using a pool boiling apparatus for the boiling of pure water. In this, the aqueous solution of anionic (SDS, SLES) and non-ionic surfactants (Triton X-100, Triton X-305) are used with different molecular weights of (288.2, 422, 624, 1526). One change is made in an apparatus they use a cylindricalheaterintheaqueoussolutionofsurface-activeagents.Theystudiedthatmaximumheattransferis enhancedinnucleateboilingwithadecreaseinsurfactantmolecularweight.Thevariationofgrowthinsizesof thebubblesatdifferentconcentrationsofsurfactant solutioninppm.

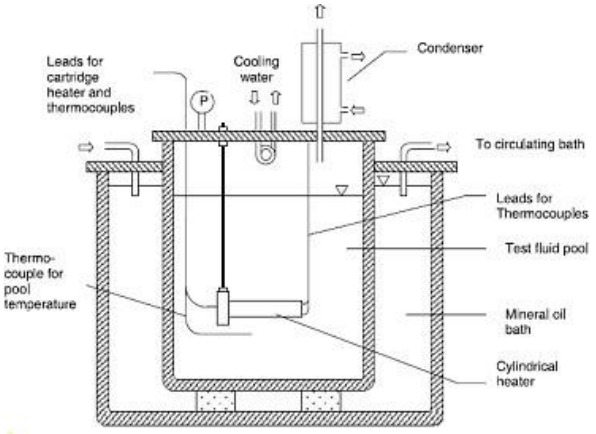

Fig3. Schematic of pool boiling apparatus [5]

Hetsroni et al. [6] Conducted experiments for subcooled water boiling with a surfactant solution for boiling. Thisexperimentwasperformedbyusingtwosetups.Insetup1,theheaterusedisatubularheaterandinsetup 2, a heater is of stainless-steel foil. In this experiment, the use of the Habon G solution as a surfactant to find various thermal properties that affect surface tension, viscosity, the thermal conductivity of the surfactant solution in subcooled boiling. Experimental results show that boiling curves are quite different for both fresh and degraded solutions. By using Hetsroni et al. [6] Conducted experiments for subcooled water boiling with a surfactant solution for boiling. This experiment was performed by using two setups. In setup 1, the heater usedisatubularheaterandinsetup2,aheaterisofstainless-steelfoil.Inthisexperiment,theuseoftheHabon G solution as a surfactant to find various thermal properties that affect surface tension, viscosity, the thermal conductivityofthesurfactantsolutioninsubcooledboiling. Experimentalresultsshowthatboilingcurvesare quitedifferentforbothfreshanddegradedsolutions.HabonGsolutionininincreasingconcentrationgivesbetter heat transfer enhancement. Also said that before boiling there is a large vapor cluster formation because of degraded Habon G solution used and cluster formation is reduced by producing high heat flux which causes a reduction in the cluster and starts subcooledboiling.

Inoueetal.[7]studiedtheeffectofsurfactantonheattransfercoefficientandsurfacetensiontoenhanceheat transfer in pool boiling of water and ethanol-water mixture. Different type of setup used for measuring different properties such as surface tension and heat transfer coefficient. The increase in the concentrationof

surfactant gives a decrease in surface tension which decreases ethanol fraction because of this low ethanol fraction range there is an enhancement of heat transfer coefficient. They utilized the surfactant concentration upto1000ppmtotakeresultsforstudyingboilingbehavior,bubbleformationtvariousconcentration,andheat transferenhancementslikethecoefficientofheattransferandheatflux.Howeverwithanincreaseinheatflux the coefficient of heat transferdecreases.

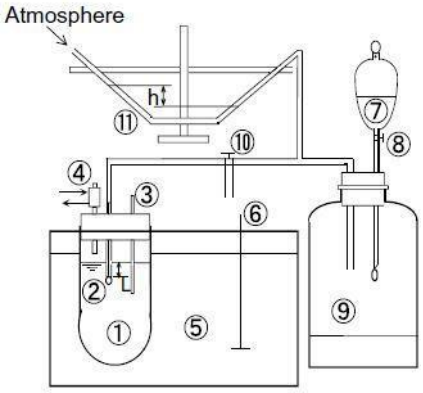

Fig. 4 Apparatus for measuring surface tension.1 Test vessel, 2 fine pipe, 3 thermometers, 4 condenser, 5 thermostat bath, 6 agitator,7 oil, 8 valve, 9 pressure vessel, 10 valve, 11 manometer.[7]

Zhang et al. [8] studied many useful properties like equilibrium and dynamic surface tensions, wettability for various surfactant solutions by hypothesis estimation. In which the decrease in dynamic surface tension to an equilibriumvalueforalongtime,it'sthe mostdifficult factorforthephasechange phenomenonwhichcausesan impact on the adsorption process of the surface-active agent, which istime-dependent.

Nafey et al. [9] experimented on heat transfer enhancement in solar water distillation by adding surfactant in it. They used an electric heater of 2000 watt was taken instead of natural heat (from the sun) to get the same input power. Accordingtosetup,theboilingpoolconsistsofamixtureoffreshwaterandbrinesolution.Theeffectof surfactant addition with distinctive concentrations of SLS (Sodium lauryl sulfate) of 50, 100, 200, and 300ppm usedinthisexperiment.Theyfoundthattheconcentrationofadditivegreaterthan300ppmwasnotaffectedby the day by day profitability of the system. The productivity was decreased by 6% when more than 400 ppm the concentration of additive taken and suggested that for increasing productivity the solution mixture surface tension must be decreased. Finally concluded that the separation of water brine solution water is getting filtered and separated from brine in the originalform.

Ngemaetal.[10]studiedthemethodsforgettingpureethanolfromwaterandethanolmixturebypervaporation andextractionprocess.Inpervaporationprocessdoesnotrequiresaltbutinextractionprocesssaltandalsoother additives used in thisprocess.

Penget al.[11]studiedtheimpactofsurface-activeagentswiththerefrigerant-basednanofluidinnucleatepool boiling heat transfer. The nanofluid made of Cu nanoparticle and R113 refrigerant, which is added with three different additives in the experiment those is (SDS) Sodium Dodecyl Sulfate, CTAB (Cetyl trimethyl Ammonium Bromide) and Sorbitan Monooleate. The experimental setup made in three sections test sections, boilingapparatus,andcondensationloopareassembledtoformonecompletepoolboilingapparatustoperform the nucleate boiling process. Their results show that with different percentages of three nanoparticles concentrations 0.1%wt, 0.5%wt, and 1%wt with Cu- R113, as well as pure R113 refrigerant which results in nucleateboilingheattransfercoefficient,islargerforCu-R113nanoparticleascomparetopureR113refrigerant. Hence the maximum heat transfer enhancement occurs when a high concentration of nanoparticles wasused.

Elghanam et al. [12] studied with the help of three different surfactants (SDS) sodium dodecyl sulfate, (SLES) Sodium lauryl ether sulfate acts as anionic and Triton X-100 acts as a nonionic surfactant used for boiling of distilled water. Their results show that using SDS and SLES gives an increase in heat transfer also the Triton X-100givesanincreaseinheattransfercoefficientupto500ppmbeyond500ppmgivesinsignificantenhancement found. Their heat transfer coefficient ranges from 194% for SLES up to 240% for SDS and 132% for Triton X- 100 which shows improved enhancementoccurs.

A.R. Acharya, A.T. Pise[13] demonstrated the warmth move coefficient was expanded up to solvency furthest reachesof thesurfactantinwater.Theexpansionofthesurfactantpastasfaraspossiblewaspracticallysteadyor

somewhat diminishes the warmth move coefficient. The nearness of surfactant in water builds normal air pocket speed.

Acharya et al. [14] experimented was done using pool boiling apparatus for heat transfer enhancement in pool boilingusingammoniumchloride(NH_4Cl)asasurfactant.Theystudiedthatbyusingasmallnumberofsurfactant mixeswithothersolutiongivesgoodheattransferraterequiredforthephasechangeofboilingapplication.They found that the concentration of NH_4Cl added up to 800 ppm with pure water gives average growth in the size of the bubble with high heat flux observed and also up to 2800 ppm enhancement can be madepossible.

Gajghateetal.[15]studiedtheenhancementofpoolboilingheattransferwiththeadditionof2-Ethyl1-Hexanol, in this, they use (500-1000 ppm) concentration in pure water and they found that it's sufficient for pool boiling purpose. Which causes a reduction in surface tension of the solution and starts the formation of bubbles at increasing excess temperature. The addition of surfactant concentration beyond the limit gives a bad impact on the boilingprocess.

Najim et al. [16] investigated using SDS, Nicotine as an innovative surfactant on a Nichrome wire heater to conductpoolboilingheattransferexperimentally.Theystudiedhowtomeasuresurfacetensionandthedynamic viscosityofthesolution.Thebubbleformationatvariousconcentrationsisshowninphotographicviewandhigh-speedvideotechniquesotheboilingbehaviorcaneasilydetect.BycomparingSDSandNicotine,nicotinegives thebestheattransferenhancementwith2500ppmconcentrationofnicotinewhichisalmost50%lessthanwater, as we know the nicotine is produced from plants and it is biodegradabletoo.

Acharya et al. [17] presented the literature review on the augmentation of heat transfer in boiling using surfactants. They studied the decrease in heat transfer rate with an increase in pressure and heat flow during the boilingprocessduetosurfaceroughness.Also,theimprovementcanbemadeintheheattransfercoefficientby usingagoodsurface-activeagentintheboilingprocess.Themainaimofthisstudywastoperformpoolboiling heat and mass transfer for LiBr-H_2O and water using surfactant and boiling behavior of the mixture with or without adding surfactant.

Kadametal.[18]foundthatbyusingsurfactantinwater-ethanolmixtureseparationofethanolispossible. This process was performed by the distillation process. In this, they found how much time needed, energy consumption for the process using surfactant as SDS (Sodium dodecyl sulfate), and SLBS (Sodium lauryl benzenesulphurated).Theirresultsshowthattimefordistillationof10%and20%ethanol(v/v)islessforSDSalso the energy consumed for distilling the mixture is less for SDS compared with SLBS. By adding more amount surfactant results increase in specific gravity, SLBS gives variation in specific gravity which good for the enhancement of separationprocess.

R.Kadametal.[19]Investigatedtheseparationofethanolfromanethanol-watermixturebyadifferentsurface- active agent such as SDS (Sodium dodecyl sulfate), NH_4Cl (Ammonium Chloride), SLBS (sodium lauryl ether sulfate).Theyfoundthattimeandenergyrequiredfortheseparationprocessislessfor SDSascomparedtoNH_4Cl andSLBSthatisfor10%and20%(v/v)ofethanolandtheconcentrationofsurfactantupto2500ppmbeyondthis require more time and energy for the separation process. Finally said that SDS is good as compared with SLBS andNH_4Cl.

Fig.5 Distillation Apparatus [18][19]

K. Kadam et al. , R. Kadam et al. [18] [19] They conducted their experiment using the same distillation apparatus but with different surfactants. Concluded that further modifications shall be made for improving using this experimental setup.

Ali. H. Askar, S.A. Khadim, S.H. Mshehid[20] studied the surfactant's impact on the warmth move upgrade and dependability of nanofluid at steady divider temperature. Concluded that adding nanoparticles to the base

liquid enlarged the warmth move rate, and this growth expanded slowly as the focus expanded, where the greatest addition in the Nusselt number came to at the most elevated volume fixation. Managing stable nanofluid taking a shot at improving results.

III. RESULTSVIEW

Studied the enhancement of heat transfer in the boiling process takes place at different conditions and different configurationsandtheirresults.Understandingthebehaviorofthe boilingprocess.Themostcommonthinginall is a surfactant, which is used for better boiling performance. Understanding the separation phenomenon[17][18] the time taken and energy required for separating ethanol from mixture Further modifications can be made for improvingresults.

IV. CONCLUSION

Accordingtotheliteraturesurvey,itisconcludedthatfocusingonastudyareductionintimeandconservationin the required energy required for boiling and mostly in the distillation process. By observing the performance surfactant of type ionic and anionic i.e SDS(Sodium Dodecyl sulfate), NH4Cl (Ammonium Chloride), SLBS (Sodiumlaurylbenzenesulfate)are mostlyusedandresultedfrom NH4Clgivesbetterresultsamongallthree. So thereisachancetoimprovebyusingdifferentsurfactantsinsteadofNH4Cl.Soinsteadofthoseabovesurfactants, we can perform by taking new surfactants that are not in use yet, hence there is scope for extending the research for better results. The main issue found from literature in the separation process that is to get pure ethanol from ethanol-water mixture requires lots of time and wasting energy on the separation process so while taking this aspect in mind further research shall be conducted and for this issue fractional distillation apparatus and a surfactant is beneficial.

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