ALCOHOL SCHOOL

DISTILLATION AND MOLECULAR SIEVES: A PRACTICAL VIEWPOINT
FUNDAMENTALS OF DISTILLATION
TYPICAL DISTILLATION RELATIONSHIPS

LOWER TEMPERATURE

FEED

THERMAL ENERGY

VAPOUR

BOILING LIQUID

VAPOUR

CONDENSER

COOLING WATER

REFLUX LIQUID

OVERHEAD PRODUCT

TRAYS (CONTACTING DEVICES)

BOTTOMS PRODUCT
VAPOUR-LIQUID EQUILIBRIUM
ETHANOL-WATER
MOLE % ETHANOL IN VAPOUR

MOLE % ETHANOL IN LIQUID
MOLE % ETHANOL IN VAPOUR

MOLE % ETHANOL IN LIQUID

(10 VOLUME % FEED)
STRUCTURING THE DISTILLATION SYSTEM STRATEGY
OPERATING LINE

Locus of possible concentrations of liquid and vapour passing in tower for a given energy input
VAPOUR-LIQUID EQUILIBRIUM
STAGE ANALYSIS
VAPOUR-LIQUID EQUILIBRIUM
STAGE ANALYSIS

MOLE % ETHANOL IN VAPOUR

MOLE % ETHANOL IN LIQUID

OPERATING LINE STRIPPING
TYPICAL L/V = 5.0

BEER FEED (10 VOLUME %)

STILLAGE (0.02 WT. %)

TYPICAL - 14 RECTIFYING STAGES & STRIPPING STAGES
100 PROOF SPIRIT
DISTILLATION ENERGY CONSUMPTION
STEAM REQUIREMENTS
ETHANOL STRIPPER-RECTIFIER
BTU (In 1000’s) PER GALLON ETHANOL (ANHYDROUS BASIS)

CONSTRAINTS:
• 190 PROOF PRODUCT
• 0.02% (WT.) BOTTOMS
• SATURATED FEED
MJ PER LITER ETHANOL (ANHYDROUS BASIS)

BEER CONCENTRATION (VOLUME %)

CONSTRAINTS:
• 190 PROOF PRODUCT
• 0.02% (WT.) BOTTOMS
• SATURATED FEED
ENERGY
EFFICIENCY
TRADITIONAL

VAPOUR

REFLUX

CONDENSER

OVERHEAD

PRODUCT

FEED

FEED

STEWARDS

STEAM

(ENERGY)

BOTTOMS

PRODUCT

Energy Inefficient
ENERGY TRANSFER BY FORCED - CIRCULATION REBOILER
ONE - LEVEL
ENERGY
CASCADE
ENERGY CASCADe

VAPOUR

REFLUX

FEED

STEAM

(ENERGY)

BOTTOMS

PRODUCT

TOWER 1

OVERHEAD

PRODUCT

RECOVERED

ENERGY

REBOILER

TOWER 2

OVERHEAD

PRODUCT

BOTTOMS

PRODUCT

CONDENSER

OVERHEAD

PRODUCT

FEED
ENERGY CASCADE - FEED PREHEAT

VAPOUR

TOWER 1

REFUX

HOT FEED

STEAM (ENERGY)

BOTTOMS PRODUCT

OVERHEAD PRODUCT

TOWER 2

REFLUX

OVERHEAD PRODUCT

RECOVERED ENERGY

REBOILER

BOTTONS PRODUCT

OVERHEAD PRODUCT

FEED

CONDENSER

FEED
TWO - LEVEL ENERGY CASCADE (3 – TOWER)
BTU (In 1000’s) PER GALLON ETHANOL (ANHYDROUS BASIS)

**CONTRAINTS:**
- 190 PROOF PRODUCT
- 0.02% (WT.) BOTTOMS
- SATURATED FEED
MJ PER LITER ETHANOL (ANHYDROUS BASIS)

CONSTRAINTS:
- 190 PROOF PRODUCT
- 0.02% (WT.) BOTTOMS
- SATURATED FEED
ENERGY REQUIREMENTS

BASIC

Stripping-Concentrating

14 lb STEAM per U.S. GALLON (absolute)
or
1.7 Kg STEAM per LITER
ENERGY REQUIREMENTS

ADVANCED-INTEGRATED

Stripping-Concentrating

9 lb STEAM per U.S. GALLON (absolute)
or
1.1 Kg STEAM per LITER
CONTACTING DEVICES (TRAYS)
DISTILLATION TRAY FUNCTIONS

- Mix rising vapour with falling liquid
- Allow for separation after mixing
- Provide path for liquid to proceed down the tower
- Provide path for vapour to proceed up the tower
PERFORATED TRAYS

OUTLET WEIR

INLET WEIR

DOWNCOMER AREA

ENRICHED LIQUID

VAPOUR

V-L SEPARATION

V-L MIXING

STRIPPED LIQUID
RELIABILITY

BEER STRIPPER

FOULING
DISC-DONUT TRAYS

DISC

DONUTS

DESCENDING LIQUID

ENRICHED VAPOUR

STRIPPED STILLAGE

FOULING
BAFFLE - TRAY EXPERIENCE

- 39 COMMERCIAL SYSTEMS
  - SULFITE PULPING LIQUOR
  - FERMENTED SULFITE LIQUOR
  - FERMENTED LIGNO-CELLULOSE HYDROLYZATE
  - FERMENTED WHOLE GRAIN
  - ALCELL PULPING LIQUOR
  - FERMENTED CHEESE WHEY
  - FERMENTED CANE MOLASSES
BAFFLE - TRAY EXPERIENCE

- 5 YEAR CLEANING CYCLE FERMENTED GRAIN
- 1 YEAR CLEANING CYCLE FERMENTED CHEESE WHEY
- ELIMINATED ANTI-FOAM AND ANTI-SCALANT
- 6-12 MONTH CLEANING CYCLE FERMENTED “C” MOLASSES
RECOMMENDED TRAY DESIGNS

BEERSTILLS (ALL FOULING FEEDSTOCKS) - BAFFLE TRAY
RECTIFIERS - PERFORATED TRAY
EXTRACTIVE TOWERS - PERFORATED TRAY
TECHNICAL ALCOHOL TOWERS - PERFORATED TRAY
- PACKED ( < 24” )
CONTROL STRATEGIES
TEMPERATURE AND PROOF PROFILE

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TEMPERATURE AND PROOF PROFILE

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DEHYDRATION
VAPOUR-LIQUID EQUILIBRIUM ETHANOL-WATER
STRUCTURING THE DISTILLATION SYSTEM STRATEGY
TERNARY AZEOTROPE DEHYDRATION
VACUUM TUBE
MOLECULAR SIEVE DEHYDRATION

- VAPOUR PHASE ADSORPTION
- NO ENTRAINER
- LOW ENERGY
MOLECULAR SIEVE TYPE 3A

CHEMICAL FORMULA:

\((K_2O \cdot Na_2O) \cdot Al_2O_3 \cdot 2SiO_2 \cdot XH_2O\)
Molecular Sieve Media

Type 3A
MFGE DISTILLATION & DEHYDRATION
PSA MOLECULAR SIEVE
## DISTILLATION-DEHYDRATION TECHNOLOGY

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