

# Optimal Solution for **Mass Transfer Processes**





# TOP SOLUTION PROVIDER FOR MASS TRANSFER PROCESSES

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Most of the refinery, petrochemical, and chemical processes have a distillation system. Distillation systems consume approximately 50% of the total plant energy. Oil & Gas and Chemical plants are always looking to improve energy efficiency, product quality, and capacity of their distillation systems.

Benit M is passionate to find the solutions from basic design to the column design by applying its accumulated knowledge of up-to-date technologies of chemical processes and tower internals. Our expertise is in two major fields: (1) distillation engineering and (2) water recovery/desalination.

## Introduction

**B**enit M was established in March 2016 in Ulsan, Korea. As a mass transfer specialist in distillation, most of the projects Benit M performs are to improve the separation efficiency, to reduce energy consumption, and to separate the chemicals which have thermodynamic difficulties.

To overcome the global water challenges, Benit M provides the novel technology to improve the existing water recovery and desalination technologies.

We are committed to spreading the technology and expertise in the mass transfer around the globe while sustaining the true quality of the values.

## Benit M Performs

- ✓ Distillation process simulation and PROCESS DESIGN
- ✓ Distillation process TROUBLESHOOTING
- ✓ Operation analysis and CONSULTING for optimization
- ✓ FEASIBILITY STUDY for improvement of distillation process
- ✓ Mass transfer equipment DETAIL DESIGN REVIEW
- ✓ Mass transfer equipment fabrication/installation INSPECTION

## Accumulated Experiences in Mass Transfer Process Design

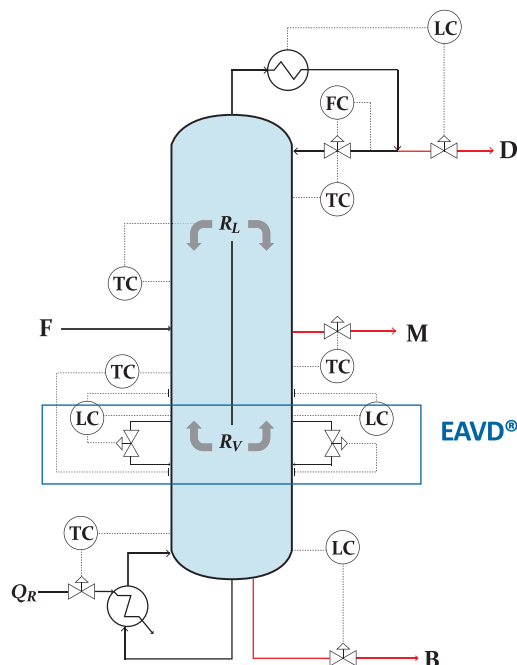
- ✓ Conventional, Azeotropic, DWC, Batch, Extractive, Reactive, Distillation, Absorber, Extraction, etc.
- ✓ Acid Gas Removal and CO<sub>2</sub> Capture
- ✓ Solvent Recovery
- ✓ Water Recovery
- ✓ Desalination



# DISTILLATION ENGINEERING

## Dividing Wall Column with EAVD®

VIDEO  
LINK



### Advantages of Dividing Wall Column (DWC)

- 15-50% energy saving by converting two conventional columns to DWC
- Higher purity of middle product
- Reduce investment cost
- Smaller space/area

### Problems in Conventional DWC

**By nature: liquid rate  $\uparrow$  ; vapor rate  $\downarrow$   
Vapor split control is mandatory for optimal operation.**

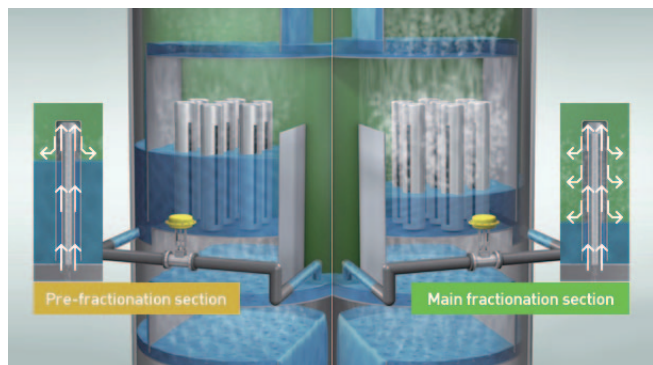
- Liquid and vapor split ratios play a very important role in the design of DWC (Benyounes et al., 2015).
- The energy required for separation in DWC depends on using an optimal vapor split (Dwivedi et al., 2012).
- A small deviation of vapor split can significantly reduce DWC energy efficiency (Lee et al., 2011).

## Noteworthy Benefits of Enhanced Active Vapor Distributor (EAVD®)

PATENT REGISTERED FEB. 02, 2017

- ✓ Optimal vapor split ratio of the DWC can be achieved accordingly
- ✓ High energy saving by applying optimal DWC design can be maintained
- ✓ Wide operating range of packed column by maintaining uniform vapor distribution

## How it works



The caps covering the chimney, have opening area for the vapor flow path which can be simply adjusted by altering the liquid level on the chimney tray. Therefore, EAVD® enables efficient vapor split ratio control during DWC operation.

## Published Articles



DOI: 10.1021/acs.iecr.7b01023  
IECR, 2017, 56, 6493-6498

Hydraulic Driven Active Vapor Distributor for Enhancing Operability of Dividing Wall Column



DOI: 10.3303/CET1869140  
CET, 2018, 69, 835-840

Optimal Operation of a Dividing Wall Column using Enhanced Active Vapor Distributor



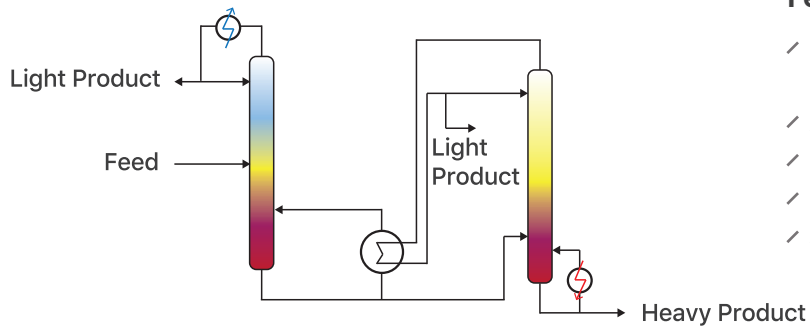
DOI: 10.1016/j.cherd.2019.02.038  
CHERD, 2019, 144, 512-519

Optimal operation of a dividing wall column using enhanced active vapor distributor

# DISTILLATION ENGINEERING

## Multi-Effect Distillation

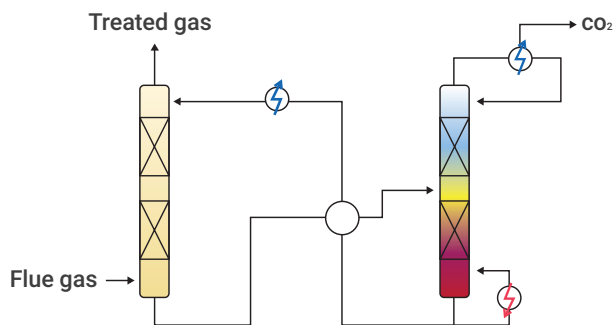
PATENT REGISTERED FEB. 01, 2019



### Features and Advantages

- ✓ Combination of azeotropic distillation - conventional distillation
- ✓ An effective method of utilizing waste heat
- ✓ Minimize heat loss
- ✓ Energy saving by 35%-65% (double, triple)
- ✓ Applications : Methanol dehydration, Acetic acid dehydration, etc

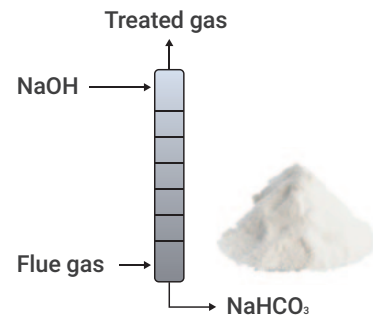
## CO<sub>2</sub> Capture



### Basic Design package for Solvent-Based CO<sub>2</sub> Capture

- ✓ High efficiency of CO<sub>2</sub> removal
- ✓ Cost-effective design
- ✓ Wide operating range

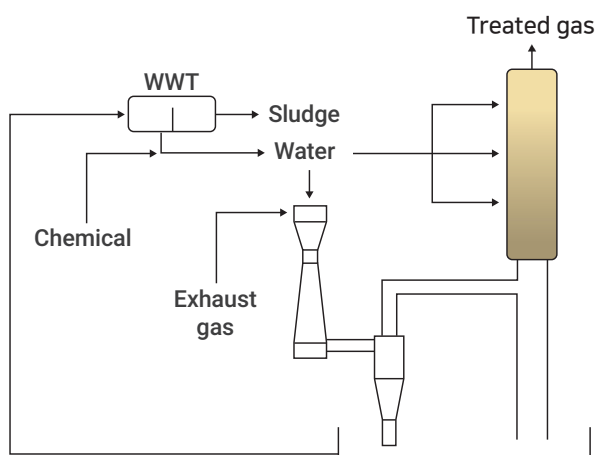
## CO<sub>2</sub> Utilization



### Carbonation Column Design for CO<sub>2</sub> Utilization

- ✓ Valuable product of CO<sub>2</sub> utilization
- ✓ Special tower internal design
- ✓ No fouling

## DeSO<sub>x</sub> Scrubbing Process



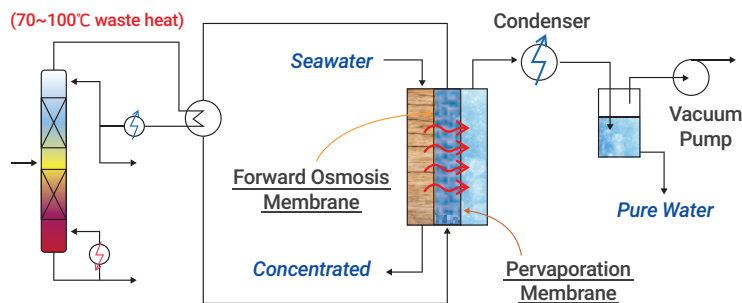
### Basic Design package for SO<sub>x</sub> Scrubber

- ✓ SO<sub>x</sub> emission level is suitable with ECA regulation : SO<sub>x</sub> ppmV/CO<sub>2</sub> %V < 2.0
- ✓ Higher distribution quality
- ✓ Enhanced DeSO<sub>x</sub> scrubbing performance for the same footprint

# WATER RECOVERY / DESALINATION

## Forward Osmosis Combined Membrane

PATENT REGISTERED APR. 16, 2019

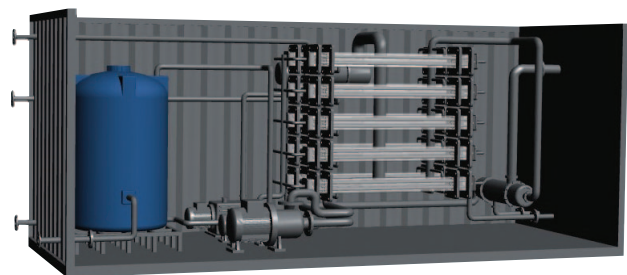


### Features and Advantages

- ✓ Utilize low temperature waste heat
- ✓ Water quality :  $< 1 \mu\text{S/cm}$  (in-situ analysis)
- ✓ Salt water as draw solution
- ✓ Draw solution regeneration in one module
- ✓ High performance/flux of FO can be maintained
- ✓ Application : water recovery from wastewater  
seawater desalination

### How it works

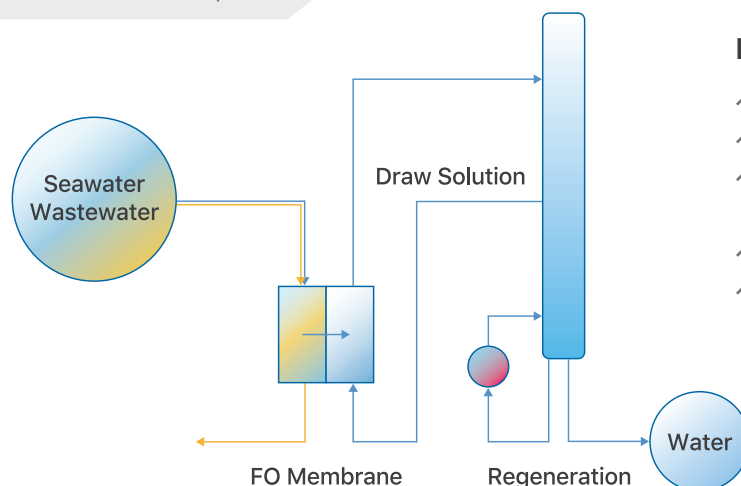
- ✓ The combined membrane consists of FO and Pervaporation (PV) in one module.
- ✓ When water passes from the feed solution to the draw solution, water product is simultaneously removed from draw solution through the PV membrane.
- ✓ It eliminates the need for a separate draw solution recovery system since regeneration is built-in in one system.
- ✓ Low-temperature heat source can be used because PV is operating under the vacuum condition.
- ✓ The integration with distillation in chemical plants might be beneficial for zero-energy water production.



FO combined membrane desalination, 10 m<sup>3</sup>/day

## Forward Osmosis – Distillation Hybrid

PATENT REGISTERED APR. 27, 2018



### Features and Advantages

- ✓ Ammonium Bicarbonate draw solution
- ✓ Utilize low temperature waste heat
- ✓ Low steam consumption,  
0.2~0.35 ton steam/ton-water product
- ✓ No plugging or fouling trouble
- ✓ Application : Water recovery from wastewater  
Seawater desalination



# PORTFOLIO OF RELEVANT PROJECTS

## Absorber Design for CO<sub>2</sub> Capture Process

The client intended to test the special solvent and they were expecting to compare the performance with the conventional amine system by altering the gas feed rate. The EAVD® was installed in the absorber to cover the wide operating range of absorption process while maintaining the high efficiency.

## MeOH Recovery in Batch Distillation column

It is well-known in the batch column operation that significant variation of vapor rate occurs over a different period among foreruns, main, and final cuts. By applying the unique EAVD® design, the client found out the performance of a packed distillation column was stable without losing its efficiency from the beginning to the end of the batch operation.

## LPG-Amine Extraction Process Basic Design

The client used to have capacity limitation during the liquid-liquid extractor operation. Based on the research conducted by Benit M, it was found that the existing tray design and column diameter was not enough to cover the desired LPG-amine loading. Benit M supplied the retrofit design of the extraction process, and as a result, the proposed LPG-amine process was able to cover the desired loading.

## Process and Equipment Design of NaHCO<sub>3</sub> Reaction Column

Fouling is a big headache for the client during the production of NaHCO<sub>3</sub>, it commonly occurs due to the solid particle formation during the reaction. To overcome this issue, Benit M delivered process modification including special tower internal design to minimize the fouling tendency. The longer operation of reaction column was well-achieved.



EAVD®



“From the simple idea to the Industrial Market”

## NCC C<sub>2</sub> Fractionation Column Revamp Study

The client asked Benit M to evaluate the technical proposals of tower internal suppliers for C<sub>2</sub> fractionation process in NCC Plant. Benit M performed not only technical bid evaluation but also the recommendation of high-performance tower internal design. As the outcome, the client was able to achieve the successful operation at the target loading.

## Troubleshooting of VOC Removal Process in PTA Plant

The environmental pollution problem has occurred in the client's PTA plant. Although the VOC content in the feed was only a few ppm, the effluent gas could not meet the environmental regulations. Benit M concluded according to its accumulated experiences that VOC accumulation was occurring because of the existence of multiple azeotropic mixtures, in which the client didn't realize earlier. Benit M provided the solution to remove VOC by utilizing the existing equipment.

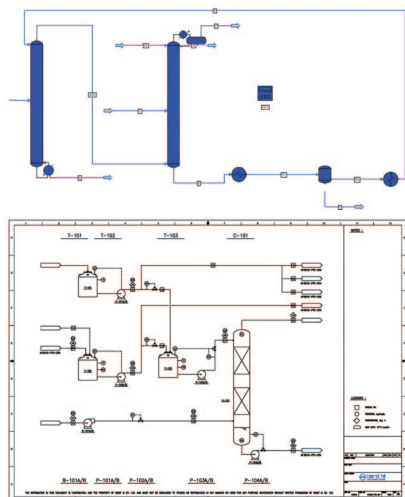
We are

enthusiastic to deliver the optimal solution through our accumulated knowledge and experiences in mass transfer processes.

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## R&D activities to deliver the optimal solution with outstanding value

Not only for the services in distillation engineering, but the R&D center also will enable Benit M to take step forward in the worthwhile area such as water recovery and desalination with high value and sophisticated technology. Benit M continuously conducts profound research resulting in acquiring worldwide patent rights.



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## To spread the technology and expertise in the mass transfer processes around the globe

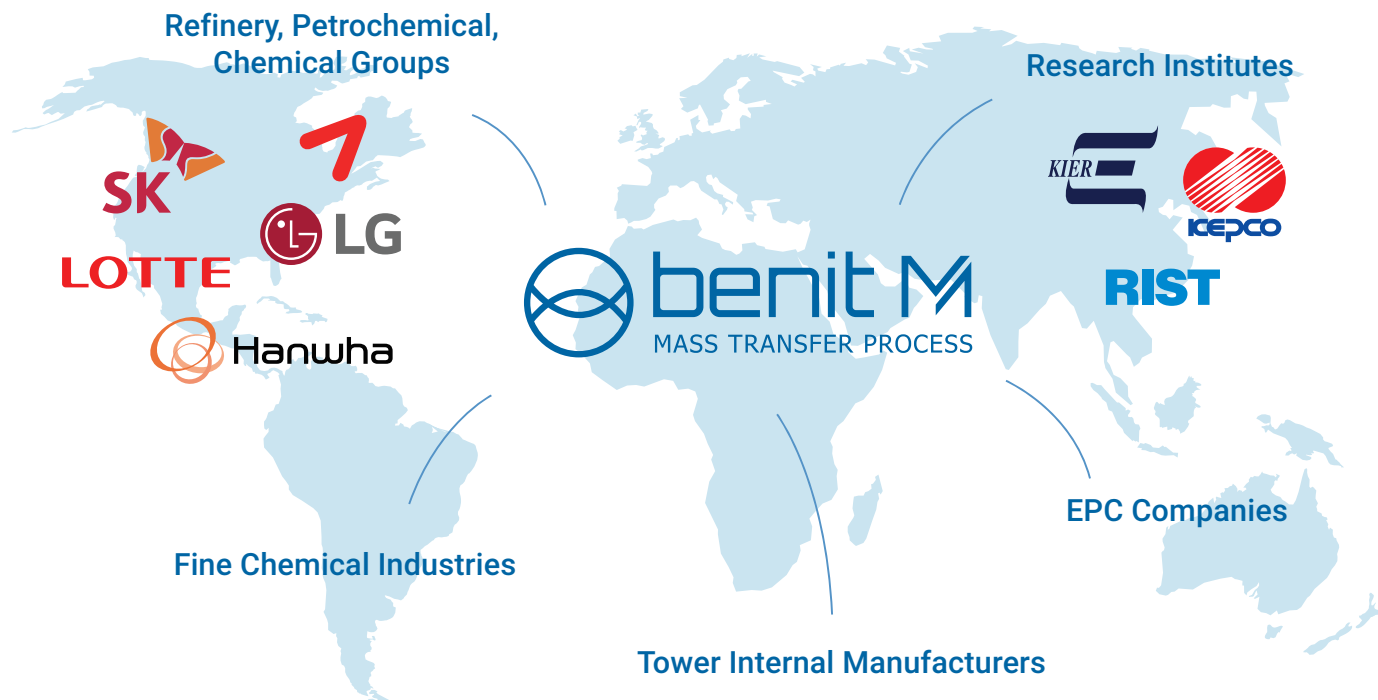
We are actively joined the conferences and exhibition to spread the knowledge and innovation related to Benit M's special expertise. Moreover, we are passionate to learn up-to-date technologies which support the needs of our innovation, know-how and creativity when handling the clients' problem in mass transfer processes.



Distillation & Absorption Conference 2018



Oil & Gas Asia 2019 Exhibition



## Areas of Expertise

- ✓ Refinery, Petrochemical, Chemical, Fine Chemical
- ✓ Acid Gas Removal and CO<sub>2</sub> Capture
- ✓ Solvent Recovery
- ✓ Water Recovery
- ✓ Desalination



## Activities

- ✓ Mass Transfer Process Engineering
- ✓ Operation Analysis, Troubleshooting
- ✓ Design and Operation Consulting
- ✓ Optimization for Energy Saving and Debottlenecking
- ✓ Column and Tower Internals Engineering Documents Review

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