King Saud University's Experience in Transferring Multiple Effect Distillation (MED) Technology

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Presentation Outline

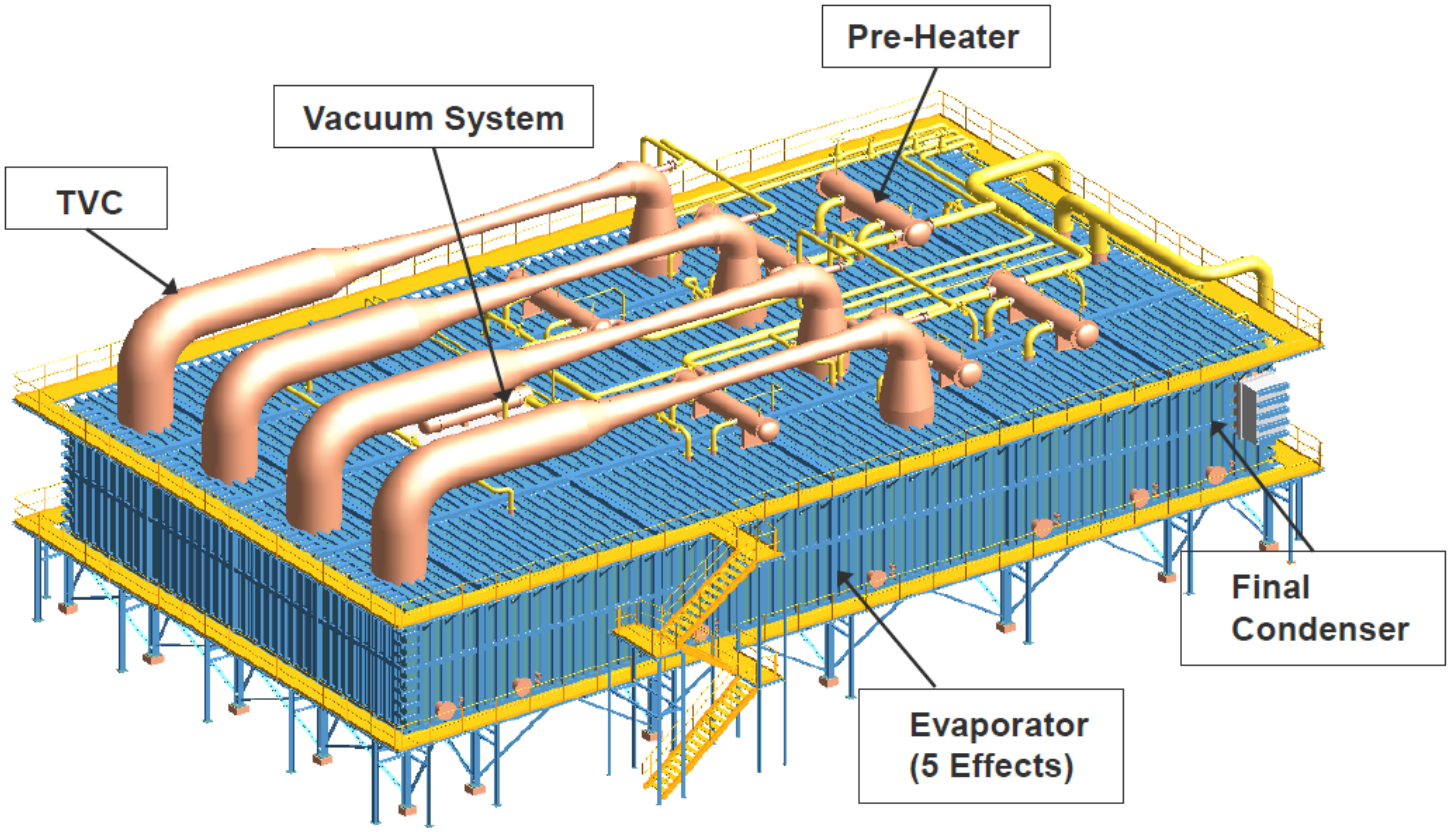
- Collaboration Background
- Project Details
- KSU’s Scope of Work
- Knowledge Transfer Phases
- Results
- New Related Activities
- Conclusion

Collaboration Background

- The Saline Water Conversion Corporation (SWCC) and King Saud University (KSU) signed a consulting agreement in November 2011.
- The agreement involved transferring the knowledge of MED technology (with thermal vapor compression – TVC).

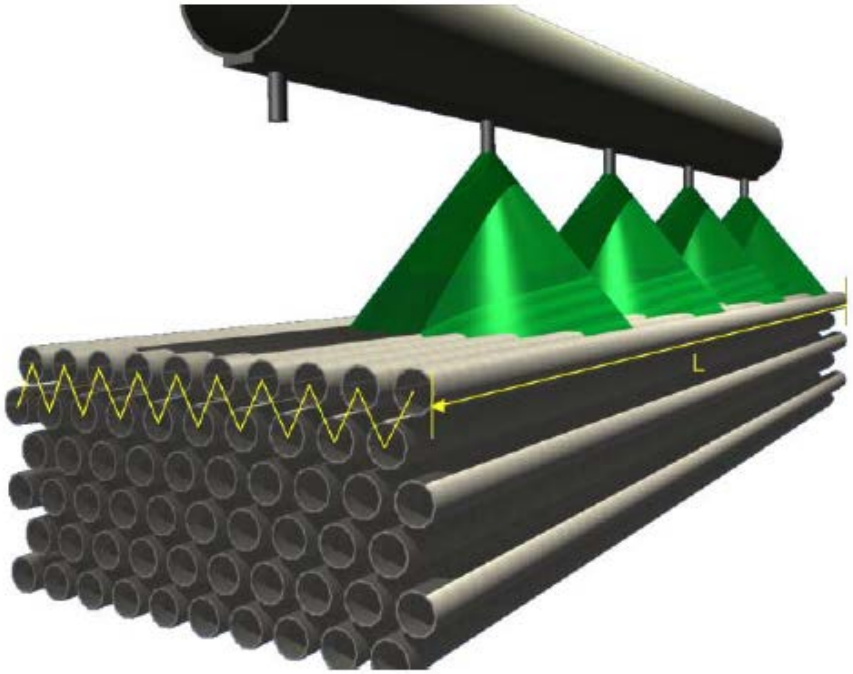
Collaboration Background

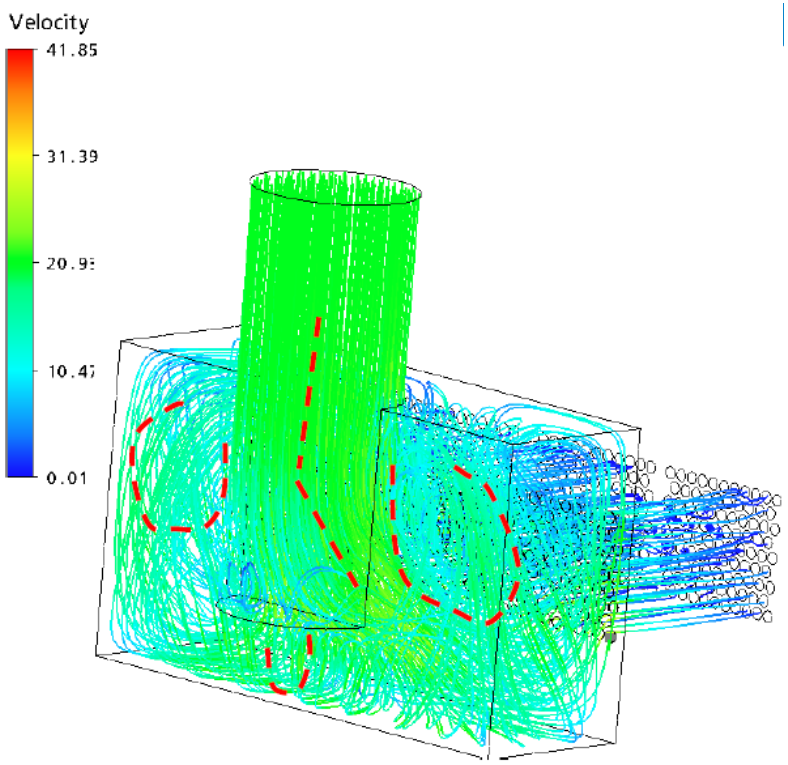
- The knowledge transfer process was to be performed during the construction of Yanbu MED-TVC.
- It involved building a 68,000 m^3/day MED-TVC plant.
- This is the largest MED-TVC plant in the world.



Collaboration Background

- Project award to Doosan Heavy Industries had a condition of sharing all design knowledge with SWCC.
- SWCC entrusted KSU with documenting, analyzing, and verifying information.





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Project Details

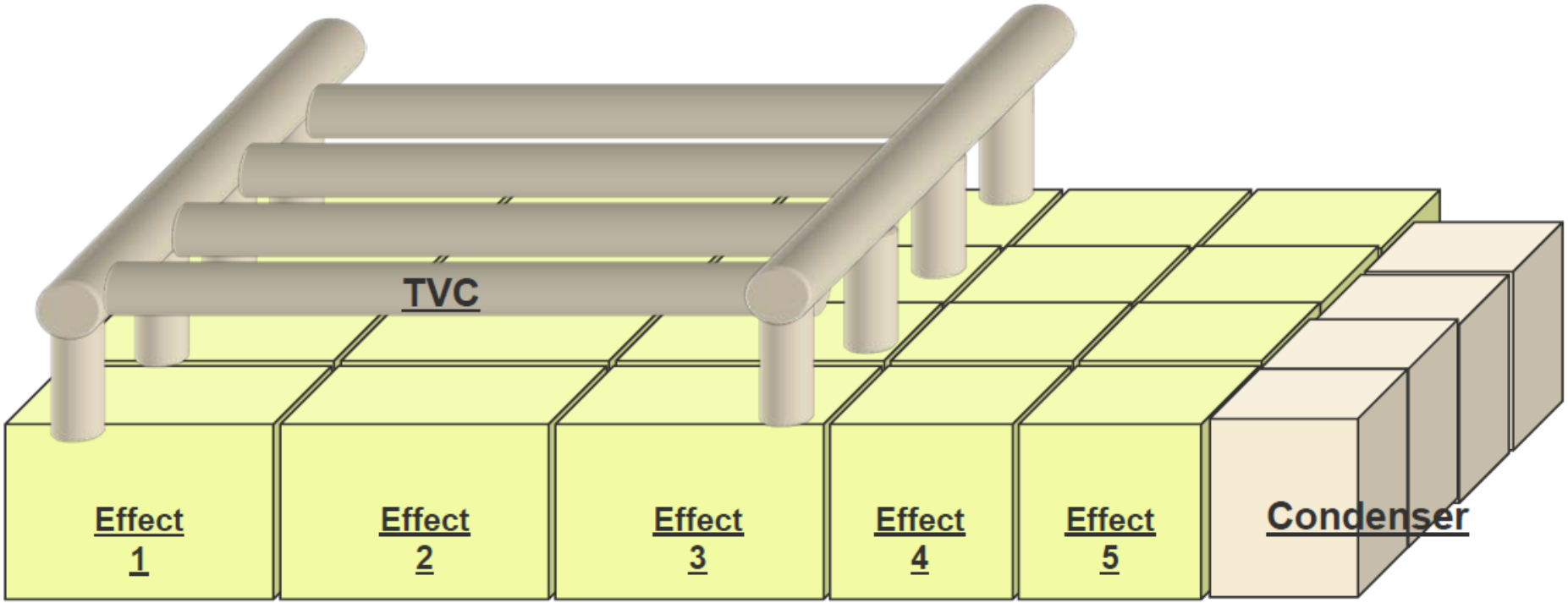
Basic Design Parameters

Heating steam available	293 ton/h, 65 bar, 525°C
Unit capacity	68,000 m^3/day (15 MIGD)
Top temperature	63.0°C
Available sea water flow rate and conditions	20,000 ton/hr, 33°C, 45,000 ppm
Gain Output Ratio	9.7

Project Details

Basic Design Concept

- Five effects, with TVC suction from 3rd effect.
- A steam transformer is used to reduce pressure and temperature of source steam.



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KSU's Scope of Work

- Documentation, analysis, verification, independent design, and comparison of data received from Doosan.
- Work focused on the most critical technology components:
  - **Evaporators**
  - **Condenser**
  - **Thermal vapor compressors**
  - **Steam transformer**
  - **Preheaters**

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Knowledge Transfer Phases

1. Assembly of a multi-disciplinary team
2. Data collection and analysis
3. Application of design principles
4. Preparation of scientific material

Knowledge Transfer Phases

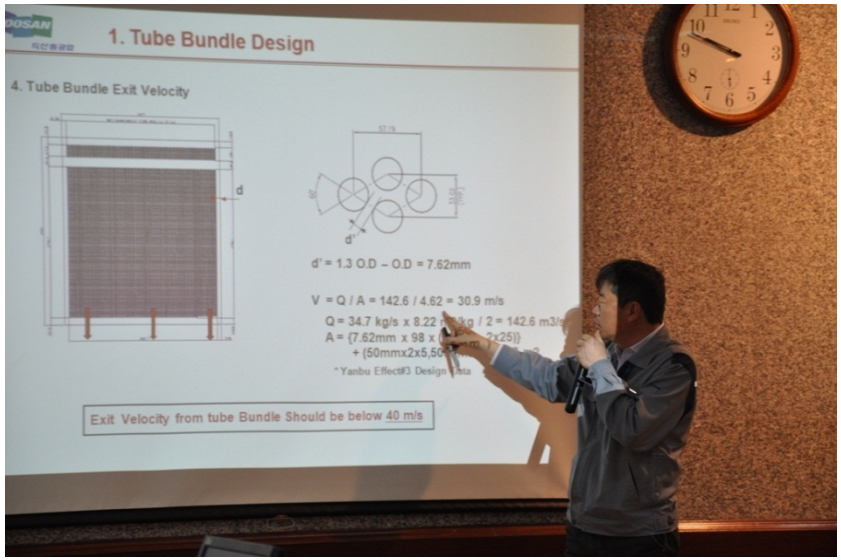
Assembly of a Multi-Disciplinary Team

- KSU dedicated a team of 9 professors to the knowledge transfer program.
- The team consisted of professors specializing in mechanical, chemical, electrical, and industrial engineering.

Knowledge Transfer Phases

Data Collection and Analysis

a. Technical meetings (four multi-day technical meetings with Doosan in Yanbu and KSU)



Knowledge Transfer Phases

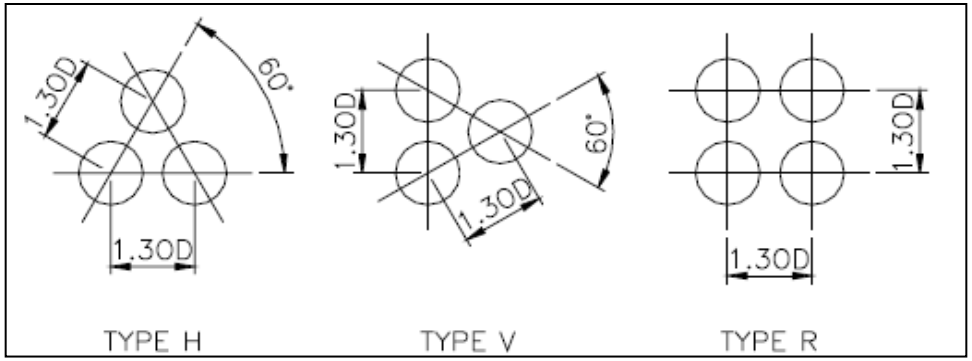
Data Collection and Analysis

b. Onsite visits (team made 5 visits to Yanbu during plant construction and commissioning)

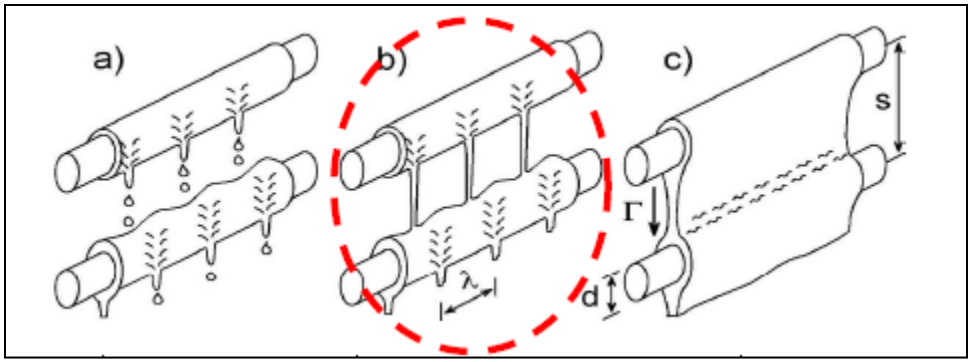
Knowledge Transfer Phases

Data Collection and Analysis

c. Comprehensive study of design materials



Tube Bundle Arrangement



Optimum Liquid Loading

Knowledge Transfer Phases

Data Collection and Analysis

c. Comprehensive study of design materials (more than 50 internal meetings were held)

Knowledge Transfer Phases

Application of Design Principles

a. Independent design calculations, e.g.
   - **Overall heat transfer coefficient**
   - **Heat transfer area**
   - **Number of tubes**

b. Comparison of results with actual Doosan design

Knowledge Transfer Phases

Preparation of Scientific Material

- The knowledge transfer effort culminated in the preparation of a “design guide”.
- The “design guide” is neither a manual nor a conventional academic publication.
- It is targeted to both design and plant engineers who need the fundamental knowledge to start the design process of MED-TVC plants.
- It is a part of KSU’s social responsibility to disseminate knowledge and make it accessible to all beneficiaries.

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Sample Results

Validation of Overall Heat Transfer Coefficient

	Doosan	KSU	Relative difference
1st Effect	3681	3568	-3.0%
2nd Effect	3623	3562	-1.6%
3rd Effect	3582	3527	-1.5%
4th Effect	3531	3470	-1.7%
5th Effect	3465	3432	-0.95%

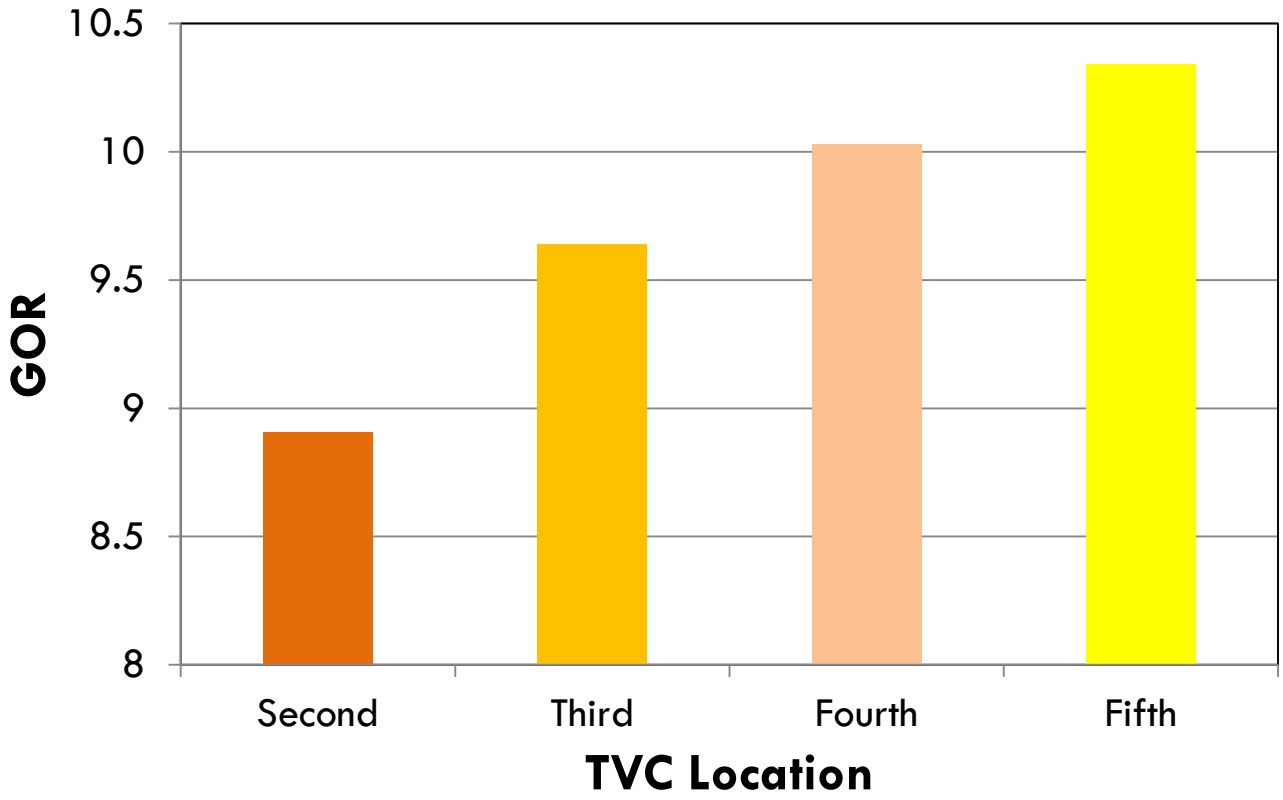
* Values are in $W/m^2.°C$

- Results show very close agreement.

Sample Results

Parametric Study

Effect of TVC Location on Performance



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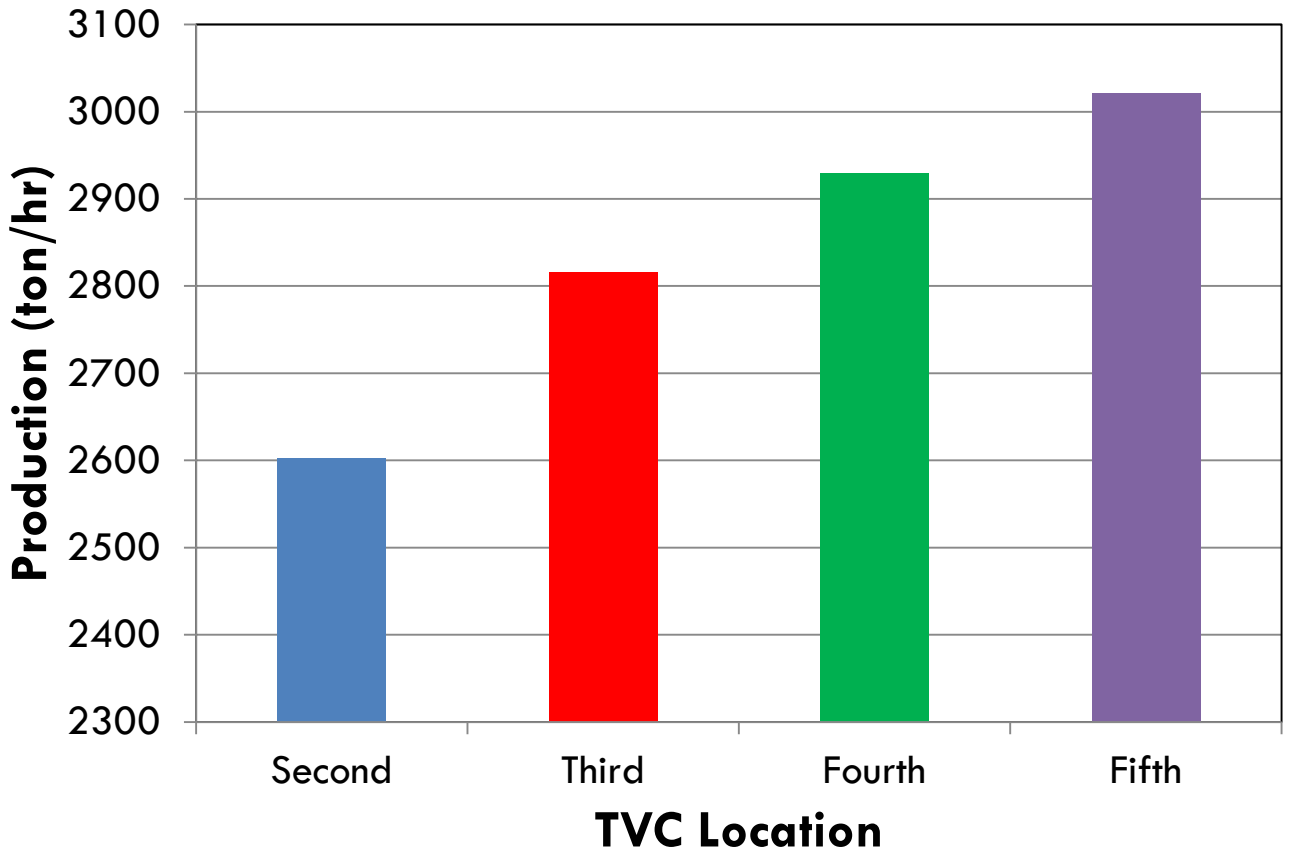


Sample Results

Parametric Study

Effect of TVC Location on Performance

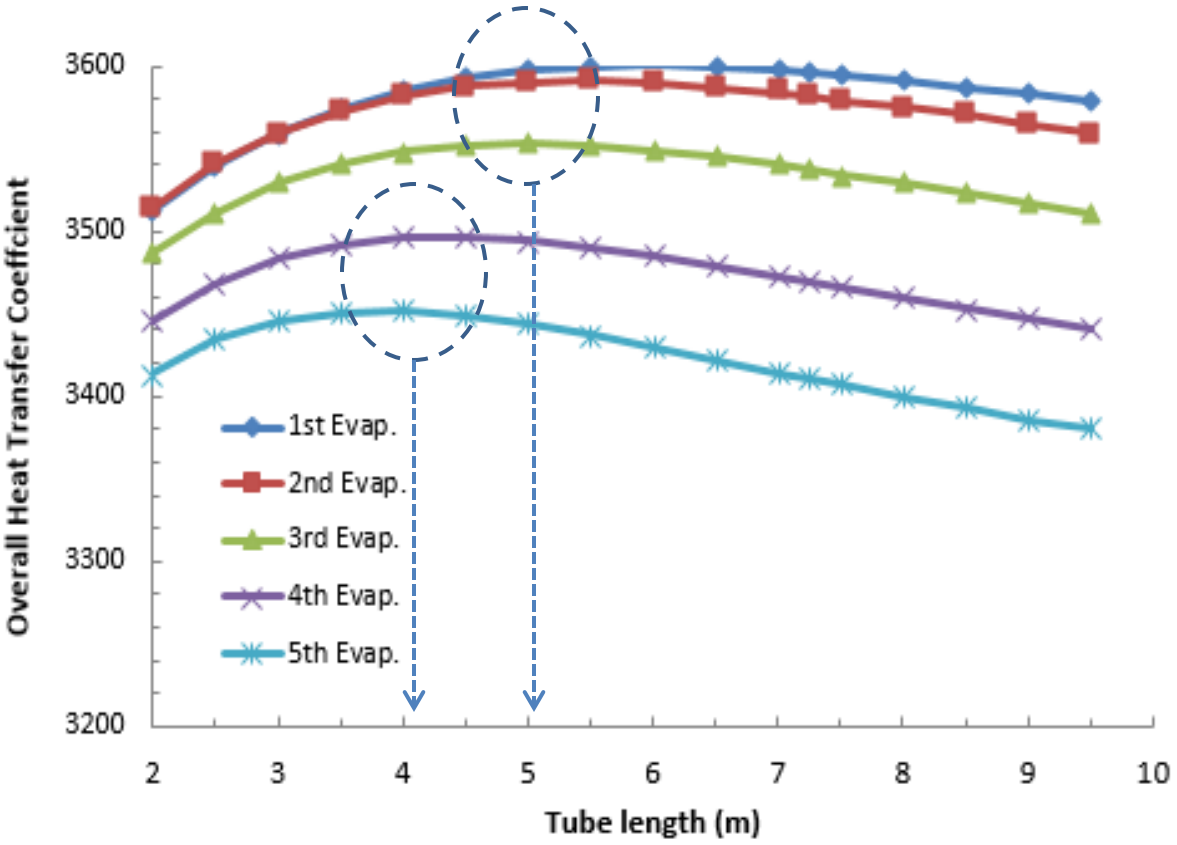
- Moving TVC to the last effect is more beneficial from a performance point of view.
- This will increase the size of the last two effects significantly.
- Cost may have been the primary reason for not implementing this idea at Yanbu MED-TVC plant.

Sample Results

Parametric Study

Effect of Tube Length on Overall Heat Transfer Coefficient

- Optimum tube length for first three effects is ~ 5.5 m
- Optimum tube length for last two effects is ~ 4.5 m
- These values were chosen by Doosan based on best practice.
- KSU team was able to validate these values analytically.



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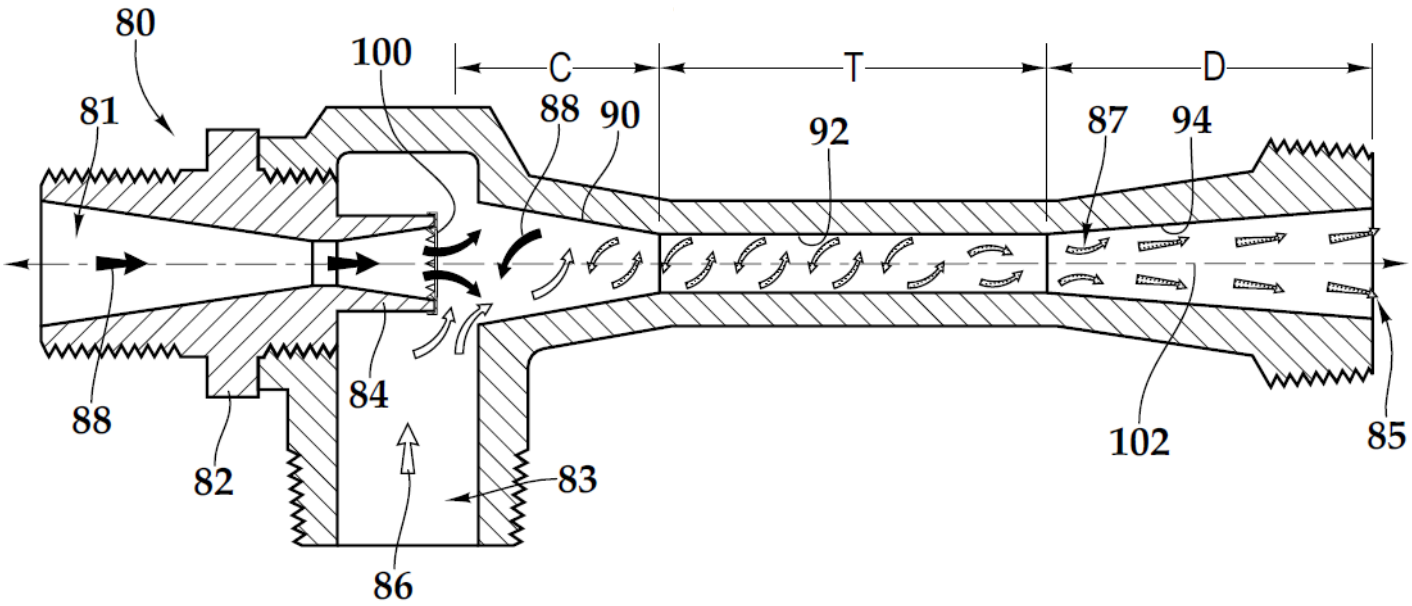
Research Activities

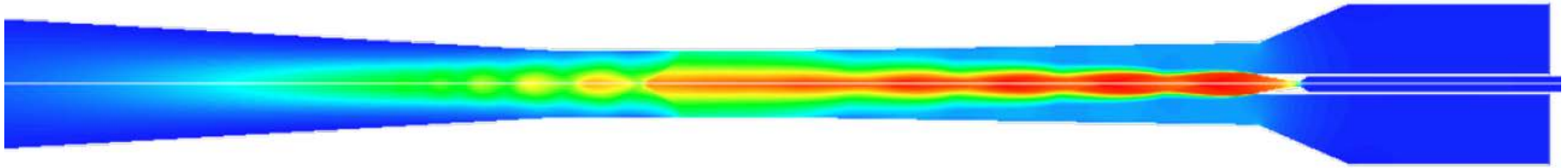
Improvement of TVC Performance



- Induction of vortices inside the TVC to improve mixing and increase suction flow.
- MSc student is now experimentally testing this concept

Research Activities

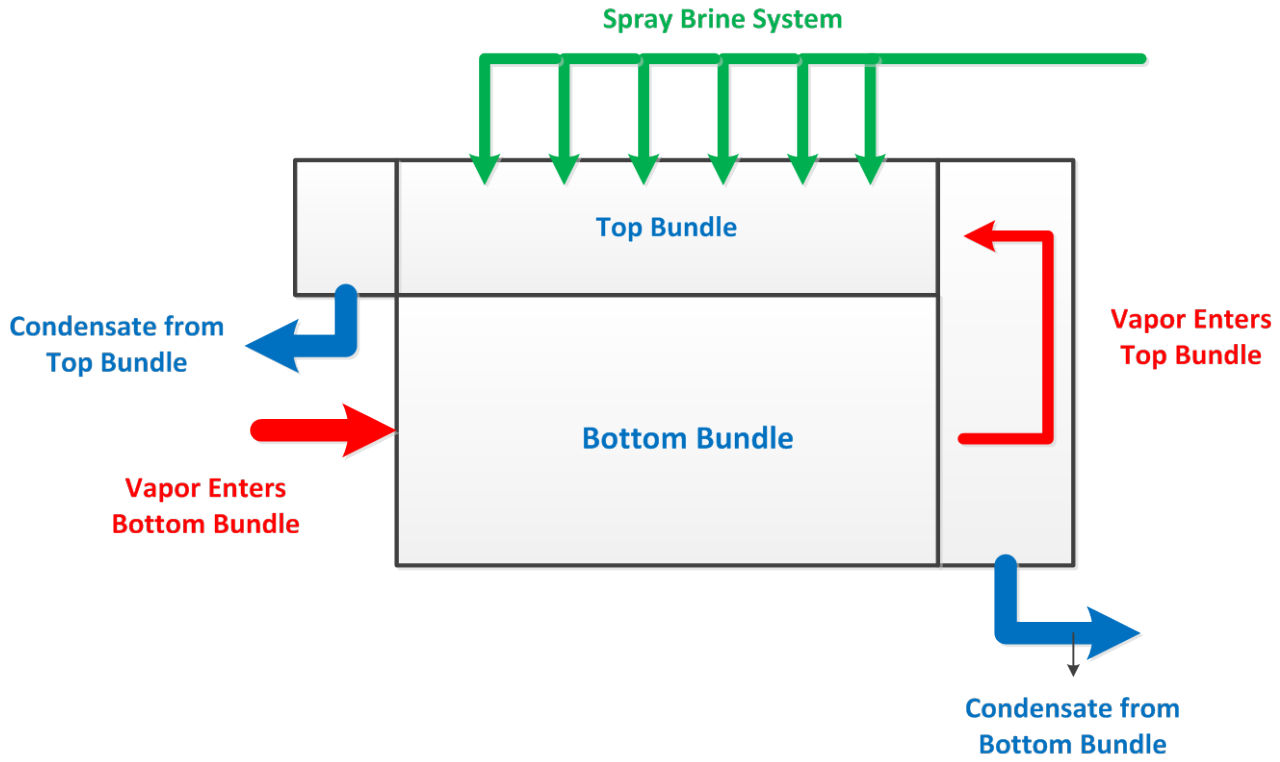
Modeling of TVC Performance



- Simplified and improved one-dimensional models are being developed in collaboration with Doosan.
- Models take into account flow phenomena observed from CFD analysis.
- Models will be validated by experimental data.

Research Activities

Improvement of Evaporator Design



- Current evaporator design includes two tube passes.
- The 2nd pass (10% by area) is used to complete the condensation process, but it adds to capital cost and system complexity.

Research Activities

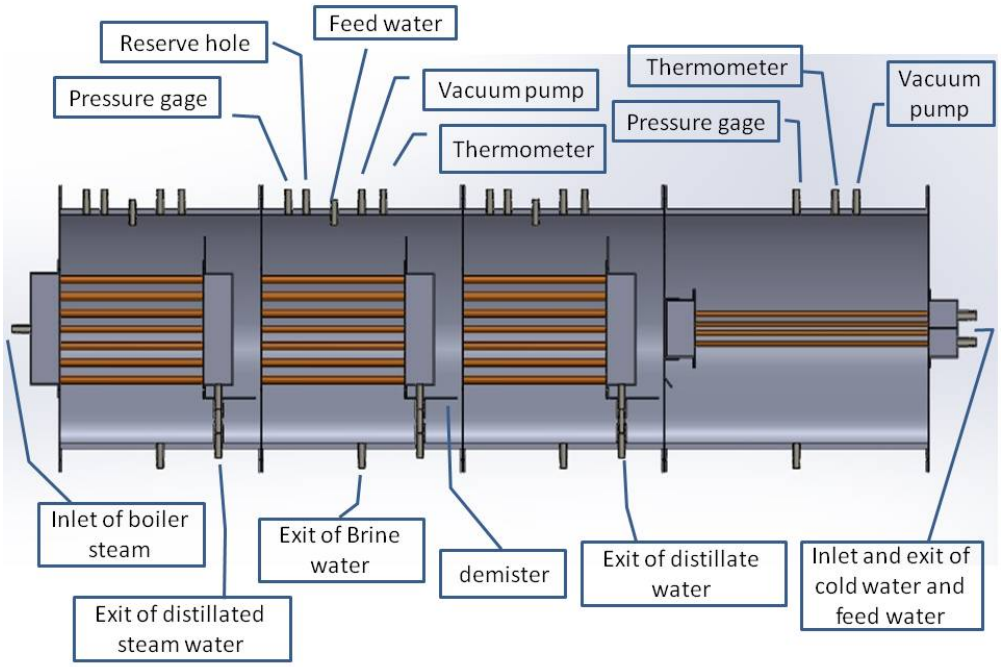
Improvement of Evaporator Design

- KSU researchers developed a design that eliminates the need for the second pass, while maintaining performance.
- The new design reduces the cost associated with the second pass.
- Analysis of this design is underway.

Educational Activities

Design of MED Unit

- Students from the Chemical and Mechanical Engineering Departments joined forces in a senior design project to design and fabricate a small MED unit.
- One of the primary objectives was to put the knowledge transfer experience into practice.



Educational Activities

Design of MED Unit

- The unit has already been fabricated, and it is now being tested and optimized.

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Conclusion

- The knowledge transfer experience between SWCC and KSU has been highly successful.
- Full knowledge of the MED-TVC system's critical components is now locally preserved and documented.
- KSU is ready to disseminate this knowledge through the "design guide" that it developed.
- This experience has led to additional research and educational activities.
- New collaboration stemmed from the project.
- This knowledge transfer program can serve as a model for similar (but larger and more comprehensive) programs in the future.

THANK YOU

FOR YOUR ATTENTION