

CAD/CAM and Control Automation Case Study of Reverse Osmosis Drink Water Treatment Unit

Mohammed Almoqbel **430106274**

Ahmed Alsaggaf **431104511**

Mohammed Alsubaie **431105096**

Supervisor: Prof. Ali M. Al-Samhan



Outline

- Vision
- Objectives
- Background
- Design Constraints
- Methodology
- Conclusion



Vision

Introduce and develop a product to Saudi market by joint cooperation between KSU team and R&D industrial Saudi team



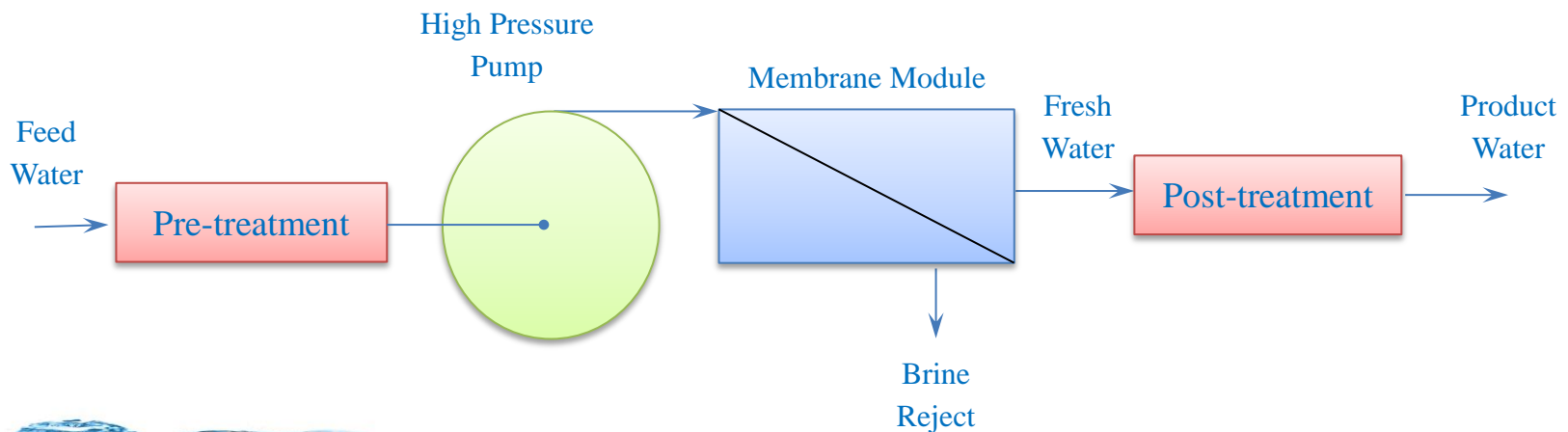
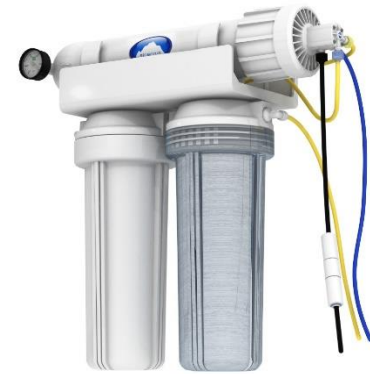
Objective

- Learn the technology techniques adopted by R&D at the industry.
- Select Reverse Osmosis desalination unit with capacity of 1500GPD for commercial applications.
- Consider CAD/CAM and control tools to design the proposed product.

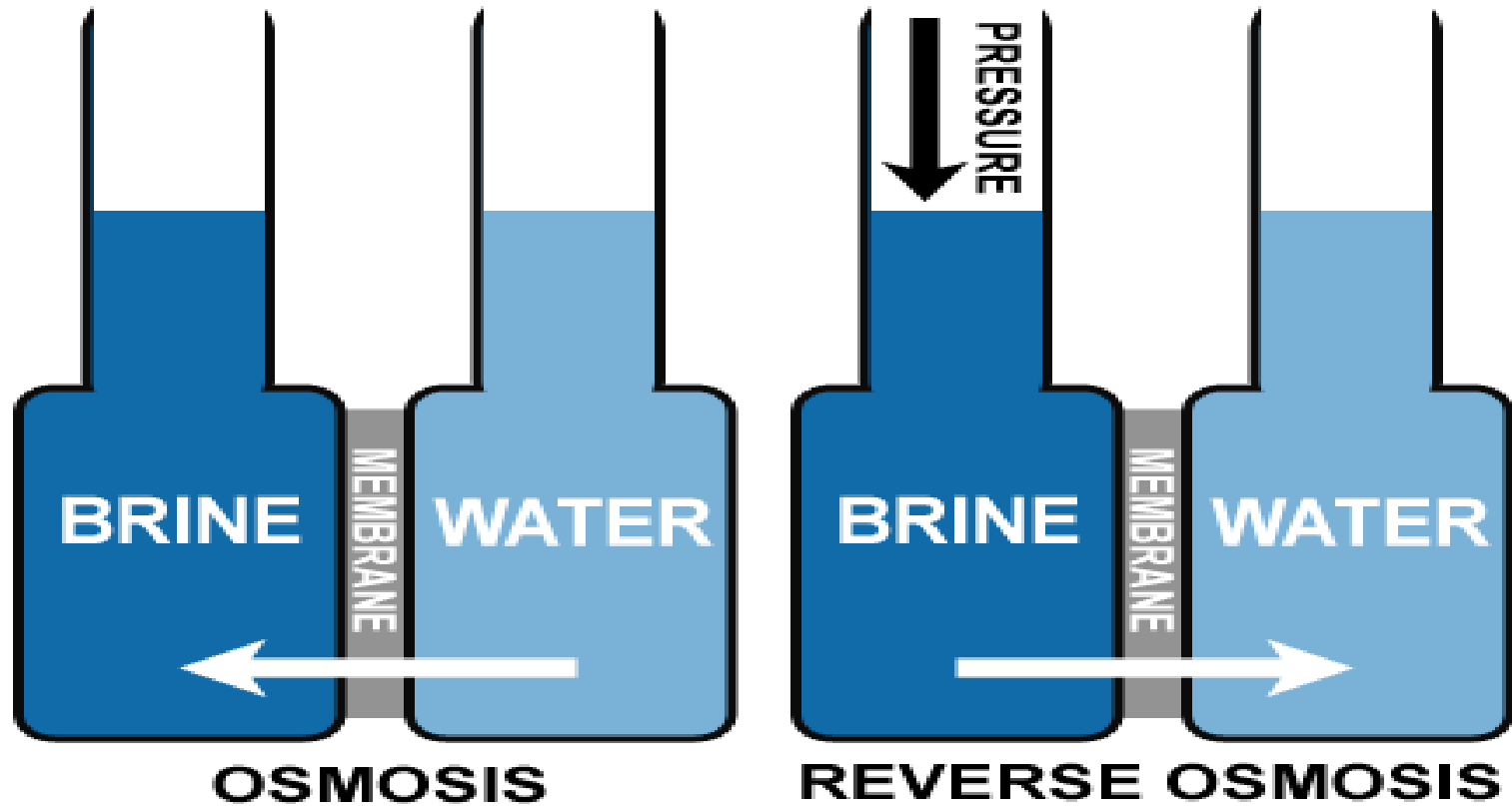


Background

- Reverse Osmosis is a process in which a cellophane-like membrane separates purified water from contaminated water.
- Four major systems of RO plant:

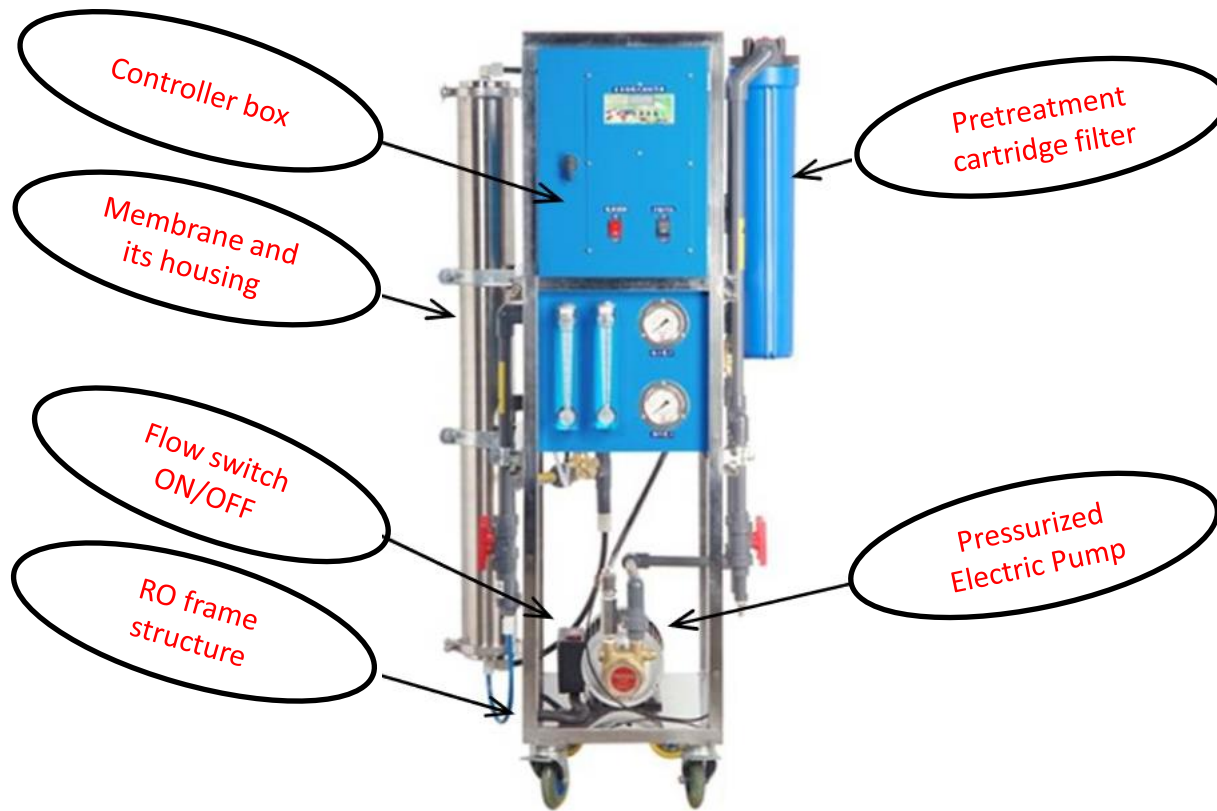


Background



Background

Commercial RO unit (similar to the selected product)



Background

- Operation parameters:
 - a) Feed, permeate and brine pressure
 - b) Feed and permeate TDS
 - c) Feed and permeate flows
 - d) Feed water temperature
 - e) Recovery percent
 - f) Concentration factor and flux



Design Constraints

- Consider Brackish feed water with TDS of 1000 and water property output 170TDS.
- RO unit capacity 1500 GPD and can be extended to 2500 GPD.
- Use single stage RO system design with recovery of 20%.
- Time and spare parts availability one of the main project constrain.



Methodology

Visit local market

First Semester

Get familiar with RO spare parts

Get familiar with NSF/ANSI 58 water purification standard

CAD analysis for selected case studies

CAD analysis for the RO unit

3D CAD drawing & assembly of the RO unit

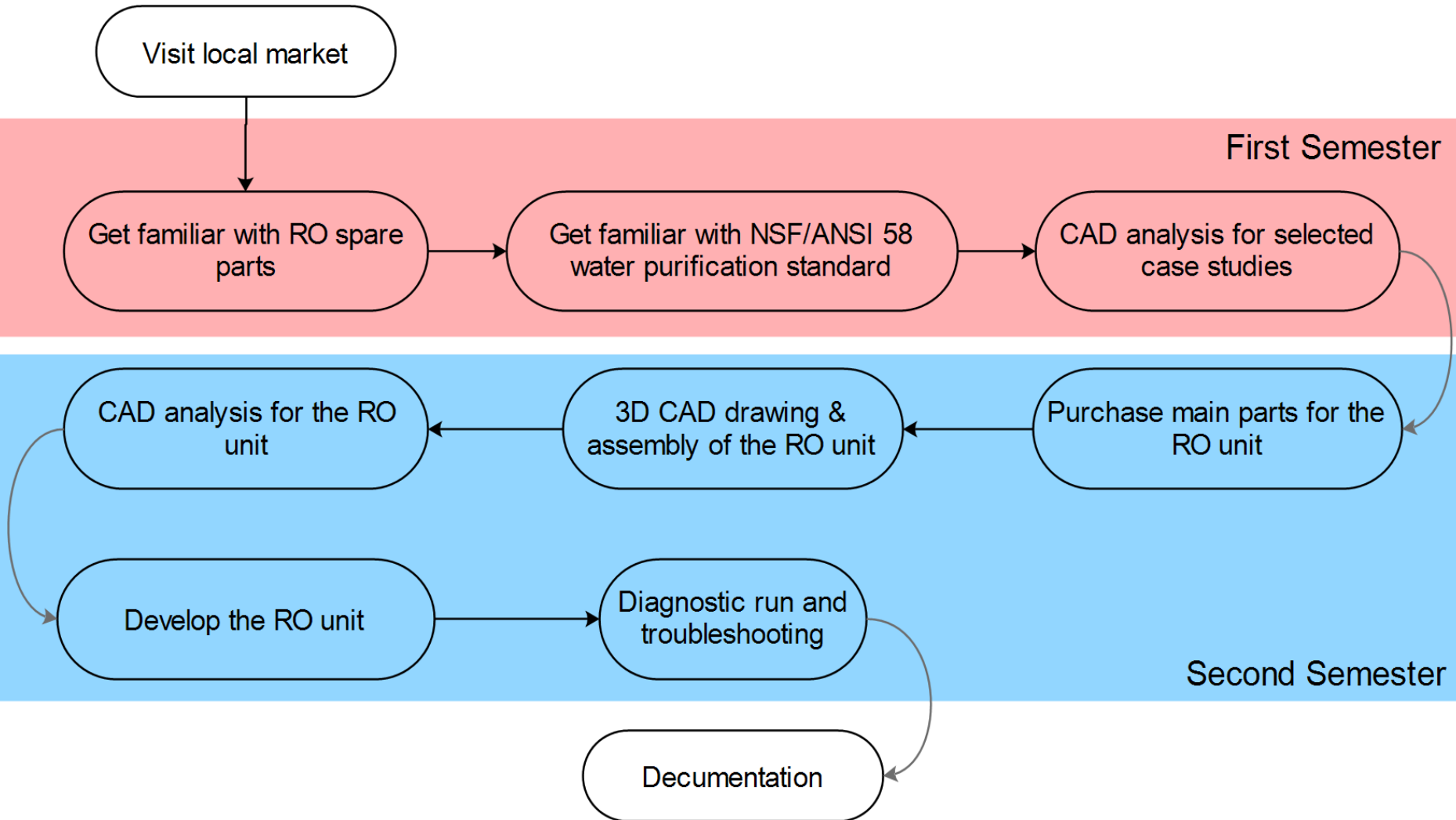
Purchase main parts for the RO unit

Develop the RO unit

Diagnostic run and troubleshooting

Second Semester

Documentation



CAD Analysis

- Membrane manufacturers provide free downloadable CAD software programs to assist the RO OEM to assemble and develop their RO system:
 - DOW Chemical Company provide ROSA (Reverse Osmosis System Analysis) analysis software for their membrane product.
 - TORAY Industries, INC provide Toray Design System 2 (TorayDS2) software to design the RO system for their membrane products.



TORAY
Innovation by Chemistry



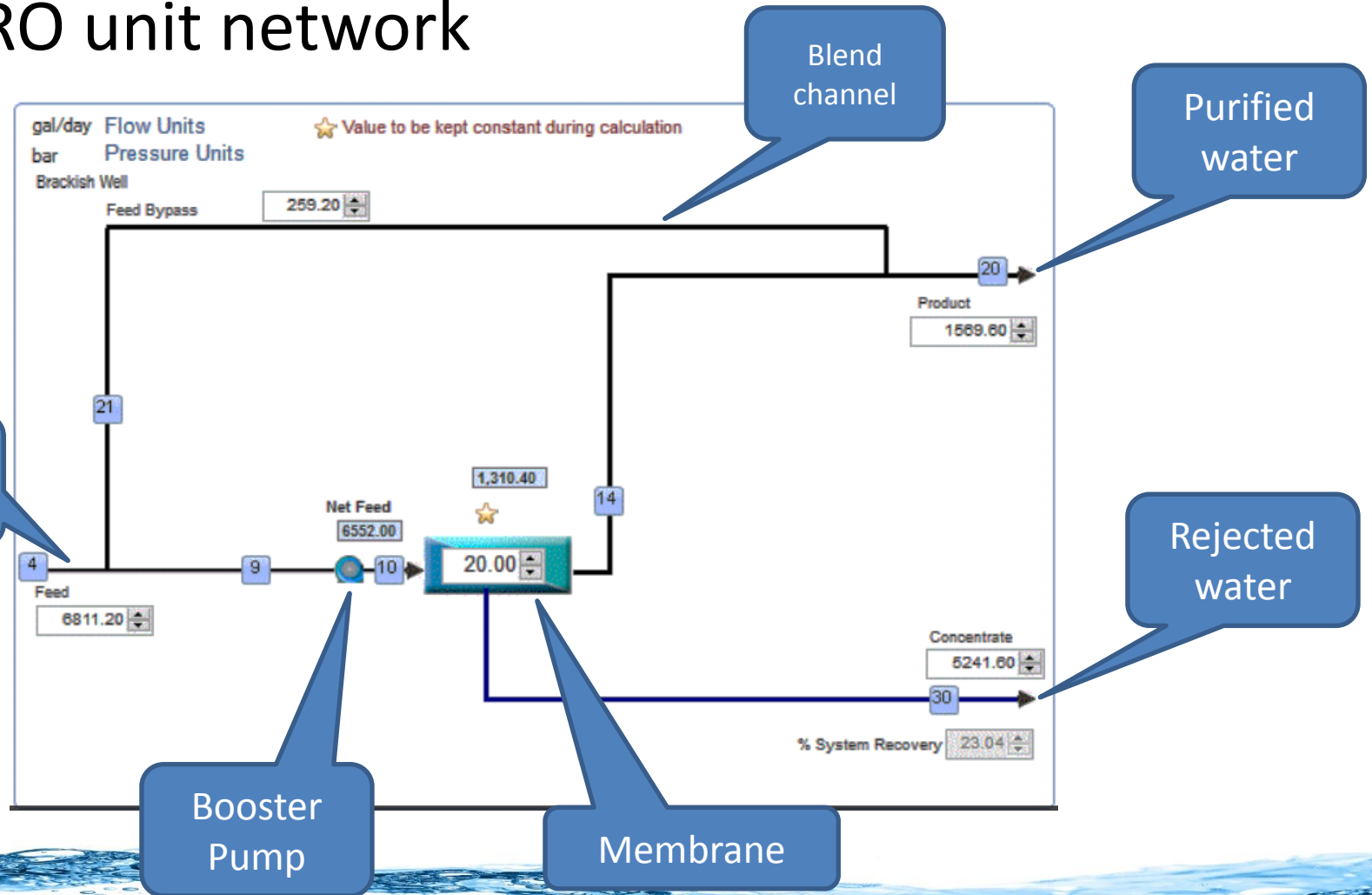
CAD Analysis – TorayDS2 Software

- Parameter design inputs:
 - Feed water properties 1000 TDS.
 - Membrane type TM710.
 - Product flow or RO capacity 1500GPD (1.09 GPM)
 - Blend channel network.
 - Single stage, single pass network with system recovery of 20%.
 - No Antiscalant dosing pump is considered in the current unit development
 - Feed water temperature 25° C



CAD Analysis – TorayDS2 Software

- RO unit network



CAD Analysis – TorayDS2 Software

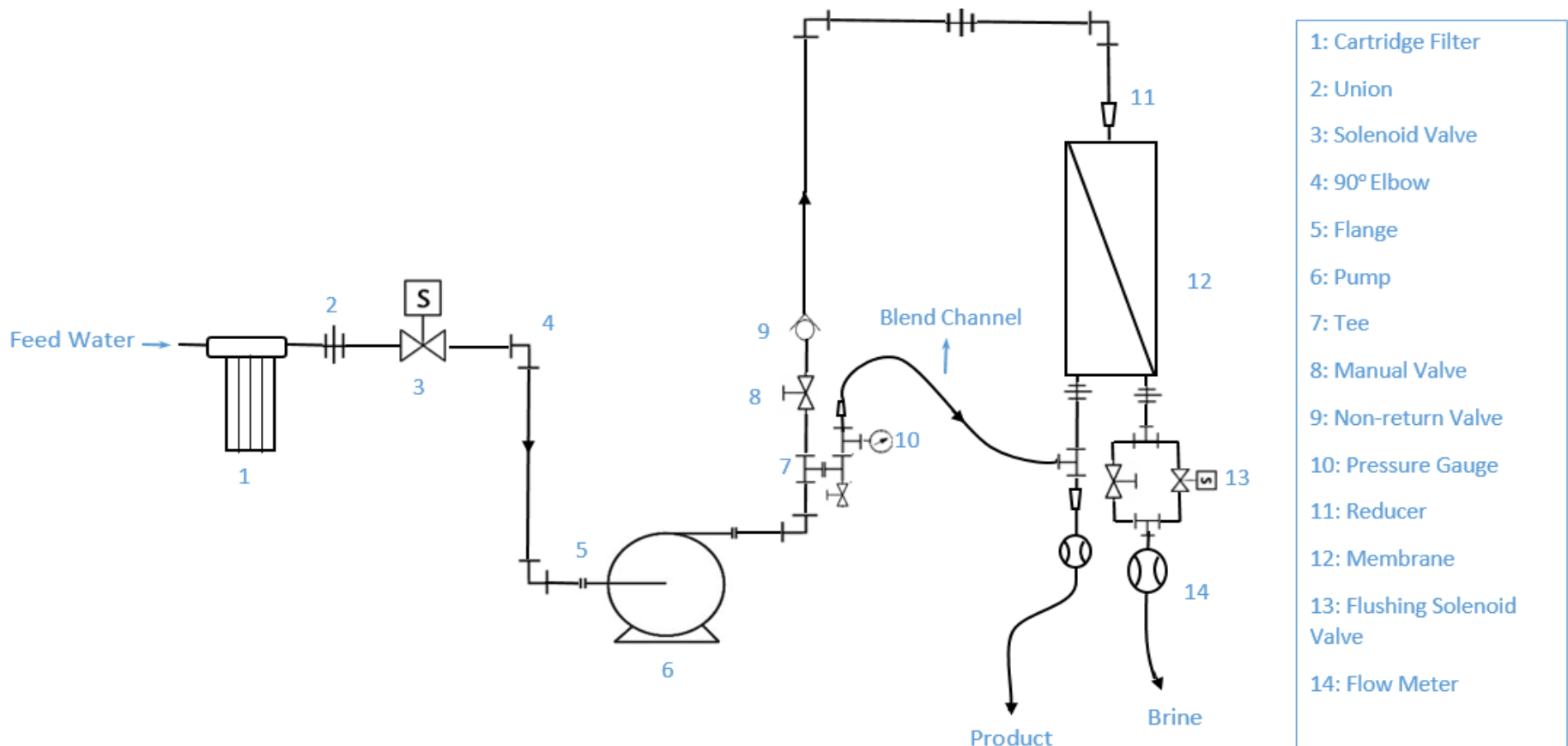
- Design simulated results:

		Overall	Pass 1
Raw water TDS	mg/l	1,000.2	1,000.2
Feed EC @25C / @25.00C	uS	1,905.6 / 1,905.6	1,905.6 / 1,905.6
Feed Pressure	bar	0.0	9.435
Temperature	deg C	25.00	
Total DP	bar	0.0473	0.0473
Brine Pressure	bar	9.387	9.387
Fouling Max	3.00 yrs		0.848
SP % Increase (Max)	3.00 yrs		33.10%
Recovery	%	23.04%	20.0%
Feed Flow	gal/day	6,811	6,552
Product Flow	gal/day	1,570	1,310
Average Flux	l/m ² /hr	25.83	25.83
Concentrate Flow	gal/day	5,242	5,242
Product TDS	mg/l	170.4	6,228
Concentrate TDS	mg/l	1,249	1,249
Primary HP Pump kW	kilowatt	0.339	0.339
Power Consumption	kWh/m ³	1.367	1.638

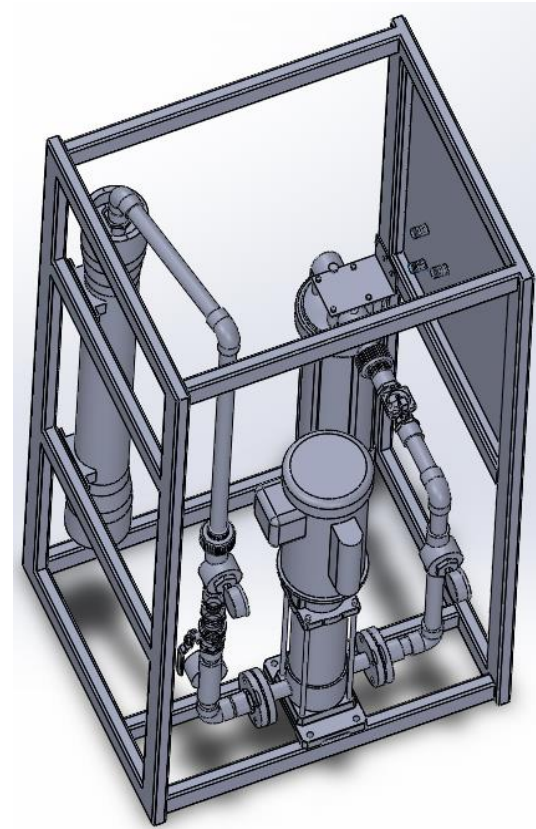
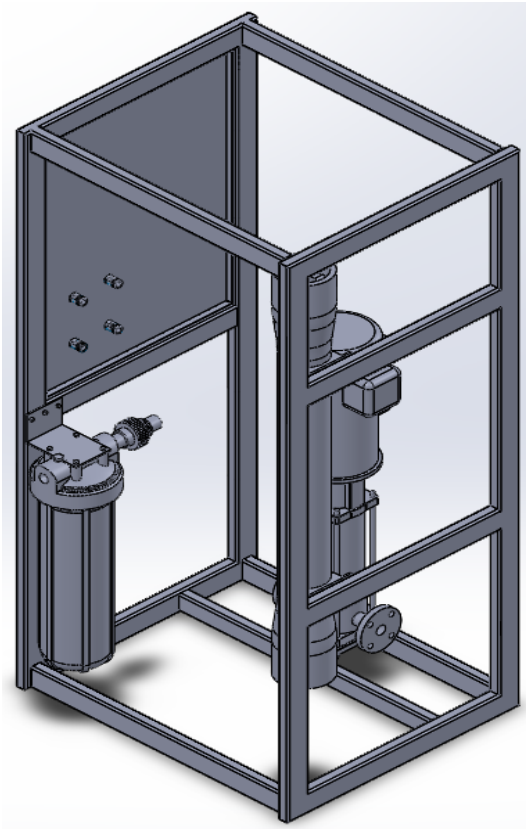
$$\text{Pass Recovery \%} = \frac{1559.6 - 259.2}{6552.0} \sim 20\%$$

$$\text{System Recovery \%} = \frac{1559.6}{6552.0} \sim 23\%$$

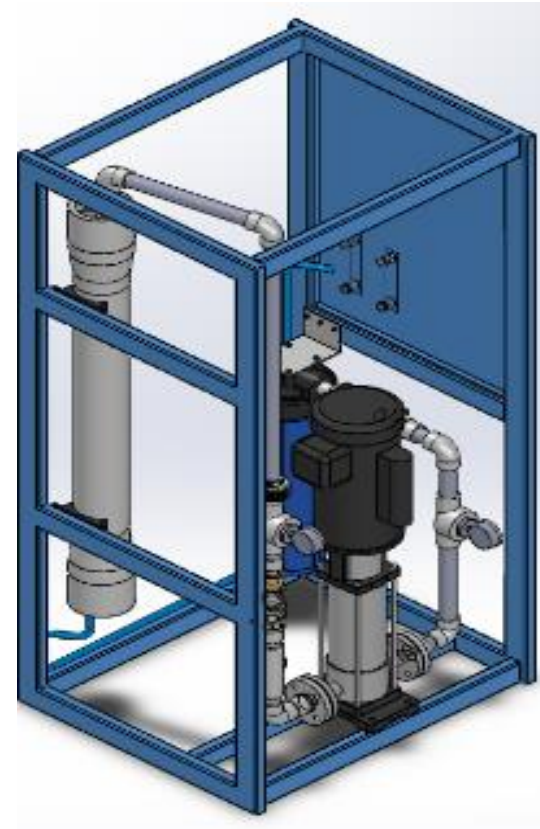
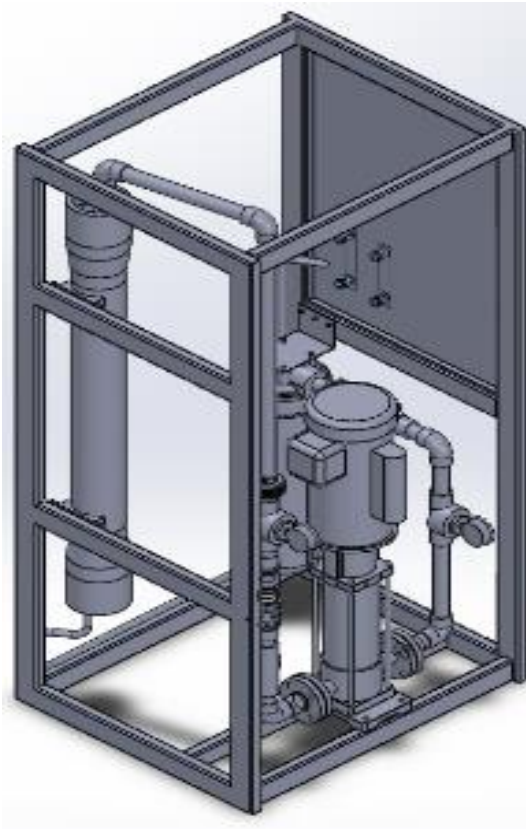
CAD Analysis – Piping Network



CAD Drawings & Assembly



CAD Drawings & Assembly



RO Unit Development

- Four steps are carried to develop the RO unit:
 - Step 1: Cutting & Welding of mounting structure



RO Unit Development

- Step 2: Electro-static powder coating of the developed RO unit structure



RO Unit Development

– Step 3: Parts assembly;

- Pump, membrane, flowmeters and cartridge filter
- Controller



RO Unit Development

– Step 4: Piping;

- Pipe cutting
- Pipe gluing



RO Unit Development

– Final RO unit assembly



Diagnostic Run

- In order to test the functionality of the system, four steps are carried as follows:
 - Step 1: Remove membrane and turn-off controller, to;
 - Clean up the pipe network
 - Check any possible pipe leakage
 - Step 2: Close blend channel and disable all flushing cycles.
 - Step 3: Turn-on controller, therefore pump will start to build up the pressure. Adjust the main manual valve to obtain the specified pressure and flow.



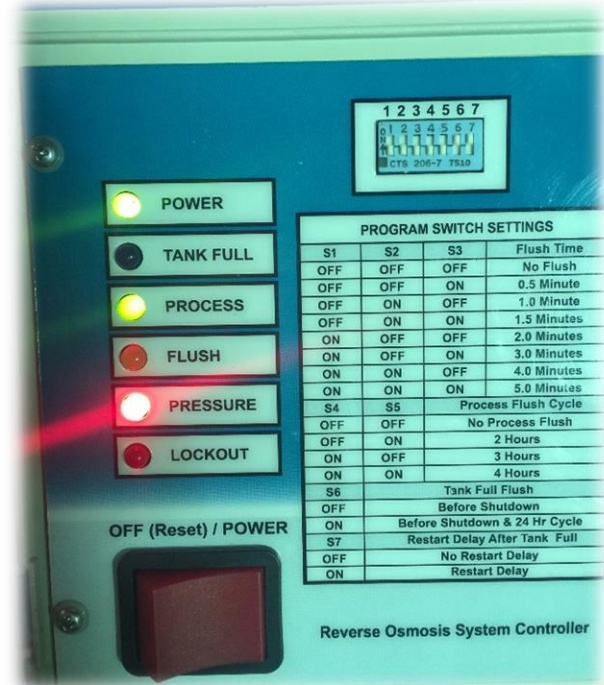
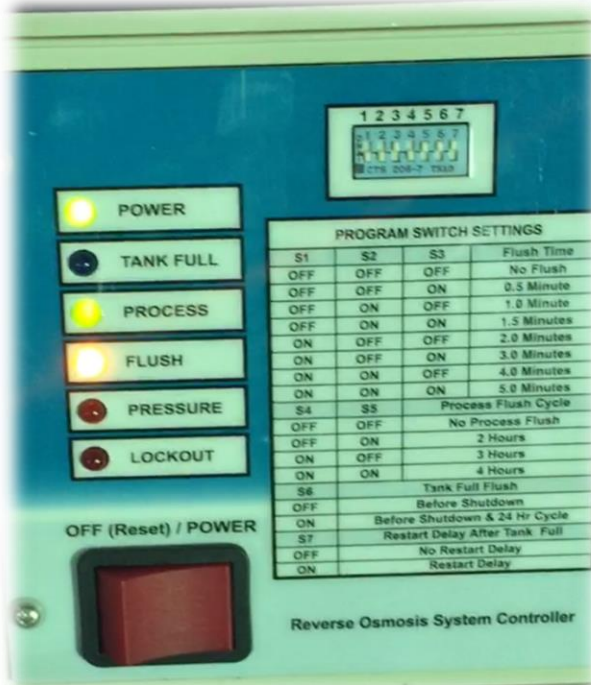
Diagnostic Run

- Step 4: Report, the flow meters (brine and product flow rate) and compare to the obtained values; from TorayDS2.
- Step 5: Open blend channel and enable flush cycle at different time intervals.
- Step 6: Run the system into abnormal conditions, e.g.;
 - No Feed water supplied to the system
 - Run the system while the water tank is full
 - Test lockout selector



Diagnostic Run

- Different system conditions, were indicated by the controller;



Conclusions

▪ **Methodology Conclusions**

- In general, the RO system design using the CAD software is helpful in RO system development.
- The CAD model is helpful technique in predict the overall dimensions and parameters of the RO unit structure and assembly.
- Assembly drawing and MS Project software are good management tools for predicting the volume of RO unit and obtain the bill material (BOM).



Conclusions

▪ **Objective Conclusions**

- Field application for BSc student project is beneficial technique to transfer and settlement of the taught Engineering technology.
- The developed RO unit is adopted as estate product to be introduced to Saudi market.
- It is recommended to adopt and develop this beneficial technique for selected BSc project.
- To enrich this type of project work, it is recommended to develop a team project work from different disciplinary engineering fields.



THANK YOU