**SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA**
**FACULTY OF CHEMICAL AND FOOD TECHNOLOGY**



REGISTRATION NUMBER: FCHPT-123283-44224


# CREATING VIDEO INSTRUCTIONS AND VIDEO PRESENTATIONS OF OUR LABORATORY EXPERIMENTS

**BACHELOR THESIS**


**2017** **Imrich Koncz**

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Study programme: Automation, Information Engineering and Management in Chemistry and Food Industry

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Thesis supervisor: Ing. Richard Valo, PhD.

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Slovak University of Technology in Bratislava
Institute of Information Engineering, Automation and Mathematics

Faculty of Chemical and Food Technology
Academic year: 2016/2017
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STU FCHPT

# BACHELOR THESIS TOPIC

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|---|---|
| Student: | **Imrich Koncz** |
| Student's ID: | 44224 |
| Study programme: | Automation, Information Engineering and Management in Chemistry and Food Industry |
| Study branches combination: | 5.2.14. Automation, 5.2.52. Industrial Engineering |
| Thesis supervisor: | Ing. Richard Valo, PhD. |
| Workplace: | Institute of Information Engineering, Automation, and Mathematics |

Topic: **Creating Video Instructions and Video Presentations of Our Laboratory Experiments**

Language of thesis: English

Specification of Assignment:

Our thesis has two main objectives: To introduce the operation of some of our laboratory experiments to a wider audience, and at the same time, to create instructions for these experiments in the form of videos easy to be understood by present day students.

This thesis focuses at laboratory experiments carried out at Institute of Information Engineering, Automation, and Mathematics, Faculty of Chemical and Food Technology, Slovak University of Technology in Bratislava.

Tasks:

- Creating promotional videos of some processes at our Institute
- Creating video instructions for each of these processes

Length of thesis: 25
Assignment procedure from: 13. 02. 2017
Date of thesis submission: 14. 05. 2017

**Imrich Koncz**
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Study programme supervisor

# Acknowledgements

Firstly, I would like to express my deepest gratitude to my thesis supervisor, Ing. Richard Valo, PhD. for the continuous support of this thesis, for his patience, motivation and knowledge. His guidance helped me in all the time.

# Abstract

A video tutorial is a way to help people learn and understand new information by the means of a video. They are more interactive than a book and more popular among the younger generation. This bachelor thesis deals with chosen laboratory experiments of our institute. It shows the principles of how they operate in the form of videos. It deals with the modern way of distillation via distillation column, reverse osmosis, ultrafiltration and nanofiltration using membrane processing and pasteurisation.

**Key words:** tutorial, instruction, experiment, distillation, reverse osmosis, pasteurisation

# Abstrakt

Video tutoriál je jednou z ciest ako môžeme zoznámiť ľudí s novými poznatkami vo forme videa. Video tutoriály sú viac interaktívne ako učebnice a sú modernou formou šírenia informácie a učenia. Je to prezentačná a zároveň demonštračná forma zdieľania nových informácií. Táto bakalárska práca sa zaoberá s vybranými laboratórnymi experimentami nášho ústavu a ukazuje princíp ich fungovania vo forme videí. Zaoberá sa modernou destiláciou pomocou destilačnej kolóny; reverznou osmózou, nanofiltráciou a ultrafiltráciou pomocou membrány a pasterizáciou.

**Kľúčové slová:** tutoriál, inštruktáž, experiment, destilácia, reverzná osmóza, pasterizácia

# Table of Contents

# List of Illustrations

# List of Abbreviations and Technical Terms

USB – Universal Serial Bus

PC – Personal Computer

PLC – Programmable Logic Controller

RO – Reverse Osmosis

UF – Ultrafiltration

NF – Nanofiltration

SCADA – Supervisory Control and Data Acquisition

PVC – Polyvinyl chloride

l – litre

min – minute

V – Volt

Hz – Hertz

µm – Micrometre

mS - Millisiemens

cm – Centimetre

mm – Millimetre

mA – Milliampere

IPXX – Internal Protection Marking

LCD – Liquid Crystal Display

IP – Internet Protocol

HTST – High Temperature Short Time

UHT – Ultra High Temperature

PID – Proportional-Integral-Derivative (Controller)

LED – Light Emitting Diode

DC – Direct Current

I/O – Input Output

HD – High Definition

# Introduction

The process of distillation and filtration is widely known. It was known by the Chinese in the first century. The first written proof of alcohol distillation was found in the eleventh century. Fractional distillation was invented by Tadeo Alderotti in the thirteenth century. [22] [23]

Filtration was used by the ancient Greeks and the famous physicist, Hippocrates was trying to solve this problem. Nowadays we use membrane filtration process which is based on osmosis. The membrane process is more convenient since it does not use heating therefore it saves energy and money. [20] [24]

The movement of the solvent through a semi-permeable membrane separating two solutions is called osmosis. Osmosis is a very important process in biological systems, it is the primary means of transportation of water into and out of our cells. Reverse osmosis is used for separation with the use of pressure. The pressure forces the solvent through a semi-permeable membrane which retains the solute on one side and the solvent on the other side. This process is used for water purification or paint filtration for luxury cars. [7] [8] [18] [19] [21]

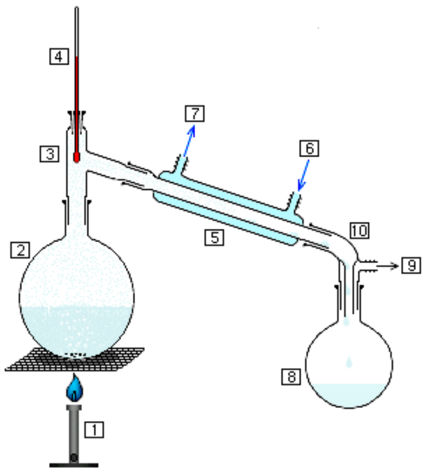
This bachelor thesis deals with the UOP3 distillation column and fractional distillation which is a more advanced technique of distillation. It deals with different filtering methods like reverse osmosis, ultrafiltration and nanofiltration with the help of a membrane processing unit. It also deals with the process of pasteurization with the help of the PCT23 training unit.

For each process a separate video instruction and a video presentation can be found with information about the device as well.

# 1 UOP3 Continuous Distillation Column

## 1.1 The process of distillation

Distillation is a process of separation, where the mixture of two or more substances of a liquid or vapour are separated into their components or fractions. Distillation is based on the different boiling points of the substances. The vapour of the boiled mixture after the process will be richer in the components which have lower boiling point. Thus, after cooling the vapour the condensate will be richer in volatile components and the former mixture will be less volatile. This process is the most common separation technique but it requires a lot of heat and cooling. [9] [15] [16]

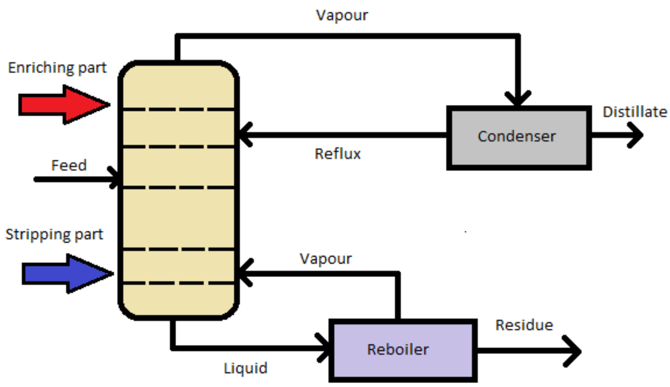



Picture 1 Simple distillation apparatus [17]

The simple distillation requires a mixture of substances which have different boiling points. The boiling points must differ significantly in order to have an effective separation. The process requires a source of heat (1) like a Bunsen burner or an electrical heater, a still pot (2) in which we put the mixture, a thermometer (4) to monitor the temperature which is inserted into the still head (3), a condenser (5) which cools the vapour until it condenses. It has an inlet for the cool water (6) and an outlet (7) for the warm water a still receiver (10) and a receiver flask (8) or another still pot to store the condensate/product. It can be equipped with a distillation vacuum unit as well (10). [16]

Distillation is used in the laboratories, industries, in the field of medicine and food processing. It can be divided into batch and continuous distillation and the main difference between them is that we must wait for the process to finish, feed the apparatus with a new mixture and continue the work while in the industry they feed the apparatus and take away the product at the same time continuously. [16]

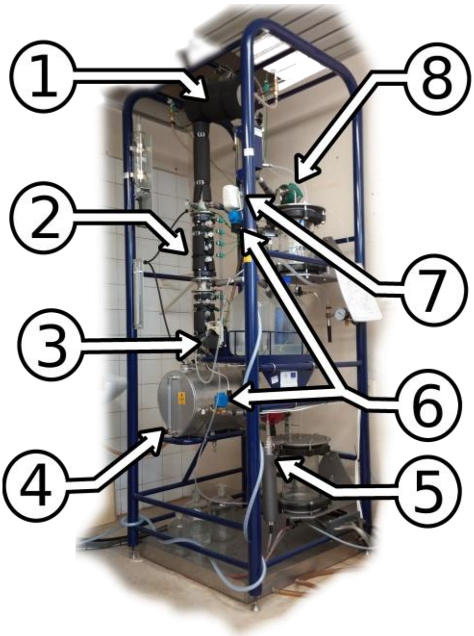
For a more efficient distillation, distillation columns were designed. Just like simple distillation, distillation columns can be divided into batch and continuous. The distillation column consists of a vertical shell where the liquid components are being separated, in the shell we can find the trays. In the middle of the shell we find the feed tray. The feed tray divides the shell into the top section and the bottom section. The top section is called the enriching section while the bottom one is called the stripping section. The reboiler is located under the column and it collects the feed which flows down the column and it generates the vapour as well. The condenser is located above the distillation column and it cools down the leaving vapour from the enriching part of the column. [9]




Picture 2 Schematic of a typical distillation unit [5]

# 1.2 The parts of the UOP3CC distillation column

Our Institute owns a computer-interfaced batch distillation column, the UOP3CC from Armfield. It is a self-contained distillation facility and it consists of two units which are connected with each other, a floor standing process unit and a control console.




Picture 3 The UOP3CC distillation column [2]

1, Condenser
2, Distillation column
3, Feed pump
4, Reboiler
5, Feed preheater
6, Automated valves
7, Manual valve
8, Reflux

The distillation column has a fifty-millimetre diameter. It consists of two glass parts and each part is equipped with four sieve plates. In the middle of the column we find the feed section. The column is arranged vertically for the counter-current vapour/liquid flow and it is insulated to minimalize the heat loss. [1]

Picture 4 Sieve plate [5]

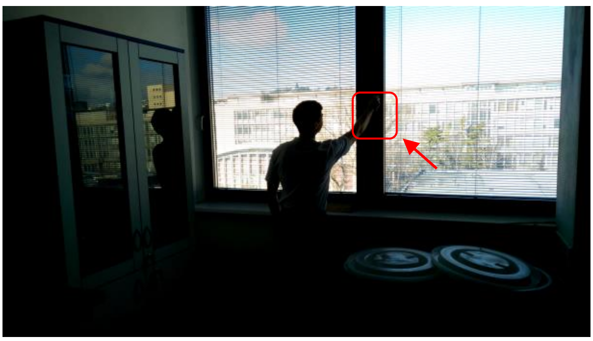
The reboiler is located at the bottom of the column. It is made of stainless steel and incorporates a flameproof immersion type heating element. It is possible to preheat the feed by directing it through a spiral coil in the bottom product cooler. This uses the heat of the product which leaves the reboiler at the boiling point. When feeding cold feed directly to the column, the product from the reboiler is cooled in the bottom product cooler by circulating cold water through the spiral coil. [1]

To reduce the system-pressure the column uses a vacuum pump. The vacuum level is adjusted by a needle valve and is indicated on the pressure gauge. [1]

The control console is attached to the distillation column by a cable, which is long enough to let the console be positioned at least two metre away. We can find two data port on the rear of the control console, a USB cable for the connection with a PC and a twenty-way signal output port, which provides readings from each of the sensors. The connection between the PC and the control console is filtered so the signals are more consistent. The PC is equipped with Matlab R2012b from Mathworks. On the front, we find switches for the reflux control, reboiler heater and feed pump. There are two separate indicators for the temperatures, which show the temperature of the column and the whole process. [1]

## 1.3 Video instructions for the UOP3CC distillation column

To get the distillation column into a working state, we must follow the following steps. We are working with chemicals, so the first step is to open the window. This helps with the air circulation.

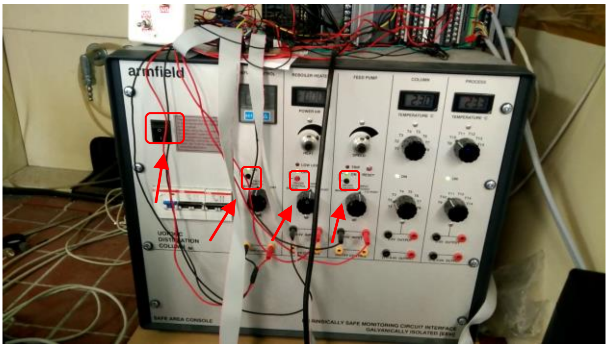


Picture 5 Opening the window

The second step is to turn on the switches under the PC so it gets power.

Picture 6 Switches under the PC

The third step is to start up the control console behind the PC and turn on the following buttons so the green lights are lit. We start reflux control, the reboiler heater to Input socket and lastly we turn the feed pump to the Input socket position.




Picture 7 Armfield control console

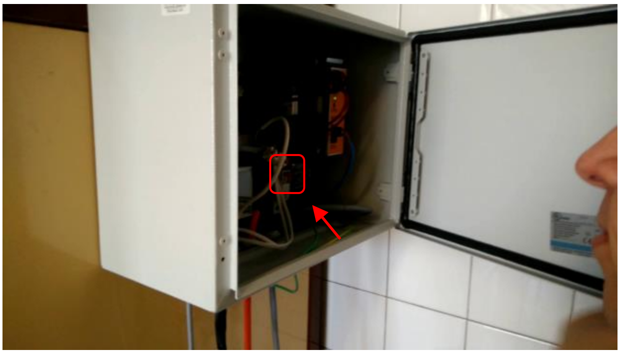
Our next step is to check the liquid level in the reboiler heater and in the feed tank.


Picture 8 Liquid level in the reboiler

We open the valve to let cold water flow

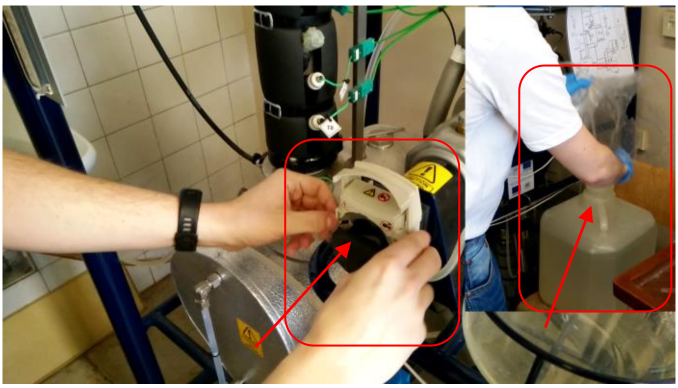
Picture 9 Opening the valve

We switch on the B&R PLC by flipping the red switch in the cabinet above the sink



Picture 10 Turning on the B&R PLC

The next step is to put the tube from the feed inside the peristaltic pump



Picture 11 Feed tank and peristaltic pump

Our next step will be opening Matlab R2012b (or the latest) on the PC and we must start the scheme which is located in the following folder: C:\Users\KIRP636\Desktop\Distilation_column_Drgona_Klauco\REAL\RIADENIE KOLONY

Next we start the init file: MPC_kolona_init.m and finally we start this scheme: Kolona_MPC

We can check the state of the distillation column in Matlab via Stateflow. The start up process takes about ten to fifteen minutes. After the last state the distillation column is ready to connect different types of controllers and ready for experimenting. To turn the process off just reverse the steps.

The full-length video instruction can be found on the attachment DVD.

## 1.4 Low level in the reboiler

When the red light shows up on the control console, indicating a low level in the reboiler, we must turn on the feed. This can happen when the feed is turned off during the initiation process. To correct the problem, we must open the corresponding block, in our case it is called "manual feed" and set the value to 1.2 ml/s.

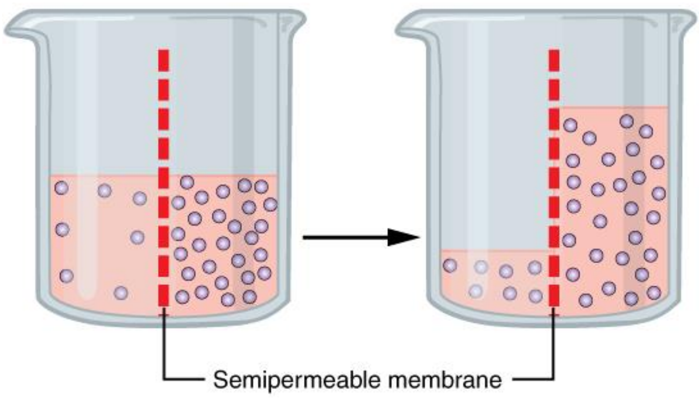
When the level reaches the minimum value, the light turns off. Now we can open the block again and turn it off by entering the value 0 in ml/s.

# 2 Batch Membrane Processing Unit

## 2.1 Reverse osmosis, ultrafiltration and nanofiltration

The diffusion of a solvent or water through a semi-permeable membrane is called osmosis. It means a lot for biology, the term itself was introduced by Thomas Graham, a British chemist. [7] [8]

If we use a membrane which is permeable to separate the solvent from the solution, the solution will absorb the solvent through the membrane. We can stop the process if we increase the pressure to a specific value, this is called the osmotic pressure. [8]




Picture 12 The process of osmosis over a semi-permeable membrane, the blue dots represent particles driving the osmotic gradient [14]

In a separation technique called reverse osmosis, a pressure is applied opposite to and in excess of the osmotic pressure to force the solvent through a membrane against its concentration gradient. This technique is used widely in the industry, desalinization of sea water, removing pollutions from streams, recovering contaminated solvents or even in biochemistry, dialysis. [6] [18] [19]

Nanofiltration is a membrane filtration based technique which uses cylindrical shaped pores which are nanometre sized. The pore size varies from one to ten nanometres as it is mainly used for water treatment, like water softening or purifying. Recently the industry started to find new uses for this technique like milk and juice production but it is used in fine chemistry, oil and petrol industry and even in medicine. [20]

Picture 13 Reverse osmosis (RO) filter

Ultrafiltration is the process of particle separation of different sizes by the means of a filter. A semi-permeable membrane acts as a filter and these have different pore sizes. It is used in the industry and for scientific researches for example to purify water or concentrate macromolecular solutions. [13]

## 2.2 The parts of the batch membrane processing unit

The processing unit was developed for filtration and the separation of different liquid mixtures by membrane separation which exploits osmosis. The device can be used for different filtration techniques like nanofiltration, ultrafiltration or reverse osmosis. These are often used in the chemical and food processing technology. It is a modular system interconnected with stainless steel or plastic tubes and Swagelock or JohnGuest fittings for quick disconnection. [4]

The process is controlled by PLC (Siemens S7 300), SCADA and a PC which is used for designing controllers and gaining data from different sensors like pressure, thermal and conductivity with the help of Matlab R2013a. It allows to test and create new controller algorithms. [4]

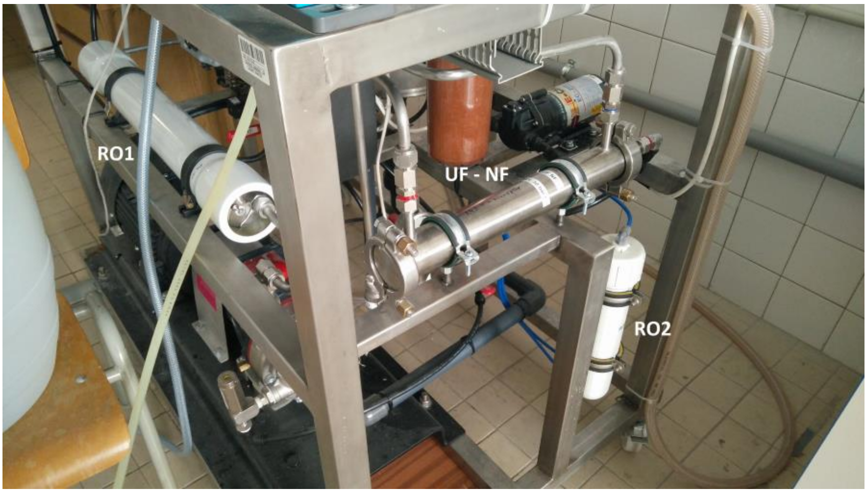
The concept of the system was modularity, easy to access parts, the ability to customize the device like the customer wants. [4]

Picture 14 Batch membrane processing unit

The device comes with two peristaltic pumps, P1 and P2. They can transfer twelve to sixty-four litres of liquid per hour. The control is either on or off and the pump speed can be set from 0 to 100%. On the back of the unit we find two stainless-steel tanks, T1 and T2. The PVC mixer is located in the tank. The liquid levels are measured with LISA01 sensor. Two high pressure pumps, P3 and P4. P3 is a piston pump capable of delivering up to 70 bars and it is capable of a flow-rate of 22,7 l/min. It is driven by the Danfoss VLT2800 frequency converter and it is controlled by a SCADA interface equipped PC or manually with the buttons and screen on the converter. [4]


Picture 15 Danfoss VLT2800 frequency converter

Pump P4 is capable of 10 bars and they both require 230V at 50 Hz. The V10 safety valve allows a maximum of 70 bar gauge-pressure. [4]




Picture 16 The filters of the unit

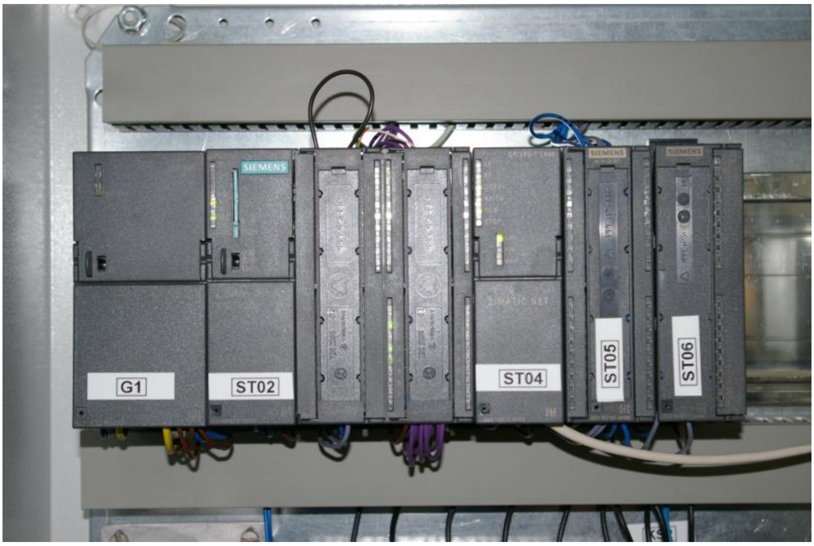
Reverse osmosis RO1 is the module for saline water SW30-2521 in a high-pressure case 70 bars. Reverse osmosis RO2 is in a high-pressure case, 10 bars. Ultrafilter, UF1 module up to 0.03 µm. Different types of valves; control, automated and ball valves. There are different sensors available throughout the whole unit for monitoring temperatures (TICA0, TIRA02), flow-rate sensors (FIRC01, FIR02) and conductivity sensors (QIRA01 and QIRA02). QIRA01 and TICA01 have two electrodes and a range from 0.0001 to 2 mS/cm. QIRA02 and TICA02 have four electrodes and have a range from 0.02 to 400 mS/cm. All of the fittings are made out of stainless-steel. [4]


Picture 17 M200 transmitter

The M200 Transmitter displays the values of conductivity and temperatures which is collected from the sensors which use the easySense technology. These data are transferred to the

PLC Siemens as well (4 outputs with 20mA). The enclosure is rated IP65 which means it’s dust and water resistant. The user interface consists of a four-line backlit LCD and a five-button key pad. The service interface is uses USB.

The unit comes with SCADA and WinCC flexible runtime from Siemens with one licence for all the basic functions. It includes a PLC (Siemens S7 300) for measurements and control and an Ethernet module for remote management. [4]




Picture 18 Siemens PLC

## 2.3 Video instructions for the membrane processing unit

The first step to turn on the unit is to plug in the three-phase power plug into the socket so the unit gets power

Picture 19 Plugging in the three-phase plug

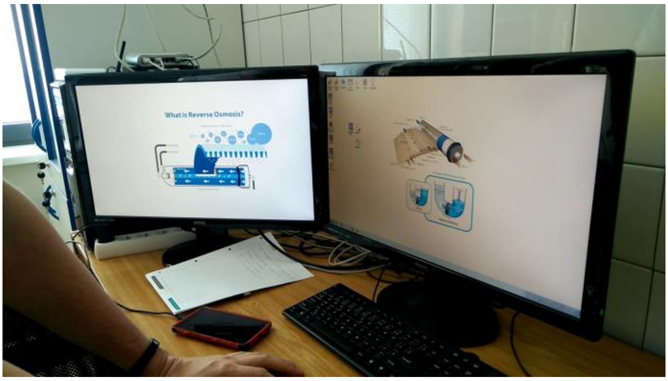
Next we must turn the valve which supplies the unit with water

Picture 20 Opening the valve

We flip the switch on the front of the unit to turn the process on

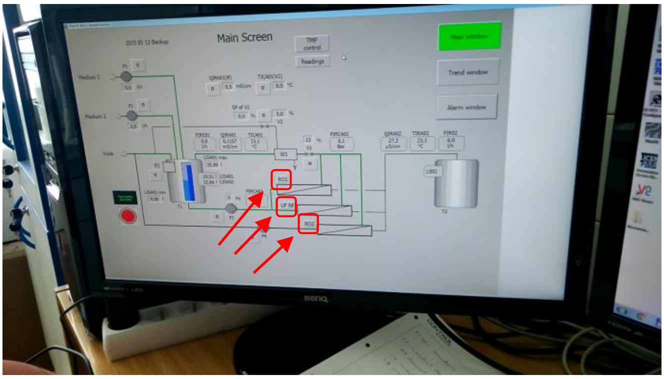
Picture 21 Flipping the switch (From 0 to I)

When we are done with the previous steps, we turn on the PC



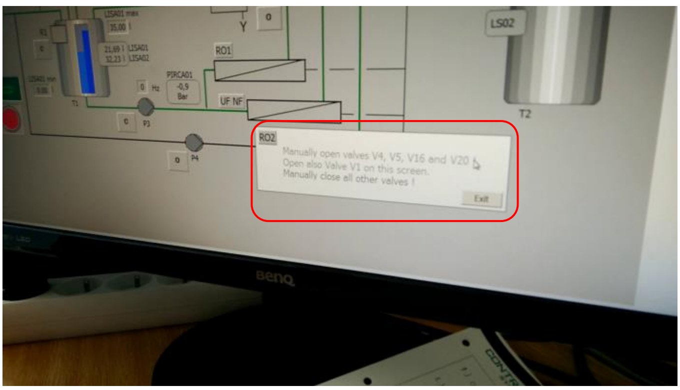
Picture 22 Turning on the PC

The user has to open the visualisation scheme and select the filtering method




Picture 23 Visualisation of the process

After we choose the filtering method, the visualisations shows which of the valves should be open in order to start the filtering process.

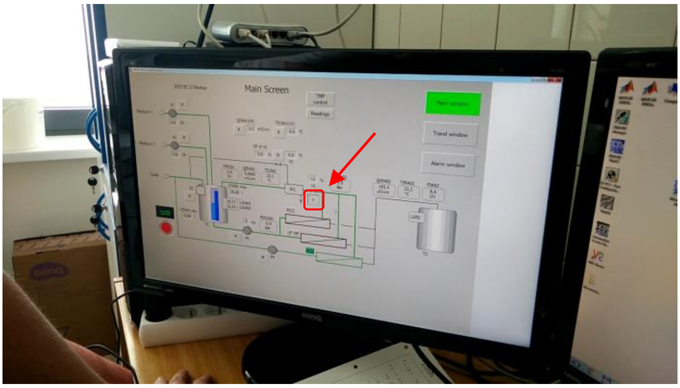



Picture 24 Indication of the required valves

After the previous step is completed we can turn on the V1 valve from the visualisation.

It is recommended to open the valve more in order to prevent the system from over-pressure

If we want to speed up the whole process, we start up the pump (P3 or P4 depending on the filtering method)




Picture 25 Turning on valve V1

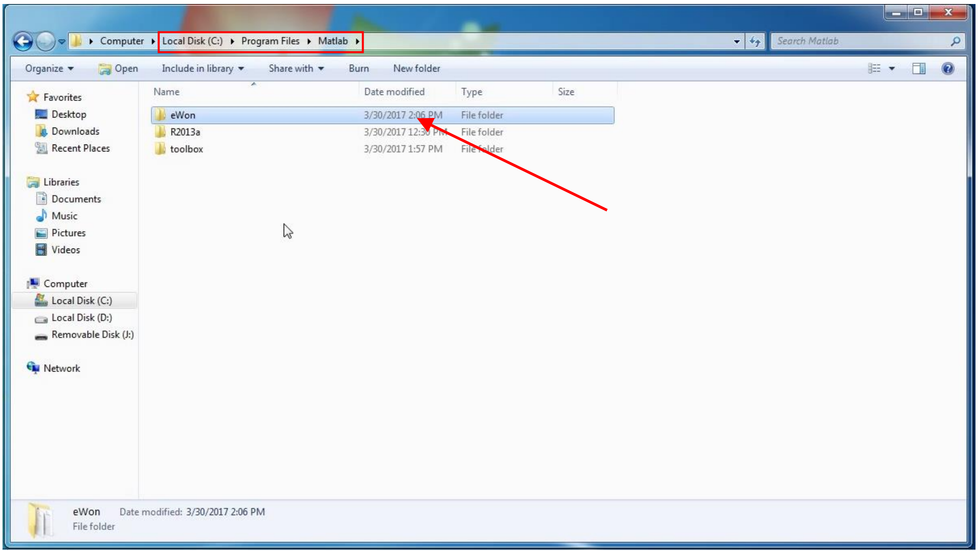
Next we open Matlab and open the chosen scheme. In case the user wants to use his/her own PC, jump to chapter 2.4

To turn off the unit, firstly we turn off the V1 valve, then we turn off all of the valves which we opened in the turning on process. The easiest way to do this is to check which valves are parallel with the tubes. After we are done with this we can safely turn off the process by flipping the power switch to the zero state. Next we pull out the three-phase power plug from the socket and followed by turning off the valve for the water. Finally, we turn off the PC.

## 2.4 Setting up eWon router on a secondary PC

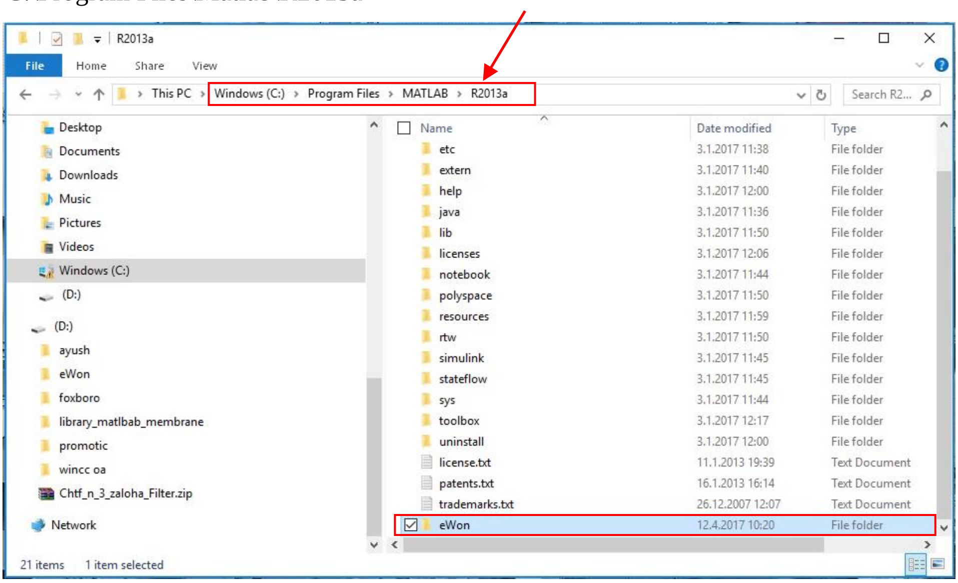
For a more convenient way for the user, here is a short tutorial how to set up the communication between a secondary PC and the Membrane processing unit, if the user wants to use his/her own PC. This requires to set up the communication with the eWon router and to have the latest Matlab installed (recommended).

First the user should copy the eWon folder from the primary PC. The folder is located here: C:\Program Files\Matlab\



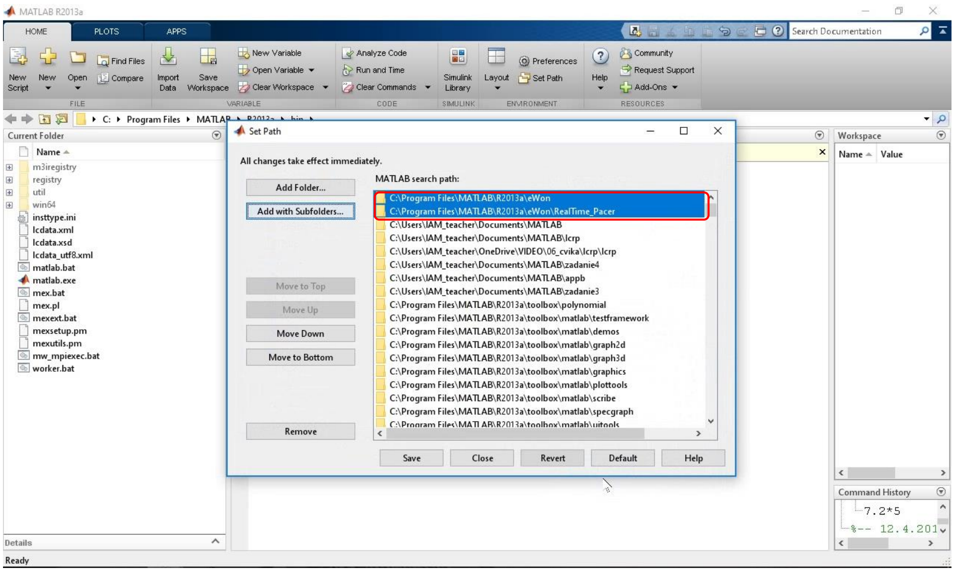

Picture 26 Location of the eWon folder

The next step is to copy the eWon folder to the secondary PC somewhere inside the C:\Program Files\Matlab\ folder (Keep in mind, the location of the Matlab folder can vary depending on the users choice during installation). In this case, the user decided for the following path: C:\Program Files\Matlab\R2013a



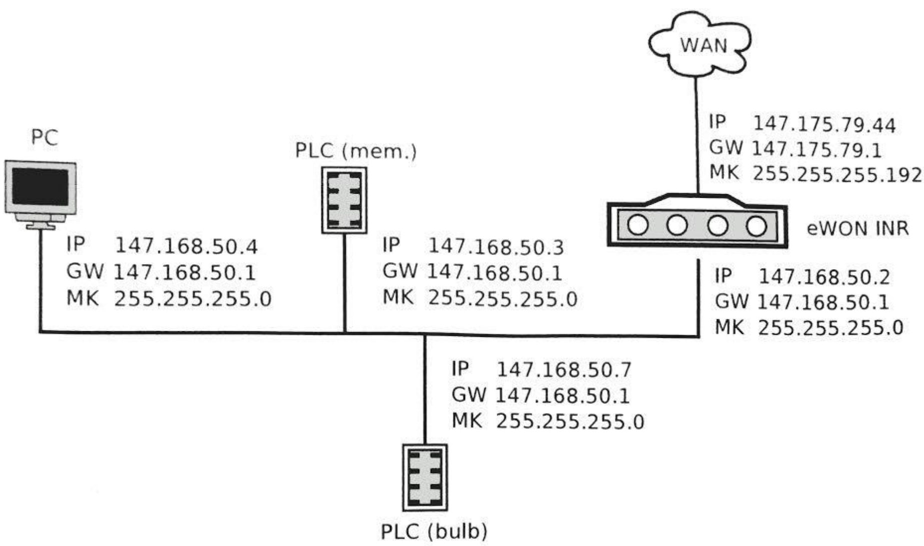

Picture 27 The secondary PC

Next we must set the eWon folder in Matlab so the program can use it. We can do this by clicking on the “Set Path” option and then “Add with Subfolders…”. Here we select the eWon folder which we copied to the secondary PC in the previous step.




Picture 28 Importing the eWon folder

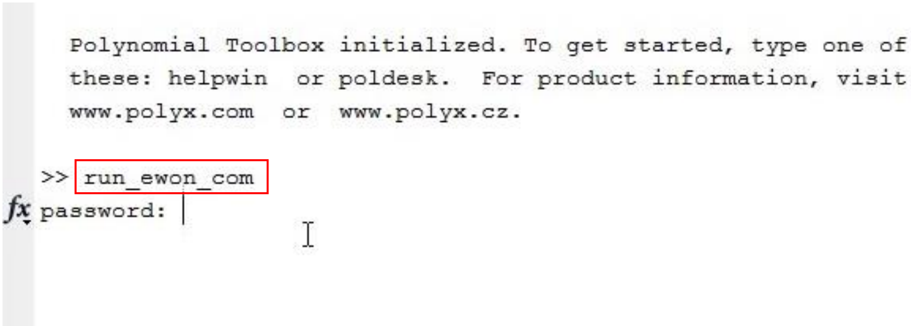
Next we must connect to the network and set up the IP address on the secondary PC. We have to choose an IP address, which must be different from the IP addresses on the following picture in order to prevent collision between the devices.




Picture 29 Used IP addresses

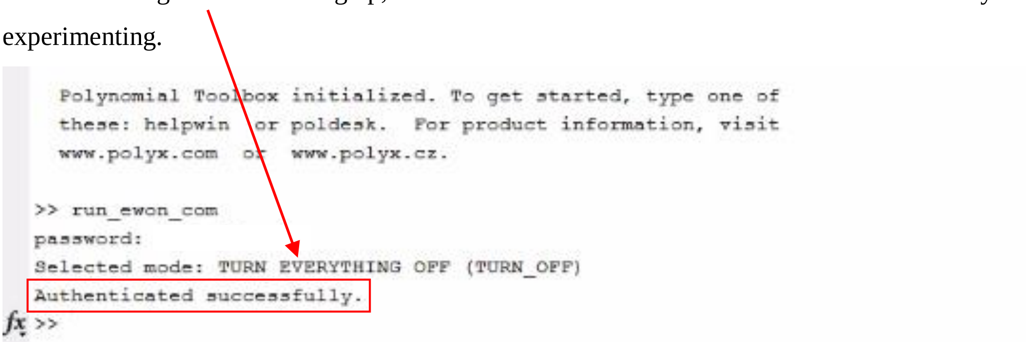
We have to choose an IP address in the following format: 147.168.50.X where “X” has to be different than the used up IP addresses.

After we are finished setting up the IP address, we start the communication with the eWon router. This can be done by running the following command in Matlab: run_ewon_com and typing in the password which can be found in the laboratory.




Picture 30 Communication with the eWon industrial router

If the following state is showing up, the communication is all set and the Membrane is ready for experimenting.




Picture 31 Successful authentication

The full-length video instruction for this process can be found on the attached DVD.

# 3 The PCT23MkII Processing Plant

## 3.1 Pasteurisation

The process of heating wine for preservation purposes has been known in China since 1117. The idea behind pasteurisation is to kill the germs and bacteria which spoil the liquid or food, then to store the treated product in a hermetically sealed container. The process was refined a few times, first they tried to use much heat and for a long period but this meant degradation and quality loss. [10] [11]

In 1864 a French chemist, Louis Pasteur developed a more refined method. It was developed to prevent the wine from souring. His experiments showed optimal results when he heated up the wine and beer to about 60 degrees of Celsius to kill the germs. [11] [12]

Just like wine and beer, raw milk needed a safer way of treatment and storing. It caused diseases and in a lot of cases even death. In the 20th century Milton Joseph Rosenau set the standards for milk pasteurisation. His method was to slowly heat the milk up to 60 degrees of Celsius for 20 minutes. If milk is heated to a high temperature, it starts to curdle since the aggregation of the micelles of the milk protein casein. Depending on the pasteurisation technique, milk can be safely stored from two weeks up to nine months. The milk can't be heated to a high temperature because it starts to curdle, so the temperature either must be lower and heating must be done for a longer period or at a high temperature for a short amount of time. In the process of high-temperature short-time pasteurisation (HTST), the milk is heated up to 72 degrees of Celsius for 15 seconds. Ultra-heat treatment (UHT) processes the milk at 140 degrees of Celsius for only 4 seconds. With the help of UHT milk can be stored for a few months without refrigeration. Home pasteurisation involves heating up the milk to 63 degrees of Celsius for 30 minutes. [12]

In the industry, commonly pasteurised products are: beer, canned food, dairy products, eggs, milk, juices, low alcoholic beverages, syrups, vinegar, water and wine. [12] [10]

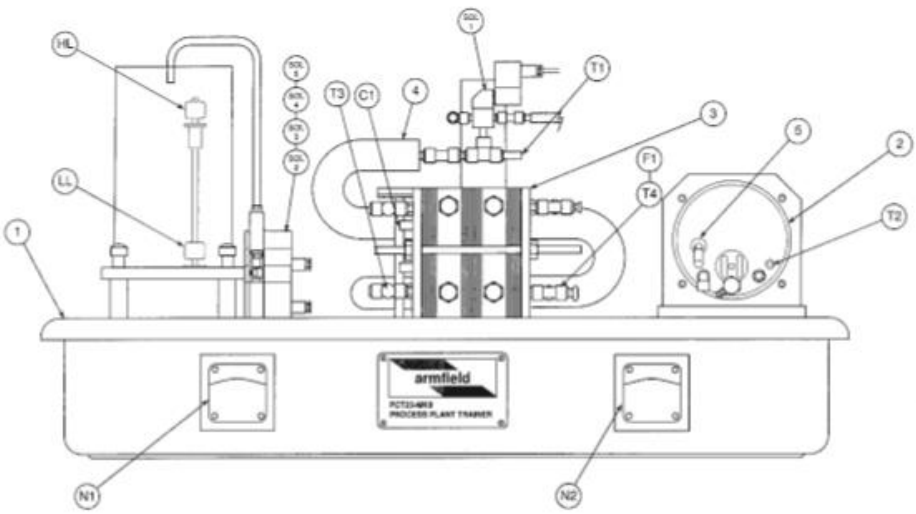
## 3.2 Parts of the Armfield PCT23MkII

The Armfield PCT23MkII process plant trainer can be used for demonstration purposes for a wide range of process control methods and strategies. It is a miniature replica of a true production process. It can be used to simulate real process control problems with instabilities and realistic dynamic behaviour. The device features multiple inputs, control strategies, different types of sensors like temperature, level, flow and conductivity. PID, PLC and SCADA support and it features an USB port for easy PC connection. The PC is equipped with Matlab R2007b [3]

The process unit uses the HTST pasteurisation process. It uses a three-stage heat exchanger to recycle, heat and cool the liquid. Both the feed system and the water heating unit uses peristaltic pumps. The product tank features a level sensor while the reagent tank uses high/low level switches. It uses 2-way solenoid valves for filling feed tanks and cooling exchanger and 3-way solenoid valves for selecting feed tank and diverting waste product. The unit has connections for the control console. [3]

The control console provides the electrical interface and signal conditioning for the process module. It features a USB interface for easier connection. The drive signals to the process module can be selected as either manual control from the front panel, control from a PC via the USB port, on/off control from an external source or analogue control from external source [3].

The flow rates of the product stream, washing reagent range from 0 to 480ml/min and the flow rate of the heating fluid ranges from 0 to 600ml/min. The maximum temperature of the heating fluid can be 80 degrees of Celsius. The feed and reagent vessels have a capacity of 5.7 litres, and the heating vessel has a capacity of 3.7 litres. The signal voltages can range from 0 to 5V. The level sensor range from 0 to 250mm and the flow sensor ranges from 0 to 500ml/min. The temperature sensor range is from 0 to 100 degrees of Celsius. For safety, the heating vessel features a thermostat which limits the maximum temperature, a low-level switch and a vent to avoid pressurisation. [3]




Picture 32 PCT23MkII processing unit [3]

1, ABS plinth

2, Hot water vessel

3, Three stage indirect plate heat exchanger

4, Tube arrangement

6, Feed vessels

SOL1 Product divert solenoid valve

SOL2 Feed select solenoid valve

SOL3 Product cooling solenoid valve

SOL4 Tank A fill solenoid valve

SOL5 Tank B fill solenoid valve

N1 Feed pump (peristaltic)

N2 Water pump (peristaltic)

PRV1 Pressure reducing valve

V1 Flow control valve

T1 – T4 Temperature sensors

C1 Conductivity sensor

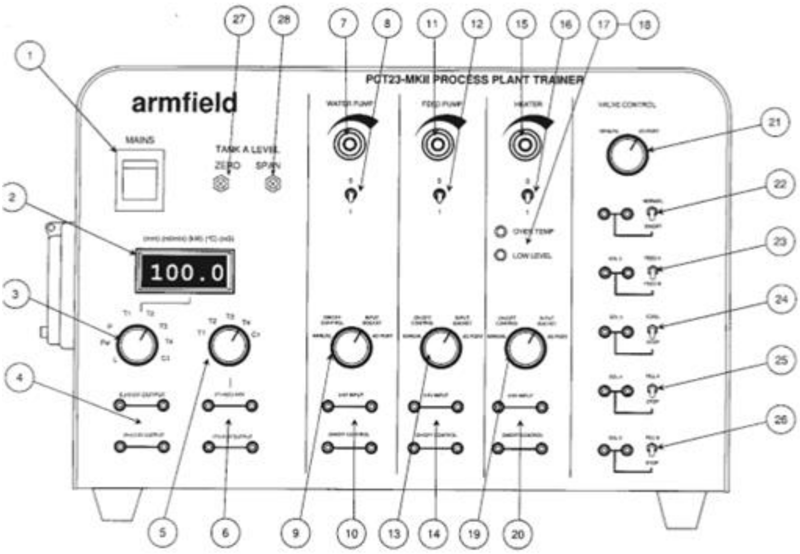
F1 Flow sensor

L1 Level sensor

LL Float switch

HL Float switch

The control console is used for access to the different signals associated with measurements and to control the process with different control techniques. [3]




Picture 33 The front of the control console [3]

1, Main switch

2, Multi-purpose display (shows the values from the selected sensor)

3, Multi position switch

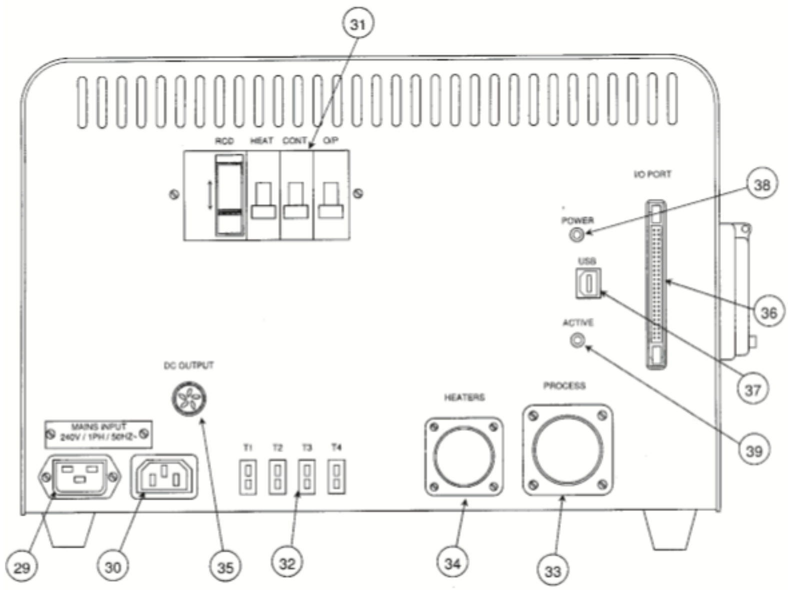
4, Four sets of output sockets (from 0 to 5V)

5, Multi position switch

6, Signal

7, Ten turn potentiometer (for the hot water circulating pump)
8, ON/OFF Switch
9, Selector switch
10, Input sockets
15, Ten turn potentiometer (for the water heater)
16, ON/OFF Switch
17, LEDs for overheating
18, Low level indicator
19, Selector for other control modes
20, ON/PFF control
21, Switch for control input
22 – 25, Controls for the solenoid valves
26, Control for the solenoid valves when in manual mode
27 – 28, Level sensor calibrating tool

On the rear of the device we find the main connection socket and an outlet. For the safety of the user, a residual current circuit breaker and three miniature circuit breakers are installed. The process unit is connected via four thermocouple input sockets, a 40-way process connector, two heater connectors and a DC output. The process can be controlled either by the 50-way data I/O port or the USB port. If it is controlled via the USB port, the red power LED and the green LED will be lit, indicating that the USB is used for all the control functions. However, when the LEDs are not lit, the process takes control functions from the 50-way connector. [3]




Picture 34 The rear of the control console [3]

29, Main connection socket
30, Outlet

31, Safety elements
32, Thermocouple input socket
33, 40-way process connector
34, Heater connectors
35, DC output
36, 50-way data I/O port
37, USB port
38, Red power LED
39, Green LED

## 3.3 Calibrating the water-level

If the water levels are off on the Control Console, we have to calibrate the sensors to make them show the correct value. The first thing we will have to do is to close all the valves under the tank and then we start to slowly fill the system until the water-level reaches 200 mm. We stop the water and take a look at the value on the Control Consoles display. We take a small flathead screwdriver and start to turn the “Span” potentiometer until it shows the correct value. Then we open the valves and drain the tank until the tank is empty and we take a look again on the value on the display and if it’s off we put the flathead screwdriver into the “Zero” and turn the potentiometer slowly until it shows 0 on the display. Next we fill the system up again until it reaches 200 mm and stop the water and we do the same steps until it shows the correct values.

## 3.4 Video instructions for the Armfield PCT23MkII

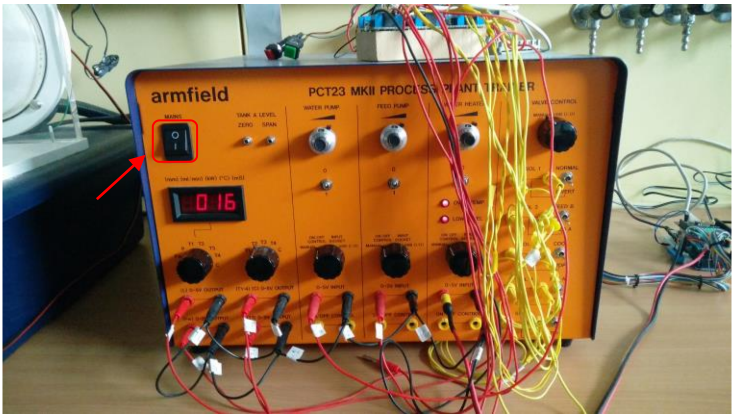
The first step is to open the water valve so the system receives water from the system

Picture 35 Opening water valve

The second step is to check the switches

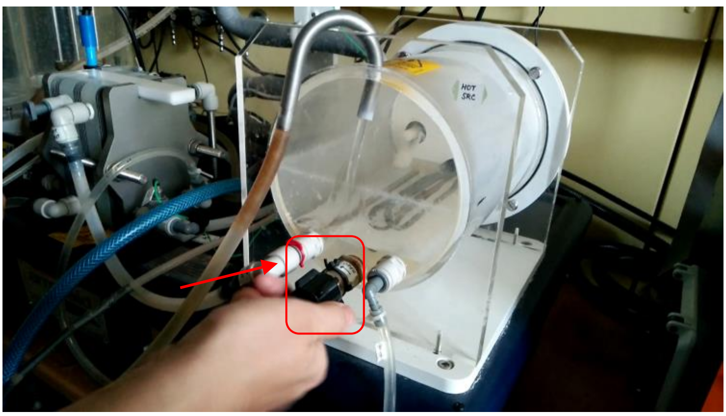
Picture 36 Switches

The third step is to turn on the control console.




Picture 37 The control console

Next we fill the water-heater until the sign on the side of the tank with the “Cool” switch. Don’t forget to close the drain valve!

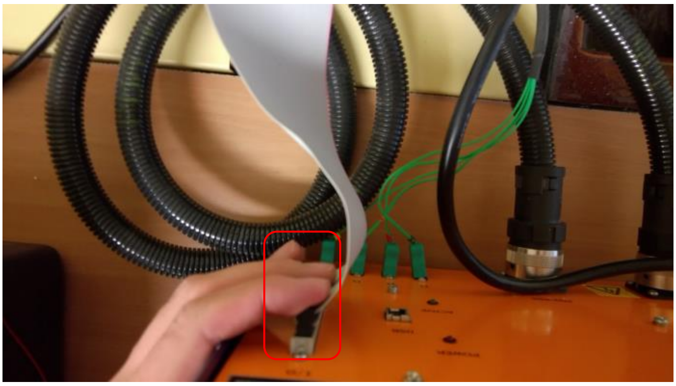


Picture 38 Closing the draining valve

Turn on the PC

Picture 39 Turning on the PC

Connect the cable to the control console



Picture 40 Connecting the cable

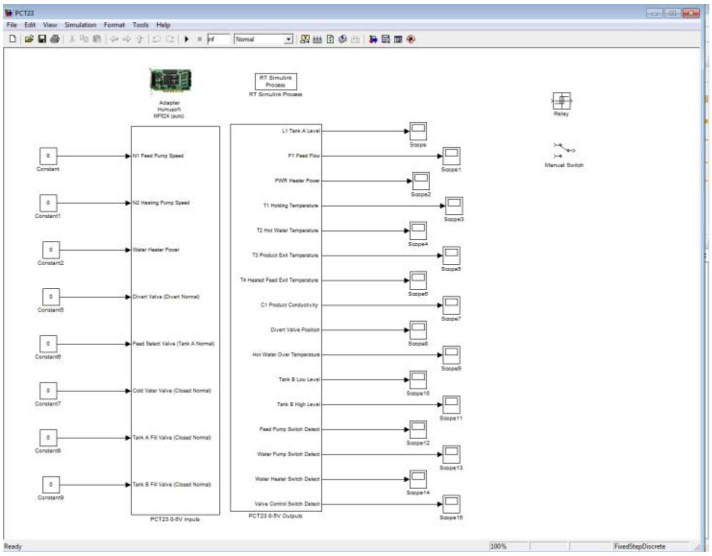
We put the water-pump, feed-pump and water-heater to the “1” state


Picture 41 Flipping the switch

We flip the switches to “USB I/O” so the process will use the USB port as the source of input


Picture 42 Selecting USB I/O

Next we run the scheme PCT23 which is located in the following directory: Student\TAR3\Kniznica




Picture 43 The PCT23 scheme

To turn the process off we have to send zeros to every variable. We close the scheme and Matlab. We turn off the PC. We turn off the Control Console. We drain the system and cool the heater. We remove the plastic tubes from the peristaltic pumps in order to avoid deformation of the tubes. We close the water valve.

# 4 Conclusion

In the introduction of this thesis we introduce ourselves to the process of distillation, both the simple and more advanced, fractional distillation. We widened our knowledge about the membrane processes next, such as reverse osmosis; ultra- and nanofiltration and finally, we looked on the process of pasteurisation. We learned about how they evolved in the past years and how they were improved.

We studied all the above-mentioned processes and we understood their principles of how they work with the help of the included user manuals. These manuals are available to the public and are provided by the companies who make the products.

The goal of this thesis was to get familiar with each process and to understand each of them. This meant to learn about the principles and make research about different methods and techniques, then based on the manuals and the available literature we had to make improvements to make the use of these devices easier for our students and the exchange students as well. The next aim was to make a promotion of these devices to the audience which is easy to understand.

The practical part of this work was to film each of the process and to create a prompt set of instructions in a form of a video which can be easily followed and understood by the students who watch them. The video promotion provides more information about the principles of the experiments and about the devices in the laboratories.

The footage was cut and edited in an editing software, it was exported in full HD resolution to meet the video standards of today. The video instructions are prompt so they are easy to follow and the promotion materials offer more information about the devices and about the technique. The finished videos were uploaded to YouTube and they are publicly available for the students and the audience.

In the written part of the thesis you can find detailed information about the laboratory experiments coupled with instructions how to operate them. The videos in full HD quality can be found on the included DVDs (Appendix A and Appendix B).

# 5 Resumé

Destilácia sa používa na oddeľovanie kvapalných látok s rôznymi bodmi varu, ďalej sa to používa na oddelenie prchavých látok od neprchavých. Proces má široké využitie v priemysle napríklad pri výrobe benzínu, pri výrobe etanolu, alebo výrobe destilovanej vody. Destiláciu používame aj v našich laboratóriách. Na destiláciu pri atmosférickom tlaku potrebujeme zdroj tepla, destilačnú banku, destilačnú hlavu, teplomer na sledovanie teploty, chladič a zachytávač destilátu. [15] [16]

Ak sa teplota zmesi postupne zvyšuje a pri rôznych teplotách sa zachytávajú rôzne súčasti z jednej zmesi, hovoríme o frakčnej destilácii. Frakčná destilácia sa v priemysle využíva na výrobu pohonných látok z ropy ako benzín, petrolej, alebo plynový olej. Na frakčnú destiláciu potrebujeme destilačnú kolónu. Na ústave informatizácie, automatizácie a matematiky študenti majú prístup k destilačnej kolóne od výrobcu Armfield. Kolóna sa skladá z dvoch časti, zo stojacej procesnej stanice a z riadiacej skrine. Riadenie sa uskutočňuje pomocou počítaču ktorý je prepojený s riadiacou skriňou a tým pádom umožní návrh rôznych regulátorov pomocou softvéru Matlab. [9]

Osmóza je presun látky cez polopriepustnú membránu, ktorá oddeľuje dva roztoky s rôznymi koncentráciami. Rozpúšťadlo preniká z menej koncentrovaného roztoku cez polopriepustnú membránu do viac koncentrovaného roztoku. Na oboch stranách membrány máme rôzne tlaky a ich rozdielom je daná veľkosť osmózy. V obyčajnej bunke sa tiež prebieha osmóza kde cytoplazmatická membrána sa správa ako polopriepustná. Cytoplazmatická membrána prepúšťa molekuly vody z okolia bunky do vnútra bunky. [7] [8]

V prípade reverznej osmózy aplikujeme vonkajší tlak zo strany koncentrovanejšieho roztoku a tým sa obráti prirodzený jav osmózy. V dôsledku procesu dôjde k rozdeleniu vstupného prúdu na permeát a retentát. Reverzná osmóza sa v prvom rade využíva pri výrobe pitnej vody zo slanej, ďalej sa využíva v akvaristike alebo pri výrobe sirupov. Náš ústav je vybavený so zariadením na úpravu kvapalín membránou SUPER RO, typ BM 30 od firmy AC ROSA. Je navrhnuté na mnohoúčelovú filtráciu a separáciu rôznych kvapalných roztokov pomocou membránovej technológie. Slúži na rôzne typy filtrácií ako nanofiltrácia, ultrafiltrácia a reverzná osmóza. Riadenie systému je implementované pomocou PLC (procesná úroveň) a PC (vyššia úroveň). Na tvorbu riadiacich algoritmov používame softvér SIMATIC Step 7 a Matlab a na vizualizáciu softvér SIMATIC WinCC flexible. Komunikáciu medzi nimi rieši priemyselný router eWon. [6] [18] [19]

Sterilizácia je proces tepelnej úpravy tekutých nápojov. Vykonáme ju tak, že krátkodobo zvýšime teplotu. Výška teploty musí byť dostatočná na odstránenie mikroorganizmov. Následne produkt ochladíme. Proces zdokonalil francúzsky vedec, Louis Pasteur v 19. storočí. Pasteur skúmal príčinu pokazenia piva a vína a prišiel na to že za to môžu mikrooganizmy. Jeho cieľom bolo likvidovanie mikroorganizmov z potravín, takou metódou ktorá neznehodnocuje kvalitu potravín. Vyvinul teda proces, vďaka ktorému sa zvýšila trvanlivosť potravín a zabránili šírenie ochorení. Proces podľa jeho autora nazýva Pastérizácia. [11] [12]

Náš ústav disponuje procesnou stanicou PCT23MkII od spoločnosti Armfield. Procesná stanica predstavuje pasterizáciu a študenti môžu navrhnúť riadenie pre tento proces. Riadenie je možné buď manuálne pomocou riadiacej skrine, s počítačom pomocou Matlabu, priemyselnými technológiami (PLC), alebo pomocou Arduína. Pomocou riadiacej skrine môžeme ovládať jednotlivé funkcie procesu ako ohrev varáku (ohrevná špirála), rýchlosť čerpania tekutín (peristaltické čerpadlá), otváranie a zatváranie ventilov (solenoidy), alebo monitorovanie teplôt, výkonov a výšok hladín v nádržiach.

Cieľom tejto bakalárskej práce bola tvorba video inštruktáží a video prezentácií procesov, ktoré sa nachádzajú na ústave automatizácie, informatizácie a matematiky. Inštruktážne videá sú viac interaktívne ako knihy. Najprv sme sa zoznámili s teoretickou časťou fungovania všetkých vybraných procesov. Potom sme sa pomocou používateľských príručiek zoznámili s časťami jednotlivých zariadení. Po zoznámení so zariadeniami sme začali s tvorbou inštruktážnych videí pomocou ktorých sa študenti rýchlejšie zoznámia s prácu s fungovaním a ovládaním zariadení. Pre všetky zariadenia sme navrhli sled krokov ako ich spustiť. Po overení týchto krokov sme ich nahrali pre všetky vybrané zariadenia a následne sme videá zostrihali. Pre video prezentácie sme vytvorili aj krátke animácie pomocou ktorých vysvetľujeme funkčností procesov (destilácia, pasterizácia a membránová separácia). Do inštruktážnych videí sme pridali aj rady potrebné na bezproblémovú prácu so zariadeniami. Všetky videá sú v angličtine aj s anglickými titulkami. Boli vytvorené v prvom rade pre študentov, ktorý ovládajú anglický jazyk. Videá sme potom vyexportovali vo formáte mp4 a v kvalite full HD. Videá sú verejne dostupné na Youtube aj ako príloha tejto práce na videonosičoch.

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# Appendix

Appendix A – Enclosed DVD-ROM with the following content:

Distill column_man.mp4

Distill column_prop_final.mp4

Membrane_manual.mp4

Appendix B – Enclosed DVD-ROM with the following content:

Membrane_prop_en.mp4

Pasteur_manual_en.mp4

Pasteur_prop_en.mp4

Appendix C – Enclosed CD-ROM with the digital version of the bachelor thesis in PDF format (Bachelor Thesis – Imrich Koncz.pdf)