EXTENSIONS IN UNISIM DESIGN SUITE R390 – ENVIRONMENT IN APPLICATIONS FOR TRAINING IN MODELLING AND CONTROL

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Abstract: The purpose of this paper is to discuss the opportunities for student training in modeling and control of technological plants using UniSim Design Suite R390. In the case a process of designing and the usage of complex model of distillation column are examined. For effective usage some extensions concerning XML and WEB applications are developed.

Key words: training, modelling, control, distillation, Unisim Design.

1. INTRODUCTION

The software product UniSim® Design Suite R390 of Honeywell is given up to the UCTM-Sofia for academic needs. UniSim is intuitive and interactive process modeling tool that offers unified decisions to keep high efficiency over the life cycle of the technological equipment – from the off-line design through steady state simulation, analysis of different control strategies, operators training, online usage for control and optimization, productivity control and business planning. UniSim extends the capabilities of Honeywell's Experion® Process Knowledge System (PKS) by improving its ability to gather data throughout the plant and coupling it with process knowledge embedded in process simulation models, so called **Scenario Manager**. UniSim software, but not the academic one, is also designed to integrate with Invensys, Siemens, Yokogawa, Emerson and ABB advanced control and operator training systems.

The purpose of this paper is first to illustrate the opportunities of UniSim® Design Suite for development of technological model for a distillation installation for ethanol and on the other hand to show how with the assistance of the XML and WEB interface it can be used to test different scenario and strategies for control of the distillation process. Server version of the system, intended for 100 work stations and distributed control system are used for the purpose.

2. UNISIM DESIGN SUITE R390 FEATURES [5, 6, 7, 8, 9]

The software packages of the family UniSim are:
UniSim Design Suite enables the steady-state simulation of oil and gas, refining, chemical, and other processes. The user is empowered to interactively make decisions by getting immediate responses to assumptions using a high-speed engine with backward calculation capabilities.
The UniSim Operations Suite, which provides highly accurate, multi-function dynamic simulation to improve operating capabilities and enhance staff skills.
The UniSim Optimization Suite, which ensures responsiveness to changes in business demands through close linkages with planning, scheduling and management functions.
Dynamic Engineering Studies Services helps you evaluate the impact of future process design changes prior to plant modifications.
UniSim Design offers a high degree of flexibility because there are multiple ways to accomplish specific tasks. This flexibility combined with a consistent and logical approach to how these capabilities are delivered makes UniSim Design an extremely versatile process simulation tool.

The intensive application of **UniSim Design** is due to four key aspects:
A. **Event driven operations -** This concept combines the power of interactive simulation with instantaneous access to information. Interactive simulation means the information is processed as it is supplied and calculations are performed automatically. Also, you are not restricted to the program location where the information is supplied.
B. **Module operations -** Modular Operations are combined with the Non-Sequential solution algorithm. Not only is information processed as it is supplied, but the results of any calculation are automatically produced throughout the flow sheet, both forwards and backwards. The modular structure of the operations means they can be calculated in either direction, using information in an outlet stream to calculate inlet conditions. Process understanding is gained at every step because the operations calculate automatically and results are seen immediately.
C. **Multi - flowsheet architecture.**
Multi-flowsheet architecture can be used to create any number of flowsheets within a simulation and to easily associate a fluid package with a defined group of unit operations.
D. **Object oriented design.**
The separation of interface elements (how the information appears) from the underlying engineering code means the same information appears simultaneously in a variety of locations. Each display is tied to the same process variable, so if the information changes, it automatically updates in every location. Also, if a variable is specified, then it is shown as a specification in every location. This means the specification can be changed wherever it appears and you are not restricted to a single location for making changes.

2.1. Interface Basics.

UniSim Design has the same basic features as found in other Windows 2000 or XP based programs: Minimize, Maximize/Restore and Close icons are located in the upper right corner of most views; Object icon, located in the upper left corner of most views, contains the normal MS Windows menu.

Primary Interface Elements
Although you can input and access information in a variety of ways, there are five primary interface elements for interacting with UniSim Design (Table No 1).
Table No 1.

Interface	Description

Element	
PFD	A view containing a graphical environment for building your flowsheet and examining process Connectivity. Process information can be displayed for each individual stream or operation as needed.
Workbook	A view containing a collection of tabs that displays information in a tabular format. Each Workbook tab displays information about a specific object type in varying levels of detail.
Property View	A single view that contains multiple tabs. UniSim Design extensively uses these single views, which include all information about a specific object - individual stream or operation.
Summary View	Displays the currently installed streams and operations.
Simulation and Navigation	A view that provides a single location for viewing all stream and unit operation property views in the simulation case, regardless of the flowsheet they exist in.

Each of these interface elements, plus the complimentary tools such as the Data Recorder, Strip Charts, Case Study Tool, Plots, etc., are all connected through the model itself. Changes made in any location are automatically reflected throughout UniSim Design. In addition, there are no restrictions as to what can be displayed at any time. For example, you can have the PFD and Workbook open, as well as property views for operations and streams.

2.2. Multi-Flowsheet Architecture/Environments.
UniSim Design is developed around a Multi-flowsheet Architecture. After creating the fluid package(s) for the simulation, the main flowsheet is entered. This is where the bulk of the model is created (where the streams and operations that represent the process are installed). Sub-flowsheets can also be created at any time within the main flowsheet. Sub-flowsheets appear as a single operation with multiple connections. The main simulation does not know what is inside the subflowsheet, meaning it could be a refrigeration loop or a decanter system. The sub-flowsheet is seen by UniSim Design as any other operation and it calculates whenever conditions are changed within it. So one can at any time, enter the sub-flowsheet to examine conditions in greater detail or make changes. The definition of a flowsheet (or sub-flowsheet) in the context of the overall program is defined by what it possesses: Independent fluid package (optional); PFD; Workbook; Flowsheet Elements (streams and/or operations); Solver.

2.3. Navigators.
All flowsheets in a simulation are connected as a whole by navigators: **Simulation Navigator; Object Navigator; Variable Navigator.**

2.4. Objects.
The term object is used extensively throughout the documentation to refer to an individual stream or operation. Within UniSim Design, information associated with an object can appear in a variety of ways (**Workbook, PFD, Property View, Plot**, etc.).

2.5. Structure Terminology.
UniSim Design cases include certain structure elements, for example: **Flowsheet Element (or Object); Flowsheet; Fluid Package; Simulation Case; Session - Сесия**.

Column operations and flowsheet templates are special Flowsheet Elements because they are also flowsheets. A flowsheet template can be a column sub-flowsheet or a more complex system.

The special capabilities of the column and flowsheet template are as follows: Contain their own flowsheet, meaning they possess their own PFD and Workbook; can be comprised of multiple flowsheet elements; can be retrieved as a complete entity into any other simulation case.

3. MODELLING AND CONTROL OF PROCESSES IN A DISTILLATION COLUMN SEPARATING MIXTURE WATER-ETHANOL

As an illustration for the opportunities for modeling and control of chemical plants using Unisim a column in the Tampere University of Technology (Finland) will be considered. It is designed for separation of a mixture containing 30 mass % ethanol and 70 % water. It should be noticed that at the temperature of 78.15 ºC this mixture forms aceothrop, which contains approximately 10.57 mole % water and 89.43 mole % ethanol. There are 12 bell type plates at the distance of 300 mm each. Their inside diameter is also 300 mm. The feed enters the column on the tray No 6, numbering from bottom to the top. The liquid mixture in the bottom is separated in two parts. One of them is going to the heater and enters back the column, and the second is separated as a bottom product. The vapour from the head of the column is liquefied in two condensers and flows to the accumulator vessel. Then two flows are formed – reflux and distillate. First is returned to the column on the upper tray and as it is super cooled the flow of the inner reflux is grater than the outer one [1, 3, 4].

3.1. Development of a column model using UniSim Design Suite R390. Steady-state model.
After **UniSim Design R390** is started and a new project is created an initial simulation manager appears. By its means a data base of measuring units for the project is created and modified. **UniSim** does not allow to change them, but they can be cloned or modified – fig. 1.
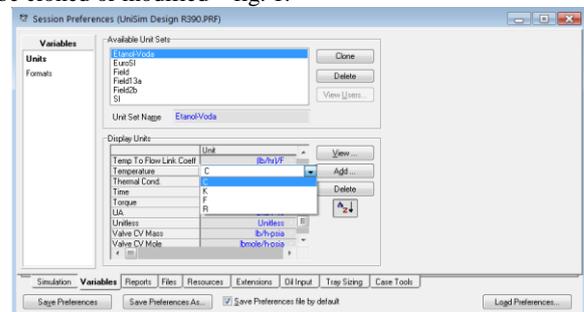

Fig.1. Measurement units data base cloning.

Creation of modeling environment.
Before a fluid package is defined, a list of the necessary components has to be defined. The list is added from the library for pure components. For the project it is necessary to add: H2O and Ethanol – fig. 2:
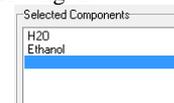

Fig. 2.

The fluid package comprises components and methods, which **UniSim** uses in the calculations for specific technological process. According the needs the package may contain additional information.

For this example of distillation the fluid package will contain so called property package - Wilson, in distinction from the one used in crude-oil distillation - Peng-Robinson, which is not recommended in the case of aceothrop (ethanol).

Simulation Environment of UniSim Design R390
The first task in the simulation environment is to add one or moor feeding streams. In this particular case there is only one feed to the column. To simplify the flowsheet some of the

preceding vessels as tanks, mixers, heaters are disregarded and only one stream with the requested parameters is defined. It is necessary to specify the temperature, the feed and the pressure of the stream. When this information is supplied, the rest of the parameters are calculated automatically by the software product, so the feed is completely defined – fig. 3.

UniSim Design allows adding, or removing different criteria for column calculations. Two specifications for the calculations and one for assessment are listed below:
- The temperature on the second tray should be 92ºC.
- The temperature on the eleventh tray should be 78,5ºC
- The concentration of the ethanol in the outgoing stream from the top should be 0,86 mass parts.
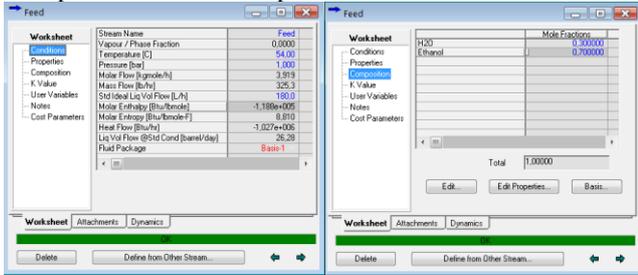

Fig. 3. A composition and condition of the feed.

The next step is to add the distillation column itself to the diagram of the process. There are several templates of the columns prepared in advance in the **UniSim Design**. It is possible to change the number of the trays, feeds, to add additional vessels, and also other parameters. To facilitate the process a **UniSim** assistant is created. It organizes the initial information for the column at several steps. At the beginning the ingoing and outgoing streams are defined as well as the number of the trays. On the next stage of the column design with the help of the assistant the profile of the pressure is specified. The third stage is for additional information for correct assessment. It is optional, but the disposal of this information has as a consequence faster achievement of exact results. At the last stage of the preliminary configuration the **Reflux Ratio** and the **Liquid Rate** can be set. After the process of the preliminary configuring is over the standard display of the column is represented – fig. 4.

Now processes in the column can be calculated. **UniSim** starts the computing and the information on the display is refreshed on every iteration. In the particular example the calculation are over after ten iterations.
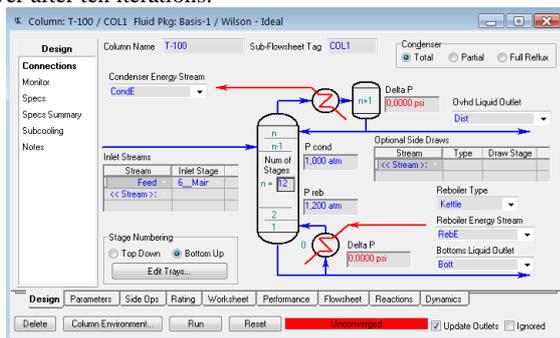

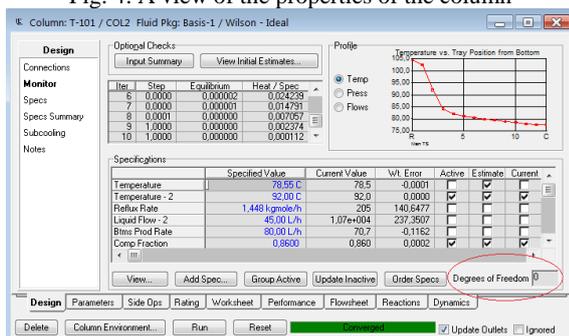Fig. 4. A view of the properties of the column

Fig. 5. Working environment of the column.

The display of the column comprising the temperature profile on the trays, the number of iterations necessary to gain the desired result, and the specifications needed for the calculations are depicted on fig. 5. There is an opportunity to observe the profile of the pressure and the streams on the trays as diagrams. Also the flows, temperatures and pressures may be seen in table form.

3.2. Modeling the dynamics in the column.
Before the dynamic simulation starts, it is necessary to add valves for the streams. There are two ways to do this:
- the connections of every stream are broken, a valve is added, the streams are connected with the valve, which afterwards is sized;
- the second simpler way is to use a dynamic assistant.

Defining the size of the column.
To make the transition to the dynamics the first step is to define the correct size of the column sections. A tool integrated in the **UniSim** is used for the purpose – fig. 7.
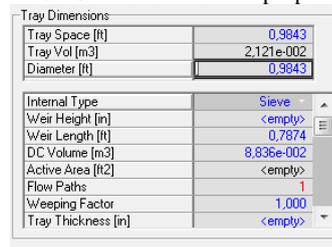

Fig. 7.

Adding controllers.
It is possible to add the controllers before or after the transition to the dynamic mode. The basic loops of the process are stabilized using PID controllers. The latter are not obligatory for the dynamic mode, but give to the model more realism. After inserting them to the graphics environment, from the view of the properties are set the parameters of the controller: the process variable, the output, the set point and their span. For the particular column controllers are added for: the level in the condenser, temperatures on the second and eleventh tray. As an example the parameters of the controller of the temperature on the 2 tray are: name of the loop - **Temp_Control_Tray_2;** Process variable – **PV** – the temperature on the second tray; output – the position of the valve; action - direct; Kc=1; Ti=10 min; span of the PV - min = 87 ºC ; max = 97 ºC ; set point = 92 ºC.

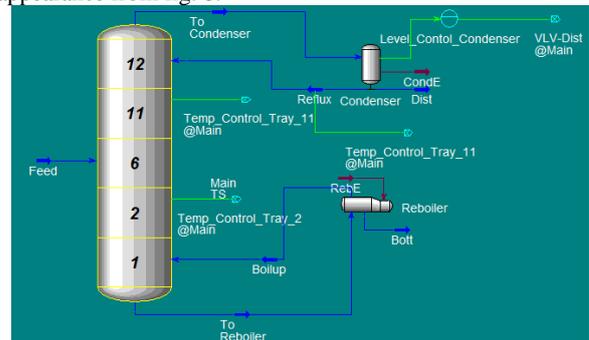After adding and tuning of the controllers the column has the appearance from fig. 8.

Fig. 8. Sub-flowsheet of the distillation column.

Visualization of the results in dynamics
After the model is prepared for dynamic simulation, graphics are added for visualization of the key variables. In this case these are the temperatures on 2 and 11 tray, compositions and flows of the streams of distillate and bottom product. A tool called Databook is used for the purpose. It offers the opportunity to observe in table and graphics form data during simulation, logging it etc. For better supervision three charts are chosen. Тхеъ ape called **Flow, Composition** and **Temperature** - fig. 9.
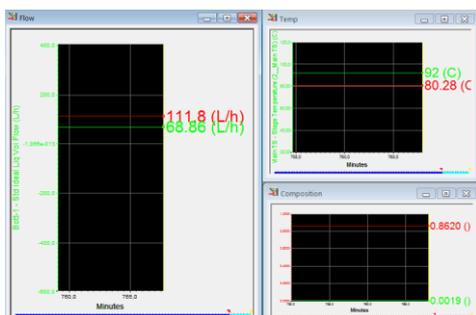
Fig. 9. Charts of the dynamics of the column.

4. NETWORK INSTALLATION OF THE UNISIM DESIGN SUITE IN THE DEPT. "AUTOMATION"

The network version of the Unisim Design Suite is installed on a server INTEL SR2500. Complex connections are realised for long distance access to the software as it is described in [2]. The server version is able to support up to 100 working stations.

5. ADDITIONAL EXTENSIONS

For the integration of the UniSim Design Suite R390 is a distributed control system comprising different controllers a software modulee named "xml2array", developed by Binny Abraham [10] is used. With its assistance the module "unisim2mysql" is realized using PHP. It transforms the exported from UniSim XML-files for the steady state and dynamics to Mysql data base (fig. 10). The latter is accessible through standard ODBC or WEB interface for programmable controllers (NETMASTER or MIC 5000 Ce) or WEB interface to Ignition through SQL Bridge module [11, 12]. Ignition by Inductive Automation is new generation of accessible, scalable, and datacentric Web-based HMI/SCADA/MES software. Ignition was designed from the ground up to be highly flexible and capable of scaling up to the largest projects. Ignition complies with the OPC and ODBC standards making it fully compatible with virtually all major PLCs and all major SQL databases. It supports native .NET database connectors as well, available for nearly all brands of database.

Fig. 10

6. CONCLUSION

An application of the software package UniSim Design Suite R390, used to simulate the processes in a distillation column is the object of this paper. As we mentioned above UniSim Design was chosen because of its flexibility. An advantage of the package is also the availability of many prepared models [6] that need only to be adapted for particular installations, for example: distillation of gases; crude oil distillation; a stripper for sore water; column for separation of propane/propylene, heating plants etc. That is why user guides in Bulgarian are prepared for some of them.

In addition the developed models except for simulation of the processes can be connected to PLC's by means of XML-files. So the applicability of complex algorithms and control strategies may be tested. This is the direction for the future usage of the UniSim Design in the dept "Automation" in the UCTM - Sofia. For the purpose the package is integrated in a SCADA system.

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