Control physical models

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Abstract: - This paper describes design of model physical model of rectification column. Physical model is appointed as a demonstration system control for distillation by means of control system SIMATIC PCS7 from company SIEMENS. The SIMATIC PCS7 Process control system assembles and elaborates all information which are coming from field instrumentation on the operation panel. The distillate cycle is a closed cycle. The distillate and the distillate rest are going back in to the vessel or raw material.

Key-Words: - distillation, process control system, physical model, description

1 Introduction

By planning of new production methods are at first made a verification by the laboratory conduction. Contemporary at verification using of technology is possible design and verify algorithms of control. Physical models are often simplified and reduced then real technological equipment. For conception idea, I use physical model of rectification column which is control by means of decentralize control system SIMATIC PCS7.

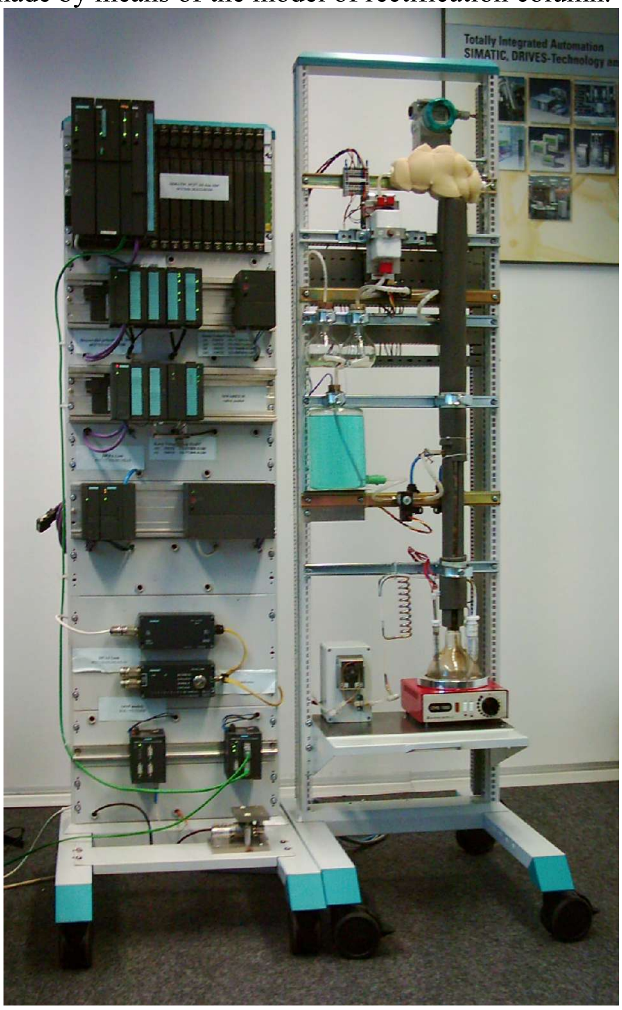
In this time of information technology is important interconnection of control system with heist lavels control company. Information about production situation, his quality and quantity is transfered in both direction up to level of plant management, which can make flexible decision about the strategy the hole company. Design of control and transmition dates should be made jet control system in this physical model.

2 Problem Formulation

At Modeling by means of physical model could happen the changes of using methods for the purpose of decreasing production price for the model. For example at chemical model we used instead steam heating one electric heating in other smallest dimensions and lowest prices in laboratory solutions. This changes, which are possible must not be change the substation of production procedure. The changes of used methods change part of control system, which controls physical model.

Procedure of the design and realizations of physical model is divided into some steps. The basic distribution of design of control system is made on the ground horizontal integration. The vertical integration is using for distribution dates from lowest levels to the higher level of controlling.

Design of control system and the using method I made by means of the model of rectification column.



2.1 Procedure of the design for controlling of physical model

At the proposal complex control system it is necessary to keep the horizontal and vertical integration. In course of time of the proposal is also necessary to make of dates, which shell be translated into higher levels of the control. The next step of control is to fix the technological fails. At the physical model could be also discussed with the question about complete automation of the plant. At this questions of complete automation must be considered three following time-sequential steps:

first loading time section
working operation
putting out of operation

Generally the first loading time section and the putting out of operation is made by the operators self.

2.2 Description of the physical model for rectification column.

The rectification process is namely multiple distillation process which has own special assembly of the internal part of the column. At the design of the rectification column must be the economic question take in to consideration. That means the consumption of electric energy.

On the Fig. 1 is the design of Control-Measuring assembly drawing. In this drawing are shown couplings about the control functions. The equation (1) describes the consolidated process situation by which no where to the heat storage and mass storage appear. The enthalpy balance question has number (3). The equation (2) describes the component balance for different components. The mass balance equation describes the separation of the distillated blend which consist of distillate and the residue. Enthalpy equations describes energy balance inside of the column.

$$\dot{m}_s = \dot{m}_d + \dot{m}_z [kg \cdot s^{-1}] \quad (1)$$

$$x_s \dot{m}_s = x_z \dot{m}_d + x_d \dot{m}_z \quad (2)$$

$$\dot{m}_s h_s + R \dot{m}_d h_d + \dot{Q} = \dot{Q}_{kond} + \dot{m}_z h_z + \dot{m}_d h_d + \dot{Q}_{ztr} \quad (3)$$

$\dot{m}_s$ - mess flow of the raw material $[kg \cdot s^{-1}]$
$\dot{m}_d$ - mess flow of the distillate $[kg \cdot s^{-1}]$
$\dot{m}_z$ - mess flow of the distillate rest $[kg \cdot s^{-1}]$
x_s - fraction meas flow of considered component [-]
x_d - fraction meas flow of considered component [-]
x_z - fraction meas flow of considered component [-]
h_s - specific enthalpy of row material $[J \cdot kg^{-1}]$
h_d - specific enthalpy of distillate $[J \cdot kg^{-1}]$
h_z - specific enthalpy of distillate rest $[J \cdot kg^{-1}]$
R - ratio of reflux [-]
$\dot{Q}$ - energy flow to the system $[J\, s^{-1}]$
$\dot{Q}_{kond}$ - energy flow for condensation of distillate $[J\, s^{-1}]$
$\dot{Q}_{ztr}$ - loss radiation energy flow $[J\, s^{-1}]$

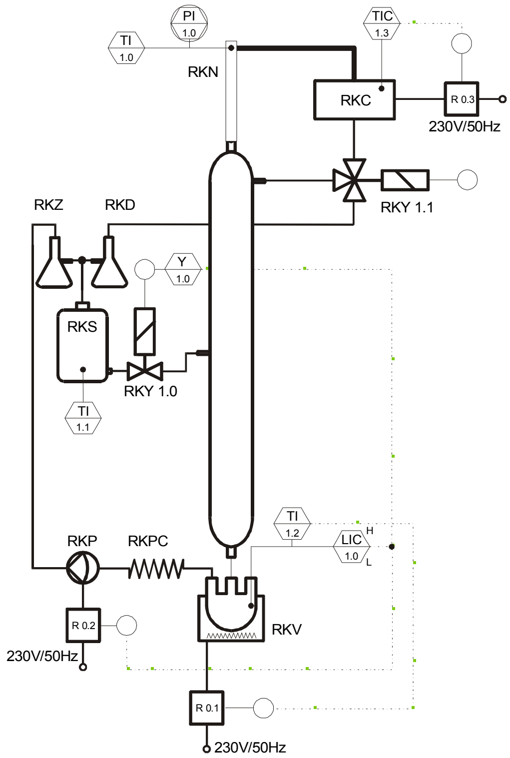


Fig. 1: Design of Control-Measuring

3 Problem Solution

At the project of the control system is necessary take into account the difference between physical model and the real technological equipment of the plant. Physical model is constructed with different components, for the purpose lower price and smaller dimensions, than real technological equipment. In case of physical model are used electrical devices for supplying of heat energy and for condensation.

3.1 Horizontal integration

In the point of horizontal integration the whole control system is could be divided in some levels. The first level, is very different from the technological equipment in the plant and physical model. To this level belongs control of power and measure devices. The own algorithms used for controlling actions are directly connected to actions members of the control loops. Technological fails are same for physical model and real technological equipment as next part of design of control system. In case of differences technological fails means change technological manufacture and physical model will be different from real technology. The level of acquisition dates and visualization are same for model and real technology. Higher level of control system for coordination of production is the same for both, that means for process equipment and physical model .

This concept of control system bring possibility for easy control and in the future could be done the modularity and increment and is also advantage for changes and combination more type of control systems.

3.2 Vertical integration

Vertical integration has a task to create signal transports from the lowest levels in the sphere of Supervisor Control System. This SCS has the commission which is called “Coordination of individual process equipments”. Some dates are transformed up to economic and strategic part of the hole factory which is called MIS (Management information system), MES (Management execution system), ERP (Enterprise resource planning).

3.3 Monitoring of defects

Each state of physical model and of own really technological equipment have conditions, witch must be strictly monitored. These states are traced by means of measured values. In the case that the measure value is different from required value and if this differents is undesirable, than appear signal witch notifies defect. If the value of this signal is critical, than the physical model must be stopped. From the theoretical point of view its very difficult to determine in advance all possible defects. On these grounds the stopping of the motion of the physical model decide the operator only.

3.4 Visualization

Visualization is higher level of horizontal integration than data acquisition. Visualization give to the operator all information about the state of process technology. In case of fails the operator is inform by means of this visualization.

3.5 View of physical model column

With regard to the horizontal integration the column is equipt with RTD-temperature transmitter, witch are located in the lowest part of the column, in the cooler, in the vessel for entrance the crude liquid and in the column head. In the view on the vertical integration transfer dates to the supervise systems is not made, but we can divide the whole model in too some controlled circuits, which can be by means of supervise algorithms connected i other to the control of the whole column optimized can be Configuration of control system of rectification column is illustrated on the Fig. 2.

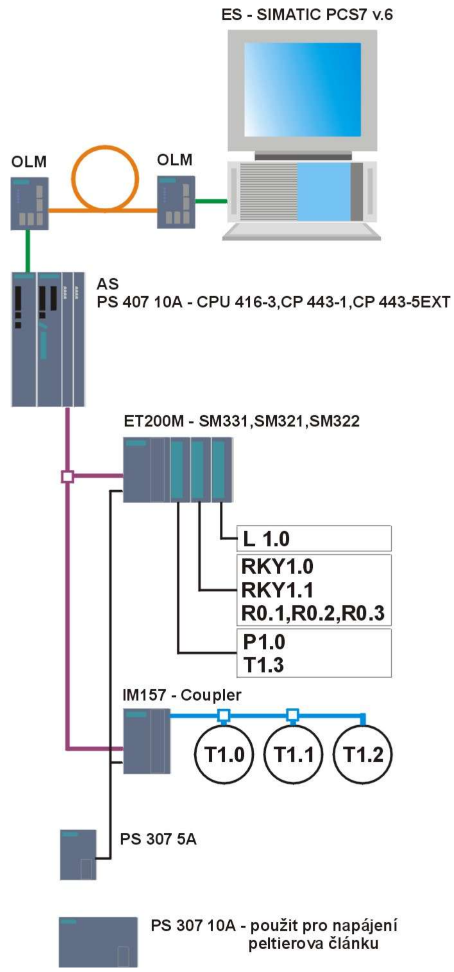


Fig. 2: Control system of rectification column.

Control we can separate on the part of measuring of temperature in lowest part of the column, which is control by energy supply to the heating system located in to the lowest part of the column (RKV). The second control circuit is energy supply to the peltiér system, on ground temperature in cooler system (RKC) made by means of this peltier system. The third control circuit is control level of distillate rest at the lowest part of the column. Distillate rest is transfers by means of pump (RKP). Measure temperature in the head of the column is informative only and its value depends on the quantity and temperature of the reflux and steam from heating system.

3.5.1. Separation of the process control

The process of the physical model is divided in three sections. First loading time section mads change from still state in to the working operation. Working operation is state own distillation. Putting out of operation is state change from working operation to still state. For the putting out of operating is coming at the technological fails or stopping during of the operation. At the first loading time sections and at the stopping of the column is created the most fall, which has not required quality of product. This states should be very short.

The supervising algorithms can on the ground of gained dates from control circuits make the optimization of first loading time and putting out of operating.

3.5.2. The failures in technology

At the physical model of rectification column is possible identify the technological fails on ground limits of measure values of the temperature and level liquid. In the case of temperature change in the column head is necessary model stop. This temperature is important value from the point of quality view.

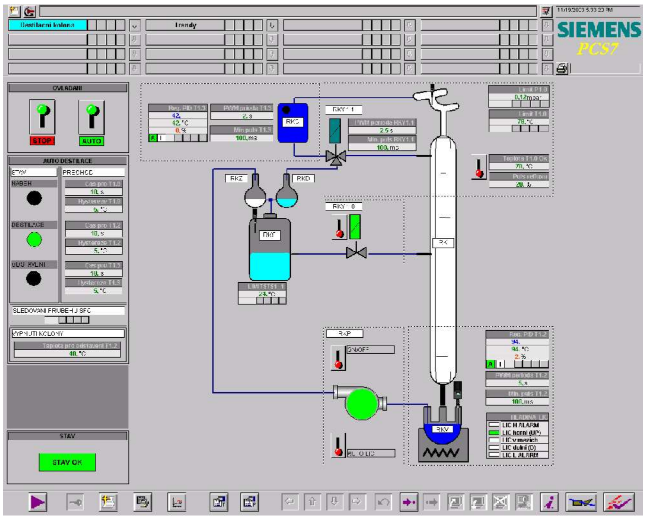


Fig. 3: Visualization

3.5.3. Visualization

Visualization Fig.3. physical model of the rectification model was created in the WinCC, witch is part of SIEMENS SIMATIC PCS7. Visualization contains screen of own model with information of measured values, screen witch is used for history, fails report and operator action.

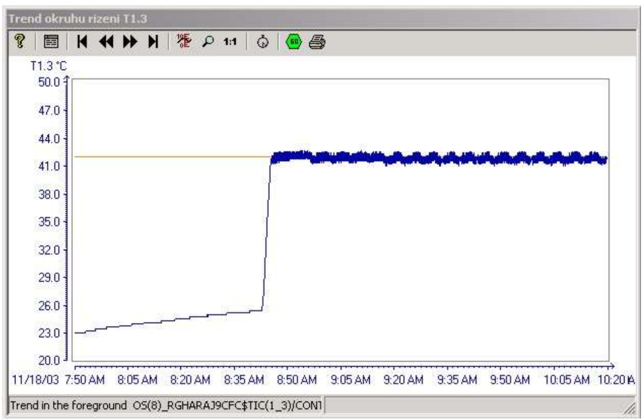


Fig. 4: Temperature of the cooler

3.5.4.Results of the control circuits

On the a Fig. 4, 5, 6, 7 are results from control circuits. Small oscillations on the still value are created on the ground discontinual control of the level in lowers part of the column which is made on max. and on min. limits. This fenomen can be made of by means of level measurement and of stabilization of this level.

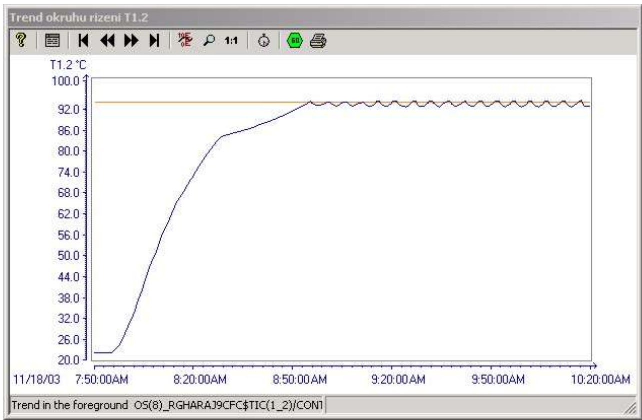


Fig. 5: Temperature in the lowest part of the column

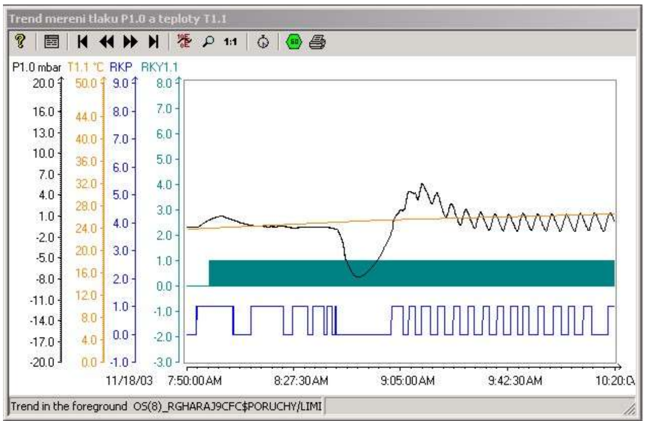


Fig. 6: Pressure in the column head, temperature of the raw material, start up of the pump, control of the valve for reflux.

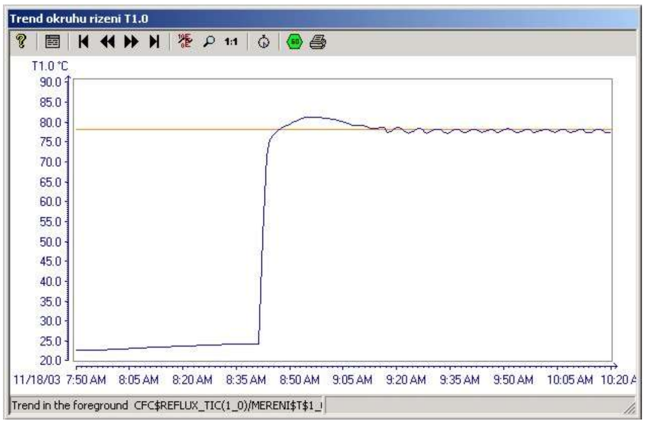


Fig. 7: Temperature in the column head

This solution is expensive in ground of high prices of the ultrasonic sensors which are used for measure small levels.

4 Conclusion

In this conclusions I would like to represent results of the quality destilated raw material. For the row material was used concentration 30% technical ethanol. The results destilate, destilate rest and own raw material had been analyzed and the results are at the Tab. 1.

Name	*Density [kg/m3]*	*%mass ethanol*	*%val. ethanol*
Destilate	0,82	89,2	92,7
Raw material	0,96	26,2	31,8
Destilate rest	0,99	2,3	3

Tab. 1: Results

The cleanness of technical ethanol was bean authorized by means chromatographycal method, results of this method is at the tab. 2,3,4

RT	*AREA*	*AMOUNT**	*AMOUNT*	*NAME*
-	-	0,000	0,0000	ETHER
2,56	2265	0,087	0,1733	ACETALDEHYD
2,93	339	0,004	0,0083	ACETON
-	-	0,000	0,0000	OCTAN ETHYLNATY
3,38	3691	0,049	0,0971	TBA
3,78	6979597	99,443	1,99E+002	ETHANOL
4,67	529	0,005	0,1001	SBA
5,03	10222	0,092	0,1830	N-PROPANOL
-	-	0,000	-	IBA
8,94	34087	0,321	0,6410	NBA
Total area = 7032842				

Tab. 2: Raw material

RT	*AREA*	*AMOUNT**	*AMOUNT*	*NAME*
-	-	0,000	0,0000	ETHER
2,56	12216	0,085	0,1685	ACETALDEHYD
2,93	3225	0,007	0,0141	ACETON
-	-	0,000	0,0000	OCTAN ETHYLNATY
3,38	21584	0,052	0,1023	TBA
3,89	38699072	99,375	1,98E+002	ETHANOL
4,68	3830	0,007	0,0132	SBA
5,04	67995	0,110	0,2198	N-PROPANOL
-	-	0,000	-	IBA
8,84	213261	0,365	0,7231	NBA
Total area = 3,90212E+07				

Tab. 3: Distillate

RT	*AREA*	*AMOUNT**	*AMOUNT*	*NAME*
-	-	0,000	0,0000	ETHER
2,56	357	0,036	0,0713	ACETALDEHYD
-	-	0,000	0,0000	ACETON
-	-	0,000	0,0000	OCTAN ETHYLNATY
3,38	417	0,014	0,0286	TBA
3,74	2685698	99,919	1,99E+002	ETHANOL
-	-	0,000	0,1001	SBA
5,03	1340	0,031	0,0627	N-PROPANOL
-	-	0,000	0,0000	IBA
-	-	0,000	0,0000	NBA
Total area = 7032842				

Tab. 4: Distillate rest

The next possible solution of this problem is in the optimization all the process destilation.

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