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DEVELOPMENT OF A PROCESS AUTOMATION SYSTEM FOR HEATING, VENTILATION AND AIR CONDITIONING FOR THE FOOD INDUSTRY ON THE BASIS OF HONEYWELL EQUIPMENT

Abstract

Currently, the development of industrial automation makes it possible to implement high-precision control systems that consider the dynamic properties of complex objects. The construction of distributed control systems based on modern software products provides decentralized management of technological processes. The modernization of existing control systems with the help of modern industrial equipment makes it possible to increase the productivity of enterprises and safety at work. This study is devoted to the development of an automated control system for heating, ventilation, and air conditioning processes for the food industry. In this study, a heat exchanger was selected as the control object. A mathematical model of the control object for stability, controllability, and observability was investigated. A PID regulator was synthesized, and its coefficients of the PID regulator were obtained. A comparative analysis of the behavior of the system dynamics at different regulator coefficients was carried out. The results of the modeling and experiments were carried out using real industrial equipment at the Honeywell laboratory at JSC KBTU. Software implementation was carried out using the Experion PKS distributed control system. The configuration of the C300 controller is presented. A Safety Instrumented System (SIS) was developed for the safe and trouble-free operation of the system. SIS was also developed using the Safety Manager and Safety Controller tools. Risk reduction factors (RRF) and Safety Integrity Level (SIL) were calculated and analyzed. A process-controlled mnemonic was developed.

Key words: Heating, ventilation, and air conditioning, food industry, manufacturing, programmable logic controller, complex object.

Introduction

It is crucial to understand the effects of condensation on food-processing plants before delving into remedies. Surfaces, equipment, and even air handling systems can experience condensation. Increased moisture encourages the development of bacteria, moulds, and fungi, which can taint food and harm human health. The slippery conditions for plant employees can result from condensation on floors and other surfaces.

Dehumidification systems play a vital role in mitigating excess moisture, averting condensation-related issues, and maintaining optimal humidity. These systems function by directing air through a cooling coil to extract moisture, thereby creating a dry, conducive environment.

The conditions found in food processing plants are notoriously complicated, involving a wide range of machinery and equipment that must operate at various temperatures and humidity levels. Condensation is one of the major problems faced by these facilities. Significant problems such as mould growth, contamination, and equipment malfunction can result from condensation formation.

Investing in efficient HVAC systems yields various benefits including enhanced product quality, regulatory compliance, energy conservation, and improved worker comfort and safety. This translates into extended shelf life for food products, adherence to industry regulations, reduced energy consumption, operational cost savings, and a safer working environment. Effective management of condensation-related challenges in food processing facilities necessitates the implementation of expert HVAC strategies. By prioritizing elements such as systematic system design, incorporation of dehumidification systems, insulation practices, and implementation of routine maintenance, food processing establishments can ensure a secure and optimal working environment. Investment in efficient HVAC systems not only safeguards product quality, but also guarantees compliance with industry standards while simultaneously reducing energy consumption and operational costs.

Literature Review

In the modern world, it is important to design modern systems for the automatic regulation of air ventilation across diverse production environments. However, in the course of development, novice specialists may encounter confusion when confronted with terms such as Air Handling Unit (AHU) and Heating, Ventilation, and Air Conditioning (HVAC), leading to uncertainty regarding their distinctions. In [1], the authors indicated that there is no difference between HVAC and AHU, as AHU is a subsection of the HVAC system, where the main focus is on the movement of air around the room. For any HVAC system, there are four basic requirements: primary equipment, space requirements, air distribution, and piping. Each of these requirements was discussed in the research [2]. Modern hardware and software tools are widely used for HVAC systems. Various solutions have been offered for the creation of HVAC systems. In particular, a study on automated design for HVAC layouts [3] proposed a new methodology for an algorithmic method that fully automates the HVAC air system's air duct design, selection, and hydraulic computation. This study presents a strategy that can increase designer productivity, reduce human error in design, and provide code-compliant air duct designs. Additionally, [4] examined the basic concepts of HVAC and its components, which provide the necessary means to maintain indoor environments at comfort levels according to American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards, including temperature, humidity, and air quality measurements. It examines how the standards are supported by regulating the amount of clean air and heat supplied to the heaters and removed from coolers. The authors of [5] discussed the importance of monitoring the internal HVAC environment (temperature, humidity, and wind speed) to determine optimal control. In addition, evidence that operating conditions are important for humidifier performance was found in [6], and a parameterization and optimization study of a new drying system consisting of a large solid binderless humidifier with water cooling and heating devices was explored.

Paper [7] showed that many HVAC systems in existing buildings use high energy, with older buildings being particularly affected. To reduce energy consumption in the building sector, it is important to prioritize upgrading the HVAC systems in existing buildings. Some research [8] examined recent research in the HVAC sector to improve system efficiency and provide occupants with more thermal comfort in climate-controlled interior spaces. A recent study on thermal modelling [9] underscored the pivotal role of HVAC systems in humidity and temperature control to ensure production quality in manufacturing processes. Despite the relatively stable energy consumption of the machinery sector, escalating production demands necessitate a strategic focus on energy-efficient management, with HVAC systems identified as a key area for potential energy reduction. Another study [10] highlighted the effectiveness of asynchronous optimization in coordinating manufacturing and HVAC schedules, achieving a notable 15.1% reduction in peak energy demand without compromising manufacturing productivity. This innovative approach presents an energy-efficient management methodology for manufacturing facilities. The developed model demonstrated a high level of accuracy, with 96.5% precision in predicting energy consumption and the ability to accurately identify patterns in energy profiles. Additionally, a study on energy dynamics in hotter regions [11] provides an overview of the energy dynamics in tropical insular regions. This paper argues that the abundant renewable resources in these areas make them suitable for smart microgrids and energy storage technologies, with a notable 40% of energy consumption dedicated to space cooling owing to consistently high temperatures.

However, this is not the only problem. Paper [12] pointed out that desiccant regeneration is only 28.2%, and that there are significant heat losses when utilizing a conventional system with an adsorption drier. Heat loss was minimized in this study by directly heating the adsorbents through the unique electrothermal adsorption of the installation. According to an article [13], solid desiccants are economical, have a high rate of moisture removal, as well as a low regeneration temperature and stability, which makes the dehumidification process environmentally friendly and effective in all senses. There are other types of air conditioning systems. One such type is the goal of this study [14]. This study evaluated the performance of vapor compression refrigeration installations and developed a prototype dehumidifier based on it. Vapor-compression refrigeration, also known as a vapor-compression refrigeration system (CRS), is a refrigeration cycle in which the refrigerant changes phases. It is the most popular type of air-conditioning system in buildings.

HVAC systems are an important aspect of the food industry. Any errors in the system can have severe consequences. The authors of [15] made recommendations to improve the existing systems in the food industry. For example, in rooms with significant heat emissions, the air supply to the work area should be provided by standard air diffusers, emissions from the upper areas should be concentrated, and drying sections should be provided with local exhaust air conditioning. Moreover, a review of the relationship between HVAC systems and the Coronavirus disease (COVID-19) pandemic [16] emphasizes the need to update crucial components in air conditioning systems to mitigate virus transmission risks.

Some studies have proposed methods that use artificial intelligence and machine learning. For instance, a study on high-temperature generators [17] sought to use AI approaches to analytically depict the absorption chiller performance while accounting for solar intermittency, whereas some [18] investigated various HVAC and weather combinations using fuzzy-based approaches and Building Information Modelling (BIM) to reduce uncertain variables. Additionally, a review on natural ventilation [19] explored approaches for validating Computational Fluid Dynamics models and investigating the natural ventilation of large air masses, while others [20] proposed a domain-specific technique that can operate HVAC systems while adapting to changes in the building environment.

By optimizing energy efficiency in manufacturing processes to address challenges in existing buildings, studies emphasize the need for continuous advancements and innovative solutions in the field.

Statement of the problem is to develop a ventilation system that maintains a certain temperature and humidity in the food production sector using Honeywell equipment.

Main provision

Before understanding dehumidification, it is crucial to understand the basics of psychometrics, that is, the study of the properties of air and how they relate to human comfort and HVAC processes. Psychrometric charts are valuable tools for HVAC engineers to assess air conditions including temperature, humidity, and enthalpy.

The primary principle behind dehumidification is cooling the air below its dew point temperature. When the air is cooled, it reaches its dew point, causing moisture to condense into liquid water. This condensed moisture was then collected and drained away, leaving air with reduced humidity levels.

Temperature control via an HVAC system can be achieved in two ways. The first method is Air Heating. The HVAC heating unit should be turned on if air heating is required. Electronic heating components are used in the heating function of the HVAC system. The heating element may be a thermostat, induction coil, electronic heater, etc. In the route of the suction air, the heating element creates a heated zone; when the air flows through the heated region, it heats. In this manner, warm air was introduced into the space. The second method is Air Cooling. The cooling unit was turned on to chill the air. Air is carried via a coil, which is a component of the heat exchanger, in the cooling unit. The heat exchangers may be of the cross-flow coil or shell and tube type. The refrigerant in the exchanger unit expels heat from the suction air, and only the cooled air is introduced into the space. The compressor that liquefies the refrigerant is built into cooling units.

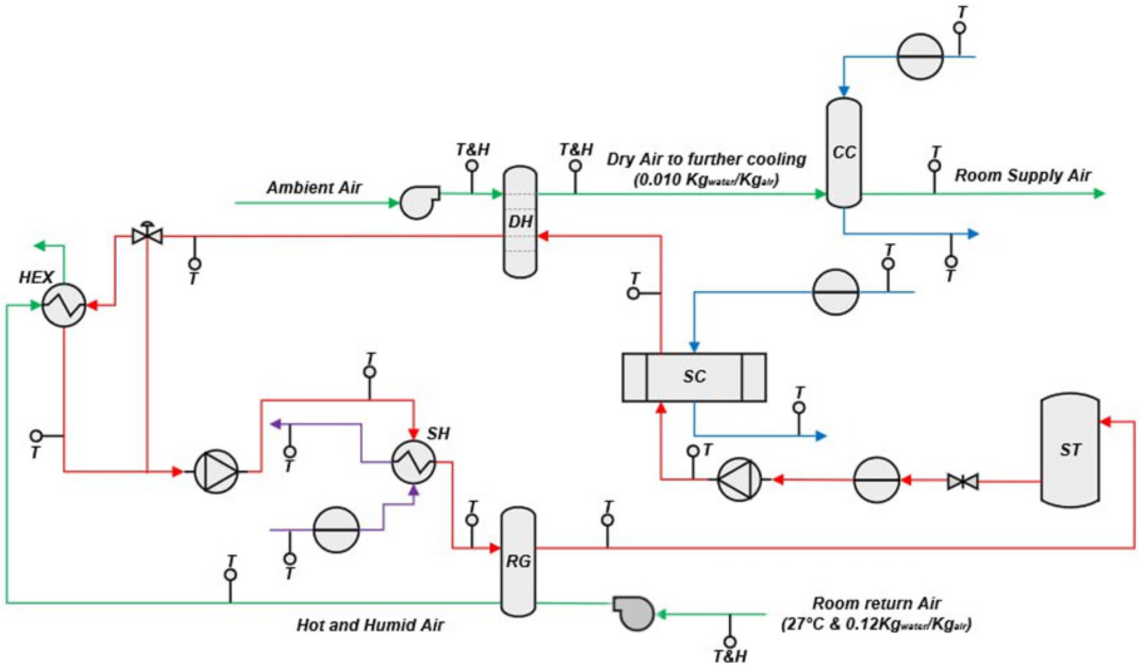

Figure 1 – Structural scheme of the dehumidification process

For a better understanding, the following symbols of the liquid desiccant air conditioning system coupled to the chiller technological process diagram are used: HEX – air solution heat exchanger; SH – solution heater; DH – dehumidifier; RG – regenerator; SC – solution cooler; CC – cooling coil; ST – solution storage tank.

Description of technological process

Air conditioners function by taking heat from the surrounding air and releasing it from the space. This produces cool air that is subsequently circulated around the space, ultimately chilling it. The heat exchanger oversees this function, and the effectiveness of the AC component defines the cooling capability of the unit.

A heat exchanger is a device that transfers heat between two fluids, without mixing them. The dynamics of a heat exchanger depend on many factors, such as the temperature difference, heat transfer area, flow rate of fluids, and flow patterns. Heat exchangers are widely used in a variety of sectors, including petroleum, food, petrochemicals, power generation, nuclear energy, and spacecraft.

Shell and tube heat exchangers are arguably the most popular forms of heat exchangers that can operate over a wide range of temperatures and pressures. It offers a higher surface-to-volume ratio than double-pipe heat exchangers and is simple to construct for a wide range of sizes and configurations. The shell and tube heat exchanger can withstand high pressures, and its design allows easy disassembly for routine maintenance and cleaning. A shell-and-tube heat exchanger is a variation of the double-pipe design. A shell-and-tube heat exchanger, as opposed to a single pipe within a larger pipe, is composed of a bundle of pipes or tubes contained within a cylindrical shell. In a shell-and-tube heat exchanger, one fluid flows through the tubes, whereas another fluid flows through the shell. One fluid passed through the tubes, and a second fluid flowed between the tubes and shell in the shell and tube heat exchanger.

The role of HVAC systems is undeniable and pivotal in the field of food processing. These systems not only provide the essential environmental conditions necessary for food safety and quality but also contribute significantly to energy efficiency and overall operational sustainability.

The HVAC systems in food processing facilities maintain precise temperature and humidity levels, thereby ensuring that food products are stored, processed, and preserved under optimal conditions. This is critical for preventing spoilage, extending the shelf life, and adhering to strict industry regulations and standards.

Materials and Methods

Mathematical modelling is a fundamental part in implementation of serious control processes, especially in analysis and design stages, and results of such a model are present through the whole development of the project.

In constructing a mathematical model [21], the system's behaviour and characteristics are studied and represented using mathematical equations, particularly it is described with differential equations. In this document a control plant, specifically, a heat exchanger is considered. Heat and mass transfer processes in the heat exchanger are described using a set of nonlinear equations:

$$G_{oil}\rho_{oil}C_{oil}(T_{oil}-T_{oil.in})+m_{oil}C_{oil}\frac{dT_{oil}}{dt}+\alpha_{oil}F_{ins}\left(T_{oil}-T_{pipe}\right)=0 \quad (1)$$

$$m_{pipe}C_{pipe}\frac{dT_{pipe}}{dt}-\alpha_{oil}F_{ins}\left(T_{pipe}-T_{air}\right)=0 \quad (2)$$

$$G_{air}\rho_{air}C_{air}(T_{air}-T_{air.in})=\alpha_{air}F_{ex}\left(T_{pipe}-T_{air}\right) \quad (3)$$

The parameters used in the equations are described in the Table 1.

Table 1 – Parameters of the equation

Parameter	Description
1	2
G_{oil}	volumetric flow rates of oil
G_{air}	volumetric flow rates of air
ρ_{oil}	densities of oil
ρ_{air}	densities of air
C_{oil}	heat capacities of oil
C_{air}	heat capacities of air
m_{oil}	mass of oil
m_{air}	mass of pipe
α_{oil}	heat transfer coefficient from the oil to the tube wall of the heat exchanger

Continuation of table 1

1	2
α_{air}	heat transfer coefficient from the tube wall of the heat exchanger to air
F_{ins}	internal heat exchange areas
F_{ex}	external heat exchange areas
T_{oil}	average value of oil temperatures at the outlet of the air-cooling device
T_{air}	average value of air temperatures at the outlet of the air-cooling device
$T_{oil.in}$	average value of oil temperatures at the inlet of the air-cooling device
$T_{air.in}$	average value of air temperatures at the inlet of the air-cooling device
T_{pipe}	average temperature of the pipe
t	time

The first and third equations in the system represent the conservation of power for the heat flows of oil and air, respectively. The second equation is a heat balance, accounting for the heat supplied to the tube, heat given to the air, and heat accumulated in the heat exchanger material. In the oil air cooler, the input control is the volumetric air flow rate, controlled by the average oil temperature at the heat exchanger outlet. Perturbing factors include changes in the oil temperature and air temperature at the inlet of the air-cooling device, as well as variations in the volumetric oil flow rate.

Equation system demonstrates that the heat exchange process in the oil air cooler is a nonlinear control object. Nonlinearity primarily arises from the multiplication of variables such as G_{oil} and G_{air}, as well as T_{oil} and T_{air}.

A linearized system of equations describing the dynamics of the heat exchange process in the air-cooling device is obtained by transitioning in equation to increments, breaking down the primary nonlinearities using a Taylor series expansion, and limiting the expansion to the first terms:

$$(m_{oil}C_{oil}p + G_{oil}\rho_{oil}C_{oil} + \alpha_{oil}F_{ins})\Delta T_{oil} - \alpha_{oil}F_{ins}\Delta T_{pipe} = 0 \tag{4}$$

$$(m_{pipe}C_{pipe}p + \alpha_{oil}F_{ins})\Delta T_{pipe} - \alpha_{oil}F_{ins}\Delta T_{oil} + \alpha_{air}F_{ex}\Delta T_{pipe} - \alpha_{air}F_{ex}\Delta T_{ex} = 0 \tag{5}$$

$$\rho_{air}C_{air}(T_{air0} - T_{air.in0})\Delta G_{air} + (G_{air0}\rho_{air}C_{air} + \alpha_{air}F_{ex})\Delta T_{ex} = \\ = \alpha_{air}F_{ex}\Delta T_{pipe} \tag{6}$$

These calculations are useful when it comes to Laplace method by marking $T_{oil}(p) = L\{\Delta T_{oil}\}, G_{air}(p) = L\{\Delta G_{air}\}$, we will find the transfer function of the heat exchange process concerning the control input:

$$W_{air2}(p) = \frac{T_{oil}(p)}{T_{air.in}(p)} = \frac{k_{air2}}{a_0p^2 + a_1p + 1} \tag{7}$$

Where k_{air2} is represented as below:

$$k_{air2} = \frac{\dfrac{\alpha_{oil}F_{ins}\alpha_{air}F_{ex}G_{air0}\rho_{air}C_{air}}{G_{air0}\rho_{air}C_{air} + \alpha_{air}F_{ex}}}{(G_{oil}\rho_{oil}C_{oil} + \alpha_{oil}F_{ins})\left(\alpha_{oil}F_{ins} + \alpha_{air}F_{ex} - \dfrac{\alpha_{air}^2F_{ex}^2}{G_{air0}\rho_{air}C_{air} + \alpha_{air}F_{ex}}\right) - a_{oil}^2F_{ins}^2} \tag{8}$$

Indeed, for an oil air cooler with the following parameters of those represented in Table 2 below.

Table 2 – Values of the parameters

Parameter	Value
G_{air0}	$13.6m^3/s$
G_{oil}	$0.0166m^3/s$
ρ_{oil}	$843kg/m^3$
ρ_{air}	$1.1839kg/m^3$
C_{oil}	$1670J/kgK$
C_{pipe}	$460J/kgK$
C_{air}	$1005J/kgK$
m_{oil}	$434kg$
m_{pipe}	$1215kg$
α_{oil}	$286W/m^2K$
α_{air}	$11W/m^2K$
T_{air0}	$36.83^\circ C$
$T_{air.in0}$	$25^\circ C$
F_{in}	$144m^2$
F_{ex}	$1135m^2$

The transfer function will take the following form:

$$W_y(p) = -\frac{0{,}1781}{286{,}0733p^2+50{,}1418p+1} \quad (9)$$

According to the results of the Routh-Hurwitz analysis shown in Table 3, the system is stable.

Table 3 – Routh-Hurwitz table of the system

s2	286.1	1
s1	50.14	0
s0	1	0

From the calculations, it was concluded that the PID coefficients were as follows: P = 9.4737; I = 0.32842; D = 32.1799. Figure 2 (p. 35) shows the difference in the step response, comparing controller usage with modified parameters.

Through the mathematical model, an optimization of the design and operation of the heat exchanger has been made possible, with factors such as fluid flow rates, heat transfer coefficients, and material properties being considered. This optimization can lead to significant energy savings, decreased operational costs, and enhanced overall performance of HVAC systems.

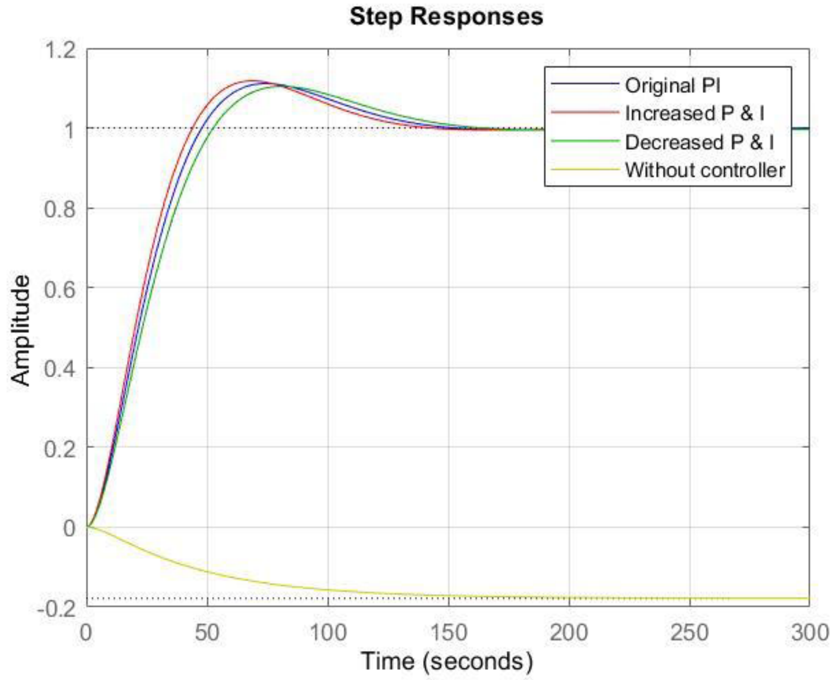

Figure 2 – Plot of the modified step response

Results and Discussion

The experiment was conducted at the Honeywell Laboratory at the Kazakh-British Technical University, as shown in Figure 3.

Figure 3 – Laboratory «Honeywell», C300 controller and Safety Manager

1. C300 controller configuration and HMI realization

For this system, a Honeywell C300 controller was programmed. The logic of fan control module code can be seen in Figure 4 (p. 36)

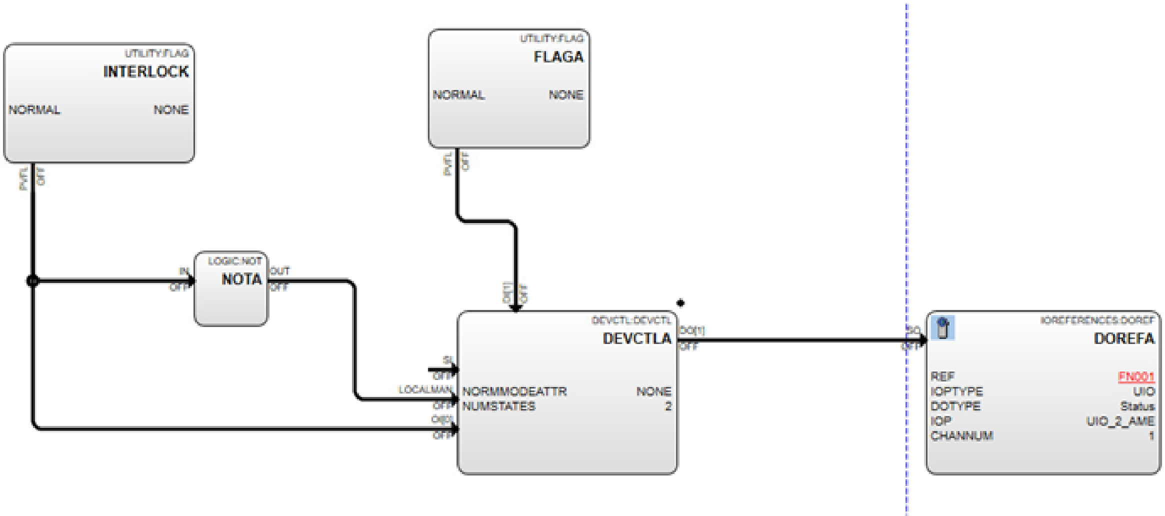

Figure 4 – Fan control module logic

The HMI panel in the HMI Web Display Builder is depicted in Figure 5, showcasing the process of air and desiccant solution flow through the regenerator, solution heater, and heat exchanger, as well as auto and manual modes and tabs for trend representation of the tuned parameters. The figure displays the outcomes of the PID controller implemented through a digital signal processing device, the coefficients of which were equal to those of the mathematical model.

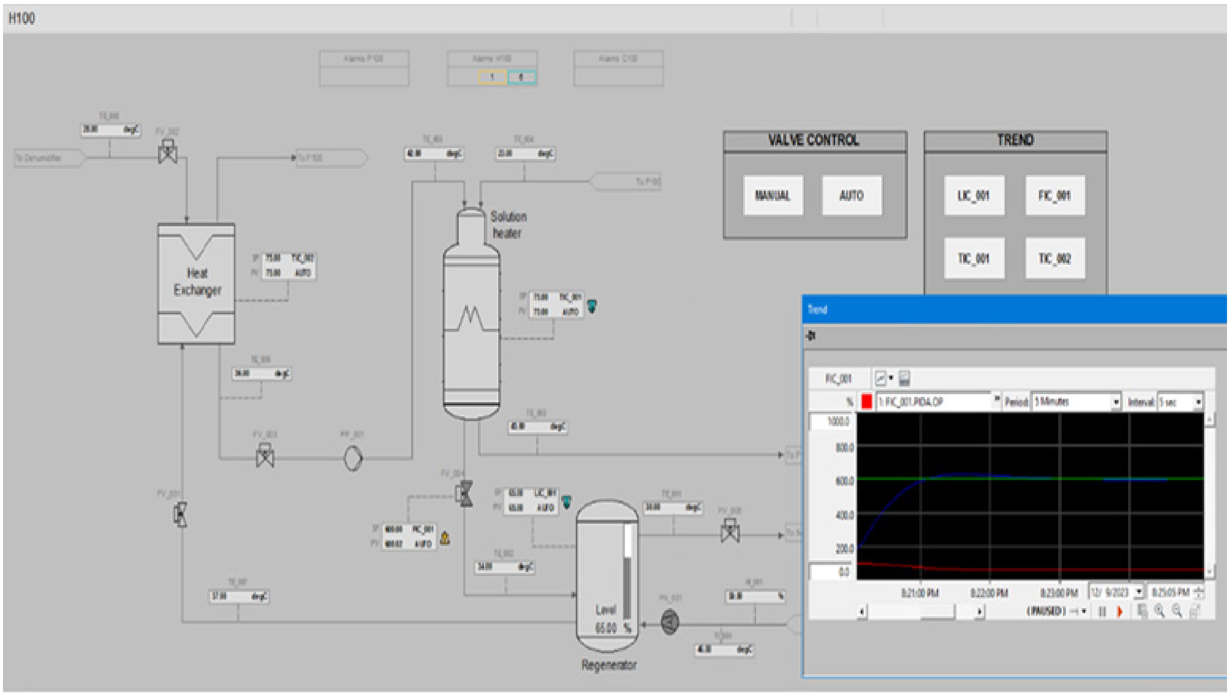

Figure 5 – HMI display with a dynamic trend for PID tuning

2 Safety System realization

The Safety Manager, a second-generation safety platform, adopts the Quadruple Modular Redundant (QMR) architecture seen in its earlier predecessors. Operating on a fully redundant

(2oo4D) architecture, Safety Manager seamlessly integrates process safety data, applications, system diagnostics, and critical control strategies. It executes SIL-defined safety application logic, ensuring a robust safety framework.

Figure 6 below presents the structural diagram of the safety function implementation on the control object with additional valves.

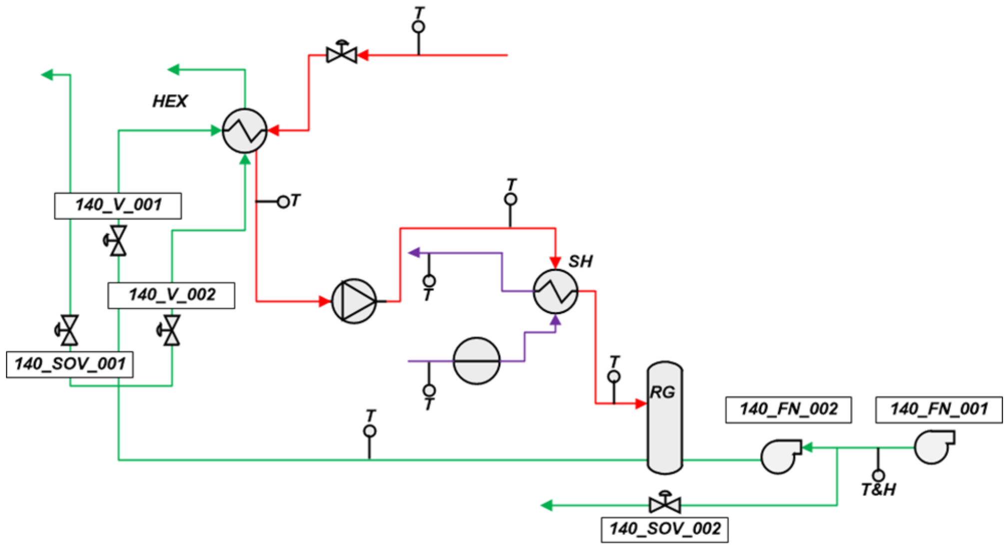

Figure 6 – Structural scheme of the safety function

Calculating RRF is necessary to determine SIL. RRF is a measure of the effectiveness of a risk mitigation or control measure in reducing the risk of a particular event or outcome. Using the created Fault Tree Analysis (FTA) diagram RRF can be calculated by formulas. In this process RRF = 11.327. After that, we can measure the SIL, which is used to quantify the level of risk reduction required to achieve an acceptable level of safety. The higher the SIL, the greater the required risk reduction.

Table 4 – SIL Determination

Safety Integrity Level (SIL)	Probability of Failure on Demand (PFD)	Safety Availability (1 – PFD)	Risk Reduction Factor (1/PFD)
4	0.0001 – 0.00001	99.99 – 99.999%	10000 – 100000
3	0.001 – 0.0001	99.9 – 99.99%	1000 – 10000
2	.01 – .001	99 – 99.9%	100 – 1000
1	0.1 – 0.01	90 – 99%	10 – 100

In this analysis, SIL 1 emerged as the most appropriate level to achieve an acceptable balance between risk reduction and the associated costs and complexities of safety measures. The determination of SIL 1 reflects a nuanced consideration of the specific context, aiming to implement effective safety measures without unnecessary over-engineering. This decision aligns with the overall goal of maintaining a safe and reliable system while optimizing resources and ensuring a pragmatic approach to functional safety.

Figure 7 (p. 38) shows how the safety function that is connected to Control Builder works.

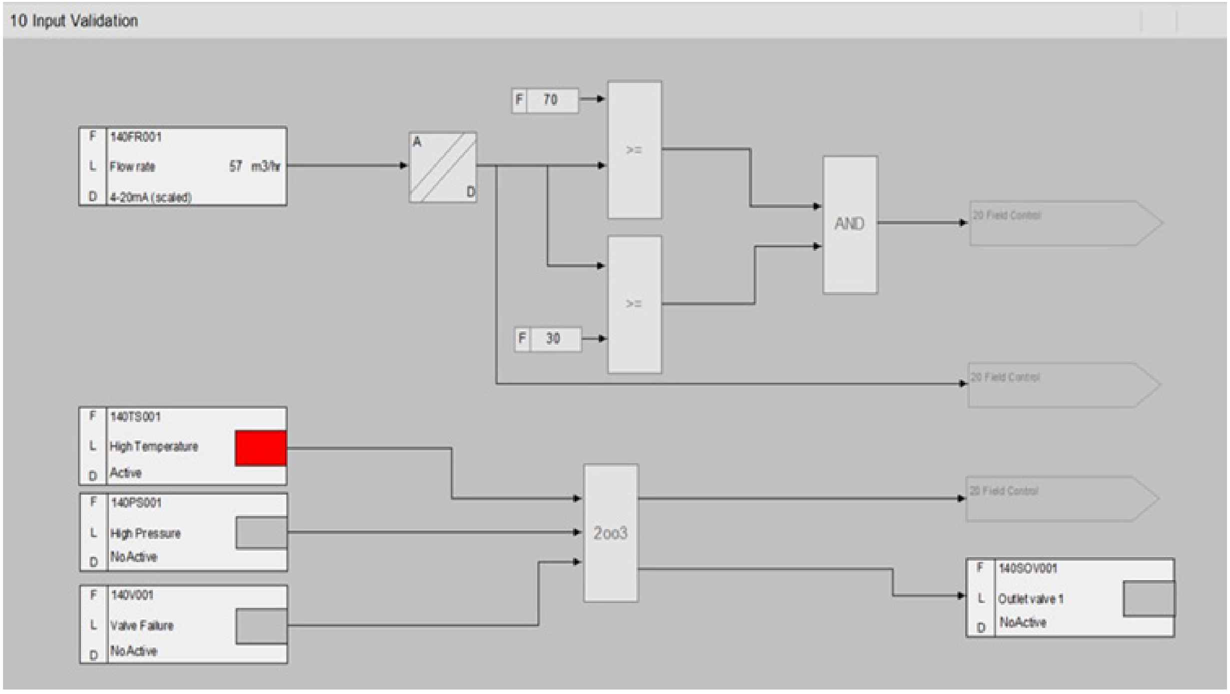

Figure 7 – Simulation of the safety function in HMI

The implementation of the program on the Honeywell Experion Process Knowledge System (PKS) has proven to be a pivotal step in enhancing control and automation within the system. Leveraging the advanced features and robust capabilities of the Experion PKS platform, that have successfully incorporated intricate logic, such as the 2oo3 voting principle, to ensure efficient and reliable field control.

Conclusion

The creation of HVAC systems for food industry course projects has been a thorough endeavor to explore the complex procedures related to polycondensation. Careful monitoring of the project's temperature, coolant flow, and material supply is necessary to guarantee the creation of an excellent product that complies with the specifications. The undertaking became even more complicated when random disturbances affecting the system dynamics were considered.

The utilization of mathematical modelling, particularly through the MATLAB software, plays a pivotal role in understanding and optimizing the control system. The study involved examining the mathematical model of the heat exchange process, incorporating the principles of physics-thermodynamics, and the specifics of air cooling. Acknowledging the prevalence of nonlinear differential equations in real-world scenarios, the mathematical model was appropriately simplified for practical application. Further scrutiny of the model's stability using the Hurwitz criteria, along with the synthesis of a regulator, demonstrated a systematic approach to the control system design.

The selection of programmable logic controllers from reputable manufacturers, such as Honeywell and various vendors, underscores a commitment to reliability and functionality. The development of control system software using Experion PKS and Safety Manager showcased the seamless integration of theoretical knowledge into practical implementation. The operator's control panel, featuring real-time control graphs and various indicators, adds a crucial dimension to monitor and manage the polycondensation process.

The project's documentation, including the technological process scheme, automation scheme, technical instrumentation, and electrical schemes, provides a comprehensive resource for understanding and replicating the developed system. In essence, this HVAC system course project has not only explored the technical intricacies of polycondensation but has also successfully translated theoretical knowledge into a practical, automated control system with economic viability and safety considerations at its core.

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HONEYWELL ЖАБДЫҚТАРЫНДА ТАМАҚ ӨНЕРКӘСІБІ ҮШІН ЖЫЛЫТУ, ЖЕЛДЕТУ ЖӘНЕ АУАНЫ БАПТАУ ПРОЦЕСІН АВТОМАТТАНДЫРУ ЖҮЙЕСІН ӘЗІРЛЕУ

Аңдатпа

Қазіргі уақытта өнеркәсіптік автоматиканың даму деңгейі күрделі объектілердің динамикалық қасиеттерін ескеретін жоғары дәлдіктегі басқару жүйелерін жүзеге асыруға мүмкіндік береді. Заманауи бағдарламалық өнімдер негізінде таратылған басқару жүйелерін құру технологиялық процестерді орталықтандырылмаған басқаруды қамтамасыз етеді. Қазіргі заманғы өнеркәсіптік жабдықтардың көмегімен қолданыстағы басқару жүйелерін жаңғырту кәсіпорындардың өнімділігі мен өндірістегі қауіпсіздікті арттыруға мүмкіндік береді. Мақала тамақ өнеркәсібі үшін жылыту, желдету және ауаны баптау процестерін басқарудың автоматтандырылған жүйесін әзірлеуге арналған. Мақалада басқару объектісі жылу алмастырғышты таңдайды. Басқару объектісінің тұрақтылыққа, басқаруға, бақылауға арналған математикалық моделі зерттелді. PID реттегіші синтезделді, PID реттегішінің коэффициенттері алынды. Реттегіштің әртүрлі коэффициенттеріндегі жүйе динамикасының мінез-құлқына салыстырмалы талдау жүргізілді. Модельдеу мен эксперименттердің нәтижелері «ҚБТУ» АҚ жанындағы «Honeywell» зертханасының базасында нақты өнеркәсіптік жабдықтар базасында жүргізілді. Бағдарламалық жасақтама Experion PKS таратылған басқару жүйесінде жүзеге асырылды. C300 контроллерінің конфигурациясы ұсынылған. Жүйенің қауіпсіз және ақаусыз жұмыс істеуі үшін аварияға қарсы автоматты қорғау жүйесі (АҚЖ) әзірленді. АҚЖ сонымен қатар Safety Manager және Safety Sontroller құралының көмегімен жасалады. Тәуекелді төмендету факторлары мен қауіпсіздік тұтастығының деңгейі есептеліп, талданады. Процесті басқарудың мнемикалық схемасы жасалды.

Тірек сөздер: жылыту, желдету және ауаны баптау, тамақ өнеркәсібі, өңдеу өнеркәсібі, бағдарламаланатын логикалық контроллер, күрделі нысан.

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РАЗРАБОТКА СИСТЕМЫ АВТОМАТИЗАЦИИ ПРОЦЕССОМ ОТОПЛЕНИЯ, ВЕНТИЛЯЦИИ И КОНДИЦИОНИРОВАНИЯ ВОЗДУХА ДЛЯ ПИЩЕВОЙ ПРОМЫШЛЕННОСТИ НА ОБОРУДОВАНИИ ФИРМЫ HONEYWELL

Аннотация

В настоящее время уровень развития промышленной автоматики позволяет реализовать высокоточные системы управления, учитывающие динамические свойства сложных объектов. Построение распределенных систем управления на основе современных программных продуктов обеспечивает децентрализованное управление технологическими процессами. Модернизация действующих систем автоматизации с помощью современного промышленного оборудования позволяет повысить производительность предприятий и безопасность на производстве. Статья посвящена разработке автоматизированной системы управления процессами отопления, вентиляции и кондиционирования воздуха для пищевой промышленности. В статье объектом управления выбран теплообменник. Исследована математическая модель объекта управления на устойчивость, управляемость, наблюдаемость. Синтезирован ПИД регулятор, получены коэффициенты ПИД регулятора. Проведен сравнительный анализ поведения динамики системы при разных коэффициентах регулятора. Результаты моделирования и экспериментов проводились на базе реального промышленного оборудования лаборатории «Honeywell» при АО «КБТУ». Программная реализация осуществлялась на распределенной системе управления Experion PKS. Представлена конфигурация контроллера C300. Разработана система противоаварийной автоматической защиты (ПАЗ) для безопасной и безотказной работы системы. ПАЗ также выполнена с применением инструмента Safety Manager и Safety Controller. Рассчитаны и проанализированы факторы снижения риска и уровень целостности безопасности. Разработана мнемосхема управления процессом.

Ключевые слова: отопление, вентиляция и кондиционирование воздуха, пищевая промышленность, обрабатывающая промышленность, программируемый логический контроллер, сложный объект.