RESEARCH AND DESIGN OF PRODUCTION PROCESS CONTROL INFORMATION SYSTEM

Anastasiya Vecherkovskaya

Abstract: *The article reviews the creation prerequisites of the information system for polypropylene fibrous filter elements production. The problem of creating information systems for process control is described. The parameters that allow to control the technological process are defined. The functional requirements to the production management information system are determined, and the client part of the polypropylene filter elements production control information system is designed.*

Keywords: *information system, technological process, technological process parameters, functional requirements.*

ITHEA Keywords: *H. Information Systems - H.0 General, D. Software - D.0 General.*

Introduction

The technological processes control software implementation is the most important method of increasing labor productivity, reducing the materials and energy cost, improving product quality, introducing advanced methods of production management and improving the work reliability.

Currently, there is a problem when creating information systems to solve specific problems in the chemical industry, as complex multifactor models. . The final result is affected by simultaneous influence of the raw materials physical and chemical parameters and the technological production process various parameters

The processing of polymers, in particular polypropylene, is preceded by the design of the product pattern, the choice of the optimal method of processing, technological equipment design and manufacturing, polymer composition formulation development, its preparation and formation arrangement.

The actual processing of the polymer involves the products formation and their further processing in order to improve the polymer material properties (heat treatment, radiative crosslinking, etc.).

At the beginning of the 20th century polymers into products processing methods copied known ways of processing such materials as clay and soft metals (molding, pressing, stamping), and only in the middle of the 20th century new technological polypropylene-made products forming methods appeared, based on the polymers specific properties use, pneumatic and vacuum forming, calendering, and others.

Now the number of target methods and polymers processing techniques is calculated by dozens. Filter materials and polypropylene filters for different liquids and gases purification levels are made of polymer. [1]

The information obtained in the control process is used to influence the technological equipment in the form of operation instructions in order to ensure the polypropylene technological processing flow in full accordance with its planned progress, that is for the technological process control.

In other words, along with the widespread use of computers, equipment with software control has been applied, which is the executive body of computer technology. This suggests that, even if there are software systems that simulate the polypropylene fibers production process, considering the individual characteristics of each production, the research topic is relevant.

Published data analysis and problem definition

The fibers obtaining from polymer melts recieved widespread development around the world in the direction of synthetic fibers modification, which refer to so-called third-generation fibers [2].

The use of polymers opens an entirely new way of obtaining small diameter fibers (from several micrometers to tenths of a micrometer) - ultrathin synthetic fibers, or microfiber. At the same time, unlike the usual methods of forming chemical fibers, complex threads of tens and hundreds of thousands of microfiber are formed by pushing the melt mixture through one hole [3,4]. This phenomenon, discovered in 1954 by the chemists of Du Pont, was patented in 1968 [5]. Experimental data indicate that during the polymers melting through the molding hole, the acts of fiber formation are not realized as usual, after the melt out of the hole (filer), and even at the entrance to the hole channel [6]. Experimental data indicate that during the melting of polymers through the molding hole, the acts of fiber formation are not realized as usual, after the melt out of the hole (filer), and even at the entrance to the hole channel [6]. By dint of fiber filters it is possible to achieve a significant increase in the efficiency of the filtration, and the pressure drop moderately increases[7].

This creates ultrathin fibers, which are then used to create treatment plants, and filter materials.

Currently, in many industries, the task of purifying and separating liquid and gas media is very acute. The degree of purification determines the quality of products; the separation of mixtures solves the issues of catching valuable substances, saving raw materials and, finally, the environmental problems - the protection of the environment from harmful emissions into the atmosphere, water and soil.

Below is a classification of solutions membranic separation processes, colloidal systems and suspensions [8]:

Table 1. Classification of solutions membranic separation processes

Process	Process purpose	The size of molecules and separated particles, µm
Reverse osmosis	Separating molecules of low molecular weight and polymer compounds from solvent	5*10-4- 10-2
Ultrafiltration	Separating of substances with the size of the molecules from the solvent	5*10-2- 10-1
Microfiltration	Separation of colloidal and suspended particles from the liquid phase	10-1- 10
Conventional filtration	Separation of suspended particles from the liquid phase	More than 2,5*10

The division of multicomponent (or multiphase) systems is carried out with the help of porous partitions (membranes, filter materials), which delay some phases of these systems and skip others. When comparing ultrafiltration, reverse osmosis and filtration, it can be noted that these processes are determined by the general law, according to which the process speed is proportional to the driving force and inversely proportional to the resistance. For these processes, the driving force is the pressure difference on both sides of the membrane or partition, and the resistance depends on the properties of the latter, as well as on the characteristics of the divided system and the division conditions. However, reverse osmosis and ultrafiltration differs from conventional filtration by the fact that the first two are single-phase systems (solutions) being divided - on a solvent and a solution with a high concentration of dissolved substance. In the case of conventional filtration two- or multiphase systems (suspensions, aerosols) undergo division (purification). In the recent publications, new technologies in the field of filter materials, filter structures, raw materials are often considered by researchers [9-14]. But as for the porous polypropylene elements production control software by the pneumatic extrusion method, then there is no similar research in this direction to date.

Purpose and objectives of the research

The conducted studies are aimed to determine the features of the polypropylene filtering element manufacturing process by the pneumatic extrusion method and factors that affect the polypropylene fiber thickness during the production process, to create different filter layers and different diameter fibers.

To achieve this goal the following tasks were solved:

- to study the polypropylene granules melting temperature regime in the extruder influence on the formed at the outlet fiber diameter.

- to investigate the influence of air pressure at the output of the forming head on the thickness and density of the filtering layer.

- to offer the production parameters control information technology system and the production process management prototype software.

Research methods for influence determination on polypropylene production process factors by the pneumatic extrusion method, and the quality of filter materials

Research materials and equipment used in experiment

For more than 60 years of extrusion technologies existence, a large variety of machine designs has been introduced for their implementation.

The principle of extruder action is determined by the essence of the extrusion process.

Extrusion complex physical and chemical process that takes place under the influence of mechanical effort provided by the presence of moisture and high temperature exposure.

The product that is being processed heats up due to the conversion of mechanical energy into heat, which is released when overcoming internal friction and plastic deformation of the product (gas mode) or due to external heating (Polytron mode).

Variable parameters of the extrusion process are the composition of the raw material, its nature, humidity, but these parameters can not be changed during the production process, so we will not consider their influence.

In the process of extrusion, changes in temperature, pressure, duration and intensity influence on raw materials are possible.

For the extrusion process implementation, a screw extruder is used, the main working organ of which is a special construction screw, that rotates in a cylindrical body. A shaping matrix is installed at the output of the body. Characteristic features of the working part extruder design is that the cameras and screws are adjusted in accordance with the set of technological tasks.

One of the methods for obtaining ultrathin fibers (diameter 0,11-0,22 microns) is the dispersion of the polymer melt (solution) by hot air jets [15].

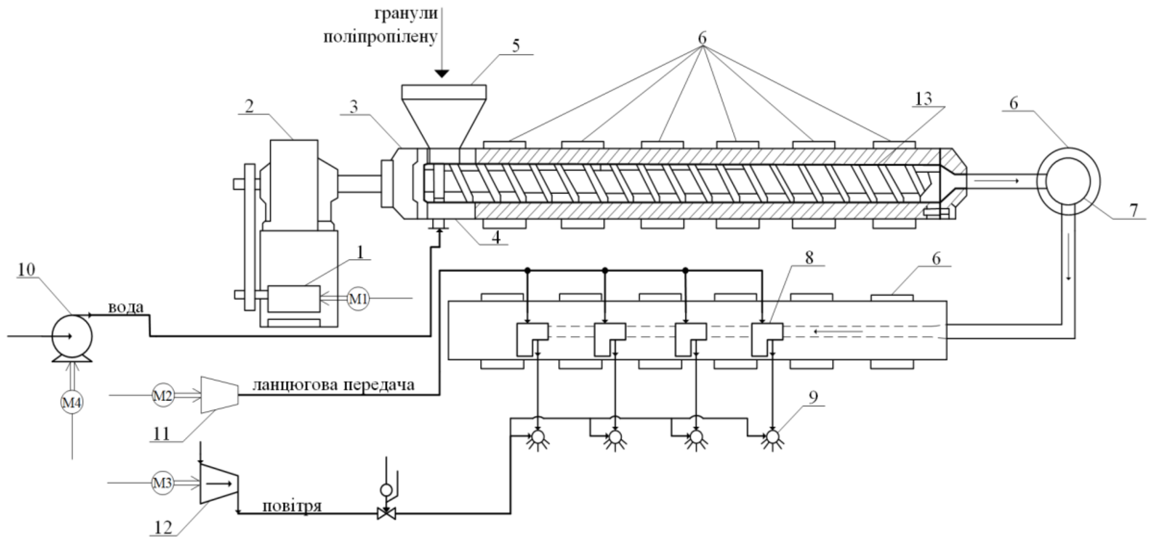

Fig. 1 The filter elements production technological scheme

1 – engine; 2 – reduction drive; 3 – thrust bearing; 4 – water shell; 5 – the raw materials loading bunker; 6 –ring heaters; 7 – elbow; 8 – dosing pumps; 9 – spraying heads; 10 – pump; 11 – reduction drive; 12 – compressor; 13 – screw.

Methodology for determining the properties of samples

In continuous technological processes automation , a special case of control - “regulation” is of great importance. Assignment of automatic control systems (ACS) - support for given or optimal values which determine the course of the technological process.

Let's review the filtration elements manufacturing process by the method which consist of forming molten polypropylene through a filier, followed by the stretching of the uncongealed extrudate with a hot air stream and applying on a rotating cylindrical rod. The design of the receiving device (the same one rotates, the screw rod) allows the continuous forming process of a frameless element (Fig. 1).

In any type of control, the following steps are performed in one degree or another:
- receiving information about the control object state;
- received data processing and analysis, on the basis of which the decision about control object necessity and impact nature is formed;
- implementation of the decision, for example, by changing material or energy flows.

The fulfillment of the first stage is connected with the definition of values that characterize the control object state: pressure, temperature, costs, level in technological apparatus, physical and chemical indicators of substances, which are processed at different stages of the technological process, etc.

In the process of producing filter elements by the pneumatic extrusion method, you can change a significant number of the technological process parameters, to provide a certain fiber structure.

These are basic parameters like:

• Melting point in the extruder and head heating zones;
• Metering pump revolutions and accordingly, the mass of the polymer fuse;
• Pressure and temperature of air supplied to the forming head;
• The receiving mechanism rotation speed and its distance to the forming head.

With manual control, a person performs all functions on the filter elements manufacturing process analysis and the process impact adoption and implementation decisions. Hand-held remote control is also used, when a person is influencing the process remotely using special devices. In this case, it receives information about the parameters of the process using automatic control systems by the automatic control devices indicators.

Due to this automated control systems (ACS) became widely used. They are intended both for technological processes control and for enterprises organizational management.

Research results

Production parameters control automation system

The first contour regulates the extruder polypropylene melt temperature: The temperature sensor is a resistance thermometer TCM – 50M, its signal enters the microprocessor controller MIK-25, control influence forms in the regulator, which through the converter EPP-63 affects the executive mechanism of the IEE type (pos.1g), and changes the amount of steam in the apparatus and normalizes the polypropylene melt temperature in the extruder.

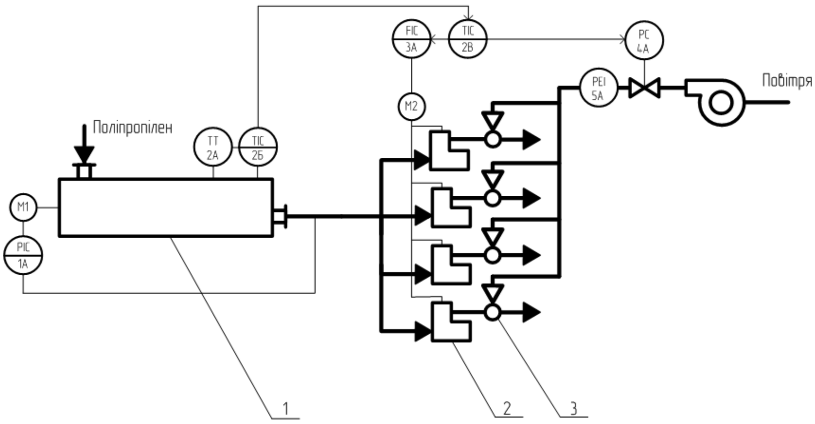

Fig. 2 Production parameters control automation system

1 - Extruder; 1B - frequency converter;
2 - Dosing pump; 3 - Head of the dosing pump

The second contour is the regulation of air pressure on the molding head:

Information about the massif level comes from the primary converter of the Vegason 62 type (pos.2a) in the form of a standardized current signal 0...5mA and gets on the regulator (pos. 2b) from which control is converted trough EPP-63 (pos.2v) into the pneumatic signal 20 -100 kPa and moves an executive mechanism of the MEO type (item 2g) which changes the amount of the input product leading to a change in level.

Information system design

Let us review the requirements that were set for the "Process Control" system, which we design to control the polypropylene filtering fibrous elements production process. At the beginning of the design we will highlight the main functional requirements that can be put forward to such systems. Here are just a some of them:

1. The software should be able to show the object of management state data;

2. The software must be able to obtain and change the performance characteristics during the technological process;
3. The software tool should allow the creation of a new filter element pattern;
4. The tool should allow you to delete existing patterns of filter elements, depending on user requirements;
5. The software should display the state of the technological process and the state of the control object data;
6. The software tool must notify the head of the department (enterprise) about the progress of the technological process, and the introduction of new patterns
7. The tool must be able to work in two modes - transmission of the technological process state data with a certain time interval or data transmission on request;
8. The software must be able to stop or resume the control object state, and the technological process state data transmission;
9. The software must allow control object quick or emergency shutdown, depending on the data received from the control object;

In In Fig. 3 shown a diagram of use cases, built as a result of the functional requirements analysis. It is also worth noting that all relationships that extend the use cases have a condition of user software selection in the interface and successfully passed authentication.

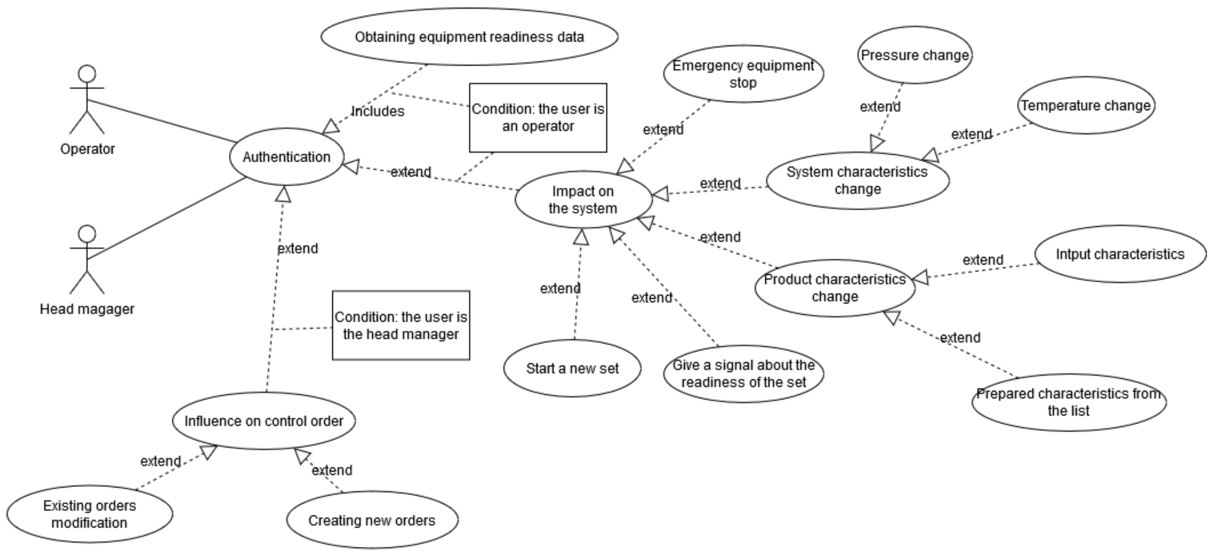

Fig. 3 Diagram of use cases

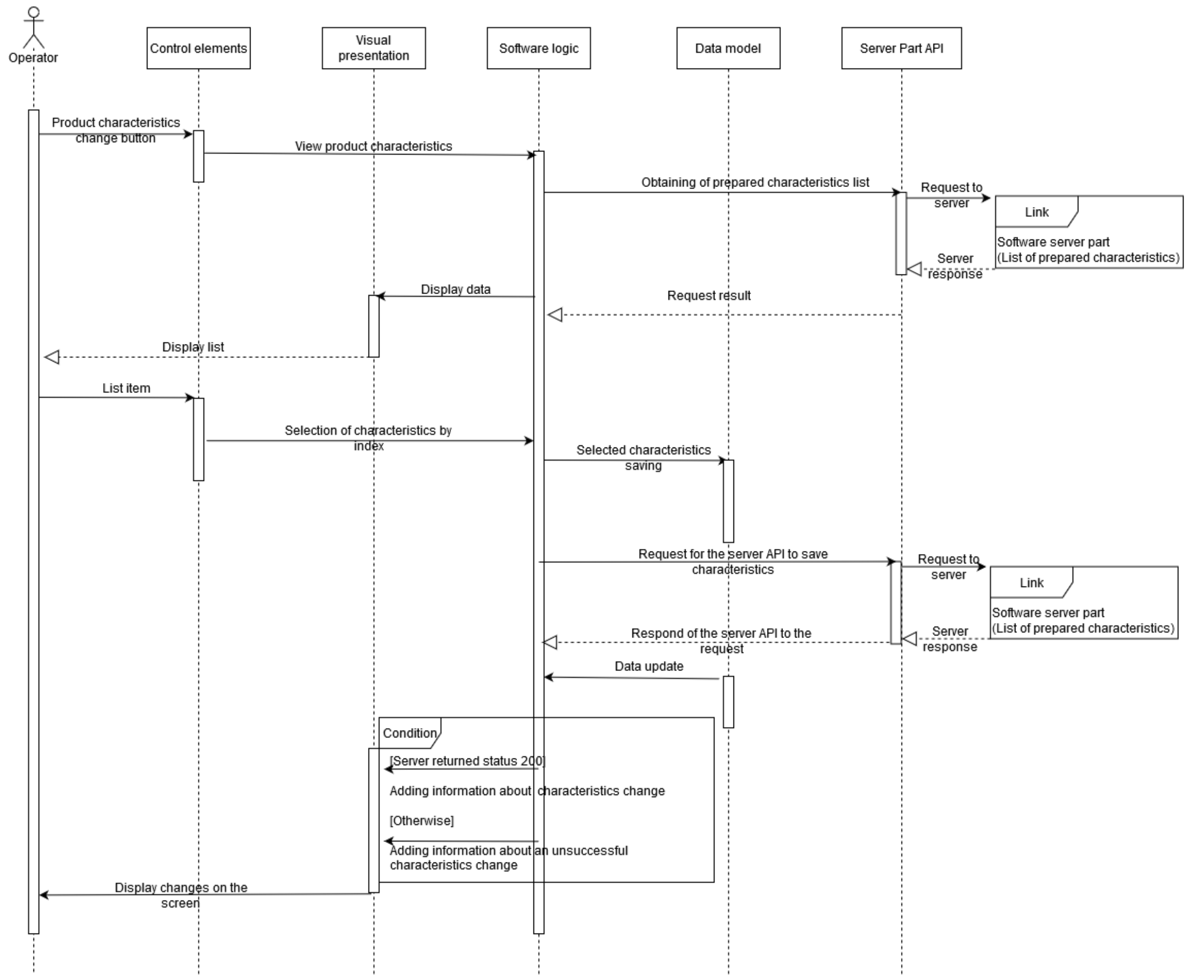

Fig. 4 Sequence diagram of the client software part.

In Fig. 4 shown a sequence diagram of the "Change of the product characteristics" case use, which shows the of the client part of the software components interaction.

This system is focused mainly on small and medium-sized businesses (up to 200 employees), and can be used by workers in any industry, entire companies or individual departments.:

Data, obtained with the help of sensors, is transmitted to a computer program, the prototype of which is shown on (Fig. 4), which allows for a model calculation of the FE.

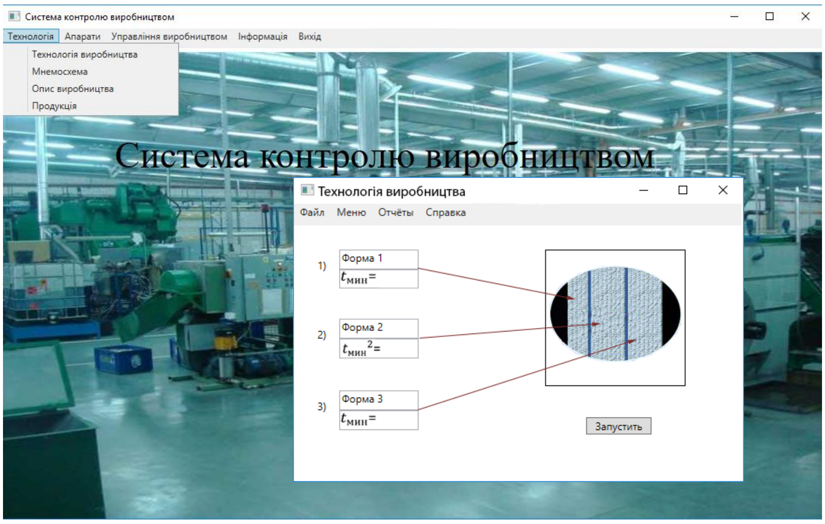

Fig. 5 The computer program prototype

This prototype allows you to select the structure and size of FEs, depending on the field of application and environments. (Fig. 5)

Conclusion

The technological processes control software implementation is the most important method of increasing labor productivity, reducing the materials and energy cost, improving product quality, introducing advanced methods of production management and improving the work reliability.

The conducted researches have reached the set purpose, and have defined the polypropylene filtering element manufacturing process features by the pneumatic extrusion method and factors which influence a polypropylene fiber thickness in the manufacturing process, for a various filter layers creation , and different diameter fibers.

In the research process, the temperature mode influence of the polypropylene granules melting in the extruder, on the fiber diameter formed at the outlet, and the air pressure effect at the forming head output on the filtering layer thickness and density were investigated. Based on the conducted research the production automation scheme was designed, and the production process management software tool prototype was developed.

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Authors' Information

Anastasiya Vecherkovskaya – *Faculty of Information Technology, Taras Shevchenko National University of Kyiv, Phd student, Kyiv, Ukraine; e-mail: vecherkovskaia90@gmail.com*

Major Fields of Scientific Research: Information technology, Information systems