Vitaliy KOLESNIKOV[1], Pavel URBANOVICH[1,2], Andrei BRAKOVICH[1]
Belarussian State Technological University (1), Lublin Catholic University (2)

doi:10.15199/48.2016.08.09

Modeling and software implementation of fibrous waste disposal processes

Abstract. The article describes the development of service-oriented computer system for situational management of industrial enterprise waste management and decision support systems in a production environment. The software is based on mathematical model, which allows to solve optimization problems in the subject area and to analyze the results.

Streszczenie. *W artykule przedstawiono opracowany zorientowany na usługi komputerowy system do zarządzania sytuacyjnego przemysłowymi kompleksowymi systemami gospodarowania odpadami i systemami wspomagania decyzji w środowisku produkcyjnym. Oprogramowanie jest oparte na modelu matematycznym, co pozwala na rozwiązanie problemów optymalizacyjnych w tej dziedzinie oraz analizę wyników.* ***(Modelowanie i wdrażanie oprogramowania procesów unieszkodliwiania odpadów włóknistych)***.

Keywords: mathematical modeling, software, fibrous waste disposal processes.
Slowa kluczowe: madelowanie matematyczne, oprogramowanie, proces unieszkodliwiania odpadów włóknistych.

Introduction

Today the problem of fibrous waste disposal (waste paper, short fibers from the shearing of artificial fur, leather waste in the form of chrome shavings and, glass, asbestos, carbon and metal fibers, etc.) is vital.

All processes of the fibrous waste recycling are significantly dependent on factors of external environment (weather, wind conditions, and, above all, from the salt composition of water used).

There is no only one optimal technological regime of utilization. It is necessary to develop a response to environmental changes, correcting values of the process control effects. An analysis of the collected data reveals hidden patterns and gives the opportunity to calculate, but not to guess the necessary corrections.

There are some examples of effective use of data mining in the processing of the results interpretation for the fixed long-term observations of an industrial complex functioning in a changing external environment. Contingency management process under these circumstances is only successful to a certain extent, depending on personal experience and qualifications. Filling the database by synchronous values of conditions and results allows, using the method of decision tree, to identify the best values of an ordered sequence of control actions [1-2]. Inputting the linguistic variables and the use of fuzzy sets for generation of membership functions for each feature solves the problem of maximizing an integrated multi-criteria evaluation of product quality under the given conditions of the external environment [3].

The procedure of using the database "conditions – the result" can be applied effectively by replacing the real enterprise system with adequate mathematical model. Further, the development and usage of such software is described.

Basic part

The general functioning scheme of developed computer software is shown in Fig. 1.

In the mathematical model basis of fibrous waste disposal system laid multiplicative principle of multiple calculating of the instantaneous material balances in multi-technological system. Calculations are made through any specified intervals. Communication with flows regime parameters is provided by a set of polynomial models. The properties dependence of the final product on the material flow composition is described by a second set of polynomial models. Thus, one mathematical model combines the consumable and operational parameters with the quality of the final product, economy and environmental protection in pseudo dynamic conditions.

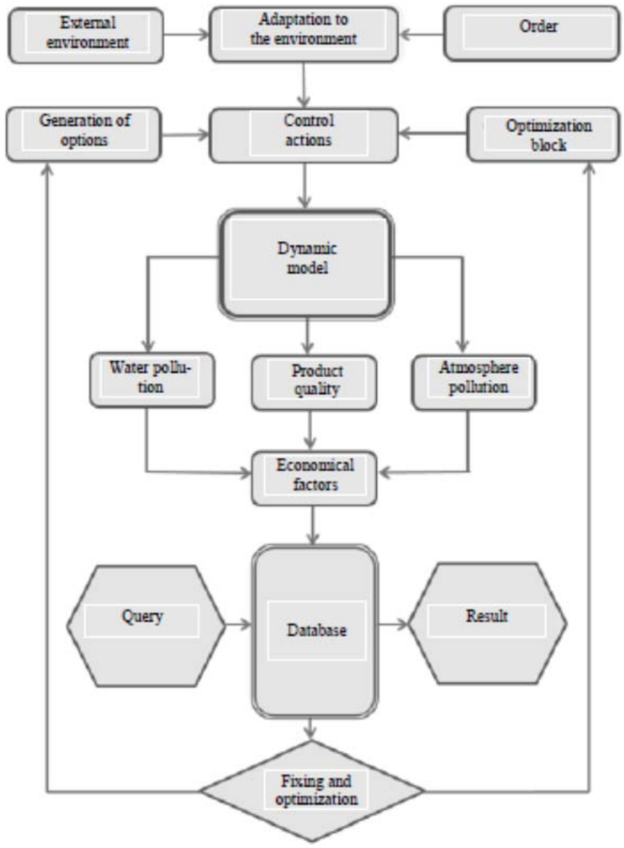


Fig.1. Scheme of the dynamic simulation and optimization of waste fiber utilization

The control system has to respond to emerging changes in parameters. Therefore, the optimizing block is included in the algorithm. The incoming information is processed in this block. In the case of the actual situation discrepancy with the specified conditions the optimization problem is solved by a issuance compromising of the necessary control pulses to the actuator and taking into account the value of the selected criteria such as for example the amount of energy and operating costs.

To formalize the procedure of material balances calculation in the dynamics all streams are encoded in the form of a two-dimensional array named as *Q*. The first coordinate of this vector is numbered material flows under which they appear in the flow diagram, the second coordinate - Digital index component of this flow.

The eight-numbering system will be used for the flows. Modeling undergoes a simplified flow diagram obtained after decomposition and aggregation of variables. It consists of 18 elements (process steps) involved by 42 material flows.

Information and mathematical system development was based on the results of long-term studies [1-4]. For receiving the stochastic models of quality factors, information network was built on the basis of orthogonal tables, obtained by the projective geometry and Galois fields, which, after the experiments, were transformed in table specified functions. The corresponding segments of the Taylor series, bicubic spline and the Chebyshev interpolation polynomials were used as linearizing convert.

Terms of computational experiment formed three groups of independent variables: random effects, the composite structure of the fiber, controlling factors. The following random effects in models are presented: the salt content of the river water, river water temperature, pH of the river water, the solids content of the raw materials, the shelf life of raw.

The results of computational experiment (product quality) were evaluated by ten special parameters.

The system-dynamic model is implemented in simulation software *AnyLogic*. It allows the user to change the model, add or remove components, change the connection between them, and it does not entail a change in the developed software. In fact, the model of an industrial enterprise for the decision support system is an external component and serves as a data source.

To control the developed system with mobile devices with limited computational resources the client-server architecture is implemented. The server performs the high-performance computing, and the client is responsible for the formulation of the problems and displays the results. For greater flexibility, the system server has been implemented as a web-service that provides customers with its API in this window.

The Django platform was chosen for the development of web-service. Each component of the web-application, built on the basis of Django, has its unique assignment. Therefore, it is possible to thread measurable independency of the other components. The developer can change the URL of the application and it will not effect on its implementation. Database administrator can rename the database table and describe a change in a single place. Django provides an abstraction layer "model" for the creation of structures and data management applications.

Working with the results of computer simulations in the form of tables is impossible due to their large dimensions. Therefore, to visualize the linkages and interdependencies of all system components in the working window displays its information stream multigraph, an example of which is shown in Fig. 2.

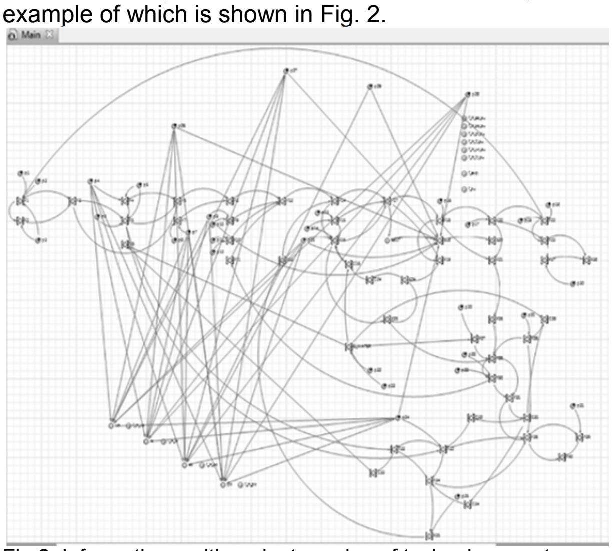


Fig.2. Information multigraph streaming of technology system

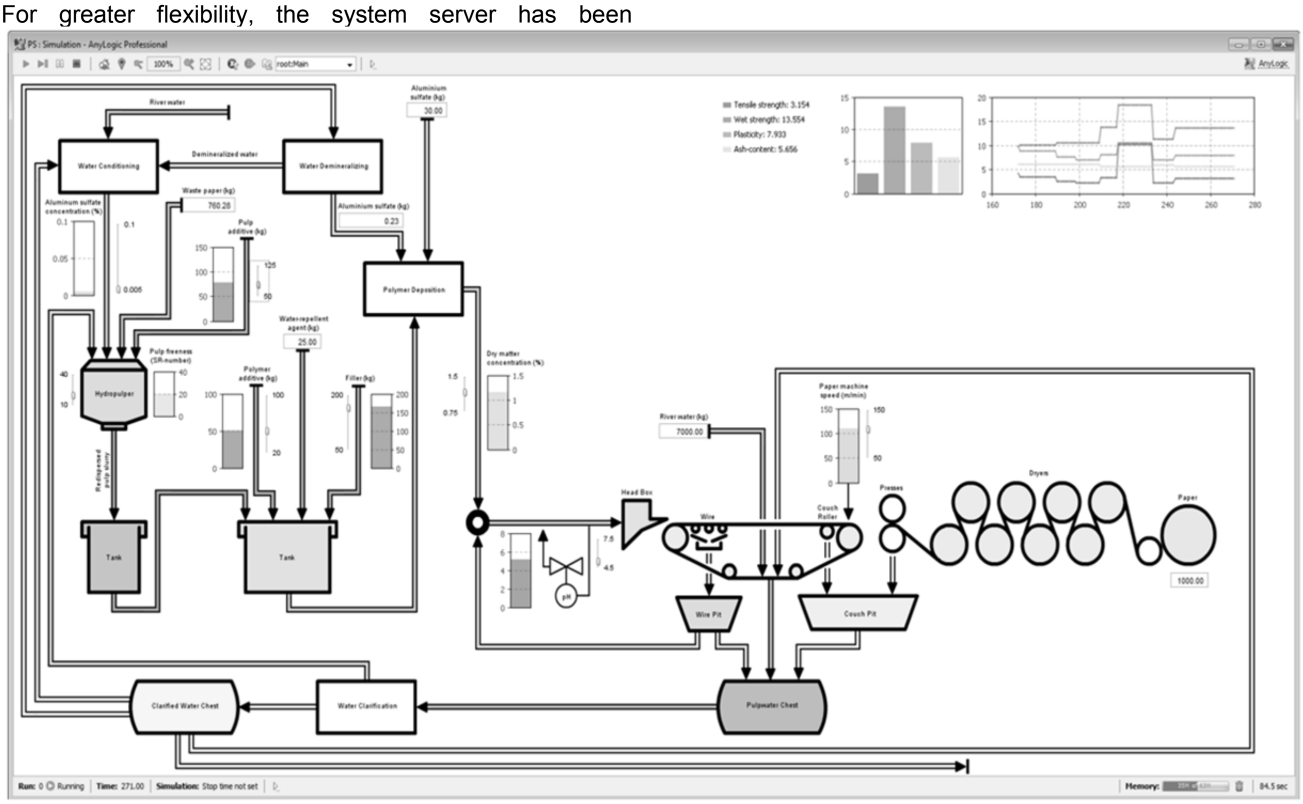
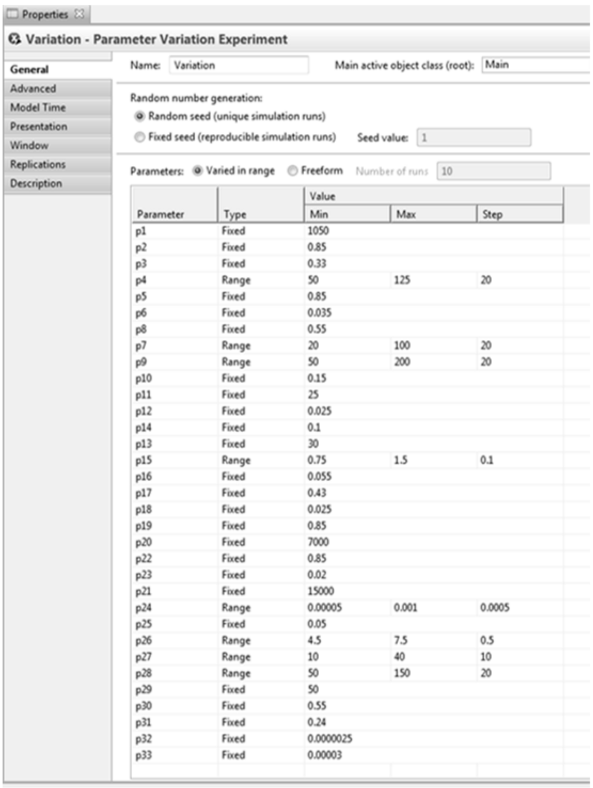


Fig.3. Window of simulation experiment of the production complex

The user can change the parameters of the system as well as evaluate its basic characteristics. The user can switch from the main presentation of the experiment on the representation of the model, which will be available to the internal variables and parameters of the model. The content of the components in any stream is displayed on the screen by clicking on the corresponding node.

Two experiments were implemented to work with the model: imitation and variation. Imitation experiment is the simulation of the industrial enterprise working in real time (Fig. 3). The user can change the basic parameters of the enterprise, as well as to monitor both the performance of the enterprise, as well as the internal variables in system-dynamic model. The experiment is designed to vary parameters for database storage performance results of product quality, economic and environmental criteria, obtained by generating random values of selected (or all) independent variable within a predetermined range (Fig. 4).

Features of models exceed the dimension of the problem of obtaining the results for only one particular company. The resulting database can contain thousands of rows, each of which represents a variation of the technological modes with the results of its performance under the current conditions of the external environment.



Parameter	Type	Value Min	Max	Step
p1	Fixed	1050		
p2	Fixed	0.85		
p3	Fixed	0.33		
p4	Range	50	125	20
p5	Fixed	0.85		
p6	Fixed	0.035		
p8	Fixed	0.55		
p7	Range	20	100	20
p9	Range	50	200	20
p10	Fixed	0.15		
p11	Fixed	25		
p12	Fixed	0.025		
p14	Fixed	0.1		
p13	Fixed	30		
p15	Range	0.75	1.5	0.1
p16	Fixed	0.055		
p17	Fixed	0.43		
p18	Fixed	0.025		
p19	Fixed	0.85		
p20	Fixed	7000		
p22	Fixed	0.85		
p23	Fixed	0.02		
p21	Fixed	15000		
p24	Range	0.00005	0.001	0.0005
p25	Fixed	0.05		
p26	Range	4.5	7.5	0.5
p27	Range	10	40	10
p28	Range	50	150	20
p29	Fixed	50		
p30	Fixed	0.55		
p31	Fixed	0.24		
p32	Fixed	0.0000025		
p33	Fixed	0.00003		

Fig.4. Window of varying of the experimental parameters

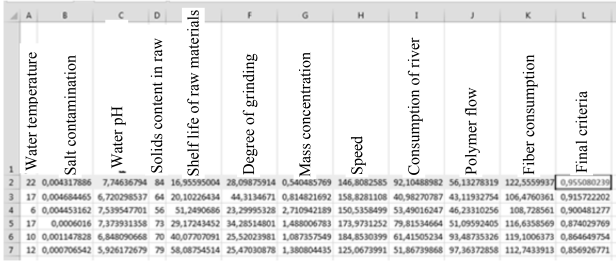
Combinations of interlaced values of quality in the database can not only meet the requirements for the product range of existing enterprises but also point to the prospect of output with fundamentally new properties.

In order to get the information from the database it is necessary to formalize the quality requirements. Such production is expected to fabricate in specific operating conditions (specific equipment, the traditional range of products, competitive market move, and others.).

The methodology and the experience in building mathematical and graphic images of product quality are described in [3]. Interface and software implementation of program software allows automatic loading the database directly from MS Excel.

The results of solving multicriteria represented as a string database. Each row contains the optimal values of the control actions to ensure the best value of all quality indicators in accordance with the given set of properties taking into account all external environment conditions contained in the database (Fig. 5).

The flexibility of the program allows you to identify the best combination of values of the control factors for selected conditions, such as salt content in river water in times of flood and drought, summer and winter temperatures.



	Water temperature	Salt contamination	Water pH	Solids content in raw	Shelf life of raw materials	Degree of grinding	Mass concentration	Speed	Consumption of river	Polymer flow	Fiber consumption	Final criteria
2	22	0,004317886	7,74636794	84	16,95595004	28,09875914	0,540485769	146,8082585	92,10488982	56,13278319	122,5559937	0,955080239
3	17	0,004684465	6,720298537	64	20,10226434	44,3134671	0,814821692	158,8281108	40,98270787	43,11932754	106,4760361	0,915722202
4	6	0,004453162	7,539547701	56	51,2490686	23,29995328	2,710942189	150,5358499	53,49016247	46,23310256	108,728561	0,900481277
5	17	0,0006016	7,373931358	73	29,17243452	34,28514801	1,488006783	173,9731252	79,81534664	51,09592405	116,6358569	0,874029769
6	10	0,001147828	6,848090668	70	40,07707091	25,52023981	1,087357549	184,8530399	61,41505234	93,48735326	119,1006373	0,864649754
7	12	0,000706542	5,926172679	79	58,08754514	25,47030878	1,380804435	125,0673991	51,86739868	97,36372858	112,7433913	0,856926771

Fig.5. The result of multicriteria task solving

Conclusions

A service-oriented system of situational management of industrial complex and decision support in real-time conditions, based on the construction of optimization models is developed and analyzed. The database and software are not designed for immediate implementation in any enterprise, and revision of existing technological conditions. The main advantages of the work are its conceptual and methodological components, demonstrating the ability to adopt production to the external environment. Targeted content database in any industry can designate new areas of research innovative solutions to meet the needs of the population and to gain confidence in the economic competition. Described system as a part of the simulation model can answer the questions about maximizing quality at a given level of energy and operating costs, to minimize the cost of production for a given level of quality, etc.

Authors: *Prof. Dr. Kolesnikov Vitaliy, Belorussian State Technological University, Minsk, Sverdlova 13a; Prof. Dr. Urbanovich Pavel, Lublin Catholic University, Lublin, ul. Konstantynow, 1H, E-mail: pav.urb@yandex.by; PhD Brakovich Andrei, Belorussian State Technological University, Minsk, Sverdlova 13a, E-mail: brakovich@yandex.ru*.

REFERENCES

[1] Kolesnikov V., Zhuk Y., Brakovich A., Fuzzification and defuzzification data for solving multiobjective problems, *Proceedings of BSTU*, (2014), nr 6: Physics and Mathematics. Informatics, 125-127.

[2] Kolesnikov V., Urbanovich P., Brakovich A., Data mining for industrial facilities, *New Electrical and Electronic Technologies and their Industrial Implementation – NEET′ 2013: Proc. of the 8-th Intern. Conf., Zakopane*, Poland, ed. T. Kołtunowicz, Lublin, (2013), 145.

[3] Kolesnikov V.L., System analysis of production systems in the printing industry, Minsk, BSTU, (2011), 235.

[4] Brakovich A., Kolesnikov V., Urbanovich P., Mathematical foundations of composite desirability function for evaluation of the product quality in the relationship with anthropogenic impacts on the environment, *Informatyka, automatyka, pomiary w gospodarce i ochronie srodowiska*, (2012), nr 4a, 36-39.