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THE APPLICATION OF EXP SOFTWARE IN THE RISK ANALYSIS OF ENERGETIC-ENVIRONMENTAL CHARACTERISTICS OF THE SODIUM TRIPOLYPHOSPHATE PRODUCTION PROCES

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Ivan Krstić

Faculty of Occupational Safety, University of Niš, Serbia and Montenegro

Abstract. *The basic hypothesis of this paper is based on the application of the equation of the balance of materially energetic flows of referential objects which are part of the technological system of IHP Prahovo, the technological process of sodium tripolyphosphate production. This enables the simulation of an optimal model of the technological process with a minimization of the negative effects of the waste materials and energy and a maximization of the positive effects achieved with the quality of production. As a practical contribution, in that sense, the sequential software package ExP is created in the program platform Visual C++. The software package ExP is designed for the examination of the energetically ecological characteristics of the referential object and as a starting point for quicker and simpler work of future users, not only in regards to usage, but also for the possibility of upgrading and adjusting to the conditions of their own projects.*

Key Words: *ExP software, sodium tripolyphosphate, energetic-environmental parameters*

1. INTRODUCTORY REMARKS

As the referential object of the research, a part of the technological system of IHP Prahovo has been chosen, the technological process of sodium tripolyphosphate production, which includes a great number of mechanical, thermal and diffusional operations, united through the wet and dry phase. The technological process of sodium tripolyphosphate production consists of two technological phases: the "wet" and the "dry" phase of the technological process.

For production, phosphoric acid and sodium carbonate are used as the basic raw materials, along with a lot of additional raw materials (three butyl phosphate $(C_4H_9)_3PO_4$, cellulose, granular active coal, kerosene, sulfurous acid, nitric acid and sodium hydroxide), and also operating and energetic fluids (industrial water, process water, compressed air, electric energy and heating oil).

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In the first phase we get concentrated liquid sodium orthophosphate, called in the activator the "wet phase", while in the "dry phase" liquid sodium orthophosphate is turned into sodium tripolyphosphate. The aim of the "wet" phase of the technological process is the refinement of the phosphoric acid of the present impurities and the procurement of the concentrated orthophosphoric solution. The "dry phase" represents the process of calcination of the mixture of monosodium and disodium orthophosphate at a high temperature, according to the following chemical reaction:

$$NaH_2PO_4+2Na_2HPO_4 \rightarrow Na_5P_3O_{10}+2H_2O \quad (1)$$

2. THE SEQUENTIAL SIMULATION OF THE REFERENTIAL SYSTEM

In order do define the mathematical model of the dry part of the sodium tripolyphosphate production process, the observation of the material and energetic flows in the existing plant has been carried out. In the first phase, the operating scheme of the production process is defined, and it shows the elements of the process, while the technological relations between them are represented as the lines of oriented arrows. The definition of the subsystem of the production process has enabled the definition of the structural scheme. In this scheme, which represents the assumption of the correct creation of the mathematical model, we can see eleven single elements of the production process and 29 functional relations between the elements (Fig. 1).

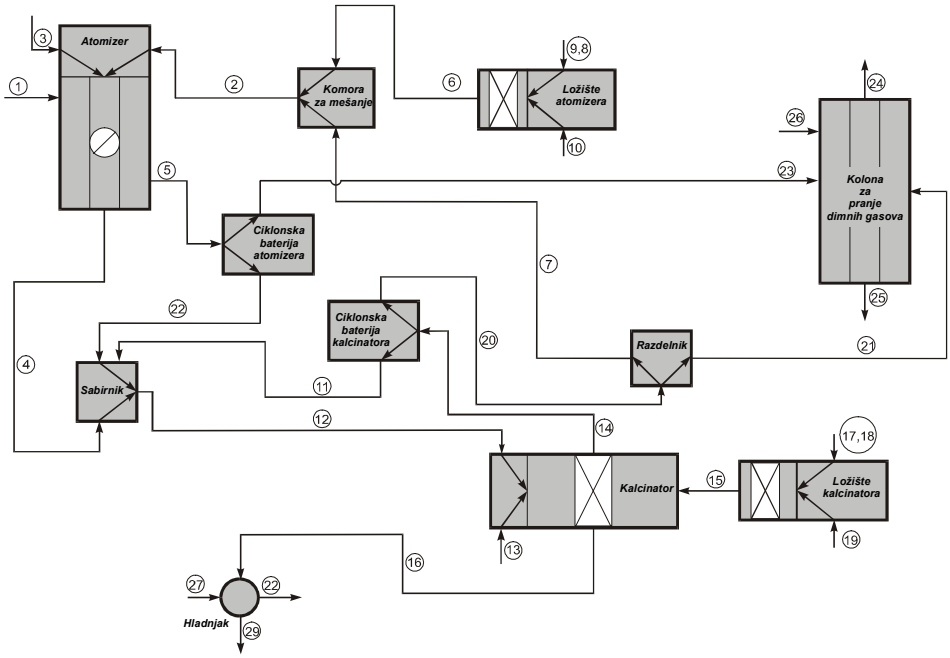

Fig. 1. The operating scheme of the sodium tripolyphosphate production process

Based on the available technical documentation, in the next step the sequential simulation of the system in question is carried out. The mathematical model suitable for the simulation is developed on the basis of:

- the material balance of the components of the system and
- the energetic balance of the components of the system.

In creating the model, the way the plant operates was responsible for the choice of simulation of the stationary condition, whereas the strategy of the creation, the modular (sequential) approach was adopted. In defining the equations of material balance, attention was paid to the structure of some components, so that the components of the fumatory gases are defined as the ideal mixtures of the dry products of combustion and the humidity in them. The components of humid air are defined as the ideal mixture of dry air and the humidity contained in it. The components with the orthophosphoric powder are defined as the mixture of the dry powder and the humidity in it.

This way of presenting the material balance of the system is conditioned by the drying processes in the atomizer and the calcinator, where it was necessary to achieve a satisfactory balance, of both the dry and wet components of the electric currents. The equations of the energetic balance are formed with respect to the first principle of thermodynamics and the composition of the electrical components resulting from the material balance.

In order to determine the specific warmth of air, the specific warmth of dry products of combustion (that is, components), and an additional program has been developed in order to obtain these values depending on the temperature and the pressure of the electric current in question.

Within this software package, as an additional tool, is also a simulation program for determining the characteristics of the water steam/condensates. (PWS). The program is based on the IAPWS industrial standard and is realized by forming a set of equations for 5 regions (Fig. 2).

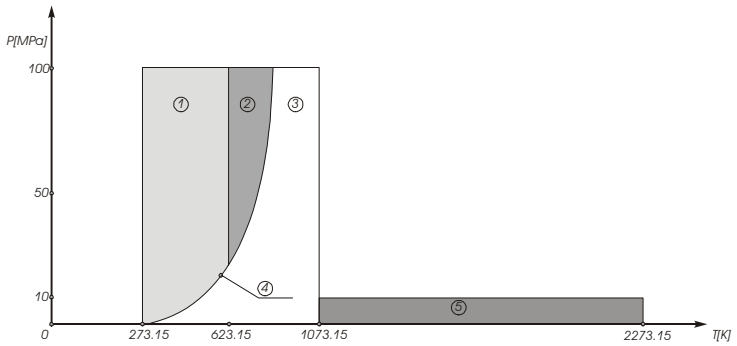

Fig. 2. The regions of the steam/condensates parameters for the realization of the IAPWS-industrial standard

Within the program package, the steam simulator is added as the add-ins component to the existing library of the standard formulas on the platform of Microsoft Excel. On it, for the defined parameters of the condition of the steam, that is, condensates, of the specific electric current (p, T), the values necessary for the realization of the energetic (h, H) balance are automatically determined.

Based on the obtained results, the Sankey diagram of the energetic flows of the system was drawn (Fig. 3).

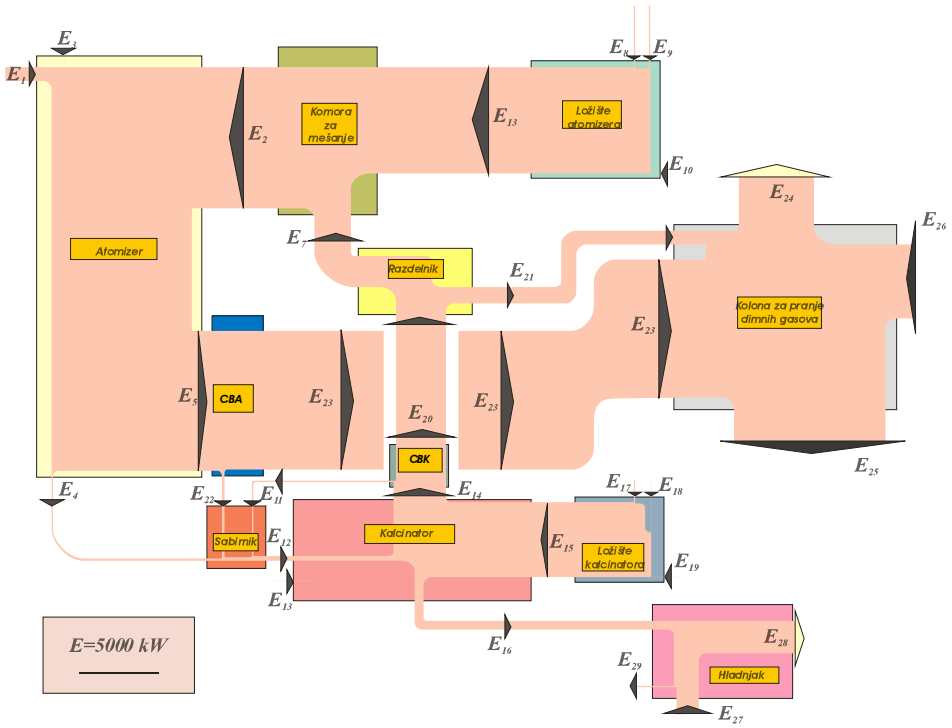

Fig. 3. Sankey diagram of the referential system

3. THE SOFTWARE PACKAGE EXP

The software package ExP was intended for the evaluation of the energetic losses of the system of the dry part of the sodium tripolyphosphate production at IHP Prahovo, realized on the program platform of the compiler Visual C and adjusted to a 32-bit surrounding of the operative system of Windows 9x, Windows 2000 and Windows XP.

A desirable hardware configuration for the realization of this software package is:

- Pentium II or higher
- 64 MB RAM
- 800x600screen resolution
- Windows 95/98/ME/NT4/2000/XP

The package consists of two functional parts:

- the part intended for the defining of the data
- the part intended for the presentation of the results

The menu of inputs contains sub-menus:

- summary of the characteristics of the electric currents;
- choice of fuel.

In the sub-menu of the choice of fuels, the operator decides on the type of liquid fuel and on the composition of the chosen fuel with an additional element for defining the coefficient of the air surplus for the realization of complete combustion, Figure 4.

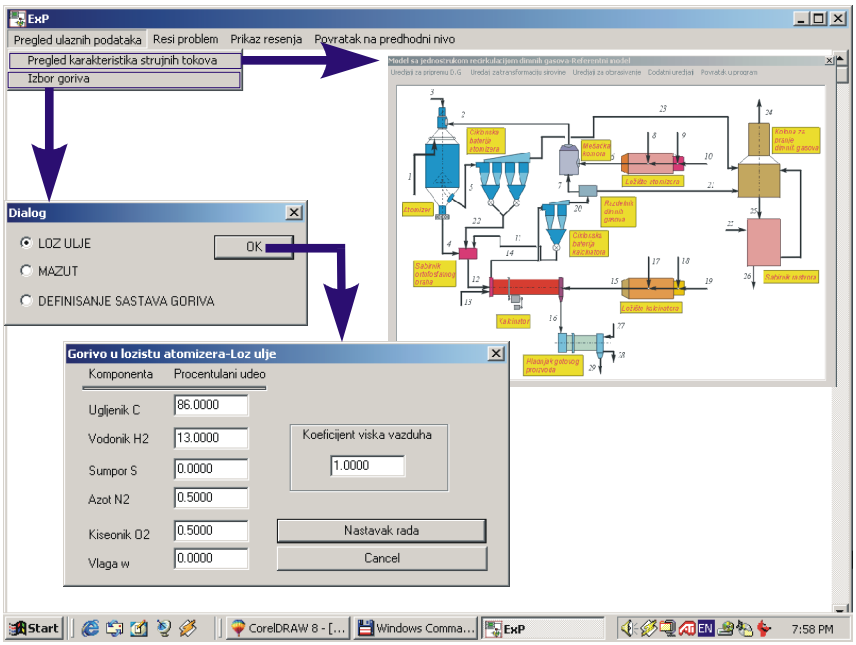

Fig. 4. The input on fuel - in the program ExP

By activating the sub-menu The summary of the characteristics of the electric currents, a new dialog box is opened with a new window and a picture of the technological scheme of the chosen model. The main menu of this window consists of a set of sub-menus, whose application opens dialog boxes related to the definition of the thermophysical characteristics of the electric currents in the system.

In the dialog boxes, by shading the fields for input, the characteristics, which are received only after the realization of the calculation, are separated (in some dialog boxes the shading functions as a warning that the specific characterization is defined in the previous dialog box). It should be mentioned that in the dialog boxes for the atomizer, calcinator and radiator, elements for calculating the loss of heat in the environment through the layers (mostly isolated) of this process units are added.

After the definition of the input parameters of the system, the realization of the calculation Menu Solve, concludes the problem.

Figure 5 shows the visual presentation of data processing related to the atomizer and calcinator, of the ExP program.

By activating the menu The overview of the solution, a dialog box is opened with the picture of the model and a set of main menus/sub-menus for activating the dialog box with thermo-physical characteristics of the energetic system in question. There are no shaded fields in this section.

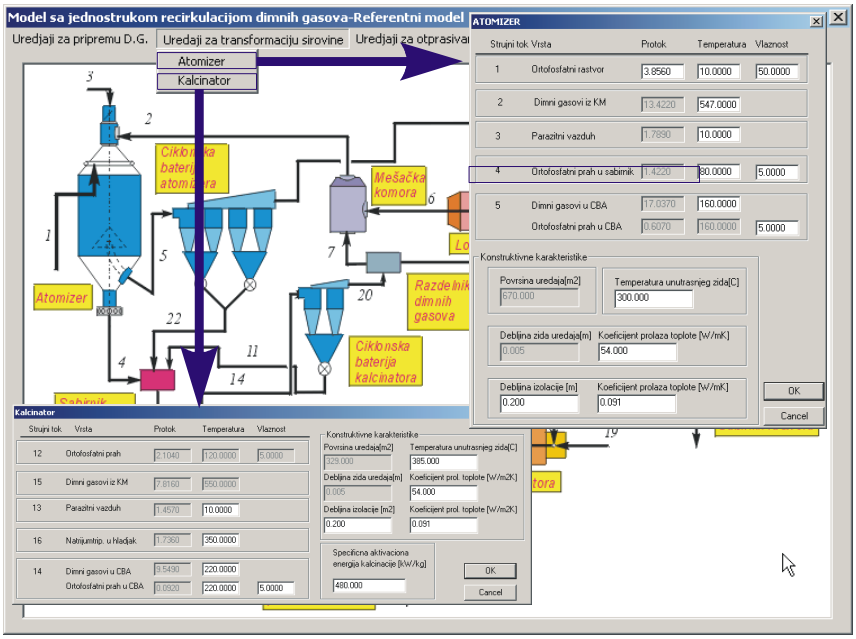

Fig. 5. Data processing related to the atomizer and calcinator-of the ExP program

As an additional element for examining the accuracy of the realized calculation (because of the non-linearity of the problem), an element is built in for the checking of the material and energetic balance of every process unit - Menu Check.

At the end of the calculation, the presentation of the results in a textual database is carried out by the protocol of connecting the software with the external notepad program Wordpad. This kind of connection enables the preview, printing, and the storage of the results, under specific names and at specific locations.

The installation of the ExP software package begins with the activation of the file ExP-setup.exe, and an uninstallation can be performed either by starting the program Uninstall ExP or by the standard procedure Add/remove programs from the Control panel.

The software package is expanded by the sub-program Ni-steam, which is based on the mathematical formulation of the standard ICF67 for the parameters of the condition of water and steam.

4. RESULTS OF THE RESEARCH

With the realization of the mathematical model by means of applicable software ExP, a possibility is created for the investigation of a wide spectrum of behavior of the energetic system of the referential object in the function of the change to different thermodynamic, electric and constructive parameters.

Figures 6 and 7 show the energetic degree of usefulness at the production of 7500 t/h.

The energetic degrees of usefulness of the atomizer and calcinator are not changed with the change in the degree of recirculation of the fumatory gases, but only with the

change of the capacity of the plant. This change can be explained with the increase or decrease of the share of the amount of heat that is released in the environment, which remains constant under the same constructive characteristics of these devices. In the case of a calcinator firebox and an atomizer firebox, as well as the radiator, the degree of usefulness remains constant, which is the logical consequence of the defined material and energetic balance of these devices. Energetic degrees of usefulness for the line for washing of the fumatory gases is distinctly increased in relation to the other devices, as a result of the fact that the dirty solution is considered a useful component at the exit of the control volume of the devices.

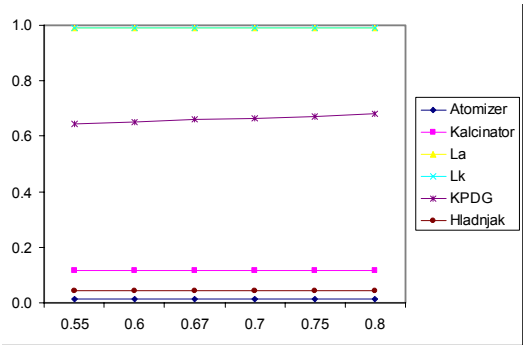

Fig. 6. Energetic degree of usefulness at the production of 5000 t/h

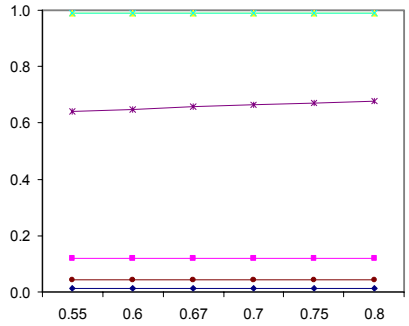

Fig. 7. Energetic degree of usefulness at the production of 7500 t/h

The energetic degree of this device is maximal in the case of the maximal degree of usefulness and maximal degree of re-circulation η_{EKPDG}=0.686, while its value at the maximal capacity and minimal degree of re-circulation is minimal η_{EKPDG}=0.634.

Similar values of the maximal degree of usefulness appear also at the minimal capacity and maximal degree of re-circulation (η_{EKPDG}=0.688), that is, minimal capacity and minimal degree of re-circulation (η_{EKPDG}=0.636). In this case also, the role of the heat is important, which is released trough the layer of the line defined by the kind and constructive parameters of isolation.

In the case of examining the production of sodium tripolyphosphate, apart from the growth trend of the energetic efficiency of the system, the trend of the increased pollution of the environment, in the function of the increasing of amount of waste fumatory gases, has been stated.

It has been stated that the system which uses heating oil as the primary fuel, has the advantage over the system which uses crude oil, both in an energetic and ecological sense.

The increase of the surplus of air can be considered as a functionally negative trend of leading the process in the fireboxes, both in an energetic and ecological way.

At the referential plant, the research has also been conducted through the change of the temperature regime in the work of the plant. After a detailed analysis, the temperature level of the fumatory gases at the entrance of the atomizer was chosen as a parameter of the research. The increase of temperature of this referential point, pointed to the positive trend both in an energetic and ecological sense.

5. CONCLUSION

Theoretical development of the program and the software package ExP, verified at the plant of the referential object IHP Prahovo, represent a starting point for future research in the area of optimization and synthesis of complex technological systems, and they also represents a considerable step toward the raising the general level of knowledge in the area of rational use of energy and the protection of the environment.

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PRIMENA EXP SOFTVERA U ANALIZI RIZIKA ENERGETSKO EKOLOŠKIH KARAKTERISTIKA PROCESA PROIZVODNJE NATRIJUMTRIPOLIFOSFATA

Ivan Krstić

Osnovna hipoteza rada zasnovana je na primeni jednačina bilansiranja materijalno energetskih tokova referentnog objekta dela tehnološkog sistema IHP Prahovo, tehnološkog procesa proizvodnje natrijumtripolifosfata. To omogućuje simulaciju optimizacionog modela tehnološkog procesa sa minimizacijom negativnih efekata otpadnih materija i energije i maksimizacijom pozitivnih efekata ostvarenih kvalitetom proizvoda. Kao praktičan doprinos, u tom smislu, izrađen je sekvencijalni softverski paket ExP na programskoj platformi Visual C++. Softverski paket ExP je izrađen u cilju ispitivanja energetsko ekoloških karakteristika referentnog objekta i kao polazna osnova za brži i jednostavniji rad budućih korisnika, kako za upotrebu tako i za mogućnost nadgradnje i prilagođavanja sopstvenim projektnim uslovima.

Ključne reči: *ExP softver, natrijumtripolifosfat, energetsko ekološki parametri*