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DEVELOPMENT OF A STRUCTURAL AND FUNCTIONAL MODEL OF AN AUTOMATED SYSTEM FOR DESIGNING ASPIRATION NETWORKS

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Currently, the situation with the sale of grain products of the Russian Federation by an external consumer is quite complicated. A large amount of grain products remains unclaimed and requires processing in the domestic market.

In this regard, the capacities of existing enterprises are not sufficient for storage and processing. To increase the processing of grain products, it is necessary to build new processing enterprises.

The technology of processing grain products requires the implementation of a number of safety-related measures, in particular with dust removal and dust protection. For the implementation of safety measures, the installation and installation of aspiration networks is carried out. The set of aspiration networks includes a large number of equipment and components. Aspiration networks of enterprises are a complex and responsible economy, on which the technological processes of functioning of the entire milling enterprise depend.

The calculation of aspiration networks, a rather laborious process currently carried out mainly manually, takes a long time. Automation of the design of aspiration networks, an urgent and in-demand necessity, both for Russia and all the countries of the Eurasian Economic Community.

The presented article shows the methodology for the development of a structural and functional model (SPM) of an automated aspiration network design system using the SADT, IDEF0 methodology. SFM is used in the development of an information logic model (IFM) and a program algorithm for calculating the aspiration network.

Keywords: aspiration network, model, SADT methodology, decomposition, program.

АСПИРАЦИЯЛЫҚ ЖЕЛІЛЕРДІ ЖОБАЛАУДЫҢ АВТОМАТТАНДЫРЫЛҒАН ЖҮЙЕСІНІҢ ҚҰРЫЛЫМДЫҚ-ФУНКЦИОНАЛДЫҚ МОДЕЛІН ӘЗІРЛЕУ

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Қазіргі уақытта Ресей Федерациясының астық өнімдерін сатудағы жағдай, сыртқы тұтынушы өте күрделі. Астық өнімдерінің көп мөлшері талап етілмейді және ішкі нарықта қайта өңдеуді қажет етеді.

Осыған байланысты қолданыстағы кәсіпорындардың қуаты сақтау және қайта өңдеу үшін жеткіліксіз. Астық өнімдерін қайта өңдеуді ұлғайту үшін жаңа қайта өңдеу кәсіпорындарын салу қажет.

Астық өнімдерін қайта өңдеу технологиясы қауіпсіздікке, атап айтқанда шаңды кетіруге және шаңнан қорғауға байланысты бірқатар шараларды орындауды талап етеді. Қауіпсіздік жөніндегі іс-шараларды іс-ке асыру үшін аспирация желілерін монтаждау және инсталляциялау орындалады. Аспирациялық желілер жиынтығына көптеген жабдықтар мен компоненттер кіреді. Кәсіпорындардың аспирациялық желілері-бұл бүкіл ұн тартатын кәсіпорынның технологиялық процестері тәуелді болатын күрделі және жауапты шару-ашылық.

Аспирациялық желілерді есептеу, Қазіргі уақытта негізінен қолмен жүзеге асырылатын уақытты қажет ететін процесс ұзақ уақытты алады. Аспирациялық желілерді жобалауды автоматтандыру, Ресей үшін де, Еуразиялық экономикалық одақтың барлық елдері үшін де өзекті және сұранысқа ие қажеттілік.

Ұсынылған мақалада sadt, idef0 әдістемесін қолдана отырып, аспирациялық желіні жобалаудың автоматтандырылған жүйесінің құрылымдық-функционалды моделін (SFM) әзірлеу әдістемесі көрсетілген. SFM ақпараттық-логикалық модельді (IFM) және аспирациялық желіні есептеуге арналған бағдарлама алгоритмін жасауда қолданылады.

Түйін сөздер: аспирациялық желі, модель, sadt әдістемесі, ыдырау, бағдарлама

РАЗРАБОТКА СТРУКТУРНО-ФУНКЦИОНАЛЬНОЙ МОДЕЛИ АВТОМАТИЗИРОВАННОЙ СИСТЕМЫ ПРОЕКТИРОВАНИЯ АСПИРАЦИОНЫХ СЕТЕЙ

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В настоящее время ситуация с реализацией зернопродукции Российской федерации, внешним потребителем достаточно сложна. Большое количество зернопродукции остается невостребованной и требует переработки на внутреннем рынке.

В этой связи мощности существующих предприятий не достаточны для хранения и переработки. Для увеличения переработки зернопродукции необходимо строительство новых перерабатывающих предприятий.

Технология переработки зернопродукции, требует выполнения ряда мероприятий связанных с безопасностью, в частности с удалением пыли и защиты от запыления. Для реализации мероприятий по безопасности, выполняется монтаж и инсталляции сетей аспирации. В комплект аспирационных сетей входит большое количество оборудования и комплектующих. Аспирационные сети предприятий - сложное и ответственное хозяйство, от которого зависят, технологические процессы функционирования всего мукомольного предприятия.

Расчет аспирационных сетей, достаточно трудоемкий процесс, осуществляемый в настоящее время в основном в ручную, занимает продолжительное время. Автоматизация проектирования аспирационных сетей, актуальная и востребованная необходимость, как для России, так и всех стран ЕвраЭС.

В представленной статье, показана методология разработки структурно-функциональной модели (СФМ) автоматизированной системы проектирования аспирационной сети с использованием методологии SADT, IDEF0. СФМ используется, при разработке информационно-логической модели (ИФМ) и алгоритма программы для расчета аспирационной сети.

Ключевые слова: аспирационная сеть, модель, методология SADT, декомпозиция, программа.

Introduction. Aspiration is the extraction of air from equipment in order to create a vacuum inside workspaces or protective casings necessary to prevent the release of dust into production facilities [1-6].

The main purpose of aspiration is to prevent dust explosions in the food industry, which is formed during technological processes [1-6].

Each aspiration (ventilation) installation consists of the following five parts:

ventilated objects (machines, apparatuses, mechanisms, bunkers, silos and other devices);

air ducts designed to move air in the desired direction at a given speed;

dust collectors for cleaning the aspiration air from dust (cyclones, filters, etc.);

winner (fan, deflector) for communicating energy to the air flow;

auxiliary equipment (recirculating apparatus, heat exchanger, heater, air conditioner, valves, instrumentation, etc.)

The totality of all these parts is called a ventilation (aspiration) installation, ventilation system, or aspiration (ventilation) network.

Figure 1 shows a typical scheme of the ventilation system of mill production.

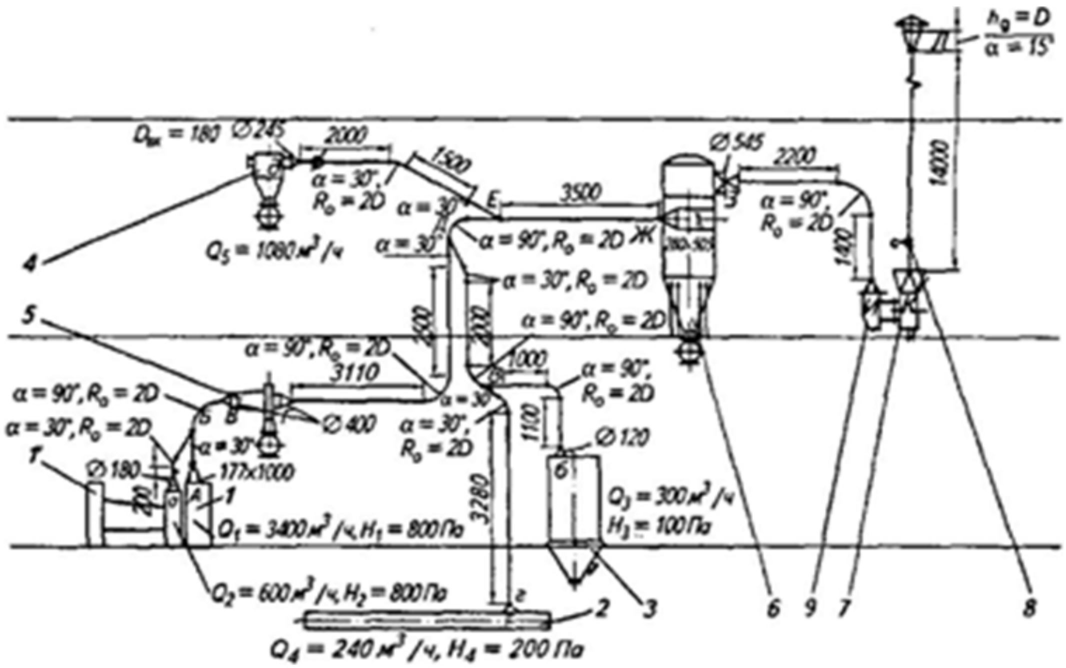


Fig. 1 – Typical ventilation scheme of mill production

where

1 is the pneumoseparating channel separator;

1* -screen body;

2-screw conveyor;

3-wallpaper machine;

4-unloader;

5-horizontal cyclone;

6-filter;

7-fan;

8-gate valve;

9- entrance box.

As a rule, this scheme is present at all mill enterprises, and therefore the composition and functionality of the equipment differs only by the manufacturer and technical characteristics.

The purpose of the study is to develop a structural and functional model of an automated system for designing aspiration networks of mill production. To fulfill the objectives of the study, it is necessary to solve the following tasks:

-determine the equipment to be aspirated;

-to calculate the multiplicity of air exchange and substantiate the choice of types of projected networks;

-perform the layout of aspiration networks;

-perform calculation, selection of dust collectors and determination of their resistance;

-preliminary selection of the fan to the network;

-arrangement of dust collectors and fan;

-perform the design of the duct route;

-perform the calculation of the aspiration network;

-design of wiring diagrams.

Methods and materials. The research uses the methodology of system analysis, the practical experience of the author, the SADT methodology of structural analysis and design, the Bp-win software tool.

Discussion of the results. When calculating the data, recommendations and theoretical calculations are considered [7-9]. Let's consider the mathematical formulation of the problem of our research. The calculation of the multiplicity of air exchange is calculated by the formula (1):

$$i = \frac{Q_{\text{общ}}}{V_n} \tag{1}$$

1) Calculation of dust collectors and selection of dust collectors is calculated by formulas (2) and (3):

$$H_{\text{ф}} = 100 \left(\frac{Q_{\text{уд}}}{60} \right)^{1,3} \tag{2}$$

$$Q_{\text{уд}} = \frac{Q_{\text{ф}}}{S_{\text{ф}}} \quad (3)$$

Q_f - the flow rate of air entering the filter;

Q_{sp} - normative specific load on the filter cloth;

2) The preliminary selection of the fan is calculated by the formula (4):

$$Q_v = Q_{net} + Q_{ps} \quad (4)$$

3) The design of the pipeline route is calculated by the formula (5):

$$D = 19\sqrt{\frac{Q}{v}} \quad (5)$$

Q - the air consumption is equal to the sum of the expenses of the aspirated machines;

v - air velocity (16..18 m/s).

4) The calculation of aspiration units is carried out according to the formula (6):

$$Q_v = \sum Q_m + Q_{ps} \quad (6)$$

where

Q_v - air consumption for fan selection;

$p_v = 1.1 \cdot H_{net} = 1.1 \sum H_{net}$.

P_v - fan pressure;

4) The total resistance of the network is calculated by the formula (7):

$$H_{net} = \sum H_{net.p.m} = H_{m1} + \sum H_n + H_e + H_{is} + H_{p.v} \quad (7)$$

5) The pressure loss in the section is calculated by the formula (8):

$$H_{los} = R_l + H_{ms} \quad (8)$$

where

$H_d = \frac{pv^2}{2}$

H_d - dynamic pressure;

The formulas presented above are used to calculate the parameters of the aspiration network in the automated design system program, the block diagram of which is developed according to the structural and functional model discussed below.

Using the SADT methodology and the technology of the graphic language of the IspIDEF0, we develop a parent diagram Fig. 2., (the text of the diagrams is in Russian).

In the parent diagram, as input data, the following are used:

-a list of classifiers;

-data on the company and equipment;

-request for the design of aspiration networks;

-request for generating reports.

The following mechanisms are used:

-personnel;

-Software and computers.

The following are used as controls :

-GOST standards;

-documentation;

-regulatory documents;

C the result of the parent model is to get:

-reports of calculations of aspiration networks;

-schemes of aspiration networks;

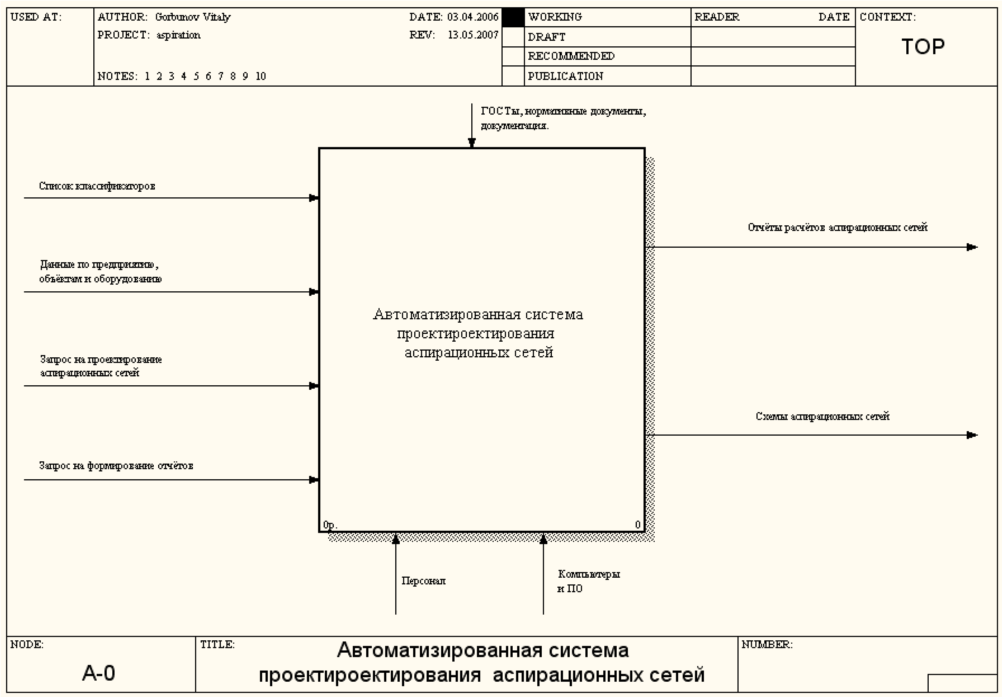


Fig. 2 – Parent diagram of the automated aspiration network design system

Let's carry out the decomposition of the parent diagram, the result of the decomposition is shown in Fig. 3.

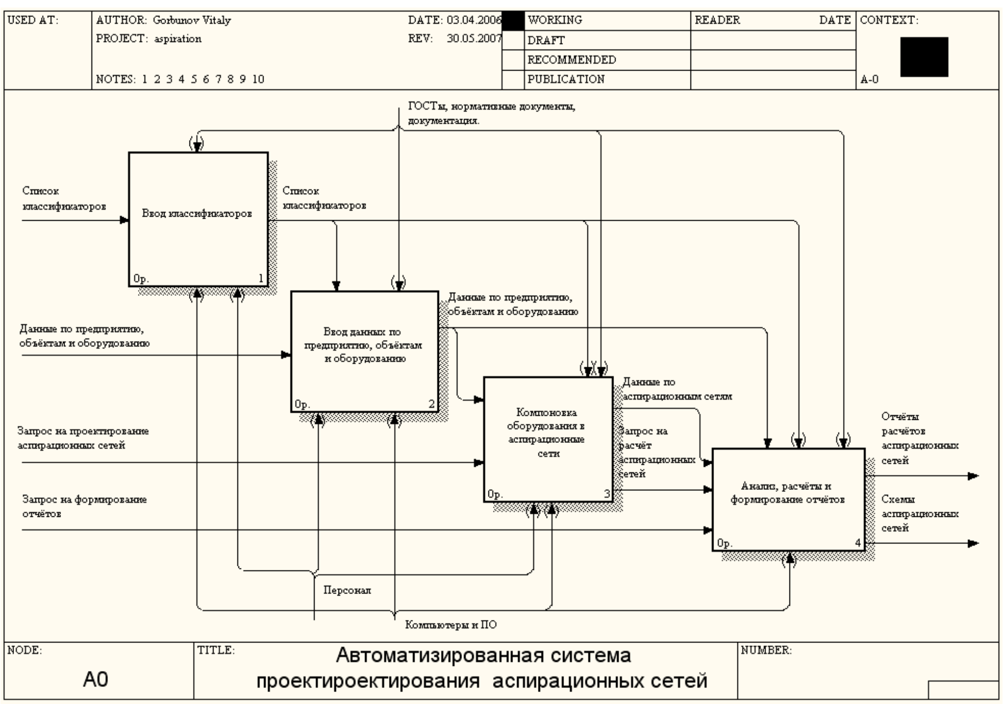


Fig. 3 – Decomposition of the parent diagram

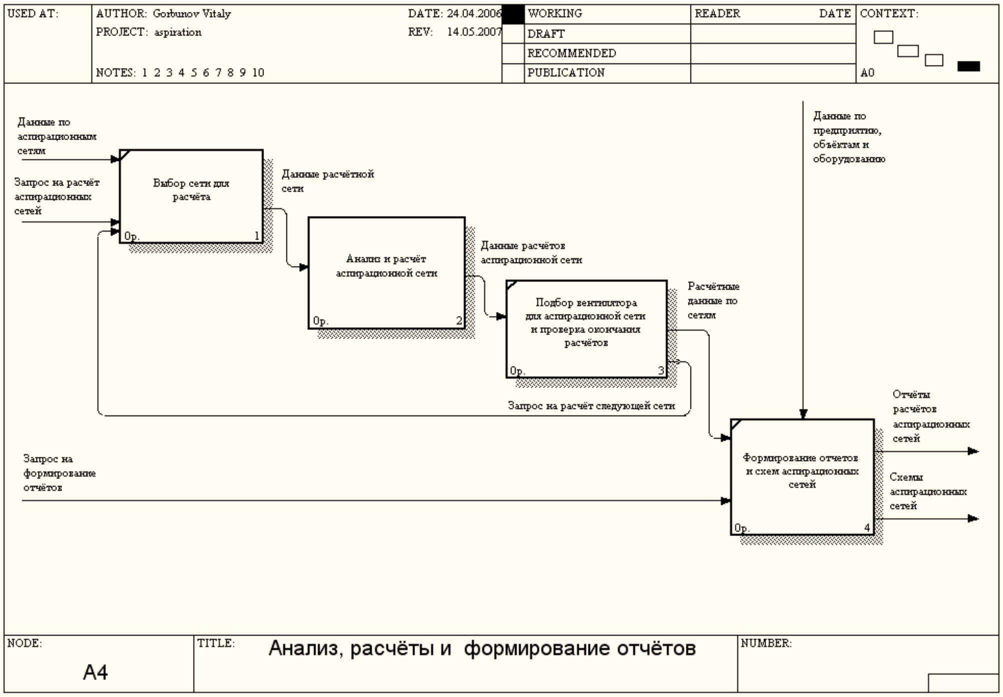


Fig. 4 – decomposition of the operator block "analysis of calculations, generation of reports"

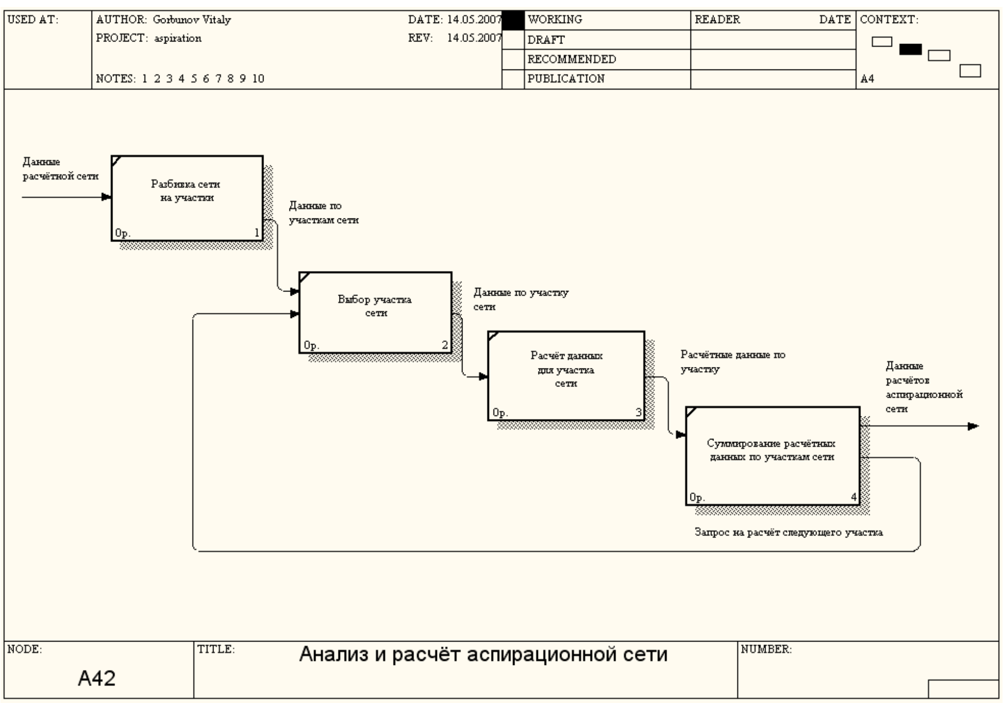


Fig. 5 – Decomposition of the operator block "analysis and calculation of the aspiration network"

In the diagram shown in Fig. 3, there are 4 operator blocks:

-entering classifiers;

-entering data on the company and equipment;

-arrangement of equipment of aspiration networks;

-analysis of calculations, generation of reports.

Each of the operators is connected by connections or interface arcs that provide conceptual and logical movement of the ongoing production (business) processes.

We will carry out the decomposition of the block operator "analysis of calculations, generation of reports", the result is shown in Fig.4.

As can be seen from Fig.4, as a result of decomposition, 4 operator blocks are obtained:

-selection of the network for calculation;

-analysis and calculation of the aspiration network;

-selection of a fan for the aspiration network, checking the end of the calculation;

-generation of reports and schemes of the aspiration network.

The SADT methodology allows you to simplify each block operator as much as possible, until you get a complete picture of the business processes and the absence of a team of authors or experts of questions on the project.

In order to obtain more complete information on the block operator "analysis and calculation of the aspiration network", we will carry out its decomposition, the resulting diagram is shown in Fig. 5.

As can be seen from the diagram in Fig.5, 4 operator blocks are obtained:

-network breakdown into sections;

-selection of the network section;

-calculation of data for a network section;

-summation of data by network sections.

We see that the decomposition of diagrams allows us to approach the solution of the project tasks in more detail, eliminate errors already at the design stages, which reduces the costs associated with revision and increasing the time for project development.

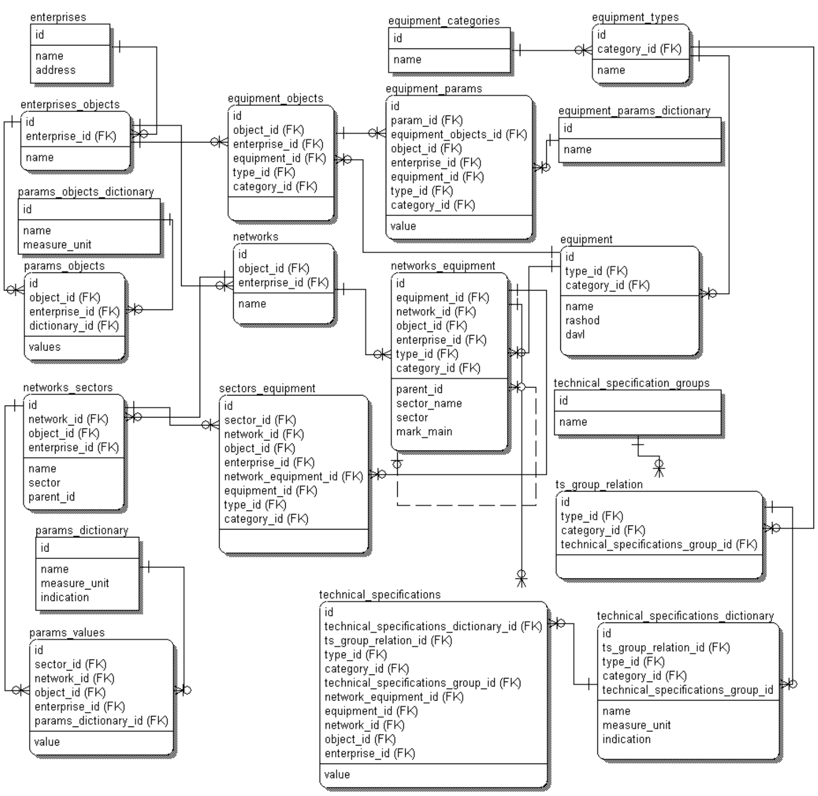


Fig. 6 – ASPAS information and logic model

The advantages of SADT technology, IDEF0 technology, include such qualities as visibility, reliability, ensuring the introduction of clarifications, the possibility of refinement without affecting the decisions of the main business processes, simplicity, flexibility. In this regard, the obtained structural and functional model of the automated aspiration network design system (SFMASPAS) was used as a base for the implementation of the grant project.

Conclusions. On the basis of the developed SFMASPAS, an information and logical model of an automated aspiration network design system (IFMASPAS) was created using the IDEF1X software tool, Fig. 6.

Description of the methodology and development of IFL is not considered in this article. Based on the IFL, an automated system for designing aspiration networks (SPAS) has been created that allows:

-automate calculations of aerodynamic characteristics of aspiration units;

-eliminate the possibility of errors in calculations;

-exclude exceeding the norms of the system parameters;

-significantly reduce the time spent on design.

The program (ASPAS) is developed in the object-oriented C++ language, in the Borland C++ Builder 6 Enterprise environment, in Russian.

The main menu of the program (ASPAS) is shown in Fig. 7.

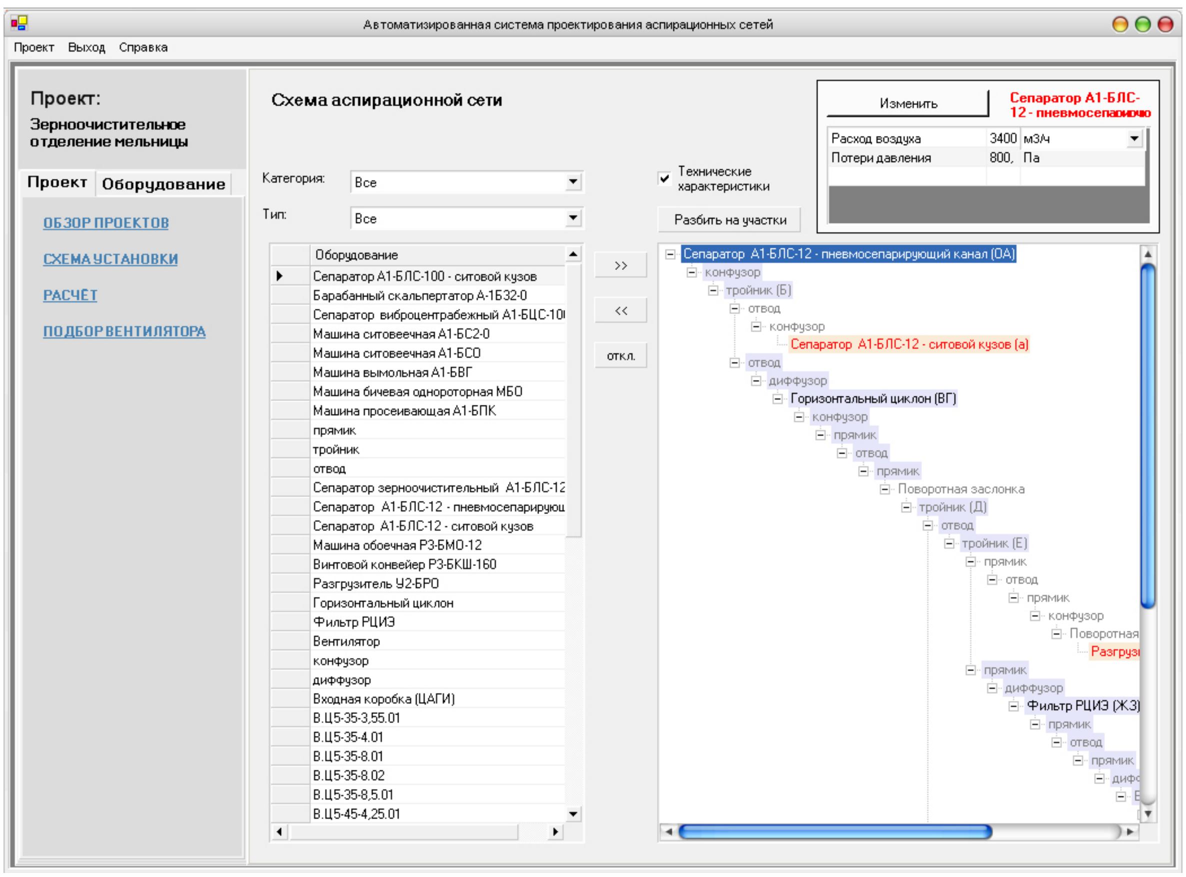


Fig. 7 – Program Menu (ASPAS)

Figure 8 shows the program interface for data input and output.

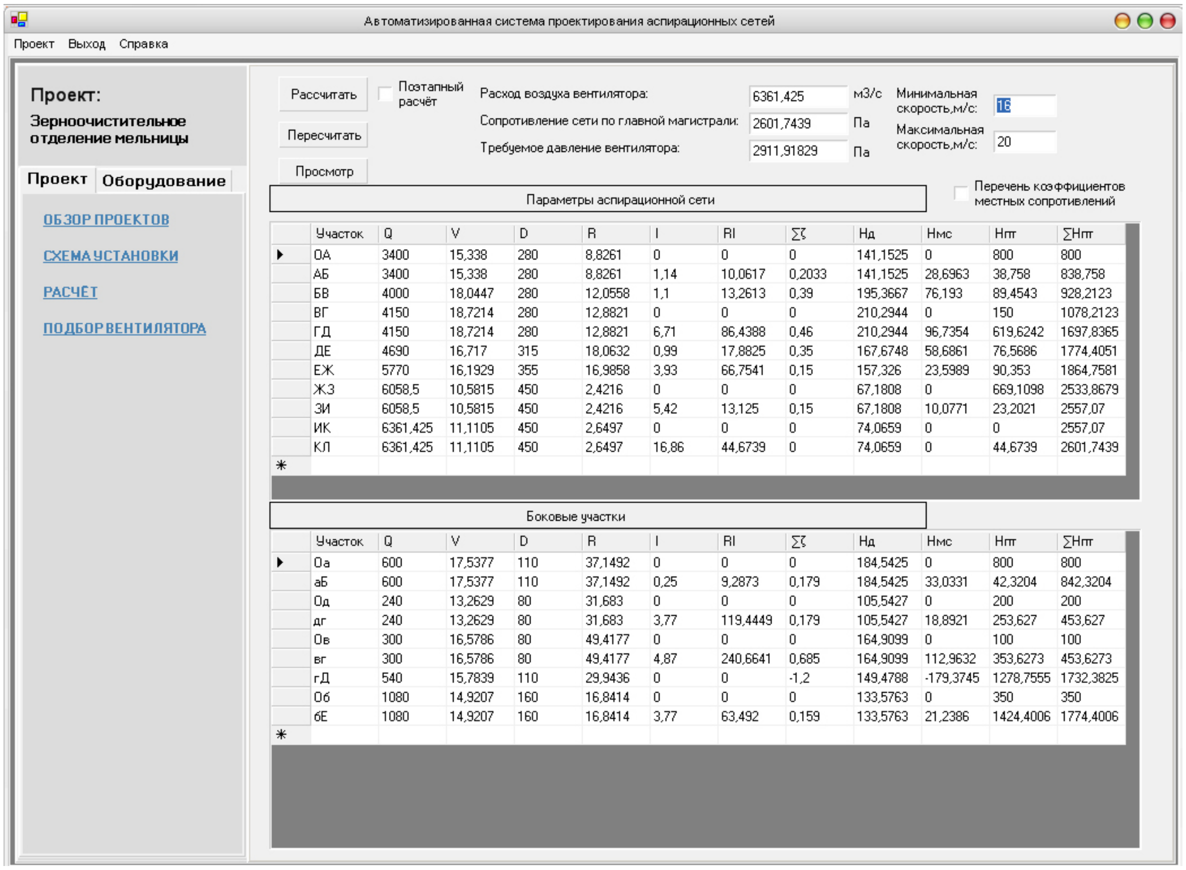


Fig. 8 – Program Interface (ASPAS)

In Fig. 9, the result of calculating the type of fan.

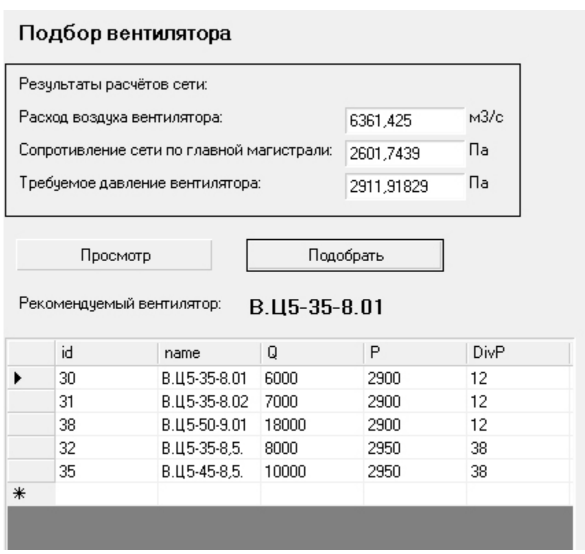
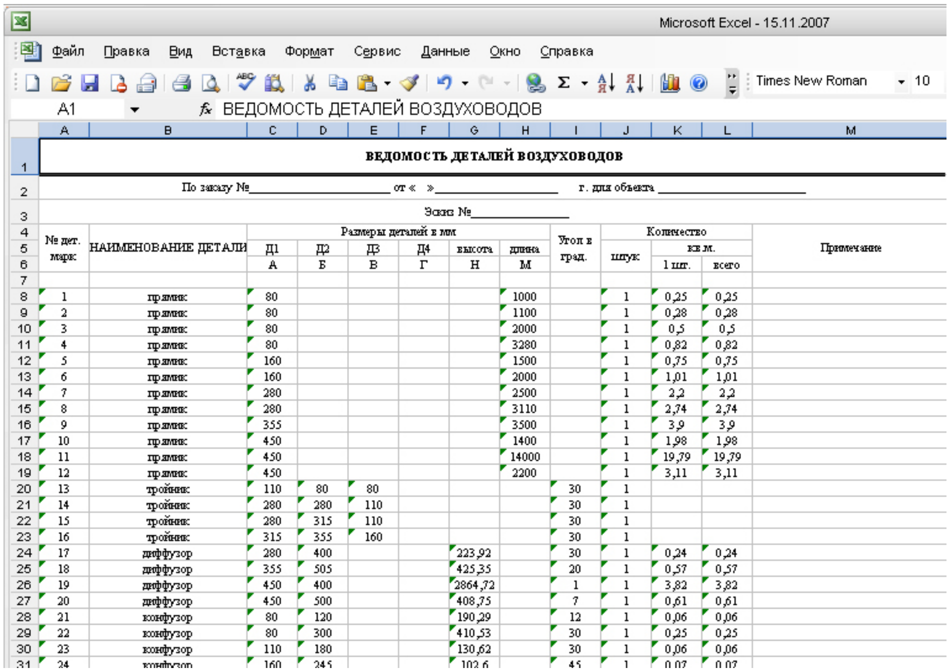


Fig. 9 – Fan type calculation

Figure 9 shows an example of the output of reports in the program (ASPAS).



ВЕДОМОСТЬ ДЕТАЛЕЙ ВОЗДУХОВОДОВ

По заказу №____________ от « »____________ г. для объекта ____________

Эскиз №____________

№ дет. марк	НАИМЕНОВАНИЕ ДЕТАЛИ	Размеры деталей в мм						Угол в град.	Количество		
		Д1	Д2	Д3	Д4	высота	длина		штук	кв.м.	
		А	Б	В	Г	Н	М			1 шт.	всего
1	прямик	80					1000		1	0,25	0,25
2	прямик	80					1100		1	0,28	0,28
3	прямик	80					2000		1	0,5	0,5
4	прямик	80					3280		1	0,82	0,82
5	прямик	160					1500		1	0,75	0,75
6	прямик	160					2000		1	1,01	1,01
7	прямик	280					2500		1	2,2	2,2
8	прямик	280					3110		1	2,74	2,74
9	прямик	355					3500		1	3,9	3,9
10	прямик	450					1400		1	1,98	1,98
11	прямик	450					14000		1	19,79	19,79
12	прямик	450					2200		1	3,11	3,11
13	тройник	110	80	80				30	1		
14	тройник	280	280	110				30	1		
15	тройник	280	315	110				30	1		
16	тройник	315	355	160				30	1		
17	диффузор	280	400			223,92		30	1	0,24	0,24
18	диффузор	355	505			425,35		20	1	0,57	0,57
19	диффузор	450	400			2864,72		1	1	3,82	3,82
20	диффузор	450	500			408,75		7	1	0,61	0,61
21	конфузор	80	120			190,29		12	1	0,06	0,06
22	конфузор	80	300			410,53		30	1	0,25	0,25
23	конфузор	110	180			130,62		30	1	0,06	0,06
24	конфузор	160	245			102,6		45	1	0,07	0,07

Примечание

Fig. 10 – Example of generating reports in the program (ASPAS)

The developed program (ASPAS), as shown by practical application and comparison with existing analogues [10-11], has the following advantages:

-significant reduction in the cost of design and calculation of aspiration units;

-reducing the time to search for information and reference materials;

-reduction of labor costs of employees for the design of aspiration networks in design organizations, grain companies and large grain enterprises;

--reduction of time for the formation of specifications and wiring diagrams of aspiration systems;

-reduction of the development time of aspiration system projects by 10-15 times compared to the manual method;

-compliance with modern requirements for the design of production and technological systems.

Currently, the developed program (ASPAS) is used in the educational process of Moscow Academy of Food Production, as well as in project organizations in Russia.

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