Conceptual Approaches to the Development of a Cloud Resource for the Calculation of Air

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Abstract: One of the components of the Industry 4.0 concept is the use of cloud computing in the production processes of enterprises such as "smart factory". The strategy for the development of the chemical and petrochemical complex for the period up to 2030 provides for state support of enterprises for the purpose of updating and expanding capacities, implementing innovative developments, conducting research and development work to introduce innovative developments. The paper presents the development of a cloud service concept for calculating air coolers in the technological processes of the chemical and petrochemical industry. Air coolers are one of the most important elements of many chemical and petrochemical processes, and the development of software for calculating the characteristics continues to be an urgent task.

1 INTRODUCTION

The strategic objectives of the growth of the Russian economy cannot be solved without the use of modern information technologies. At the same time, the construction of new manufacturing enterprises and the modernization of existing ones should be based on the integrated optimization of production business processes through the implementation of the principles of Industry 4.0, which imply a wide digitalization of production, the use of Internet technologies, including the industrial Internet of things, cloud computing (Guryanov, 2018).

The strategy for the development of the chemical and petrochemical complex of Russia (Strategy, 2013) defines targets for the modernization of technological equipment for the transportation of gas and oil resources, ensuring an increase in efficiency and environmental friendliness.

Air coolers (AVO) are widely used, since they are used in chemical production processes: ammonia, methanol, nitric and sulfuric acid, organochlorine products, in petrochemical production processes: styrene, ethanol, polypropylene, acetaldehyde, caprolactam, motor and diesel fuels, cracking and reforming hydrocarbons.

AVOs have a number of advantages over other types of heat exchangers: they do not require preliminary preparation of heat carriers, are reliable in operation, environmentally friendly, and have simple connection schemes. (Sidyagin, 2009).

In (Khalismatov, 2016), it is concluded that the demand for further expanded use of AVO in the coming decades will increase with increasing requirements for increasing reliability and improving technical and economic indicators.

The most relevant, at present, is the use of AVO at booster compressor stations for the purpose of cooling natural gas, booster compressor stations (CS) ensure the maintenance of the required gas pressure in the main gas pipelines (MG).

Figure 1 shows a diagram of the use of air coolers when completing them in gas cooling units during gas transportation (Kalinin, 2018).

Compression of gas at the compressor station causes an increase in its temperature at the outlet of the station, and not using cooling devices leads to a decrease in the efficiency of transportation due to a decrease in the supply of process gas and an increase

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in energy consumption for its compression, and also to a deterioration in the state of the gas pipeline. The relevance of the use of gas compression increases with the time of well operation, as the reservoir pressure decreases and the need to increase the degree of compression (Kichatov, 2012).

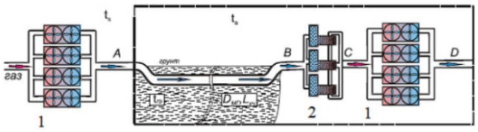

Figure 1: Diagram of AVO application (1).

The level of gas cooling utilization depends on the climatic features of the location of the gas pipelines.

In hot and dry climates, the cooling efficiency is reduced and water spray is used to equalize temperatures. In (Alhazmy, 2004), the results of a study of the application of water atomization and air cooling of gas are presented, studies have shown that water atomization increases the efficiency of gas cooling.

For cold conditions, taking into account the fact that the routes pass in the zone of frozen soils, lowering the gas temperature to the soil temperature allows maintaining the stability of the linear part of the gas pipeline and increasing its reliability (Sidyagin, 2009).

In the general case, for enterprises using AVO, the efficiency of the final technological process is reduced to the management of integral economic efficiency (Chekardovsky, 2015). The task of managing the integral economic efficiency, in turn, is decomposed into the tasks of managing the structural efficiency of the air cooling system, the thermal efficiency and the efficiency of automated control.

The quantitative indicator of thermal efficiency is the heat transfer coefficient of the air cooling system, and the optimization task is its maximization. The search for a solution to the problem of maximizing thermal efficiency is directed towards the development of new designs of apparatus (Balchugov, 2019), the modernization of air cooling elements, for example, finned tubes (Kalinin, 2018), optimization of the fan control (Pashkin, 2019).

The quantitative indicator of the structural efficiency is the material costs for the manufacture of AVO, and the optimization task is its minimization. The solution of the problems of optimization of apparatus designs has now led to block AVO (Sidyagin, 2009), which allows consumers to form designs according to the needs of the technological process.

The tasks to be solved when assessing thermal efficiency are reduced to the calculation:

- the actual thermal characteristics of AVO;
- the actual hydraulic characteristics of the AVO;
- the actual aerodynamic characteristics of AVO

Tasks to be solved in the automation of AVO control:

- operational calculation of characteristics (thermal, hydraulic, aerodynamic) depending on the operating conditions (changing the characteristics of the AVO and taking into account changes in the environment). (Wanchin, 2014).

Thus, the analysis of the research carried out in the field of cooling chemical processes using ABO showed the exhaustion of traditional approaches to increasing the integral economic efficiency and the need to develop new tools based on the principles of Industry 4.0.

2 MATERIALS AND METHODS

To develop conceptual approaches to the implementation of calculation procedures for the integral economic efficiency of air coolers on cloud platforms, it is necessary to consider various model representations of a given physical object.

When constructing conceptual approaches and analyzing model representations, methods of information technology, case technologies, methods of database design, methods of comparative analysis, programming in php, using the markup language html, css tables were used.

Physical model of AVO. An air cooler is a special type of heat exchanger, which includes the following main components and assemblies: sections of finned heat exchange tubes of various lengths (from 3 to 12 m), electric fans, diffusers and louvers for adjusting the air capacity, supporting structures, control mechanisms, etc. control automation tools (Migachev, 2015).

AVO mathematical models. Mathematical models of heat exchange processes in air coolers in the general case (Hartman, 2006) are represented by nonlinear differential equations, the solutions of which, under various assumptions, are analytical expressions for calculating thermal efficiency. Another approach to constructing mathematical models is to construct empirical expressions based on experimental data using procedures for identifying the parameters of these models (Kryukov, 2017).

The use of adequate mathematical models for the verification calculation of AVO is especially important in the development of energy and resource-saving measures, since the overestimation of the calculation results when determining the operating and design parameters leads to large safety factors and a decrease in the indicators of the technological process for energy and resource saving (Gartman, 2006).

Computational models. For the first time, the calculation of the thermal efficiency of AVO was developed in the VNIINEFTEMASH methodology (Abrosimov, 1971).

Currently, other calculation methods have appeared, such as the calculations of TyumGNGU, TyumGASU and others. In (Cherdakovsky, 2015), a comparison was made of various methods for calculating the thermal efficiency of an air cooler.

There are also various approaches to modeling and calculating efficiency using universal software systems (Liu, 2020; Faizov, 2016).

The described computational models have different computational accuracy, levels of approximation and the main drawback □ the lack of open access to these models, which does not allow an objective choice of the computational procedure under operating conditions.

Information model. The information model includes a set of parameters necessary for calculating the integral efficiency of the AVO. Figure 2 shows a diagram of the information model, which is extensible if additional parameters appear.

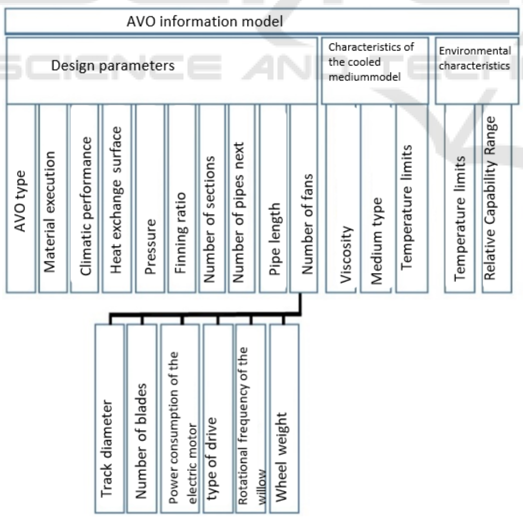

Figure 2: Information Model Diagram.

Thus, the dominant element of the ABO model representations are computational models, the implication of which is software.

Analysis of the software presented in the works showed the similarity of approaches to its functionality. As a rule, software (SW) is either a separate application that implements one of the methods for calculating one of the above-mentioned AVO efficiencies (Terekhin, A.V., 2020). Such an application is installed on a local computer and used for personal access.

In other cases (Kruglikov, 2010), the software is a set of programs that allows using the programs of the complex as modules in the calculations of other equipment.

The formulation of the problem of increasing the efficiency of the entire gas industry, which has been accumulated in Gazprom, requires the accumulation of all computational models and software implementations on cloud resources.

At the same time, the use of cloud resources is understood as a network service that provides services for solving problems of calculating and controlling air cooling and other related equipment when cooling gas without purchasing software

3 RESULTS

When investigating the issue of cloud computing, first of all, the issues of practical applications were considered. In particular, of the already implemented Internet services, it should be noted the works (Ochkov, 2011), which can be integrated into the designed cloud platform as components of a common service.

Figure 3 shows the conceptual structure of a cloud platform. The core of the platform is a unified information space implemented as a data warehouse.

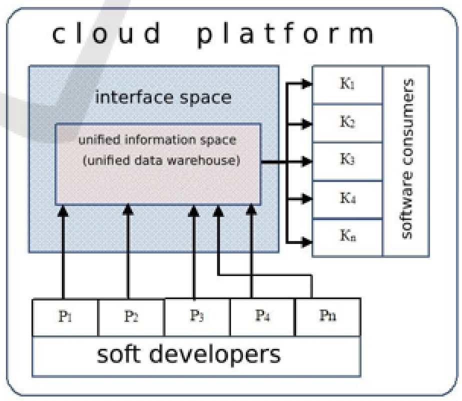

Figure 3: Conceptual structure of the cloud platform for calculating the integral efficiency of AVO.

The structure of the data warehouse is based on the information model shown in Figure. 2.

Calculations that Consumers can perform (Figure. 3) are based on computational models implemented in the form of software by the Software Developers.

The interaction of Consumers and Developers with a single information space is carried out through a standardized interface. This makes it possible for corporate Consumers to collaborate on a network, in the further implementation of crowd-computing (Smirnov, 2017).

4 SUMMATION

Creation of a cloud resource for calculation, modeling, design is advisable.

The first stage in the creation of a cloud resource is the development of a SaaS Internet service for calculation procedures of standard computational methods for the AVO produced.

The second stage of creating a cloud resource is the development of a cloud platform in the concept of a PaaS service.

Creation of a cloud platform is expedient in the form of a private cloud (Mezhueva T.A.) within the framework of the creation of domestic data centers.

5 CONCLUSIONS

The creation of a cloud resource for calculating the integral efficiency of air coolers is an urgent task. The paper considers a conceptual approach to solving this problem, identifies ways to create a unified information space, which stores both the parameters of various types of devices and local databases for users of a cloud resource.

Significant work is needed to verify the calculation methods, unify the parameters included in the computational algorithms.

In many techniques, they are used to set certain parameters - nomograms, which are built only for certain values, in many cases these are experimentally constructed nomograms, for cloud computing it is necessary to digitize nomograms, which in itself is quite laborious and not an easy task.

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