

Conference proceedings

of the 4th international conference on
energy supply and
energy efficiency

and

“5 years NESEFF”





network for energy supply and energy efficiency

4TH INTERNATIONAL CONFERENCE ON ENERGY SUPPLY
AND ENERGY EFFICIENCY IN BAKU AZERBAIJAN AND 5
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VORWORT

Klimawandel, CO₂ Reduzierung, Ressourcen-effizienz sind nur 3 aktuelle Schlagworte, die die gegenwärtige industriell- ökonomische Situation beschreiben. Dabei muss der Umbau der Versorgungssysteme mit technisch nutzbaren Energieformen im nächsten Jahrzehnt erfolgreich gelingen, um die klimatischen Veränderungen wirksam zu beeinflussen. Das im Jahre 2015 in Baku gegründete internationale Netzwerk bündelt die Forschungsaktivitäten auf dem breiten Gebiet von Energieversorgung und Energieeffizienz.

Diskutieren sie mit den Wissenschaftlern und Experten aus namhaften Universitäten über aktuelle Forschungsansätze und Ergebnisse und verfolgen sie die Anstrengungen Aserbaidischans, die Energiewende zu realisieren.

Climate change, CO₂ reduction, resource efficiency are only 3 current keywords that describe the current industrial-economic situation. In order to influence climate change effectively, the conversion of supply systems with technically usable forms of energy must succeed in the next decade. The international network founded in Baku in 2015 bundles research activities in the broad field of energy supply and energy efficiency. Discuss current research approaches and results with scientists and experts from renowned universities and follow Azerbaijan's efforts to implement the energy revolution.

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1. Testing of Small Scale Tank Prototypes under Cryogenic Conditions

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Abstract

To reduce global emissions of CO₂, liquified natural gas (LNG) is increasingly used as fuel. As there is no global pipeline network, LNG needs to be transported via ship or truck. Double-walled tanks made of steel with a vacuum insulation are currently used to keep LNG at cryogenic temperatures (-162 °C; 111 K) to ensure the LNG remains liquid over the transportation time. The double-walled construction makes the tanks heavy and expensive. Furthermore, there are some restrictions in carrying out in-service inspection using a double-wall design. Therefore, alternative tank designs, such as single wall glass fiber reinforced plastics (GFRP), are of growing interest. This paper investigates the thermal performance of different tank designs by use of an analytical calculation tool.

Keywords: lightweight design, GFRP, LNG, transportation tanks, cryogenic temperatures

Introduction

The reduction of the emission of greenhouse gases is a key step to the global goal of reducing the climate change. 2015 the emission in transportation increased about 50% compared to the year 1990 and about 12% compared to 2007 [1]. Due to the lower CO₂-emission compared to other fossil fuels, liquefied natural gas (LNG) is seen as a medium term solution for this goal. The German Government's coalition agreement sets that "LNG, shore power and hydrogen shall be established as environmentally friendly drive for ships by increasing the funding for maritime transportation". Furthermore, "Germany shall be developed into a center of infrastructure for LNG" [2]. The promotion of LNG is important, which shows that the optimization of the distribution process is a very relevant research topic.

This paper describes the experimental test setup to determine the thermal performance of small scale tank prototypes (SSTP), which will be transferred to real scale tanks for the transportation of liquefied natural gas (LNG) at cryogenic temperatures. The overall goal is to develop a transportation tank that can transport LNG over a time of 10 h.

Methods

The general structure of the examined transportation tank consists of 3 layers: thermal insulation, load bearing structure and leakage barrier. PUR-foam is used as thermal insulation, as previous testings showed promising results [3]. For the load bearing structure, glass fibre reinforced plastic is used, to achieve sufficient mechanical properties combined with low density and low costs. Aluminum is used to prevent leakage through matrix cracks of the GFRP, which occur at low temperatures.

For the analysis of the thermal performance of tank prototypes, an analytical calculation tool is used. This tool was developed at the university of applied sciences Zitta/Görlitz and provides a variety of parameters, that can be adjusted [4].

The tool is used to run a parameter study. The examined parameters are: heat transfer coefficient (inner and outer surface), emissivity, heat radiation and its surface area, ambient air temperature, air velocity.

Afterwards, two small scale tank prototype (SSTP) of different sizes (12,5 l and 133 l) are tested, to determine their thermal performance. The tanks are filled with liquid nitrogen (degree of filling: 85 %) and then closed, to measure the time until an inner pressure of 4 bar (relative) is reached ($t_{4\text{bar}}$). Both SSTPs are rebuilt with the analytical tool. The small SSTP is used to fit

the tool to the experimental testing and determine the thermal conductivity of the system (thickness of insulation: 125 mm). The larger SSTP is used to analyse the error of the analytical tool (thickness of insulation: 140 mm). Next, the tool is used for a prediction of the thermal performance of a real scale transportation tank (RSTT, 12,5 m³).

For all experimental testings and calculations liquid nitrogen is used as liquid inside the tank (boiling point at atmospheric pressure: -196 °C).

Results

The parameter study shows that the ambient air temperature and the degree of filling have the biggest influence on t_{4bar} (

Fig. 1 and Fig. 2).

This means that the main mechanism for heat transfer is heat conduction. For a simple comparison, radiation can be neglected. For the comparison of tank prototypes of different sizes, the volume, degree of filling, ambient air temperature and relation of the tank's surface to volume A/V are important.

Fig. 1: variation of pressure increasing time, depending on the ambient air temperature

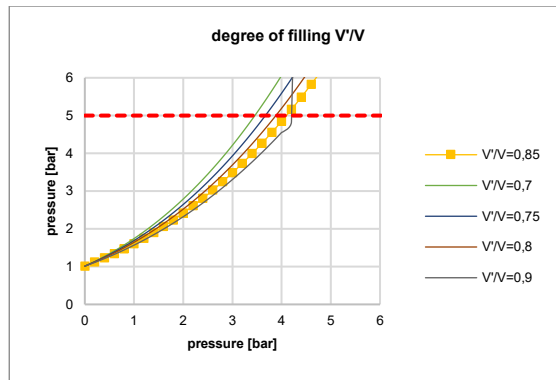


Fig. 2: variation of pressure increasing time, depending on the degree of filling

The experimental testing of the smaller SSTP gives a time of 87 min until a pressure of 4 bar (relative) is reached.

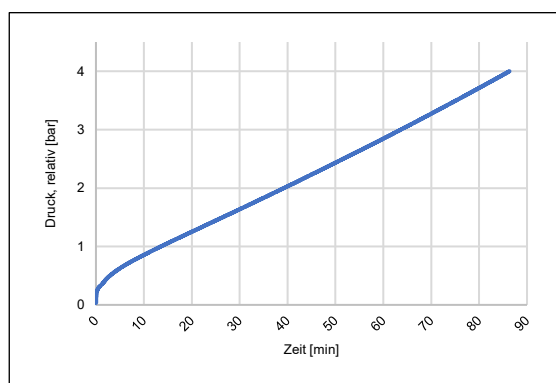


Fig. 3: increase in pressure of the small SSTP, degree of filling 85%

The parameters of the first experimental test are used to set up an analytical model (Fig. 4). The value for the thermal conductivity of the insulation is adjusted, until 87 min are achieved in the calculation as well (Fig. 5).

input		
inner diameter	$d_i =$	0,154 m
inner length	$L_i =$	0,671 m
thickness load bearing layer	$\delta_1 =$	0,0025 m
thickness insulation	$\delta_2 =$	0,125 m
radiation	$q^* =$	500 W/m ²
ambient air temperature	$T_u =$	20 °C
ambient pressure	$p_u =$	1,01325 bar
initial inner pressure	$p_i =$	1,04425 bar
degree of filling	$V/V =$	0,85 -
wind velocity	$c_w =$	10 km/h
thermal conductivity load bearing structu	$\lambda_1 =$	50 W/mK
thermal conductivity insulation	$\lambda_2 =$	0,0333 W/mK
outer heat transfer coefficient	$\alpha_a =$	5 W/m ² K
inner heat transfer coefficient	$\alpha_i =$	75 W/m ² K
emissivity	$\epsilon =$	0,8 -
area of radiation	$A_{str}/A_a =$	0,5 -

Fig. 4: Input values for the calculation of the smaller SSTP

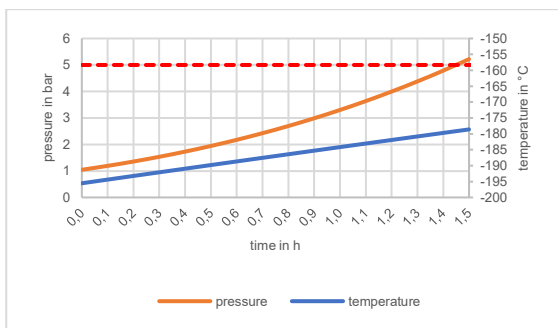


Fig. 5: calculated time and temperature until 4 bar (relative) are reached, smaller SSTP

For the testing of the larger SSTP, the degree of filling is set to 50 %. The pressure increasing time is measured as for the smaller SSTP. 4 bar are reaches after 133 min ($\approx 2,25h$, Fig. 6).

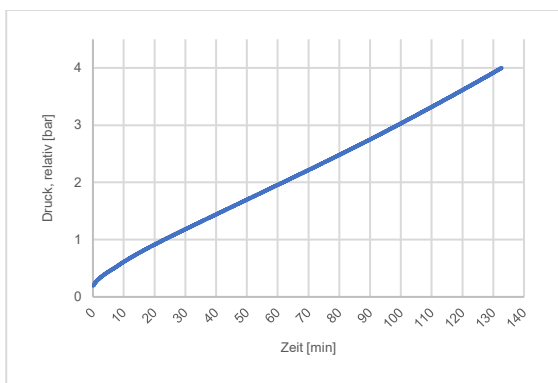


Fig. 6: increase in pressure of the large SSTP, degree of filling 50%

For the analytical tool, the dimensions of the larger SSTP and the degree of filling are applied (Fig. 7).

input			
inner diameter	$d_i =$	0,332	m
inner length	$L_i =$	1,536	m
thickness load bearing layer	$\delta_1 =$	0,013	m
thickness insulation	$\delta_2 =$	0,14	m
radiation	$q^* =$	500	W/m ²
ambient air temperature	$T_u =$	20	°C
ambient pressure	$p_u =$	1,01325	bar
initial inner pressure	$p_i =$	1,21425	bar
degree of filling	$V/V =$	0,5	-
wind velocity	$c_w =$	10	km/h
thermal conductivity load bearing structure	$\lambda_1 =$	50	W/mK
thermal conductivity insulation	$\lambda_2 =$	0,0333	W/mK
outer heat transfer coefficient	$\alpha_a =$	5	W/m ² K
inner heat transfer coefficient	$\alpha_i =$	75	W/m ² K
emissivity	$\epsilon =$	0,8	-
area of radiation	$A_{str}/A_a =$	0,5	-

Fig. 7: Input values for the calculation of the larger SSTP

The calculation shows an increasing pressure time of 2,85 h (Fig. 8). The difference between the calculation and the experimental testing is 0,6 h. For a simplified and fast analytical calculation, this degree of precision is sufficient.

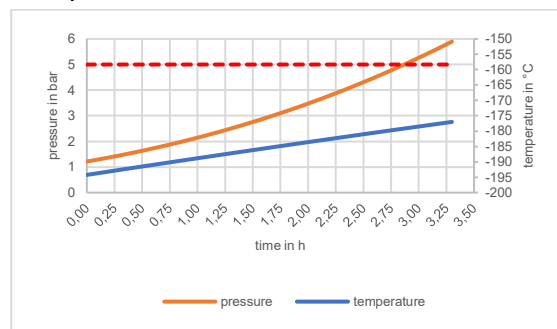


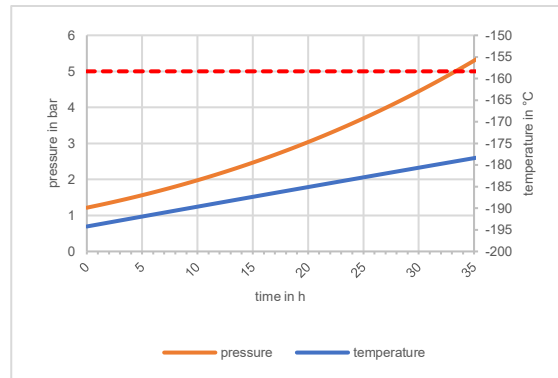
Fig. 8: calculated time and temperature until 4 bar (relative) are reached, larger SSTP

The analytical tool is used for the prediction of the thermal performance of a real scale transportation tank (RSTT). The dimension are chosen to fit the surface to volume ratio used in the previous calculations while having a volume of 12,5 m³. The input parameters can be seen in Fig. 9.

input			
inner diameter	$d_i =$	1,7445	m
inner length	$L_i =$	5,2335	m
thickness load bearing layer	$\delta_1 =$	0,013	m
thickness insulation	$\delta_2 =$	0,14	m
radiation	$q^* =$	500	W/m ²
ambient air temperature	$T_u =$	20	°C
ambient pressure	$p_u =$	1,01325	bar
initial inner pressure	$p_i =$	1,21425	bar
degree of filling	$V/V =$	0,85	-
wind velocity	$c_w =$	10	km/h
thermal conductivity load bearing structure	$\lambda_1 =$	50	W/mK
thermal conductivity insulation	$\lambda_2 =$	0,0351	W/mK
outer heat transfer coefficient	$\alpha_a =$	5	W/m ² K
inner heat transfer coefficient	$\alpha_i =$	75	W/m ² K
emissivity	$\epsilon =$	0,8	-
area of radiation	$A_{str}/A_a =$	0,5	-

Fig. 9: Input parameters for the calculation of the RSTT

The calculation gives an a time to pressure increase limit of approximately 33 h. Considering the inaccuracy of the analytical tool and the experimental testing, it can be said, that with the given tank design (insulation up to 150 mm) the goal of a transportation tank up to 10 h can be achieved.



Conclusion

- ✓ Thickness of at least 100 mm of PUR-foam give satisfying results in terms of thermal properties.
- ✓ The non-pressure testing methods gives reliable and repeatable results.
- ✓ Thermal testing will be repeated with tanks of different sizes to generate a transfer function from non-pressure to pressure testing:
 - Larger tank prototype made of GFRP and aluminum liner
 - 100 mm PUR-foam insulation
 - Boil-off rate and increase-in-pressure-time

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2. Decarbonisation of industrial processes - New DLR institute in Cottbus and Zittau

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Abstract

Environmental protection has gained considerably in importance since climate change has been recognized as one of the most difficult challenges for humankind. Despite agreed climate targets, global emissions of Greenhouse gases have actually increased over the last three decades. ^[1] Especially in the energy-intensive industrial sector, there is still great potential for CO₂-reduction, which has not yet been exploited. The Institute of Low-Carbon Industrial Processes dedicates its research efforts to these savings. The present article sheds light on the most recent and upcoming research topics for reducing or eliminating fossil energy sources as well as process-related CO₂-emissions caused by industrial production.

Keywords: high-temperature heat pumps, energy hub, simulation, CO₂, optimization, low carbon reducing agents

Introduction

Environmental protection is becoming increasingly important in Germany, and also worldwide. At climate conferences, such as in Paris in December 2015, ambitious global goals and strategies were defined. Achieving these goals brings with it many serious challenges that must be overcome within the next decades. For instance, grid stability has to be guaranteed at all times, despite the inherently variable power generation of photovoltaics and wind turbines. Energy storage systems will have to compensate both for short term and long-term generation fluctuations, specifically in the context of continuous operating industrial processes. Moreover, renewable power generation is not centralized and must be conducted over longer distances, preferably without major losses to energy consumers on industrial sites and in urban centers.

To achieve these very ambitious climate goals, it is mandatory to reduce Greenhouse gas emissions in all sectors. In spite of various actions, Greenhouse gas emissions have increased worldwide and have only slightly decreased in Germany. ^[1] Between 2011 and 2017, the CO₂ equivalent emissions reached an average of 913 million tons (Germany) and in 2019, German Greenhouse gas emissions still amounted to 805 million tons. As one of the main sources of CO₂-emissions, the industrial sector contributed roughly 179 million tons of CO₂ equivalent (2012) to Germany's Greenhouse gas emissions. ^[2] This amount even increased in subsequent years. From 2017, a major goal is to reduce all emissions by 30% until 2030 (see Fig. 1). ^[2]

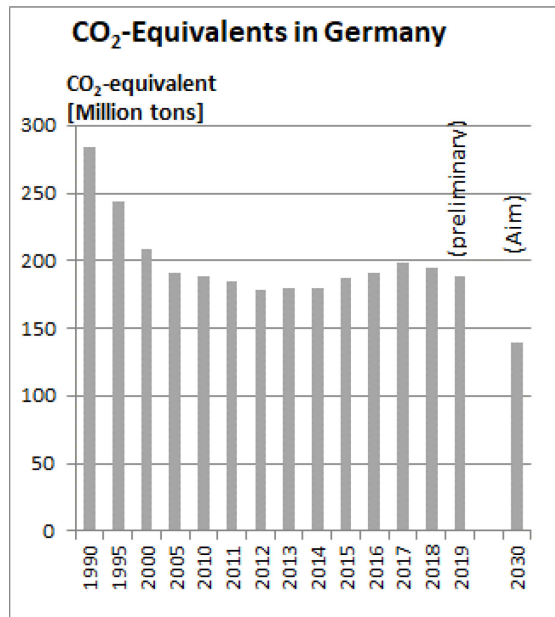


Figure 1: Industrial Greenhouse gas emissions over the course of 28 years. [3]

The emissions of the industrial sector arise mostly through high energy demands and carbon-based reducing agents (coal, coke, natural gas), e.g. in steel industry, fertilizer and cement production as well as refineries.

In 2019, the new DLR institute has been founded to develop technologies and strategies for reducing these industrial emissions. The Institute of Low-Carbon Industrial Processes focusses on three major fields of research: (i) the development of High-Temperature Heat Pumps (HTP) (ii) Simulation and optimization of industrial plants, and (iii) the substitution of conventional reducing agents with low-carbon alternatives. This new branch of research fits seamlessly into the overall strategy of the DLR and is expected to contribute substantially to the global reduction of industrial CO₂ emissions.

Department of the High-Temperature Heat Pump (HTP)

A closer look at the primary energy consumption in 2017 reveals, that process heat accounts for ~24%, from which 20%-pts. are emitted by the industrial sector, whereas the remaining 4% originate from Business sector (Business, Commerce and Service). However, only about 14% of the total primary energy demand in 2017 was covered by renewable energy.

The primary energy demand as well as the overall energy consumption did not change significantly between 1990 (9,071 PJ) and 2017 (9,472 PJ). In total, industrial sector accounted for ~28-32% of the energy demand and ~70% of this was covered by fossil fuels (hard coal and lignite, petroleum products, gases). [3] Almost two-thirds of industrial energy consumption is currently used to generate process heat. The decarbonization of industrial processes must thus start with strategies and technologies to reduce process heat-related emissions.

The unsteady energy supply is one of the reasons why renewable energy sources are difficult to integrate in industrial processes. Process heat usually has to be generated continuously, reliably and at high temperatures. To compensate for fluctuations, heat storage systems are needed that potentially increase capital expenditures. However, renewable (especially solar energy) energy is already generated at a lower price than power coming from fossil sources.

In this context, high temperature heat pumps are the missing link to electrify the heat consumption of industrial processes. Conventional heat pumps for domestic and industrial purposes have coefficients of performance (COP) of up to 5 and deliver heat at temperatures up to 120°C. ^[4] Higher temperatures lead to COPs that are significantly below 5. For instance, Arpagaus describes, a heat pump with a peak temperature of 160°C achieving an COP of 2,7. ^[4] In order to decarbonize industrial processes, heat must be generated at temperatures of 150-500 °C, while maintaining COPs as high as possible. At the same time this must be done at a levelized cost of heat that is competitive with that of current technologies. If these challenges can be met through innovative concepts, high-temperature heat pumps will enable direct use of renewable energies for process heat. The latest developments in the field of high-temperature heat storage, mainly from concentrated solar power applications, will allow the decoupling of the continuous heat demand from the varying primary energy source. Moreover, the combination of high-temperature heat pumps with heat storage, and a back-converting heat engine can form a very efficient and cost effective energy storage system. ^[5]

Modifications in the power and industrial sector usually involve high technical and financial risks. Modular control systems are therefore mandatory to ensure flexibility and to control integrated systems. Flexibility is guaranteed through a large portfolio of drive and control units. To determine which technology should be used for a given task, some principle questions must be clarified in advance:

- Which heat pump architecture and thermodynamic cycle are energetically and economically efficient?
- Which power and shaft speed range of the electrical machines are required?
- Which operating parameters are available as control variables?
- What are the requirements of the control loop regarding e.g. response time, security, or precision?

Electric machines and their control units are available in all relevant sizes: From high-precision servo motors to generators for power plants. For AC drives, there is a wide range of synchronous and asynchronous machines depending on the requirements for installation space, efficiency and speed. ^[6] The latest developments in variable speed pumped hydro power plants can be a starting point in this case. Future regulations may implement even stricter requirements, which can be met by an efficient interaction of an wide field of different components: Starting with hardware (e.g. power electronics) and ending with digitalization to control and monitor the interactions of such complex systems.

In the High-Temperature Heat Pumps (HTP) department, first HTP prototypes are currently being built at a pilot scale. The very first prototype will operate with the Brayton cycle and air as the working medium. Here, air is compressed with an electrically driven compressor that increases both pressure and temperature. Heat is subsequently transferred to the industrial process in question with a heat exchanger. The operation with air and a pressure ratio of approximately 6 can deliver heat at temperatures up to 370°C depending on the cycle architecture. Subsequently, the air is expanded in a turbine generating electrical energy which partially compensates for the energy required to operate the compressor of the system. During expansion, the temperature of the working medium drops below 0 °C. As a result, the heat pump can also deliver cooling through a second heat exchanger. An additional recuperator

allows for transferring heat from the outlet stream of the first heat exchanger to the gas stream entering the compressor. The recuperator adds an additional element of control to the system enabling to simultaneously increase maximum and decrease minimum temperatures, at which the heat pump delivers heat. Tests with varying mass flow rates fed to or bypassing the recuperator will provide initial insights into the performance of the entire system. A 3-D model of the pilot plant is shown in **Figure 2**.

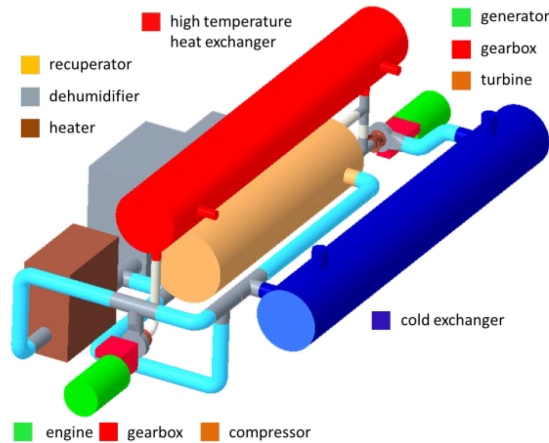


Figure 2: 3D-model of a High-Temperature Heat Pump.

Results from test runs will be used to verify and validate simulation models. Especially, the following questions will be addressed:

- Which working fluids are suitable for use in high-temperature heat pumps?
- Concerning process heat and cooling, which temperatures can be achieved, depending on the gas composition?
- Which volume/mass flows and temperatures can be achieved and how much heat can be transferred to heating or cooling process streams?
- How can HTPs use renewable power sources to deliver heat and cooling in industrial processes?
- How can HTPs be adjusted and scaled up for implementation in various industrial processes?
- Which heat pump concepts are best suited for which industrial processes?

During designing the first Brayton-HTP, calculations and simulations were carried out to examine the effect of different media on operational parameters. The temperature after compression was investigated as well as flow characteristics, the required power, and heat transferred in both heat exchangers. Monatomic gases, such as helium or argon, have no chemical bonds to which energy could be transferred. The energy absorbed in the compressor therefore only accelerates the disordered movement of the atoms. Consequently, higher temperatures can be achieved for the same pressure ratio, when noble gases are used.

The specific heat capacity of more complex gases increases for higher temperatures. At a given compressor pressure ratio, the achievable temperature is consequently lower. On the other hand, the same volume of gas can transfer significantly more energy at a given temperature. Compared to noble gases, 1 mol carbon dioxide carries 2.5 times the amount of energy at 200 °C. With sulphur hexafluoride it is even 6.2 times this amount.

The different gases represent one option to adapt HTPs to future applications. Depending on the type of gas or mixture, different temperatures and efficiencies can be achieved. The same applies to the quantity of heat stored within the HTP cycle or to how compact heat pumps can be built. Different temperatures, gas densities and flow rates strongly influence the design of the HTP and must therefore be taken into account when designing new heat pumps.

Department of Simulation and Virtual Design (SVD)

The reduction of CO₂-emissions is an extremely complex task, especially for industrial processes, to which a whole series of further conditions are attached. Jobs need to be preserved, the environment must be protected, the use of fossil fuels shall be avoided. At the same time, supply of energy must be secured, and the existing standard of living should also be maintained. To this end, solutions are urgently needed to enable industry to decarbonize. The majority of plants and industrial parks are optimized for fossil energy sources. Climate change, the planned phase-out of coal and later all fossil fuels, and the increasing demand for green energy sources will impose changes in the decades to come.

In order to adjust and transform individual plants or entire industrial parks, the Department of Simulation and Virtual Design (SVD) is developing new software solutions to scientifically examine industrial processes in a virtual environment. In parallel, experiments are carried out for improving and validating the simulations. Furthermore, models are developed based on measured data, which helps to achieve simulation results as realistic as possible. With a virtual plant, a wide class of problems can then be examined and solved in a short time. For example:

- How can the demand for fossil fuels be reduced through the optimized use of renewable energy sources?
- Can CO₂ be separated effectively from process gas, to produce basic chemicals such as methanol?
- What options are available for a plant to react to a fluctuating energy supply caused by the use of renewable energy sources?

There is a long list of challenges that industrial plants will face. Against this background, the Institute of Low-Carbon Industrial Processes currently develops a novel high-temperature heat pump, which is expected to become a key component for the heat management of future industrial plants. The SVD department supports this research by developing a flexible simulation environment and examining the model depth with which processes can be virtualized with regard to heat management and material flows. In cooperation with other institutes and research facilities, the department is working on the further development of simulation methods that optimize the interaction of all components of future energy systems.

The development of smart energy networks plays a major role in the interconnection of energy supplies and energy consumers. Such networks utilize decentralized energy sources (wind, solar, water) and consist of a large variety of power plants, storage systems, residential and public buildings as well as industrial plants. Artificial-Intelligence-based programs will have to control how the available energy is distributed, stored, converted, or retrieved at any given point in time. The simulation environment developed by the SVD department enables us to

realize a low-loss distribution of electricity, mechanical work, heat, and base materials. In the future, cities and industrial sites will have to use energy much more efficiently. For this reason, the simulation and realization of these networks are of great importance. They comprise an essential part of energy research as a prerequisite to a successful energy transition.

The implementation of such a simulation environment is a major challenge in several respects. First, reduction of carbon comprises the primary goal of the energy transition, and second, the sum of the costs must also be minimized. Otherwise, the new process cannot be operated economically. [7] A multi-criterial optimization problem must be solved so that processes become as efficient as possible in terms of energy consumption, raw material demand, operating and investment expenditures. The mathematical model describing these dependencies becomes even more complex, when renewable energies are employed. Wind turbines and photovoltaics are causing time-dependent fluctuations, which require additional ways to store energy within the grid. To secure the supply of energy at any time, the energy system must become even more complex by implementing suitable energy storage. [8] The same applies to the optimization problem, which is thus expanded to include differential equations describing charging and discharging procedures. Both, the differential equations and the equations describing the system and its components are time-dependent and also non-linear. [9] Furthermore, including energy storage adds more state and control constraints to the model. For instance, the fill level of any energy storage, can neither exceed a given maximum nor fall below zero. Another mathematical challenge is the implementation of so-called on/off-processes, such as switching a wind turbine on and off. In this particular case, the model include discrete variables resulting in an optimal control problem. [8] The SVD department develops suitable discretization procedures, which will solve the mathematical problem with CPU-efficient algorithms.

For future energy grids, a combination of simulation, mathematical procedures and the control of energy suppliers and -storage technologies is necessary. While electricity transmission networks are already well regulated, the electricity distribution networks need to become smarter due to the increasing fraction of renewable energy sources with varying supply and consumption resulting thereof. This smart grid solutions already available in this context must focus on optimizing costs and CO₂-emissions while ensuring grid stability and optimal capacity utilization of the grids. Therefore the existing control systems have to be transferred to these tasks. [10]

Department of Low Carbon Reducing Agents (LCR)

In Germany, industry is the sector with the second-highest Greenhouse gas emissions, only exceeded by the energy sector. Industrial processes, e.g. used in steel, cement, or aluminum production, which currently utilize natural gas, coal, coke, or graphite as reducing agents, electrode material or fuel for heating up rotary kilns, are difficult to decarbonize. The technological gap and the long-term challenges comprise the realization of a cost-effective as well as energy-efficient production based on alternative reducing agents (CO₂-neutral hydrogen and CO₂-neutral carbon).

In general, industrial CO₂-emissions can be divided into two major groups:

- Process-related CO₂-emissions from the use of carbon-containing energy sources and other raw materials, whose production or mining also causes CO₂-emissions
- Direct energy-related CO₂ emissions from the use of fuels for the provision of e.g. process heat or electricity (in industrial power plants) and indirect energy-related CO₂-emissions from the upstream generation of electricity used at the industrial site.

These various sources of CO₂-emissions require sector-specific approaches and measures for their reduction. Therefore, the department of Low Carbon Reducing Agents investigates options to avoid process-related CO₂-emissions by adapting existing technologies as well as

by substituting raw materials with ones having a low carbon footprint. Separation and subsequent use of CO₂ (Carbon Capture and Utilization (CCU)) are examined in cases where CO₂-emissions cannot be avoided otherwise. Furthermore, energy-related CO₂-emissions can also be reduced by improving the efficiency of energy conversion and utilization, as well as by increasing the share of renewable energy used in the process.

Research topics of the department Low Carbon Reducing Agents currently comprise:

- Decarbonization of steel production using renewable “green” hydrogen as a reducing agent
- Development of methods and processes for the decarbonization of ammonia and cement production
- CFD simulations to evaluate the achievable conversion rates with alternative reducing agents
- Production of synthetic solid reducing agents from biomass by incorporating CO₂-neutral high-temperature heat from renewable electricity (c.f. HTP prototypes)
- Experimental examination of key technologies at the component level on laboratory scale
- Emission reduction through utilization of CO₂ from coal-fired power plants for synthesis gas production, followed by further process steps yielding synthetic fuels and chemical base materials
- Comparative techno-economic analysis of decarbonized processes using gaseous and solid reducing agents

Summary

Still today, industrial processes utilize an overwhelming large quantity of fossil energy carriers. The Greenhouse gases emitted by the industry represent a considerable proportion of all emissions in Germany. However, this circumstance also bears the greatest potential for effectively reducing emissions.

The new Institute of Low-Carbon Industrial Processes – with two sites at Cottbus and Zittau – commits itself to three important fields of research: (i) development of High-Temperature Heat Pumps (HTP) (ii) Simulation and optimization of industrial plants, and (iii) substitution of conventional reducing agents with low-carbon alternatives. In all research topics a techno-economic analysis will be included and the aspects of the transition period of the energy system will be taken into account.

These topics lead to complex questions, which will be investigated in detail by the departments High-Temperature Heat Pump (HTP), Simulation and virtual Design (SVD) and Low-Carbon Reducing Agents (LCR). By answering these questions, the transition of the energy system – from a system based on fossil fuels to a sustainable system that uses renewable energy sources – will be promoted.

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3. SPILLOVER EFFECTS AND CONNECTEDNESS

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Abstract

In the research paper called “Measuring financial asset return and volatility spillovers, with application to global equity markets” by Diebold and Yilmaz (2009), an intrinsic measure of financial asset returns and volatilities interdependence is introduced and in turn, accurate return and volatility spillover measures have been thoroughly analyzed. The main objective of the authors is to examine the process of how the proportion of a certain economic, financial, firm– and country– specific crises from one country or from one financial firm spills over to another group of countries or financial firms. In their 2009 paper Diebold and Yilmaz mainly employ vector autoregressive model. Therefore, this paper follows their ambition and uses commonly known forecast error variances of vector autoregressive models to find out which factors affect it and thereby build spillover index via decomposing those variances. Consequently, following the technique by the authors, the paper extends the range of their analysis and covers wider time period from 2009 to 2020 and examines the interconnectedness between stock returns and volatilities of those same countries analyzed by Diebold and Yilmaz (2009). Despite considering a different time horizon, average connectedness of stock returns has increased only a little; in contrast, average connectedness of stock volatilities has almost doubled, which presumably stems from the extreme globalization – great improvements in international relations and connections of countries.

Keywords: forecast error variance decomposition; stock return connectedness; stock volatility connectedness; spillover table; spillover index.

Introduction

In the research paper called “Measuring financial asset return and volatility spillovers, with application to global equity markets” by Diebold and Yilmaz [1], an intrinsic measure of asset returns and volatilities interdependence is introduced and in turn, accurate return and volatility spillover measures have been thoroughly analyzed. The main objective of the authors is to examine the process of how the proportion of a certain crisis from one country or from one financial firm spills over to another group of countries or financial firms.

Before reaching the depths of this research, let us introduce previous literatures related to the abovementioned topic which have examined the financial market interdependence nature by considering both returns and volatilities. For instance, Robert F. Engle [2] has created a model which estimated the average behavior and volatilities of UK inflation with the application of autoregressive conditional heteroscedastic (ARCH) processes. Consequently, ARCH estimation process exhibits significant results, such as high degree of volatilities between UK inflation rates of different time lags. In the following fashion, by applying generalized autoregressive conditional heteroscedastic in the mean (GARCH-M) model

Chelley-Steeley [3] firstly, estimates the equity returns for UK, and then stock market returns for the US, France and Italy. Then, he substitutes the squared error term for UK into the conditional variance equations for other three countries, and the result indicates that the shocks to UK equity markets cause the significant increase in stock market volatilities of other countries. Apart from this, Forbes and Rigobon [4] in their research study the interdependence

or comovements in financial markets of different countries by using simple cross-market correlation coefficients being unconditional on market volatility. Their result turns out to be that there is a high level of market comovement across countries during both crisis and stable periods, which implies the “interdependence”. In addition to that empirical work, King et al. [5] conducted an empirical work which accounted for inspecting the time- variation in cross-market linkages between different stock markets and breaking down this time-variation nature into observable and unobservable components.

Following abovementioned investigative researches, Diebold and Yilmaz summarize the return and volatility behaviors into a single spillover index and indicate the importance of the time-varying property of spillover intensity, emphasizing that this nature of spillovers can be significantly different for global equity returns and volatilities.

In their 2009 paper Diebold and Yilmaz mainly employ vector autoregressive model. Their ambition is to use commonly known forecast error variances to find out which factors affect it and thereby build spillover index. For this reason, they first start with vector autoregressive model (VAR, hereinafter) with two variables and one lag and then transform it deliberately to moving average infinity (MA(∞)) representation of VAR model, knowing that it would help us to find impulse responses of variables to each other in our system. As a matter of common knowledge, usually in VAR models the same period innovation processes are correlated, which implies that one will be incapable of recognizing the pure responses of variables to a unit shock in another variable, instead they would simply achieve responses of variables to shocks contaminated by other shocks in the system. Therefore, the authors apply well-known Cholesky factorization technique to eliminate such contamination issue. The pleasing fact about Cholesky factorization is that it orthogonalizes our innovation terms and thus in newly achieved impulse response coefficients the abovementioned contamination effect disappears. Next, the authors consider one- step-ahead linear optimal (Wiener-Kolmogorov) forecast of dependent variable vector and find one-step-ahead forecast errors due to forecasting. As mentioned earlier, the researchers’ aim is not only to find forecast errors, rather they want to see which factors contribute to its instability. Hence, they find forecast error variances of both of the variables and acknowledge two principal contributors to it: variable’s forecast error variance coming from the shocks to the variable itself and resulting from the shocks to another variable. The authors define the former as “own variance share” and the latter as “cross variance share”. In addition, they redefine the term “cross variance share” as “spillover effect”, since that share of the forecast error variance is due to the effects spilled over from one variable onto another one. We think it is always useful to explain the rumor with a simple example: a person can get ill in two different ways, firstly because of his own mistakes and secondly as a result of getting into contact with someone who is already ill. The former way of getting ill is analogous to own shocks and similarly, the latter way is related to shocks that are spilled over to you. Eventually, recapitulating the aforementioned results, the authors build a spillover index to be able to easily interpret the total spillover of the system (sum of all cross variance shares) and it is nothing other than the value of the total spillover effects of the system relative to the total forecast error variance of the system (sum of all own and cross variance shares). After introducing the results for 2- variable case, the authors provide the general spillover index for pth- order, N variable VAR using H-step ahead forecasts in the following way:

$$S = \frac{\sum_{h=0}^{H-1} \sum_{\substack{i,j=1 \\ i \neq j}}^N a_{h,ij}^2}{\sum_{h=0}^{H-1} \text{trace}(\mathbf{A}_h \mathbf{A}'_h)} \times 100$$

At this juncture, we had nothing to do other than admiring what has been done so far by Diebold and Yilmaz, and taking the advantage of living in 2020 to extend the analysis for some more years in order to examine those same countries’ connections hitherto. Hence, we obtained the weekly data for nominal stock returns and stock high-low- open-close prices (to be used to derive stock volatilities) using the R software package “quantmod”. Due to software related technical problems the data for Thailand had to be ignored and the data for stock returns

encompassed only the short period from February 2014 to June 2019. With the intention of converting nominal returns to real returns, monthly CPI data was collected from IMF database and used to obtain monthly inflation rates. Furthermore, it was out of reach to get the CPI data for Argentina, Australia and Taiwan, as Argentina does not provide reliable inflation rates [6], Australia reports its CPI only for quarterly time frequency which makes it impossible to reach the monthly CPI data by IMF [7], and finally, Taiwan does not have its own CPI data probably due to the “One-China Policy” (as a result of current power of People’s Republic of China (PRC), Taiwan is considered as a “Mainland” part of PRC). Subsequently, following the aforementioned way of finding weekly inflation rates from monthly inflation rates by Diebold and Yilmaz, the nominal returns were transformed into real returns. Furthermore, the same Garman and Klass [8] method was used to find weekly stock volatilities and contrary to stock returns, it covers a wider period from January 2007 to June 2019 (after exclusion of missing values).

The interpretations of the elements in spillover tables, Table 1 and Table 2, remain the same as in Diebold and Yilmaz [1]. Besides, it is no wonder that spillover indices have changed. Despite considering a different time horizon, average connectedness of stock returns has increased only a little, reaching roughly 38.4%. In contrast, average connectedness of stock volatilities has changed drastically, reaching around 70%. As long as one keeps the growing interdependence of countries and overall globalization in mind, the index for volatilities seems plausible. Yet again, it does not unveil the dynamic behavior of the index and the events leading to its fluctuations.

In Figure 1, we considered rolling- sample estimates with a window width of 200. As a matter of fact, it is worth to mention that due to the great improvements in international relations and connections of countries – leading to the extreme globalization, differentiating between the events taking place during a period of interest becomes immensely challenging, if one considers a smaller window width. If one takes a closer look at Figure 1, some of the major events resulting in index hikes emerge. From October 2012 till July 2013, the major event was the amplification of the European Debt Crisis which started in the end of 2009 and developed thereafter. The contributors to the progress of the crisis were mainly the Great Recession and the failure of some of the European member states, such as Greece, Spain, Portugal, Ireland and Cyprus, to repay their government-debts. During the period from May 2014 till December 2015 main memorable event was the uncertainties regarding the Chinese Stock Market, especially its bubble period and subsequent crash, fortunately it was a short-lived crisis as Chinese government took immediate action such as devaluating the currency to boost exports; taking strict control over the Chinese stocks – restricting the sell-off of certain firms’ assets; and so on [9]. Apparently, the spillover index remained high even after March 2016 – pointing at the gossips around “Brexit” and the referendum in June. From March 2018 till August 2018 one can see modest spillover index, but obvious jumps, which could be because of the “First North Korea – U.S. Summit”. Following the rolling- sample analysis of Diebold and Yilmaz [1] paper and relying on Kanas [10] research on asymmetry of spillover effects, we observe that on average, negative events affect stock market volatilities more than the positive events; however, in our analysis, we are of the opinion that vice versa effect holds for the period of March 2018 to August 2018. From our standpoint, the meeting between U.S. and North Korea presidents regarding the denuclearization of the Korean Island and many other crucial topics, should have certainly affected South Korean stock markets positively, assuming that it would bring peace to the island. Nevertheless, according to Pham et al. [11], the response of South Korean stock market to the summit was rather ambiguous – having both positive effects, negative effects and even mixed effects (positive before the summit, negative after the summit; or vice versa) on certain sectors, yet the effect of negative reactions of returns outweighed the positive ones. For the rest of the figure after October 2018, rising tensions and tit-for-tat tariffs of U.S. and China are partly responsible. All in all, as it is obvious from the abovementioned examples, it is a demanding job to detect the exact event that led to an upward movement in volatility spillover index and it mainly depends on window width of rolling-sample analysis as well as distinguishing between positive and negative effects – namely, finding out which effect

dominates the other one. As a further research on the issues presented, Baruník et al. [12] serves a good purpose, as they distinguish between “good” and “bad” volatilities (analogous to “positive” or “negative” volatilities mentioned earlier) using the realized semi- variance technique. Last but not least, they determine that not always negative effects dominate the positive ones.

To recapitulate, Diebold and Yilmaz [1] paper provided us a useful toolkit to measure the spillover effects from one country to other country or group of countries and by this way, it enables us to see which country in the system is the most exposed to risks when one of the countries is under distress. Notwithstanding the strength of the model, the major drawback of this approach is that it uses Cholesky factorization – which is order dependent, in other words, changing the order of the variables in our system (countries’ stock returns or volatilities, in our case) would change the impulse response coefficients matrix and thereby changing the Cholesky factor that orthogonalizes the innovation processes – leading to a change in the index. Even though to check for the range of spillover index, Diebold and Yilmaz [1] considered 18 rotated and 50 randomly chosen orderings and concluded their estimations to be robust to VAR orderings, it is crucial to stress that there are 19! or approximately 10^{17} orderings possible, given 19 countries that were considered by the authors. Therefore, their robustness check for VAR orderings is apparently implausible. As a solution to the problem Diebold and Yilmaz applied generalized forecast error variance decomposition (GFEVD) technique in their 2014 paper [13]. On the other hand, as Diebold and Yilmaz [1] technique severely underestimates the range of spillover index, one can consider the algorithm developed by Wagner and Klößner [14] where they use divide-and- conquer way to find the true range of the spillover index given all possible orderings.

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Appendix:

Table above is Table 1 – using weekly data for stock returns from 2014 till 2019 (excluding the missing values), table below is Table 2 – using weekly data for stock volatilities from 2007 till 2019 (excluding the missing values). List of abbreviations: US – United States, UK – United Kingdom, FRA – France, GER – Germany, HKG – Hong Kong, JPN – Japan, IDN – Indonesia, KOR – South Korea, MYS – Malaysia, PHL – Philippines, SGP – Singapore, BRA – Brazil, CHL – Chile, MEX – Mexico, TUR - Turkey

	US	UK	FRA	GER	HKG	JPN	IDN	KOR	MYS	PHL	SGP	BRA	CHL	MEX	TUR	Contribution From Others
US	66.66	1.05	4.19	0.23	3.90	1.03	2.00	8.31	6.84	0.98	0.39	1.10	0.98	0.11	2.22	33.34
UK	4.02	71.91	1.50	2.52	1.90	2.54	3.26	1.39	1.45	1.70	0.78	0.58	3.36	1.61	1.50	28.09
FRA	2.88	42.13	39.61	0.41	2.70	0.34	2.20	1.63	1.25	0.73	0.07	1.33	2.25	1.08	1.49	60.39
GER	7.12	13.47	2.55	90.40	3.52	2.33	1.23	2.09	3.98	0.91	1.88	1.61	5.45	1.64	1.82	49.60
HKG	2.10	1.23	14.07	5.04	69.94	1.08	0.90	0.87	0.58	1.43	0.27	0.25	0.41	0.78	1.44	30.06
JPN	9.80	2.18	1.27	4.12	0.90	70.63	2.14	1.25	0.53	0.24	0.69	0.09	0.53	4.29	1.75	29.37
IDN	1.74	4.66	0.48	3.81	4.40	1.87	67.46	0.91	4.55	4.42	0.23	0.69	1.21	1.25	2.31	32.54
KOR	4.55	1.46	1.19	2.72	2.39	8.29	7.20	68.42	0.12	0.21	0.31	0.22	1.13	0.53	1.26	31.58
MYS	1.32	1.06	0.39	0.45	0.98	2.43	0.56	3.00	74.49	8.26	0.38	1.11	4.84	0.16	0.56	25.51
PHL	3.76	2.62	2.16	2.16	1.43	4.53	0.49	1.33	1.57	69.34	2.09	0.34	5.13	1.08	1.97	30.66
SGP	1.44	12.86	0.79	4.79	4.24	0.97	0.34	0.21	0.38	7.17	64.17	0.79	0.23	0.81	0.82	35.83
BRA	3.51	0.68	0.63	2.31	1.10	3.85	2.36	5.91	1.52	1.92	1.27	72.84	1.43	0.06	0.63	27.16
CHL	3.84	1.88	1.76	2.37	2.90	3.10	2.62	5.56	1.03	3.46	1.09	13.78	54.44	0.71	1.86	45.36
MEX	1.15	1.23	2.99	1.75	17.56	6.32	4.54	7.51	1.68	5.60	2.09	1.32	0.57	44.82	0.88	55.18
TUR	1.49	4.36	0.89	2.84	3.93	1.70	1.89	0.91	0.95	20.28	1.70	11.56	5.28	2.91	39.31	60.69
Contribution To Others	48.72	90.87	34.85	35.53	51.04	40.26	31.35	40.87	26.42	57.32	13.23	34.77	32.82	17.01	20.51	Numerator of the Index= 575.5666
Contribution Including Own	115.39	162.78	74.45	85.93	120.98	110.89	98.81	109.29	100.91	126.66	77.40	107.61	87.25	61.83	59.82	Spillover Index= 38.3711 %

	US	UK	FRA	GER	HKG	JPN	IDN	KOR	MYS	PHL	SGP	BRA	CHL	MEX	TUR	Contribution From Others
US	81.75	0.64	0.54	1.32	0.36	0.13	3.23	2.69	0.38	0.37	3.88	2.91	0.35	1.03	0.41	18.25
UK	71.53	13.74	0.22	1.23	1.03	0.62	1.68	2.57	0.18	0.39	3.09	1.93	0.45	0.69	0.66	86.26
FRA	72.13	8.93	4.93	1.30	0.99	0.73	1.48	2.57	0.10	0.43	2.71	1.77	0.26	1.07	0.57	95.07
GER	71.15	8.33	2.44	4.89	0.68	0.57	1.51	2.76	0.08	0.57	3.32	1.75	0.21	1.18	0.56	95.11
HKG	57.26	2.94	2.05	1.37	20.34	0.57	1.79	3.93	0.16	0.19	5.35	2.42	0.67	0.50	0.46	79.66
JPN	40.82	1.34	2.32	2.56	0.62	36.19	1.80	4.23	0.35	0.07	4.24	3.98	0.15	1.07	0.35	63.81
IDN	50.13	2.80	0.84	1.36	2.98	0.16	30.21	2.43	0.45	0.26	6.09	1.32	0.50	0.18	0.68	69.79
KOR	62.56	1.93	2.54	2.44	0.96	0.64	2.31	13.33	0.31	0.55	5.34	4.05	0.53	1.97	0.52	86.67
MYS	16.90	5.55	2.10	0.83	1.26	1.50	6.90	0.96	60.56	0.09	0.98	0.66	1.13	0.48	0.09	39.44
PHL	14.72	0.27	1.45	0.63	5.57	0.65	6.45	1.76	1.48	62.53	1.86	1.21	0.06	0.29	1.08	37.47
SGP	63.93	3.26	1.30	1.52	1.89	0.55	2.56	4.68	0.84	0.37	14.77	2.11	0.97	0.73	0.52	85.23
BRA	64.92	2.71	0.44	1.75	0.67	0.25	2.26	4.80	0.16	0.38	4.40	13.99	0.46	1.85	0.97	86.01
CHL	42.25	3.30	1.28	1.41	0.31	0.39	2.96	1.48	0.29	0.32	1.89	20.04	40.85	0.73	0.49	59.15
MEX	57.07	4.50	1.27	2.34	1.76	0.53	2.35	3.18	0.46	0.19	5.47	3.91	0.55	15.63	0.78	84.37
TUR	35.73	2.54	2.80	2.30	0.57	0.50	2.61	4.28	0.45	0.62	4.82	1.20	0.29	0.70	40.58	59.42
Contribution To Others	721.10	48.93	21.60	22.37	19.24	7.80	39.91	42.31	5.69	4.80	53.44	31.27	6.59	12.47	8.17	Numerator of the Index= 1045.701
Contribution Including Own	802.84	62.67	26.53	27.26	39.58	43.99	70.12	55.65	66.25	67.33	68.21	45.26	47.44	28.10	48.75	Spillover Index= 68.2134 %

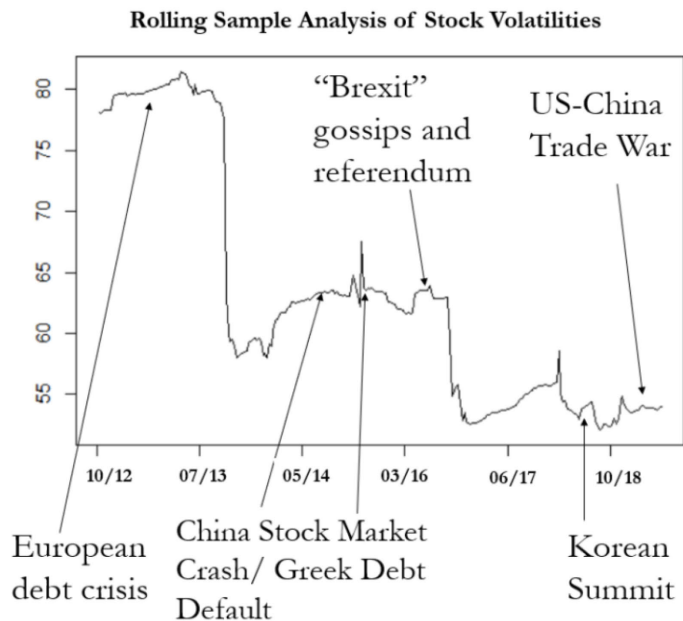


Figure 1

4. Entwicklung eines Verschleißversuchsstands zur langlebigen und energieeffizienten Auslegung von Dosier-, Förder- und Transportanlagen

Development of a wear test rig for the durable and energy-efficient design of dosing, conveying and transport systems

Разработка испытательного стенда на износ для долговечной и энергосберегающей конструкции систем дозирования, транспортировки и транспортирования

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Abstract

Neubau oder Instandsetzung von Förderanlagen ist immer mit dem Ziel verbunden, eine energieeffizientere Lösung zu gestalten. Unter den Aspekten des Product- Lifecycle Managements werden jedoch Energiekosten bisher nicht immer exakt abgebildet. Um die Gesamtenergiekosten während des gesamten Lebenszykluses minimal zu halten, sind stets auch neue Materialanwendungen notwendig. Für diese neuen Materialanwendungen gibt es häufig noch keine belastbaren Verschleissparameter. In dem vorgestellten Verschleißsmesstopf können daher schnell erste Verschleissparameter für neue Materialparungen ermittelt werden. Dabei wird auch das Verhalten des Fördergutes mit betrachtet. Eine anschließende Siebanalyse des Fördermaterials stellt sicher, dass die abrasive Eigenschaften des Fördermaterials erhalten geblieben sind. Im Rahmen der Neugestaltung von Förderanlagen kann auch eine Strömungssimulation zum Einsatz kommen.

New construction or repair of conveyor systems is always associated with the goal of designing a more energy-efficient solution. However, energy costs have not always been accurately reflected in the aspects of product lifecycle management. In order to keep the total energy costs to a minimum during the entire life cycle, new material applications are always necessary. For these new material applications, there are often no wear parameters that can withstand high loads. The wear measuring pot presented here can therefore be used to quickly determine the first wear parameters for new material parameters. The behaviour of the conveyed material is also taken into account. A subsequent sieve analysis of the material conveyed ensures that the abrasive properties of the material conveyed are maintained. Within the scope of the redesign of conveyor systems, a flow simulation can also be used.

Keywords: Anlagenauslegung, Energieeffizienz, Verschleiss, Verschleissermittlung von Schüttgütern, Strömungssimulation, Product-Lifecycle Management

Plant design, energy efficiency, wear, wear determination of bulk materials, flow simulation, product life cycle management

Проектирование установок, энергоэффективность, износ, определение износа сыпучих материалов, моделирование потока, управление жизненным циклом продукта

Introduction

The new construction and repair of industrial plants always includes the chance to establish a more energy-efficient solution. This optimization can also be limited to individual plant components. However, better results can be achieved if the product life cycle is considered in

its entirety. In the following consideration, the focus will be on the materials used, which in turn influence downtimes, maintenance and repair times and thus also costs.

Often the repair process is also tied to highly specialized experts and their special technology, who operate worldwide. The associated travel and the energy consumption required for this is also part of the overall life cycle assessment of a product. Product Lifecycle Management (PLM) knows many ways of influencing costs, but these do not correctly reflect the associated energy consumption. Energy efficiency is therefore always a contribution to climate protection

Phase im Product LifeCycle Management	Einfluss der Werkstoffauswahl Influence of material selection
Produktplanung Product planning	
Entwurf Styling	
Auslegung und Berechnung Design and calculation	X
Produktherstellung Product manufacturing	
Fertigung Manufacturing	X
Montage Assembly	X
Produktnutzung Product use	
Betrieb Operation	
Wartung / Instandhaltung Maintenance / servicing	X
Instandsetzung Repair	X
Produktentsorgung Product disposal	
Demontage Disassembly	X
Recycling	X

Figur 1: Einfluss der Werkstoffauswahl auf die Kosten im PLM – Prozess, Influence of material selection on costs in the PLM process

The figure shows an example of the individual product life cycle phases and the associated influence of the materials. The material selection influences the following selected factors

- Procurement costs
- Processing time
- Assembly work
- useful life
- Maintenance effort
- Repair expenses
- Disassembly effort
- Recycling expenses

All these factors include energy consumption and influence the energy efficiency of the product. It can be stated in general:

The longer a product's service life and the lower the maintenance, repair and overhaul costs, the more energy-efficient the product solution is [1].

In general, there is no life cycle knowledge for new products, new materials and new transport goods. Simulation methods can help to determine the optimal design and cable routing, but direct results are difficult to derive.

Each bulk material also has different wear characteristics, which in turn has a direct influence on the service life of the components used. With the presented wear test rig, fundamental trends can be quickly determined to predict service life.

Abrasive wear is generally the loss of material caused by moving bulk material, for example on the walls of containers, pipelines and rotors. In industry, wear-related downtimes occur, which have considerable financial consequences for the respective companies. In order to be able to make predictions regarding the service life of a plant, sufficient analyses of the types of wear that occur are necessary. A suitable measuring device or measuring method was not available until now. Based on the necessity to determine and in the best case to predict the wear, the task was to develop a measuring method / measuring equipment, which as a result produces a wear matrix in relation to the bulk material and the friction partner.

Methods

Typical wear measurement methods, which are mainly used for bulk materials with loose grain, use wear pots. The developed wear test stand simulates the relative movement between the transported material and the plant components. Each bulk material has different wear characteristics, which in turn has a direct influence on the service life of the components used due to erosive wear.

The experimental system consists of a rotor on which replaceable wear plates are mounted. The rotor rotates at constant speed in a bed of bulk material. The bulk material and the rotor plates can be varied. The bulk material thus forms the transport material of the real plant. The rotor plates are made of the material to be evaluated. The result is a wear rate $W(m/U)$, which can be compared with other bulk material test body combinations. This creates an overview matrix which can be correlated with real operating conditions and the occurring wear. A detailed discussion of the results under consideration of the influencing factors serves to evaluate the gained knowledge and to draw comparisons between the bulk solids. The test series are very time-consuming. Within the project, limits could be defined which lead to meaningful results in order to limit the test period and at the same time keep the real conditions constant.

A general structure of a wear measuring pot as well as the principle structure of the developed wear measuring device is shown in (Figure 3: Constructional representation of the wear measuring pot, constructional representation of the wear measuring pot).

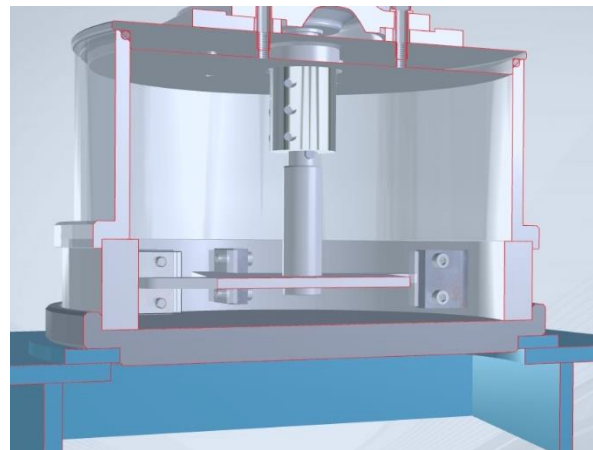
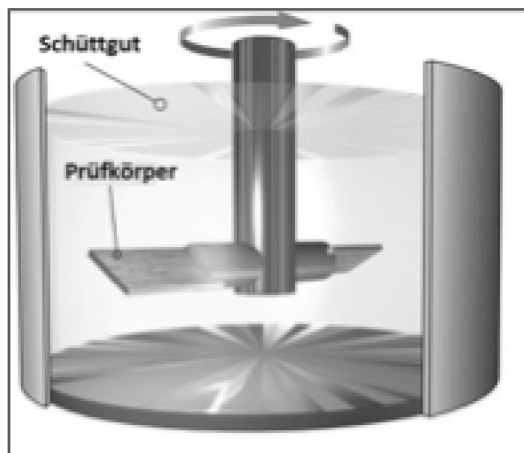


Figure 2: Schematic diagram of the wear measuring pot Figure 3: Design illustration of the wear measuring pot

The material removal W_m over a test run is measured as wear. This allows analytical approaches and conversion functions to be set up to evaluate the measured wear under different conditions. Simplified the wear can be determined as follows:

$$W_m = \Delta m = m_v - m_n \text{ [g]}$$

$W_m/\Delta m$ - Loss of mass of test plates after one test run [g]

m_v - Mass of the test samples before the test run [g]

m_n - Mass of the test samples after the test run [g]

By reference tests with established bulk materials, boundary parameters could be determined and first experiences could be made to determine the wear. Constant material parameters, which must be maintained over the entire test period, are absolutely necessary. Until $U \leq 600$ the wear rate is constant. In this range the particle destruction is without influence and the bulk material collective does not yet move with the rotor. Above $U > 600$ a decrease of the wear rate is visible. In this circulation number range, parameters such as particle size and particle shape cannot be maintained.

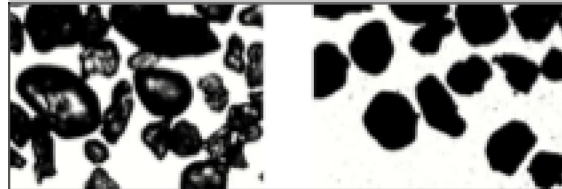


Figure 4: Schematic diagram of grain wear, left delivery condition, right after 1000 rotations

As can be clearly seen in the figure, the grain is broken and rounded off by the relative movement.

As an example, the result for quartz sand for a structural steel is shown here.

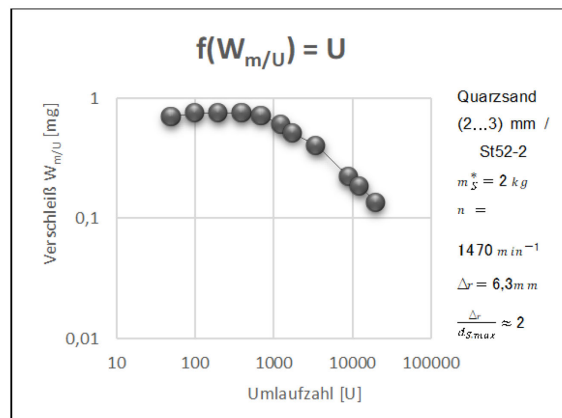


Figure 5: Wear of steel St 52-2 in combination with quartz sand

The determination of the particle destruction can be done by sieving. With undamaged particles there are more sieve residues than with destroyed and thus broken particles. Such a grading curve must be determined for each bulk material itself.

When screening with different screen sizes/mesh widths, the exact composition of the starting material and the material can be determined by mass after the wear test. If a certain amount of material is screened with a given screen width, the result is a first quantity that falls through the screen and a second quantity that does not fall through the screen, the so-called screen residue. This results in changes in the quantities before and after the wear test. The second quantity, the so-called sieve residue, increases.



Figure 6: Sieve cascade (left) with sieve of different mesh sizes (top), sieve designation (bottom)

Outlook Simulation

For the design of plants and pipelines, flow simulation can also be used, which uses the particle flow to map the movement of particles. For example, the flow behavior at different radii of pipe bends can be simulated. By marking the particles, the movement of a single particle in the respective pipe can be tracked. If the conveying or flow conditions are the same, the most energy-efficient and thus most wear-resistant conveying is achieved where the particle travels the longest distance in the same unit of time.

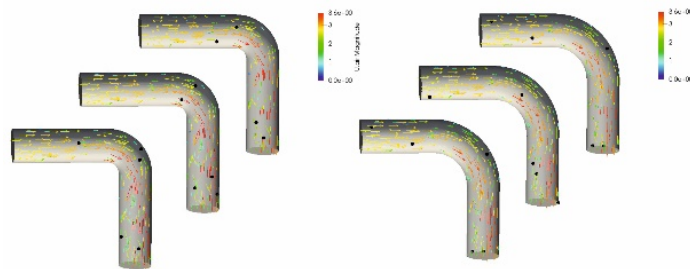


Figure 7: Simulation comparison for different curvature radii

Conclusion

The presented wear measuring pot provides a good indication of the expected plant wear for known but also for new conveyed goods and material combinations. Here, 600 rotations are sufficient, since according to previous investigations, the particle destruction of the conveyed material influences the result after 600 rotations. The particle size destruction can always be determined with a sieve analysis. For the test with the wear plug only one pair of rotor blades made of the material to be tested as well as the composition and particle size of the conveyed material are necessary.

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5. Unbalance and noise of rollers on conveyor belts

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Abstract

The further investigation of the effect of unbalance on the sound emission of a conveyor belt roller uses the help of defined adhesive strips that simulate caked material. The unbalance resulting from the adhesive strip becomes "balanced" with a second adhesive strip that is offset by 180° on the roller surface. The proof of a geometry-related excitation to sound radiation is then provided by a theoretically expected level increase of 3 dB. Depending on the rotational frequency, the change in geometry of the two adhesive strips doubles the excitation. For geometry-related changes and the peripheral speed of the test roller selected for the comparison the conditions must be constant.

Introduction

Lignite opencast mining is important for the Lusatian region. For one thing, this creates jobs in the region and on the other hand, the lignite secures the supply of energy by generating electricity in the power plants. Belt conveyor systems are used to transport coal and soil. Rollers used in the belt conveyor systems have proved to be one of the sources of noise emissions from belt conveyor systems.

Opencast mine Nochten
roller test track
Belt width 2,5 m
Soil transport
Three-part garlands
belt speed 6,1 m/s



Figure 3: conveyor system opencast mine Nochten [Rie-3]

The Lausitz Energie Bergbau AG (LE-B) has developed a roller test bench in cooperation with the Brandenburg University of Technology Cottbus-Senftenberg (BTU) and other partners. This offers the possibility to research individual rollers of a high-performance belt conveyor with regard to the mechanical and acoustic properties. With the help of the roller test bench, the properties of a roller can be shown depending on its circumferential speed under near-actual operating conditions. With appropriate rollers, the influence of various parameters, such as concentricity, unbalance or acting forces, can be examined on the idler test bench. This information is used to specify the delivery requirements for the assembly, so that the rollers are quiet and durable, but at the same time manufacture and procurement remain inexpensive. The VDI guideline 2341 "Belt conveyors rollers and roller spacing" [VDI-1] is based on the following assumption:

„Conveyor rollers with high unbalances, which are also caused by caked material on the conveyor roller surface, as well as larger concentricity deviations of the conveyor roller surface lead to increased running noises in connection with the conveyor belt.“

Up to now the tests on the roller test bench have shown that the excitation and the sound radiation mainly take place via the roller tube. Only a defective roller bearing additionally stimulates the roller tube. This leads to a further increase in noise emissions.

According to the VDI guideline the mentioned caked material on the conveyor rollers increase the unbalance of the rollers and the concentricity. It has been proven by an adhesive strip test that the greater circularity deviation (part of the concentricity deviation) increases the excitation of sound radiation [Täs-2]. But what kind of influence has the unbalance on the excitation?

During this investigation, acoustic and mechanical parameters of a noise-reduced roller just for ground-level belt conveyor systems are considered in order to bring them together.

Research methodology

This investigation examines the acoustic effect of a roller with various unbalances on the roller test bench. In addition, the effect of caked material will be examined in the form of adhesive strips. For this purpose, the test roller clamped in by rubber dampers runs by a drive roller. The test roller has a low eccentricity of the axis of rotation, since the effect of eccentricity and unbalance in the direction of the conveyor belt or the drive roller of the idler test bench cannot be separated using simple test methods. The force setting is around 3.5 kN on the contact zone between the drive roller and the test roller. The tested unbalance pairs are in the two radial planes (side cover) opposite and additionally offset by 180 degrees. The unbalance is gradually increased with pieces of weight and the current state of the remaining unbalance mass and sound power level is determined.

After the unbalance-related noise level has been identified, the two adhesive tape tests follow, in which the resulting sound emissions are measured. The results relate to the roller test bench data. The effect of the unbalance, on the service life of the roller bearings, adjacent components or assemblies, as well as resonances occurring in large devices in opencast mining, conveyor bridges or overpasses are not considered.

Determination of the unbalance

The BTU laboratory has a test bench available from Schenck type H3 BK to determine the unbalance (Figure 4). This test bench determines the residual unbalance mass and its angular position on two levels.

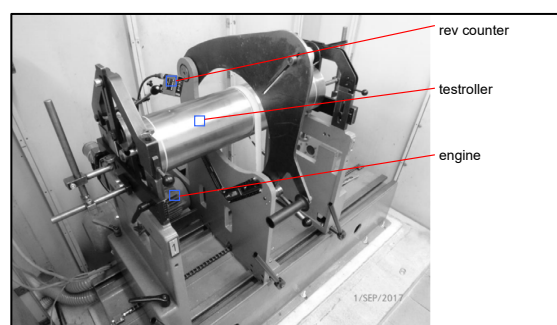


Figure 2: roller test bench for unbalance [Rie-3]

Determination of the acoustic effect

The acoustic effect of roller is determined using the envelope surface method on the roller test bench (Figure 3).

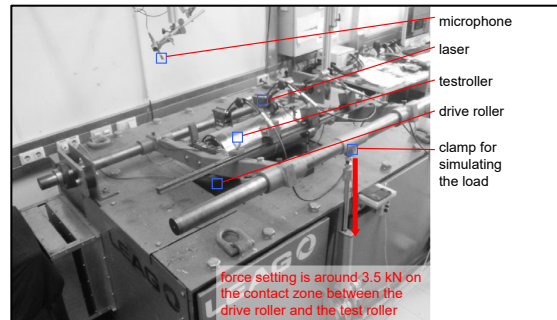


Figure 5: roller test bench [Rie-3]

Caked material and noise emissions by rollers

A series of comparative measurements is carried out with the test rollers (Figure 4). The test idlers were tested first with and then without caked material. The aim is to investigate the noise emission in connection with the unbalance caused by the caked material.



Figure 6: Initial state of the roller type A194x380-6310-G1-21-L [Rie-3]

- Laboratory conditions
- Test roller with caked material
- Measure unbalance
- Measure sound power level
- A194x380-6310-G1-21-ML
- Rotation mass of roller = 20,2 Kg
- Roller speed 10 m/s
- Allowed residual unbalance mass 28,28 g

Investigation results

The results can be tabulated as the difference between the measured values with and without caked material.

Table 1: Comparison with and without caked material #2179 till #2187 [Rie-3]

roller number LEAG:	2179	2180	2181	2182	2184	2185	2186	2187
difference mass [kg]:	0,00	0,00	0,00	0,00	0,00	-0,05	-0,05	-0,05
difference KFA max. [mm]:	-0,194	-0,589	-0,028	-0,071	-0,082	-0,003	-0,890	-0,710
difference Lw [dB(A)]:	-19	-17	-9	-7	-11	-18	-17	-21
difference balance quality G [mm/s]:	0	0	0	1	0	0	-1	0
difference mu left [g]:	0,20	-0,60	0,20	0,90	-0,30	0,40	-0,20	-0,92
difference angular position left [°]:	2	3	-2	-1	1	-2	-2	13
difference mu right [g]:	0,20	1,30	-0,20	-0,10	0,07	0,30	-1,10	0,25
difference angular position right [°]:	0	2	-1	0	-1	0	4	-3
difference mu total [g]:	0,40	0,70	0,00	0,80	-0,23	0,70	-1,30	-0,67

It can be seen that the total mass of the caked material is small compared to the total mass or the mass of the rotating parts of the roller.

A reduction of the sound power level can be observed for all test rollers from the state with caked material to the state without caked material. The reduction of the sound power level is between 7 dB(A) and 21 dB(A).

It follows that the caked material has a direct influence on the sound emission of the test roller. If the balance quality G is considered, a change can be seen in two cases. After cleaning the test rollers, idler 2181 shows an increase of 1 mm/s and roller 2186 a decrease of 1 mm/s.

The effect of the mass of caked material on the balance quality of the test roller shows only minor changes. The unbalance is mainly determined by the mass of the rotating parts of the rollers. Its proven by a comparison of the remaining unbalance masses and their angular position. There are no significant changes.

Conclusion

The caked material on the test rollers has only a minor effect to the unbalance of the test rollers. The removal of the caked material from the surface of a roller is not equal with a reduction of unbalance. After cleaning the surface of a roller, it is also possible that the unbalance becomes higher because of the random distribution.

In combination with the reduction of the sound power level for all test rollers after cleaning this result shows that the main stimulation for sound radiation is transferred over the roller surface. The caked materials change the geometry (deviation from circular shape - "KFA") of the roller surface which then increases the stimulation of sound radiation.

A direct connection between unbalance caused by caked material and noise emissions could not be proven. The influence by a geometry change of a roller surface for the noise emission of a roller was demonstrable.

This series of experiments can be repeated with any number of appropriate test rollers with caked material. The disadvantage is that the result cannot be reproduced with an already tested roller. Because it is impossible to replace the caked material to the start position.

Effect of unbalance and circular shape deviation in the sound emission of a roller

For the further investigation of the effect of unbalance on the sound emission of a conveyor roller the help of defined adhesive strips is used to simulate that caked material. The unbalance resulting from the adhesive strip becomes "balanced" with a second adhesive strip on the roller surface that is offset by 180°. The proof of a geometry-related excitation to sound radiation is then provided by a theoretically expected level increase of 3 dB. Depending on the rotational frequency the change in geometry of the two adhesive strips doubles the excitation. The conditions must be constant for geometry-related changes and the peripheral speed of the test roller selected for the comparison.

This investigation is intended to demonstrate the reproducibility of the results. A different noise-reduced test roller becomes modified for the experiment.

Investigation process

For this investigation a modified, noise-reduced test roller of type A194x750-6310-G2-18-L is used. The test roller is machined, balanced and without internal damping. For the experiment threaded rods were welded opposite to the side covers of the test roller for fastening the unbalanced masses. The test series is used to find out the acoustic effect of a static and a dynamic unbalance. The imbalance pairs are exactly opposite one another in the two different radial planes and offset by 180 degrees. In the case of the test roller the imbalance is gradually increased with pieces of weight.

An increase in the sound power would be expected depending on the increasing unbalance of the test roller. The increasing sound level differences in comparison to the initial state should be able to be represented. The adhesive strip tests are carried out for each measurement step. Regardless of the result of the unbalance - acoustic emission tests, a significant increase in the noise level can be expected in the adhesive strip tests with an adhesive strip (Figure 5).

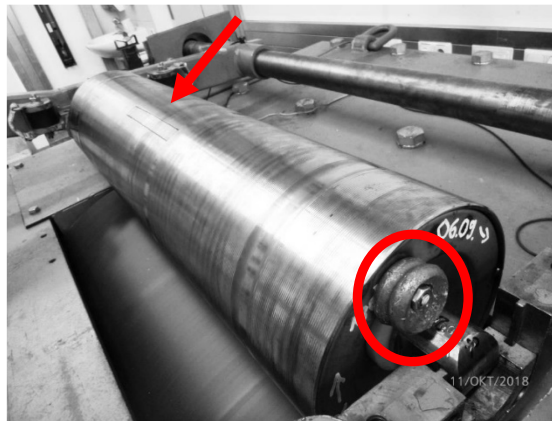


Figure 7: Test roller # 0609 with adhesive tape (arrow) and pieces of mass (circle) in roller test bench [Rie-3]

The mass of the adhesive strip with 0,12 g is small compared to the unbalanced mass attached to the side covers. Attaching the second adhesive strip 180° on the roller surface opposite side to the first adhesive strip the masses of the "simulated caked material" cancel each other. The evidence for a geometry-related excitation to sound radiation is proven by a further increase in the sound emission by 3 dB because of the double excitation by the second adhesive strip.

Investigation results

The detected changes in the sound power level through a gradual unbalance increase occur within the deviations from the roller test bench. Even after passing the unbalance quality level G250 no significant increase in the sound power level could be detected.

The results from the adhesive strip tests show an immediate increase in the sound power level compared to the unbalance sound emission tests (Figure 6).

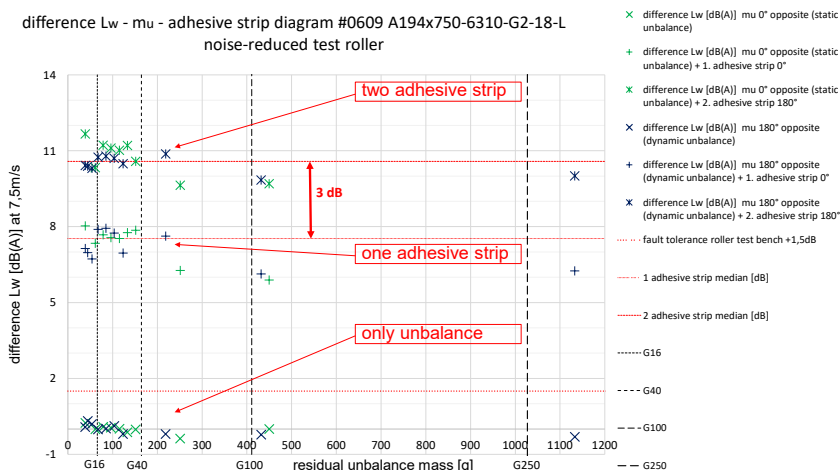


Figure 8: Differences in the sound power level over the residual unbalance mass of the test roller [Rie-3]

The median of the level differences from the tests with an adhesive strip is 7,5 dB. The measurement series of unbalance exceeds G250. This corresponds to a residual unbalance mass of 1.133 g. However, only the adhesive strip (with a negligible weight) increases the sound power level around 6 dB.

The median of the sound level differences from the tests with the second adhesive strip is 10,5 dB. It means with the adhesive strips on the opposite side there was a further sound level increase of 3 dB. The expected level increase of 3 dB from doubling the geometry-related excitation has occurred.

There was no unbalanced-related excitation for sound radiation detectable during the experiment.

Summary and outlook

Caked material has a high effect on the noise emissions to rollers. The experiments show that caked material did not cause "higher" unbalances to rollers. It has been proven that unbalances up to level G250 did not lead to an increase in the sound power level for rollers.

The combination of the unbalance test with the adhesive strips tests showed a direct connection between geometry-related excitation (circular shape deviation) and sound emission. The mass of the adhesive strips is small compared to the unbalance mass attached to the side cover of the roller. In the tests the mass of the adhesive strips cancel each other out with two adhesive strips that were attached 180° opposite one another on the roller surface. The excitation of the sound emission took place from the circular form deviation. It was proven by the help of the doubling of the excitation and the resulting sound level increase of 3 dB. It follows that the caked material on the rollers in the opencast mining does not increase the noise emissions by unbalance. Instead the change in geometry on the roller surface causes an increase of noise emissions.

The investigation allows the thesis that there is no causal relationship between unbalance and noise emissions in the case of rollers for belt conveyor systems. It means we must think about a new formulation of the theory of excitation for sound radiation and noise reduction of conveyor rollers in the future.

The first results of field tests indicate a validation of the results on the roller test bench. This means that the compliance with the geometry specifications of low noise rollers follows a higher tolerated unbalance for rollers at the belt speed up to 7,5 m/s. Cost reductions or at least simplifications in the manufacturing process for the manufacture of noise-reduced rollers for ground-level belt conveyor systems are possible.

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6. Prospects of creating digital twins of Arctic and Northern cities and their role in improving energy efficiency

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Abstract

The article is devoted to assessing the conditions that determine the differentiation of the implementation indicators of Digital Twins technologies in the Arctic and northern cities.

Today, cities have different conditions for the implementation of Digital Twins technologies. The article discusses the concept of "digital twin" as a priority area for further socio-economic development of the urban environment, capable of providing a high quality of life for the population. The main part of the work analyzes current trends, which in the coming years will contribute to the intensive development of new management systems, discusses the features of the digital economy and the use of digital technologies in the ecosystem of Arctic and northern cities; The advantages of the digital environment of the "smart city" are revealed; identified the key risks of introducing digital twins.

Aspects of the further development of the concept of a smart city and the tool "digital twin of the city" as an effective tool for analyzing and improving the performance of the entire technological system as a whole are considered.

Based on the results of the study, it is recommended that when constructing the digital twins of the Arctic and northern cities take into account their climatic and socio-economic features that affect the possibilities of using digital technologies. Taking these conditions into account will ensure an increase in the quality of life of citizens and an improvement in the social climate, the development of innovative technologies, and the enhancement of the competitive advantages and investment attractiveness of the Arctic and northern cities.

Keywords: digital twins, Arctic and northern cities, smart city.

Introduction

Due to general digitalization, the term "digital twin" is increasingly used. The concept of a virtual representation of a physical object has been in use for decades. However, over the past few years, the development of information technologies has changed the situation dramatically. The Digital Twin has not only become one of the leading trends in industry, but also finds application in everyday life.

The digital twin of the city is a trained system consisting of a set of mathematical models of an object of different level of complexity, predicting its behavior on the whole life cycle, it is a set of IT-systems, with the help of which constant monitoring, planning and development of the most important structures of the city is carried out: Roads, bridges, tunnels, metro, airports, ports, communications, water, power, land buildings and underground urban infrastructure, road construction, transportation, ecology, affordable environments, smart technologies and energy efficiency.

The city's digital twin is a prototype of a real city in digital reality. It is created on the basis of data received from various sensors, monitoring systems and resource meters. With the help of such a twin, specialists can analyze the life cycles of the city and its reaction to possible changes and external influences at the design stage, so the probability of error in reality is minimal (see Fig.2).

Google Maps "features for viewing streets and 3D buildings can be seen as a starting point in creating the city's digital twin. But demand is growing not only for a three-dimensional image of cities. Various types of modeling help to create a digital description of the city, to set

parameters of future buildings, roads, engineering networks, natural objects, places of residence and applications of labor, to calculate the ecological model of the city.

The formation of a unified information network will allow not only to control and protect vital systems of cities and individual buildings, but also to operate on big data - that is, to engage in predictive analytics - to anticipate and prevent potentially dangerous situations. After careful computer analysis it is possible to calculate where to build additional junctions, expand roads and even look into the future, determining what will happen to a particular road in 15-30 years, as it will be loaded.

The Arctic zone is characterized by extreme environmental conditions: low temperatures throughout the year, long polar night and day, frequent magnetic storms, strong winds and blizzards, dense fogs, monotonous species of Arctic deserts and tundra, permafrost; High, significantly faster than the global average, dynamics of climate change in recent decades. Natural extremeness is enhanced by the negative effects of socio-economic factors - transport inaccessibility, high production costs and cost of living, underdeveloped economy and trends towards its monopolization, isolation and dispersion of settlement.

Living conditions in the Arctic zone are very different from conditions in other territories, including due to difficult climatic conditions, and also due to the great remoteness of settlements from each other. And to solve the everyday problems of the inhabitants of the Arctic, advanced technologies are also needed.

Elements of a smart city that can be used in digital twins exist now, for example, the introduction of payment systems, car sharing and taxi services.

Digital models of the city are used to control the construction and development of the urban environment. They demonstrate all the features of the landscape, help predict future development, understand the location of buildings and roads. 3D models of the city are used in construction, geodesy, cartography.

A sufficiently large number of information systems provide the functional verticals of the city and use the level of databases. Often, to create innovative solutions in the field of smart cities, it is necessary to integrate information between these information systems, and so the task of integration and management arises.

It is in solving the problem of coordination of urban work and services that the main task of digitalization lies. Everyone suffers from duplication of functions: municipal services create and maintain the same products, without knowing what the neighboring service is doing.

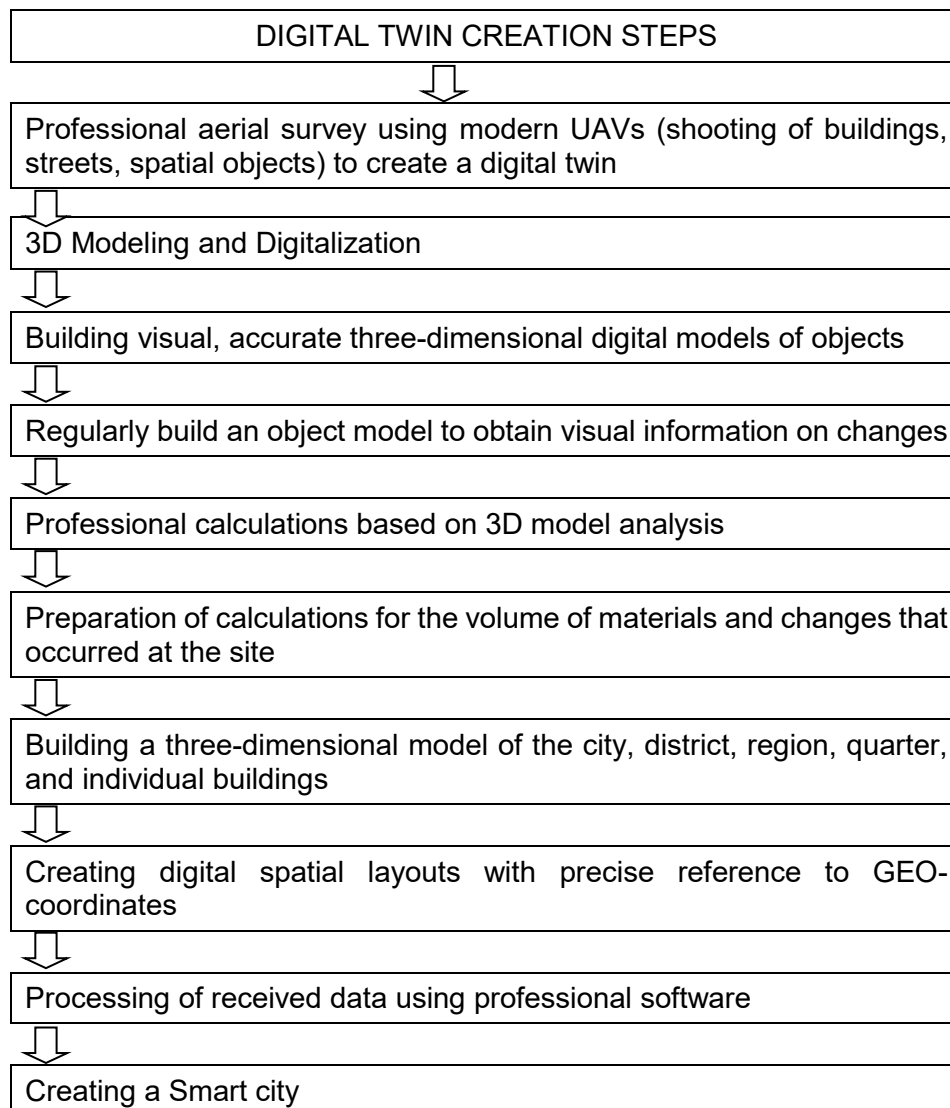


Fig. 1. Digital twin creation steps Source: developed and compiled by the authors

When creating digital twins, it is necessary to observe the principle of excessive use of resources - we are talking about the use of data and infrastructure of some urban areas to solve the problems of other areas. For example: information from road video cameras is used not only to identify violators of traffic rules, but also to monitor snow removal on the streets or to control urban transport.

Another obstacle is the lack of a single data format. Certain types of data can be difficult to combine, so an important principle is cross-platform. Each system should easily exchange information with any other system. And for this we need a single technological platform, common standards and protocols for data transfer.

Thus, in order to more coherent development of digital twins, the following steps are needed.

- Unification of data and model standards. Production data should be standardized and presented in common formats. A universal design and development platform for digital twins should be developed.
- Exchange of data, models. A publicly accessible digital twin exchange database should be created.
- Innovations in the service sector. Companies need to develop products and services to help digital twins. For example, Siemens NX software combines design, simulation, and production tools in one package.

At present, a global reproduction system of the sixth technological order is being formed. This requires a review of traditional approaches to Arctic development. In addition to large-scale resource extraction and trans-Arctic shipping in the region, there is an opportunity to develop innovative directions of the digital economy with greater environmental and social sustainability.

Smart technologies that meet modern requirements for energy-efficient and innovative engineering solutions that have been tested in practice to date:

- automated heating control systems;
- energy-saving smart lighting for common areas (using sensors of local automation);
- smart street energy-efficient lighting;
- smart energy-efficient elevators;
- smart metering of energy resources.

In Siberia, Krasnoyarsk and Novosibirsk have the greatest potential for the development of Smart City, according to experts. During the preparation for the student university games in Krasnoyarsk, a single digital platform was created, which will be used for "Smart City," control centers and a large number of telecommunication devices.

On the basis of the system it will be possible to model and analyze various scenarios of urban processes: to monitor the migration of the population, to predict the adequacy of transport junctions, urban infrastructure, to assess the tourist potential of the territory and to ensure the public safety of the region. At the same time in the city the technology can be used not only for automation of collection of meter indicators, but also for control of parking space, control of street lighting, accounting of urban transport and harvesting equipment, etc. The project provides for digitalization of urban management systems, housing and communal services, medical sphere, transport, safety systems and energy efficiency.

After the first successful implementations, the time has come for the further development of the smart city concept and the "digital twin of the city" tool is becoming an effective tool for analyzing and increasing the productivity of the entire technological system. In the Arctic, all aspects of digital twin cities can be used in terms of technology, usage options, benefits, technology provider profiles and case studies, deployment challenges and deployment forecasts.

Typical uses include flood risk modelling, power management in multiple buildings, renewable energy and traffic flow optimization, employment tracking and evacuation modeling, and urban space design.

Digital copies of buildings and utilities, infrastructure and structural elements will help to improve the quality of services in the sphere of housing and utilities and save energy consumption. These solutions should first be tested on a digital twin, and only after successful virtual tests launch in a real city.

Among its other applications is the ability to analyze the potential for solar power generation, and it can also provide insight into how environmental temperatures and sunlight change during the day, allowing urban planners to visualize the effects of new construction.

The set of capabilities depends on the data that will be integrated into the system and on the goals of the city administration. Cities capable of using digital twin technology will be more environmentally, economically and socially sustainable.

Digital copy of the city will help solve acute issues of urban environment (see Fig.2).

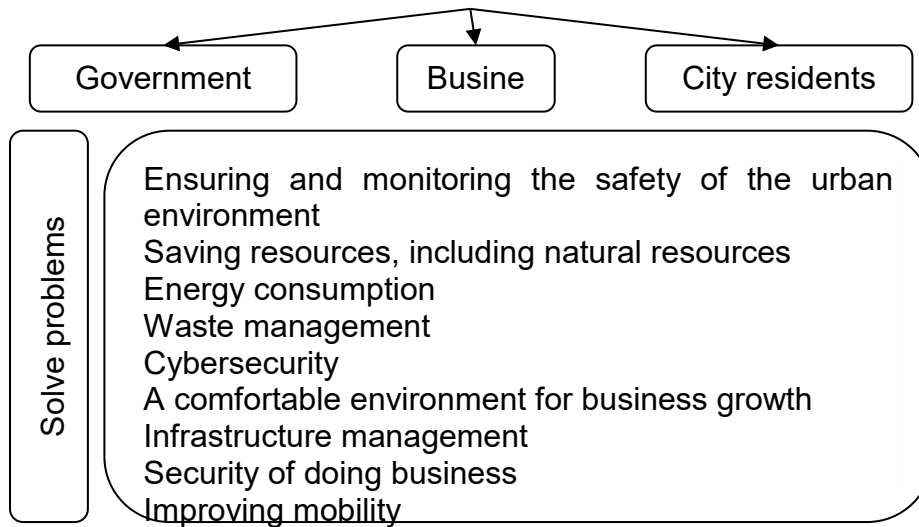


Fig. 2. Users and topics of solved problems of digital twins Source: developed and compiled by the authors.

Speaking about the peculiarities of digitalization of urban economy and housing and utilities in Arctic cities, it should be noted that this region has similar tasks, problems and barriers, multiplied by more severe climatic conditions. In Arctic conditions, issues of strength and reliability of housing and utilities systems come to the fore, so digital algorithms could predict possible problems (with accidents on thermal networks, delays in the movement of public transport, etc.).

In the Arctic, digital twins should cover many other areas: telemedicine, e-government, e-service delivery, online education, etc. In the Arctic, all these opportunities offered by digital technologies are particularly relevant. This is due to reasons such as the long distance between cities, difficult transport and harsh climate.

It should be noted the special role of energy efficiency for the northern and Arctic regions, which is due to two groups of factors. In difficult climatic and geographical conditions, energy production requires high costs, as well as its transportation. On the other hand, increased specific energy consumption both in the economy and in the social sphere determines the need for more active measures to reduce energy losses in all areas.

In the Development Strategy of the Arctic Zone of the Russian Federation for the period until 2020, the main risks and threats are high energy intensity and low efficiency of natural resource extraction, and an insufficiently active energy conservation policy in the social sphere. The most important strategic task is to increase energy efficiency, as well as expanding the use of renewable energy sources, ensuring the energy independence of remote small towns, developing and implementing projects in the field of energy conservation and energy efficiency, including through international cooperation.

The policy of improving energy efficiency in the Arctic should be based on the coordination of the interests of all sectors of activity and various levels of government, including in such strategic areas as the introduction of new generation heat supply systems with a significant reduction in losses, the use of energy and transport facilities operating on alternative fuel, and etc.

Among the many areas of alternative energy, the most promising for the Arctic macroregion is wind energy based on wind-diesel installations of medium capacity. Their application is relevant in small localities of the decentralized energy supply sector and is expected to lead not only to a reduction in the consumption of non-renewable fuel and energy resources and reduce the environmental burden, but also to savings on fuel delivery.

First of all, there should be technical specifications and a base. Today in the region the main communication - satellite, which means very slow and expensive Internet and limited opportunities for development of different "smart" programs.

During the construction and reconstruction of Arctic residential buildings, the requirements to create quality living conditions in difficult climatic conditions come first, and for this purpose advanced approaches are needed. Norilsk 's digital twin will help to renovate the city at a qualitatively new level.

Norilsk is one of the most developing Arctic cities. Thousands of professional teams are involved in the implementation of development programmes, which require a significant increase in the city 's housing stock. Moreover, global warming of the climate has led to the degradation of long-standing soils, as a result of which some residential buildings are in an emergency or pre-emergency condition. Climate dictates approaches that are not described in the normative literature, and therefore it is necessary to build housing not according to the norms, but such, which will be comfortable, more precisely multi-comfort for people. This is possible only in complex solution of problems, where volume-planning and structural solutions are deeply connected with automation and robotics of buildings.

In the future, various services can be gradually integrated into the digital architecture of Norilsk: housing and communal services, healthcare and transport management, forecast of snow transfer, heat supply, security and control over the execution of municipal services.

In cities with a polar night, the role of lighting is especially important in creating an architectural appearance. Usually, with the onset of darkness, business life in cities ceases; at night, traffic on the streets subsides. In northern cities during the polar night, the intensity of public life persists.

Living people and the work of manufacturing enterprises in the Far North are characterized by huge transportation costs and isolation. Almost all fuel for generating heat and electricity has to be delivered over long distances during the short northern summer, which forces the development of energy-saving technologies.

This is, firstly, the automatic regulation of the thermal regime of buildings and the use of alternative, including renewable energy sources (solar panels, heat pumps, etc.).

The goal of the project to create the digital twin of Norilsk is to increase the quality of life of citizens and improve the social climate, develop innovative technologies, increase the competitive advantages and investment attractiveness of the city.

The following five main components stand out:

1. Technogenic safety - ensuring the protection of citizens and urban facilities from the effects of hazardous processes caused by damage and destruction of structural, thermal, water, energy systems, operational errors and unauthorized influences:

- control and management of water supply, sanitation,
- control and management of gas supply,
- monitoring of mechanical deformations of housing and communal services objects, social objects,
- fire alarm,
- control of elevator equipment.

2. Environmental safety - monitoring the ecological state of the air environment and the water basin to ensure the protection of citizens and the environment from the possible negative impact of economic activity:

- control of outdoor temperature, wind strength and direction, rainfall,
- control of snow cover,
- control the movement of vehicles for the disposal of household waste,
- control the movement of snow removal vehicles.

3. Transport security - ensuring the protection of citizens on transport, transport infrastructure and vehicles from illegal interference:

- radio frequency identification of vehicles,
- information support for stops, parking lots.

4. Public safety - ensuring personal protection of citizens in places of residence, in places of mass recreation, at cultural and architectural-historical objects:

- video surveillance of house and house territories,
- panic button ("citizen-policeman") on social objects,
- control and management of access to social facilities.

5. Energy efficiency and resource saving - ensuring the optimization of costs and consumption of energy resources, water resources, heat resources by social, housing and communal and other objects:

- control and management of house and street lighting,
- control of electricity supply.

Today many cities acquire their digital twins. One of the first was Singapore, French Rennes and Indian Jaipur. A virtual copy of all the physical objects of the city allows you to manage it remotely, as well as solve city problems. For example, in Singapore, the main task that is solved with the help of digital twins is water management. For this, all water supply systems, water quantity control, meters and so on were digitized.

Each country is experimenting digitally depending on its priorities. In the world there are about 30 options for "digital twins" of cities and approaches to their use and content.

The Spanish company Bismart Bigov has developed for Barcelona the digital panel biGov Better City Indicator, which controls about 200 urban development indicators. In this case, both indicators created within the framework of the standard related to the sustainable development of territories and indicator sets developed by the nonprofit community City Protocol Society are used. Information is taken from existing urban systems, urban infrastructure, sensors, the Internet of things and allows you to analyze various indicators and trends [2].

Berlin's Bismart Urban Planning system uses Big Data Analysis technology to plan and develop urban areas and social infrastructure. In the construction of social facilities, it can take many years from the idea to readiness, and the demographic situation can change. Urban Planning uses the technology of machine learning and big data analysis to make more informed decisions about the placement or change of the functional social infrastructure (schools, kindergartens, clinics, hospitals, information centers, etc.) [2].

The Urban Strategy solution from the Dutch company TNO is designed for the planning and development of urban areas. It contains a large number of mathematical models that allow you to quickly make a miscalculation of options - for example, what happens if you build a specific road junction, how this will affect the traffic of the surrounding territory, child safety, economic development in this territory, etc. Models are integrated via the bus, and as a result, urban planners have a tool to help them quickly view different options for territorial development and make informed compromise decisions [3].

One of the earlier providers of urban digital twin software is CityZenith. Their Smart World platform is already being used for projects in more than 100 cities, including Chicago and London. Their latest 5D Smart City software platform has been adopted for use by Amaravati in India. This is the ideal concept of the digital twin, because the physical city has not yet been developed [4].

One of the main representatives of digital twinning is Dassault, which has teamed up with Singapore to create Virtual Singapore. Prior to that, in 2013, they acquired a three-dimensional GIS modeling company in Rennes called Archivideo and used GIS software in conjunction with their own PLM lifecycle management software to provide a platform for a digital city, using Rennes as evidence of their concepts for 3DExperiency, their digital double platform [5].

Microsoft is gradually expanding its capabilities in the IoT world, using Azure as a platform for managing IoT. Now the company has reached a new level thanks to the recently released product Azure Digital Twins.

Over the past two years, several enterprise technology vendors such as IBM, Oracle, and SAP have launched digital twin offerings; various IoT and engineering simulation software vendors such as Dassault Systèmes, GE, PTC, and Siemens have acquired tools to build or expand digital twin capabilities.

An exact virtual copy is created by special programs of the world leader in software products Bentley Systems. Today it is represented by a number of products in the line of one vendor: ContextCapture, OpenRoads Designer, OpenPlant Modeller, AECOSim Building Designer, ProStructures, etc [6].

The digital model of the city demonstrates all the features of the landscape, helps to predict future development, to understand the location of buildings and roads. Current global trends suggest the construction of models of large cities using photogrammetry - a method based on the construction of three-dimensional models based on the results of UAV photography. Such virtual layouts are used in construction, surveying, and cartography. For example, models of Singapore, Helsinki and California were built using photogrammetry.

The increased pace of digital twin creation is partly due to progress in the technologies on which they are built.

- Collection of operative data becomes cheaper and easier. The IoT sensors continue to decline in price, reducing the cost of collecting and transmitting operational and environmental data from the physical twin.

- Analytic and simulation can give a deeper understanding. Ever-improving cloud offerings and advances in machine learning make it easier to learn about large amounts of IoT and contextual data for risk forecasting and solution modeling.

- Human-computer interfaces increase ease of use. Chat bots, speech recognition, virtual assistants, and augmented reality make it easier for workers to interact with digital twins.

In Russia, informatization has long been aimed at creating common databases: cadastral, taxation, not so long ago there was a unified base of housing and communal services (GIS housing and utilities). At the same time, each region develops systems of electronic governments, where online it is possible to submit almost any application to the authorities, pay fines and check social payments. Also, an example of the implementation of Smart City technology throughout the country should be recognized as a large-scale system of photo-recording of traffic violations with subsequent information of drivers about fines.

There are few examples of Russia. A map of energy efficiency was launched in Lipetskaya region. The specialists assessed the heat consumption of more than 5,800 apartment buildings, for each of them there was an energy audit: a comparative analysis of the estimated and actual consumption of heat energy in each month over the last two heating periods. And now anyone can go to the site and see: if his house is marked red, then energy efficiency is low and you can save on payments. And the information card of the house immediately indicates the amount of possible savings. Accordingly, if a resident has a desire to pay less, he is explained what needs to be done. For example, isolate internal networks, install automated heat points, wash utility networks, insulate the building, etc. [7].

In March 2019, Russia approved the Smart City standard, one of the components of which was "digital twins." Within a few years it is planned to create "digital twins" of all cities of Russia. It is practically possible to realize the twin only by linking and agreeing on a whole set of technological, organizational and financial solutions [9].

The document includes activities in eight areas: urban management, "smart" housing and utilities, innovations for the urban environment, "smart" urban transport, intelligent systems of public and environmental safety, infrastructure of communication networks, tourism and service.

For all activities, the Standard identifies specific effects to be achieved by 2024. This includes improving the efficiency of urban infrastructure management, reducing accidents and losses on utility networks. The predictability and manageability of urban infrastructure should be improved, and the number of emergencies should be reduced. The efficiency of urban transport systems will increase, as will the efficiency of municipal tax collection.

In addition to the standard, the Ministry of Construction of Russia has formed an open base of technologies and developments "Bank of Smart City Solutions," where projects have been placed, which have already proved their effectiveness and can be replicated. The National Competence Center of the Smart City Project has also been established, whose tasks include the development, introduction and popularization of technologies, equipment and programs aimed at increasing the level of digitalization of urban economy.

Investment is necessarily needed to launch this project, and it will be required by the authorities at the start-up stage. Their purpose is to build a unifying infrastructure, integrate heterogeneous data, create common technological protocols, etc. The development of such universal standards will make subsequent investments in the project from the business more meaningful, effective, able to implement the key principle of data and infrastructure reuse.

Conclusion

For the development of the digital economy, digital government, smart cities and regions, you also need your own infrastructure with data centers and intelligent cloud computing.

The implementation of digital twin projects of cities and regions will contribute to the achievement of such important goals as:

- economic development of territories;
- enabling sustainable development;
- environmental conservation;
- improving the quality of life of citizens in the territory where smart technologies are introduced.

Today, the digitalization process is actively taking place, many devices are being dematerialized, taking the form of applications on smartphones, products supplemented by digital applications for providing digital services are popularizing - all these factors are becoming a new reality for consumers and the basis for the development of digital twin technologies.

In order to develop scientifically based measures to counter the growing economic threats to the Arctic and northern cities, to create a comfortable living environment, it is necessary to provide the ability to receive and comprehensive analysis of the very large volumes of detailed spatio-temporal, primarily economic, information about the region, as well as building on the basis of this information reliable models of the state of its urban environment, creating a set of new technologies, software and developing analytical methods use data of digital twins.

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7. Gross violations of the Charter of the Russian Academy of Sciences (RAS)

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Abstract

24.07.2016 a large group of academicians of the Russian Academy of Sciences (RAS) wrote a letter to the President of the Russian Federation V. V. Putin, in which they gave an unfavorable assessment of the current state of Russian science. The letter listed a number of measures aimed at correcting the current state of science, and noted that "the time of political correctness is over, it is high time to speak out openly calling things by their proper names". Meeting with a group of academicians of the Russian Academy of Sciences in December of 2016, the President of the Russian Federation V.V. Putin stressed the timeliness of setting the above problems and the need to eliminate the noted deficiencies, drawing attention to the fact that only outstanding scientists of international standing with significant scientific achievements should be elected as academicians of the RAS. In connection with the critical assessment of the current state of Russian science in its various fields, expressed in the aforesaid letter of the academicians, it is of some interest to analyze the scientific activities and scientific achievements of some Russian scientists, in particular, in the field of thermal power engineering. For this analysis, articles were used published in the Teploenergetika (Heat Power Engineering) journal as well as a Report prepared under agreement No. 14.574.21.0017 with the Ministry of Education and Science of the Russian Federation (hereinafter — MoE&S) on improving the thermodynamic and technical-economic efficiency of trigeneration plants at distributed and small-scale power generation facilities. As follows from this analysis, the authors of the aforesaid publications mislead the scientific community and the MoE&S concerning the alleged increase of thermodynamic and technical-economic efficiency of trigeneration plants considered by them. There are no grounds for such conclusions, since the listed materials contain no specific results of experimental and/or calculation studies of thermodynamic and technical-economic efficiency of trigeneration plants. It is therefore very strange that a Committee of the MoE&S signed an Act certifying "proper" implementation of Agreement No. 14.574.21.0017.

KEYWORDS: RAS Charter, thermal power engineering, analysis, agreement, requirements, research, results, unreliable information

В свете изложенного следует обратить внимание читателей на ряд положений Устава федерального государственного бюджетного учреждения «Российская Академия Наук» (РАН), который утвержден Постановлением Правительства Российской Федерации от 27 июня 2014 г. No 589. В Уставе, в частности, в пункте 22 указывается, что «Академиками Академии избираются ученые, обогатившие науку трудами первостепенного научного значения».

В пункте 24 Устава указывается, что «Главной целью деятельности членов Академии является обогащение науки новыми знаниями и достижениями».

В пункте 31, е) Устава указывается, что «Члены Академии обязаны... соблюдать нормы научной этики, личным примером содействовать повышению престижа науки и авторитета члена Академии».

Но вернемся к письму академиков РАН Президенту РФ В. В. Путину

В нем они сетовали на то, что наблюдается «резкая активизация проходимцев от науки». Извините, но что они сами-то делают? Избирают в академики специали-стов, которые не только не «обогадили науку трудами первостепенного научного значения», не «обогадили науку новыми знаниями и достижениями», но и не име-ют сколько-нибудь существенных научных достижений, при отсутствии у них элементарных знаний в области термодинамики, теории турбомашин и теплотехники, которые не соблюдают нормы научной этики и личным примером не содействуют повышению престижа науки и авторитета члена Академии.

Ярким примером является избрание в академики РАН Клименко Александра Викторовича. Очевидно, что академики РАН, голосовавшие «ЗА» избрание Кли-менко А. В. академиком РАН, не ознакомились с его статьями и Отчетом в МИНОБРРФ по соглашению No 14.574.21.0017 и не проанализировали их содержание.

Восполним этот пробел.

Для подтверждения вышеуказанного вывода доста-точно проанализировать содержание статей академи-ка Клименко А. В. с соавторами, обладающими, как и сам Клименко А. В., солидными учеными степенями и званиями. Отметим попутно, что эти статьи были опу-бликованы в журнале «Теплоэнергетика», где он, кста-ти, числится главным редактором [1, 2]. Дополнительно целесообразно проанализировать содержание Отчета по соглашению с МИНОБРРФ No 14.574.21.0017.

Как известно, для оценки термодинамической эф-фективности различных установок и систем давно уже разработан и успешно используется исследователями как в России, так и за рубежом эксергетический метод термодинамического анализа (ЭМТА) [3 – 9].

В соответствии с этим методом критерием термоди-намической эффективности является эксергетический КПД. Только исследования, проведенные с примени-ем этого метода, позволяют дать научно обоснованное заключение о термодинамической эффективности той или иной установки или системы.

Академик Клименко А. В. с соавторами в указанных статьях [1, 2], например, в [2, с. 39] предпочитают тер-мин «характеристика».

Отметим, что к настоящему времени некоторые фир-мы ряда ведущих стран ввели ЭМТА в качестве обяза-тельной составляющей части разрабатываемых проек-тов, а также планов модернизации производств [9].

Из текстов статьи [1, с. 42], статьи [2, с. 39, с. 43] следу-ет, что академику Клименко А. В. с соавторами известно о существовании такого метода, они неоднократно его упоминают, но только упоминают. Так, в сноске на с. 39 статьи [2] академик Клименко А. В. с соавторами указы-вают (дословная цитата):

«Для более детального исследования необходимо применение метода эксергетического анализа, позво-ляющего учесть различную ценность разных видов энергии (электроэнергия, тепло, холод). Однако это ис-следование выходит за рамки настоящей статьи» (?!).

Очень странная, если не сказать больше, логика ака-демика Клименко А. В. с соавторами в данной статье. Признают необходимость использования ЭМТА, но почему-то его игнорируют не только в этой статье, но и в других опубликованных работах [1, 10 – 13].

В связи с этим выводы академика Клименко А. В. с со-авторами о повышении термодинамической эффектив-ности рассмотренных схемных решений в [1, 2] лжена-учны и несостоятельны.

Более того, в статье [2, с. 40] академик Клименко А. В. с соавторами считают, что вместо ЭМТА для оценки тер-модинамической эффективности рассмотренных ими схемных решений для тригенерационных установок их «анализ, как правило, должен проводиться на базе си-стемного подхода, позволяющего определить эффект от внедрения с учетом его воздействия на работу всех составляющих элементов тригенерационного ком-плекса, включающего и потребителей».

Однако, кроме деклараций о целесообразности применения так называемого системного подхода, предложенного в [10] еще семнадцать лет назад, не обнаруживается ни одной публикации академика Клименко А. В. с соавторами с реальным свидетельством эффективности применения этого подхода, кроме их голословных заявлений, не подтвержденных корректными экспериментами и расчетами.

Вместо эксергетического КПД, используемого в ЭМГА, и разрекламированного системного подхода в статье [2, с. 39] академик Клименко А. В. с соавторами в качестве «характеристики» термодинамической эффективности неожиданно применяют коэффициент использования тепла топлива (КИТТ). Однако его применение для данной цели лженаучно, он в науке никогда ранее не использовался и в настоящее время не используется в качестве такой «характеристики» [8, 9]. Его использование в данном аспекте свидетельствует о слабых знаниях академика Клименко А. В. с соавторами в термодинамике и теплотехнике.

В статье [1, с. 44] академик Клименко А. В. с соавторами утверждают, что «детандер-генераторные агрегаты» (ДГА) могут служить для создания тригенерационных установок».

Между тем, академик Клименко А. В. с соавторами должны были бы знать, что тригенерационные установки предназначены для одновременной выработки трех видов энергии: электроэнергии, теплоты и холода.

Однако ДГА могут вырабатывать только два вида энергии, а именно, электроэнергию и холод, а теплоты для подогрева природного газа (ПГ) перед, за или одновременно перед и за ДГА потребляется ими из постороннего (внешнего) источника, если он имеется в наличии. Из этого вытекает принципиальный и однозначный вывод о невозможности создания тригенерационных установок с использованием ДГА.

В статье [1, с. 43] академик Клименко А. В. с соавторами утверждают, что с помощью двух ДГА, включенных параллельно или последовательно, можно «организовать одновременное централизованное снабжение потребителей электроэнергией, теплом и холодом».

Однако этот вывод противоречит основам термодинамики и опровергается результатами расчетов показателей ДГА в обширных таблицах 1, 2 и 3 в статье академика Клименко А. В. с соавторами [1, с. 41 – 43]. Из них следует, что, несмотря на значительный подогрев ПГ перед ДГА, вплоть до 120°C, температура ПГ на выходе из ДГА находится в диапазоне от 6,10 до 31,70°C. Очевидно, что такой теплоноситель (газ) с такими низкими температурами не может быть использован ни в обратной, ни, тем более, в прямой линии теплосети централизованного теплоснабжения. Если же установить за первым ДГА последовательно второй ДГА, то на выходе из него температуры ПГ будут значительно отрицательными. Применение такого теплоносителя приведет к «разморозке» систем централизованного теплоснабжения

В [1, 2] академик Клименко А. В. с соавторами молчаливо обходят стороной вопросы о том, из какого же источника в их расчетах и схемах должна быть взята теплота для осуществления эксплуатации рассмотренных детандерных и тригенерационных установок, какова ее величина, имеется ли этот источник теплоты необходимого потенциала на рекомендуемых ими объектах внедрения указанных установок, какой теплоноситель и с каким расходом используется в этих установках и куда он затем отводится.

Так, например, в статье [2, с. 42] академик Клименко А. В. с соавторами указывают, что в рассмотренных схемах тригенерационных установок предусмотрена подача в ПКТТ (парокомпрессионный термотрансформатор) дополнительного низкопотенциального тепла из внешнего источника, но что это за источник, каковы его характеристики в статье не указывается.

Без ответа на вышеуказанные вопросы рекомендации авторов ненаучны и несостоятельны.

В статье [1, с. 43 – 44] академик Клименко А. В. с соавторами утверждают, что ДГА могут найти применение в малой энергетике. Этот вывод сделан на основании расчетов параметров таких агрегатов с расходом ПГ 1000 нм³/ч.

Однако, если бы академик Клименко А. В. с соавторами по известным методикам в теории турбомашин произвели расчет проточной части осевого ДГА в широком диапазоне изменений давлений и температур ПГ для указанного расхода, то они получили бы весьма интересный результат: длина сопловой лопатки первой ступени осевого ДГА на частоту вращения 3000 об/мин не превышала бы 1,2–2,08 мм. Очевидно, что такую проточную часть невозможно изготовить на самом современном технологическом оборудовании. И говорить о КПД такой проточной части вообще не имеет смысла.

Как показывают расчеты, выполненные автором данной статьи, для получения длины лопатки хотя бы в 15 мм расход ПГ в ДГА должен составлять около 12.000 нм³/ч.

Следует учесть, что с целью обеспечения надежной работы оборудования объекта малой энергетики, на котором может быть произведен монтаж ДГА, расход ПГ в ДГА обычно принимается равным 30 – 40% от расхода ПГ, поступающего на объект. Тогда номинальный расход ПГ на объекте должен составлять от 30.000 до 40.000 нм³/ч. Напомним, что, например, в широко распространенных водогрейных котлах типа КВГМ-11,63-150 расход ПГ составляет 1.290 нм³/ч. Это означает, что на объекте малой энергетики (например, в котельной) должно быть установлено от 23 до 31 котла этого типа. Однако таких котельных в России вообще не существует.

В статье [2, с. 42 – 43] академик Клименко А. В. с соавторами утверждают, что преимуществом рассмотренных ими тригенерационных установок является повышение термодинамической эффективности энергоснабжения. Но как это можно утверждать, если авторы не проводили исследования этой самой термодинамической эффективности на основе ЭМТА или разрекламированного ими так называемого системного подхода?

В статье [2] приводятся только описания схем различных установок и перечень необходимого технологического оборудования (рисунки 1 и 2 в данной статье), указываются стрелками направления движений теплоносителей и рабочих тел (хладона, прямой и обратной сетевой воды и т. д.).

Предложенные авторами схемы тригенерационных установок на рисунках 1 и 2 отличаются значительной сложностью из-за наличия большого количества технологического оборудования разного типа. Так, например, на рисунке 2 показана схема тригенерационной установки, в которой имеются паротурбинная установка 3 (в ее состав обязательно должны входить энергетический котел и паровая теплофикационная турбина), пиковый водогрейный котел 19, трансформатор пароконденсационного типа 7, многочисленные трубопроводы различного назначения 1, 2, 4–6, 8–14, 16–18 (для хладона, прямой и обратной сетевой воды, топлива, уходящих газов, дополнительного тепла). На схеме объект генерации обозначен цифрой 20, а цифрой 21 — блок потребителей (выделены тонкими штриховыми линиями). В блок 21 входит оборудование, потребляющее соответственно электроэнергию 22, холод 23 и тепло 24. Из-за сложности схемы вряд ли подобная тригенерационная уста

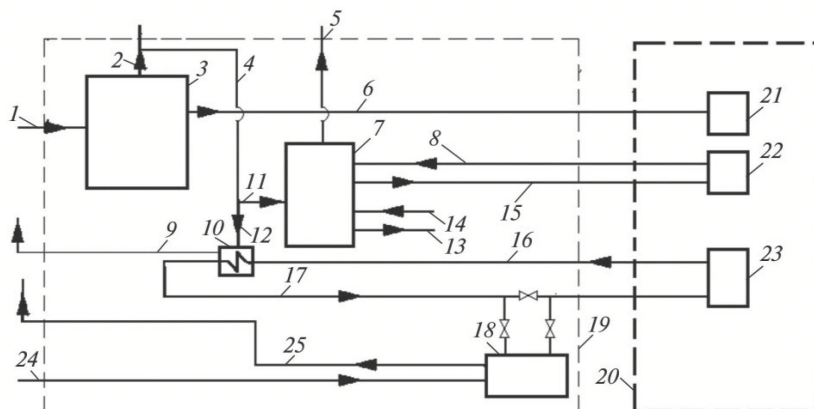


Figure 1: Структурная схема энергоснабжения потребителя от объекта генерации с газотурбинной установкой и термотрансформатором абсорбционного типа (заимствован из [2]).

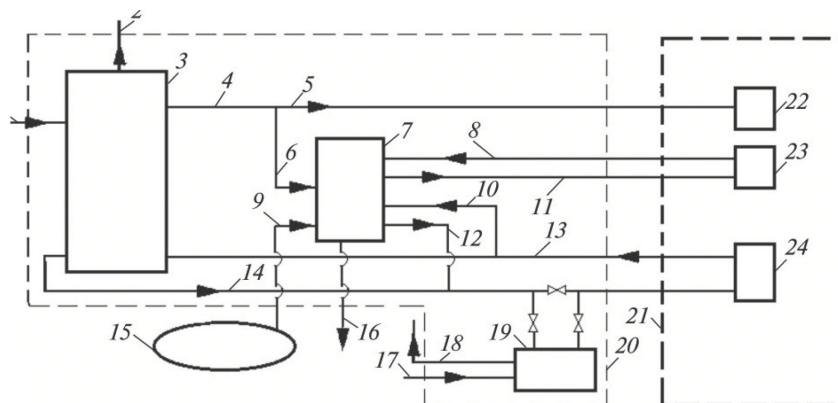


Figure 2: Структурная схема энергоснабжения потребителя от объекта малой энергетики с паротурбинной установкой теплофикационного типа и парокompрессионным термотрансформатором (заимствован из [2]).

новка может быть осуществлена в действительности. Кроме того, в схеме предусмотрен источник дополнительного тепла 15. Но по неизвестной причине он выведен за пределы объекта генерации 20. Не указано, что это за источник, каковы его характеристики. При отсутствии на объекте возможного внедрения данной тригенерационной установки источника дополнительного

тепла схема неработоспособна.

Таким образом, академик Клименко А. В. с соавто-

рами в [2] не приводится абсолютно никаких данных по параметрам рабочих тел и теплоносителей (по расходам, температурам, давлениям).

Такая беллетристика вряд ли уместна для статьи в научно-техническом журнале «Теплоэнергетика», которая, к тому же, является завершающим этапом Отчета (как указывают академик Клименко А. В. с соавторами в сноске на с. 37 в статье [1] и в сноске на с. 37 в статье [2]) по соглашению No 14.574.21.0017 с МИНОБРРФ).

Схемы тригенерационных установок (рисунки 1 и 2) авторы сумели-таки нарисовать, но из-за их сложности оказались не в состоянии выполнить расчеты термодинамической и технико-экономической эффективности этих установок.

В статье [1] академиком Клименко А. В. с соавторами приводится схема ДГА (рисунок 1, с. 38), в которой в теплообменник 8 теплоноситель подается по двум трубопроводам одновременно. Об этом свидетельствуют стрелка на нижнем трубопроводе и обозначение насоса 7 на верхнем трубопроводе. Отсутствует трубопровод, отводящий теплоноситель из теплообменника 8. Однако такой теплообменник неработоспособен (рисунок 3 в данной статье). Название этого рисунка свидетельствует о том, что в статье речь идет только о генерации холода с помощью ДГА, и, следовательно, она не имеет никакого отношения к тематике соглашения с МИНОБРРФ об исследовании эффективности тригенерационных установок.

В этой же статье [1] в таблице 3 (с. 43) академик Клименко А.В. с соавторами приводят впервые в мире новую, до настоящего времени неизвестную в науке и практике размерность для энтальпии ПГ, а именно, кДж/(кг.К).

Наличие таких «ляпов» говорит о халатности при подготовке рукописи статьи к печати академика Клименко А. В. с соавторами, в том числе и его, как главного редактора, а также о халатности рецензентов, штатных редакторов.

Публикация статей с неграмотными рекомендациями по внедрению детандерных и тригенерационных установок в журнале «Теплоэнергетика» свидетельствует также о низком уровне знаний в термодинамике рецензентов, которые дали положительные отзывы на эти статьи.

Следует отметить, что журнал «Теплоэнергетика» переводится на английский язык, и подобные «ляпы», снижающие рейтинг журнала, просто недопустимы.

Хотелось бы отметить, что статьи академика Клименко А. В. с соавторами о высоких достоинствах детандерной технологии появились в 2016–2017 гг., хотя все

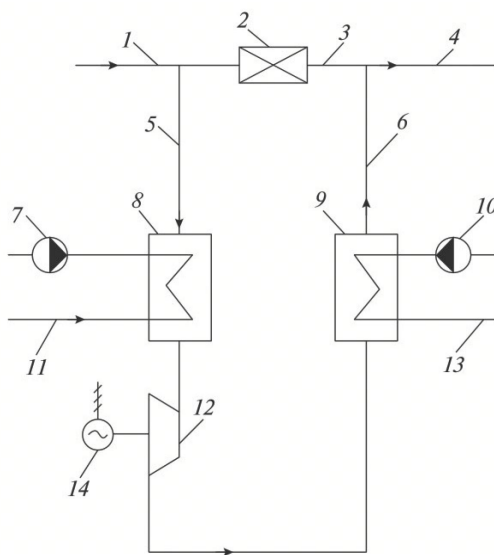


Figure 3: Принципиальная схема установки на базе ДГА для генерации холода (заимствован из [1])

четыре ДГА на ТЭЦ-21 и ТЭЦ-23 Мосэнерго были выведены из эксплуатации по решению руководства Мосэнерго еще в 2010 г. из-за крайне отрицательных результатов их эксплуатации (потеря мощности у турбины, из которой отбирался пар для подогрева ПГ перед ДГА, значительные пережоги ПГ в энергетических котлах, расположенных в соответствии с тепловой схемой за ДГА). Одновременно была полностью закрыта ранее разработанная в 2007 г. программа сооружения в Мосэнерго на различных ТЭЦ ДГА суммарной мощностью 100 МВт в течение 2007 – 2012 гг.

Единственным объяснением факта публикации в 2016 г. статей [1, 2] в журнале «Теплоэнергетика», где, напомним, главный редактор академик Клименко А. В., являлось стремление академика Клименко А. В. с соавторами хоть как-то и хоть чем-

то отчитаться за полученные и потраченные субсидии МИНОБРРФ по соглашению No 14.574.21.0017. Отметим повторно, что статья [1], в которой рассматривались возможные параметры ДГА, вообще не относилась к тематике данного соглашения, в котором должны рассматриваться вопросы создания только тригенерационных установок.

Автору данной статьи с большим трудом удалось ознакомиться с Отчетом по соглашению No 14.574.21.0017, направленным в МИНОБРРФ. В Отчете академик Клименко А. В. являлся научным руководителем, а д.т.н., профессор Агабабов В. С.¹ — ответственным исполнителем. Анализ содержания этого Отчета показал, что академик Клименко А. В. и профессор Агабабов В. С.

1) Не представили абсолютно никаких результатов экспериментальных и/или расчетных исследований

термодинамической и/или технико-экономической эффективности термотрансформаторов парокompрессионного типа с различными рабочими телами (хладагентами).

В этапе 1 Отчета академик Клименко А. В. и профессор Агабабов В. С. указали, что «подготовлены экспериментальные стенды для проведения исследований эффективности термотрансформаторов парокompрессионного типа с различными рабочими телами (хладагентами)».

Следует отметить, что академик Клименко А. В. и профессор Агабабов В. С. для слова «стенд» используют множественное число. Это означает, что стендов должно быть, по меньшей мере, два.

Однако в Отчете не приводятся сведения о назначении каждого из них, о конструкции термотрансформаторов парокompрессионного типа и других узлов экспериментальных стендов, их тепловых схемах, схемах экспериментальных измерений, использованных измерительных приборах, перечне исследованных «различных рабочих тел (хладагентов)», исследованных режимах работы этих установок.

Отсутствие в Отчете и статьях академика Клименко А. В. с соавторами сведений о «подготовленных стендах» и результатов экспериментальных исследований на стендах позволяет с высокой вероятностью предположить, что такие стенды в действительности вообще не были созданы.

Автор данной статьи обращался с просьбой к заместителю директора Департамента науки и технологий Министерства образования и науки А. В. Аникееву выехать в НИУ «МЭИ» для ознакомления с экспериментальными стендами. Но он категорически отказался. Этот отказ говорил о многом.

Стерильная чистота: никаких сведений об эффективности термотрансформаторов (по термодинамике, экономике), о КПД, расходах, температурах, давлениях хладагента, прямой и обратной сетевой воды, топлива, уходящих газов и т. д.

И в том числе по разрекламированному академиком Клименко А. В. с соавторами системному подходу.

В связи с отсутствием результатов экспериментальных и расчетных исследований весьма странным выглядит подписание Комиссией МИНОБРРФ Акта о выполнении соглашения No 14.574.21.0017, в котором «обязательства по соглашению признаны выполненными надлежащим образом».

2) В Отчете этап 3 академик Клименко А. В. и профессор Агабабов В. С. просто-напросто переписали из этапа 2. Для доказательства этого факта приведем только часть текста из этапов 2 и 3.

«Этап 2. Основные результаты:

- разработана Программа и методика проведения расчетных исследований термодинамической эффективности тригенерационных установок, включающих себя энергогенерирующее оборудование и трансформаторы различных типов, проведены расчетные исследования термодинамической эффективности тригенерационных установок, включающих в себя энергогенерирующее оборудование и трансформаторы различных типов при различных режимах работы,
- проведены экспериментальные исследования эффективности применения в трансформаторах пароконденсационного типа различных рабочих тел (хладагентов) (?),
- разработана Программа и методика расчетных исследований распределения температурных полей в открытых термодинамических системах при решении задачи моделирования распределения температурных полей в области установки геотермальных тепловых насосов,
- проведены расчеты температурных полей в открытых термодинамических системах при решении задачи моделирования распределения температурных полей в области установки геотермальных тепловых насосов,
- разработана Программа и методика экспериментальных исследований работы трансформаторов пароконденсационного типа при использовании различных рабочих тел (хладагентов)».

«Этап 3. Основные результаты:

- разработана Программа и методика проведения расчетных исследований термодинамической эффективности тригенерационных установок, включающих в себя энергогенерирующее оборудование и трансформаторы различных типов,
- проведены расчетные исследования термодинамической эффективности тригенерационных установок, включающих в себя энергогенерирующее оборудование и трансформаторы различных типов при различных режимах работы,
- проведены экспериментальные исследования эффективности применения в трансформаторах пароконденсационного типа различных рабочих тел (хладагентов) (?),
- разработана Программа и методика расчетных исследований распределения температурных полей в открытых термодинамических системах при решении задачи моделирования распределения температурных полей в области установки геотермальных тепловых насосов,
- проведены расчеты температурных полей в открытых термодинамических системах при решении задачи моделирования распределения температурных полей в области установки геотермальных тепловых насосов,
- разработана Программа и методика экспериментальных исследований работы трансформаторов пароконденсационного типа при использовании различных рабочих тел (хладагентов)».

Из сопоставления текстов этапов очевидно, что этап 3 переписан из этапа 2. Но здесь можно отметить определенный прогресс. Если профессор Агабабов В. С. в своей докторской диссертации заимствовал целые абзацы текста, рисунки и формулы из чужой кандидатской диссертации, то теперь в Отчете академик Клименко А. В. и профессор Агабабов В. С. переписывают текст уже сами у себя.

3) В Отчете академик Клименко и профессор Агабабов В. С. сообщили недостоверные сведения о представленных докладах по заявленной теме соглашения с МИНОБРРФ No 14.574.21.0017 на нескольких международных конференциях. Однако:

- на седьмой международной школе-семинаре молодых ученых и специалистов «Энергосбережение — теория и практика» 13 – 17 октября 2014 г. Клименко А. В. (в то

время член-корреспондент РАН) ограничился только приветственным словом — доклад не был представлен.

– на XXI Межвузовской научно-практической конференции молодых ученых и студентов в г. Волжском 25 – 29 мая 2015 г. — доклад не был представлен,

– на Всероссийской конференции «Энергетика России в XXI веке. Инновационное развитие и управление», г. Иркутск, 2015 г. — доклад не был представлен.

Эти сведения легко могут быть получены при ознакомлении с Программами конференций или со сборниками докладов, представленных на них.

В [2] академик Клименко А. В. и профессор Агабабов В. С. предложили так называемый метод качественного анализа различных вариантов технических решений при выборе того или иного сочетания электро- и теплогенерирующего оборудования и термотрансформаторов. Суть его состоит в том, что, исходя из личных представлений о качестве той или иной схемы и личных предпочтений академик Клименко А. В. и профессор Агабабов В. С. заранее выбирают предпочтительный вариант по «картинке» и только затем определяют его технико-экономические показатели. Но этот метод качественного анализа вариантов весьма далек от науки и напоминает действия экстрасенсов на телеканале ТНТ.

В данной статье доказано, что академик Клименко А. В., как научный руководитель темы, в статьях и Отчете по соглашению №14.574.21.0017 с МИ-НОБРРФ:

не представил результаты «первостепенного научного значения» (вообще не представил каких-либо результатов исследований термодинамической и технико-экономической эффективности тригенерационных установок),

– не «обогастил науку новыми знаниями и достижениями»,

– переписал текст из одного этапа Отчета в другой,

– представил недостоверные сведения о докладах на ряде конференций,

– и, тем самым, не соблюдал нормы научной этики

– и не содействовал личным примером повышению престижа науки и авторитета члена Академии.

В дополнение к этой негативной характеристике научного уровня и моральных качеств академика Клименко А. В., а также Отчета, направленного академиком Клименко А. В. в МИНОБРРФ, автор данной статьи направил 18.12.2019 г. обращение Ректору Национального исследовательского университета «Московский энергетический институт» (НИУ «МЭИ») д.т.н., профессору Роголеву Н. Д. с просьбой дать оценку его научной деятельности

Ректором НИУ «МЭИ» была создана Комиссия во главе с начальником правового управления Беловой О. А., которая представила Ректору НИУ «МЭИ» Докладную записку от 10 января 2020 г.

Приведем выдержки из этой Докладной записки, касающиеся непосредственно академика Клименко А. В. (цитата):

«Комиссия вышла на проверку в подразделение НИО НТИЦ ЭТТ, в которое входит НИЛ «Научно-методических проблем энергоэффективности», где непосредственно оформлен и осуществляет свою трудовую деятельность Клименко А. В.

Клименко А. В. на момент проверки указанного подразделения на рабочем месте отсутствовал, трудовой договор с ним заключен по основному месту работы в данном подразделении на 0,5 ставки.

Клименко А. В. как главный научный сотрудник НИЛ «Научно-методических проблем энергоэффективности» фактически своих обязанностей не исполняет. Его трудоустройство по факту является притворным, так как никаких задач и трудовой функции он не выполняет. Получает заработную плату Клименко А. В. из собственных средств Университета».

В соответствии с рекомендациями Комиссии Климен- ко А. В. приказом Ректора уволен из НИУ «МЭИ».

Из представленных фактов следует, что Климен- ко А. В. вообще не имеет никаких научных достижений в отечественной теплоэнергетике и, как раз, является одним из «проходимцев от науки», о которых в обращении от 24.07.2016 г. Президенту РФ В. В. Путину сообщала большая группа академиков РАН.

Вряд ли с такими академиками можно обеспечить прорыв в науке, в частности, в теплоэнергетике, на который Президент РФ рассчитывает в ежегодных Посланиях.

В интервью (ноябрь 2019 г.) Президента РАН корреспонденту «Российской газеты» («РГ») сообщалось, что академики РАН ежемесячно получают выплаты в размере 100.000 рублей.

Такие ежемесячные выплаты Клименко А. В. при отсутствии у него научных достижений (фактически «ни за что») выглядят весьма кощунственно по сравнению с выплатами, назначенными Указом Президента РФ В. В. Путина медицинским работникам, которые самоотверженно борются ежедневно с коварным коронавирусом (напомню, всего максимально по 80.000 рублей и только в течение трех месяцев).

А между тем Клименко А. В. получает вышеуказанные выплаты уже более трех лет.

На основании изложенного автор данной статьи неоднократно направлял обращения Президенту РФ В. В. Путину и Президенту РАН, академику Сергееву А. М. с просьбой принять Решения о лишении Клименко А. В. звания академика РАН и о прекращении выплат ему за данное звание.

Однако они в течение длительного периода времени не рассматриваются по существу без объяснения причин. **Примечание.** Как уже указано выше, автор данной статьи неоднократно направлял обращения Президенту РФ В. В. Путину о создавшейся в РАН ситуации.

Сотрудниками Управления Президента по рассмотрению обращений граждан эти обращения перенаправлялись в различные организации, в частности, в Министерство образования и науки РФ, в РАН, Прокуратуру г. Москвы.

Однако чиновники указанных государственных учреждений не выступили как защитники государственных интересов, не предприняли меры по возвращению в госбюджет бюджетных средств, выплаченных Министерством образования и науки РФ за «Отчет-пустышку», отмалчивались или направляли в адрес автора данной статьи «письма-отписки».

А между тем, для получения ответов на вопросы о том, были ли созданы Клименко А. В. экспериментальные стенды для исследования характеристик триггерационных установок с термотрансформаторами пароконденсационного типа, были ли проведены Клименко А. В. их экспериментальные исследования (за что были получены субсидии Министерства), достаточно было направить запрос в НИУ «МЭИ» с целью получения определяющей информации:

- какая организация разрабатывала чертежи деталей, узлов, сборочных и компоновочных чертежей, тепловых схем и схем измерений на стендах?
- какая организация производила изготовление узлов и деталей стендов?
- какая организация производила монтаж экспериментальных стендов?
- какая организация производила поставку различных рабочих тел (хладагентов)?
- имеются ли документы, подтверждающие выполнение перечисленных работ и их оплату? и т. д.

Но почему-то ни одна из вышеперечисленных организаций и, в особенности Прокуратура, не изъявила желание запросить эту информацию. Это нежелание, а также отказ господина А. В. Анискина посетить НИУ «МЭИ» складываются в общую довольно странную и неприглядную картину.

Выводы

1. Анализ работ [1, 2, 10 – 13] по детандерной и триге- нерационной технологиям позволяет заключить о сла- бой теоретической подготовке академика Клименко А. В. и его соавторов в области термодинамики, теории турбомашин и теплотехники, несмотря на наличие у них высоких ученых степеней и званий.
2. Академик Клименко А. В. и соавторы не владеют известным эксергетическим методом термодинамиче- ского анализа, и, следовательно, их выводы о высокой термодинамической эффективности рассмотренных схем детандерных и тригенерационных установок не- научны и несостоятельны.
3. Академик Клименко А. В. и соавторы рекомендуют дляоценкитермодинамическойитехничко-экономиче- ской эффективности установок и систем так называе- мый системный подход, предложенный в [10] еще сем- надцать лет назад, однако не обнаруживается ни одной публикации академика Клименко А. В. и соавторов с реальным свидетельством эффектив- ности примене- ния этого подхода, кроме их голословных заявлений, не подтвержденных корректными экспериментами и расчетами.
4. Академик Клименко А. В. и соавторы в качестве «характеристики» термодинамической эффектив- сти применяют коэффициент использования тепла топлива (КИТТ), однако применение этого коэффици- ента для определения термодинамической эффектив- ности тригенерационных установок ненаучно, он в науке никогда ранее не использовался и в настоящее время не используется в качестве такой «характери- стики».
5. Академик Клименко А.В. и профессор Агаба- бов В. С. предложили ненаучный метод качественного анализа, при котором выбор оптимального варианта технических решений для электро- и теплогенериру- ющего оборудования производится на основе личных представлений и личных предпочтений авторов, и лишь затем определяются технико-экономические по- казатели выбранного варианта.
6. Академик Клименко А. В. и профессор Агаба- бов В. С. в Отчете, направленном в МИНОБРРФ во ис- полнение соглашения No 14.574.21.0017, не представи- ли абсолютно никаких результатов экспериментальных и/или расчетных исследований термодинамической и/или технико-экономической эффективности термо- трансформаторов парокompрессионного типа с раз- личными рабочими телами (хладагентами), занимались переписыванием содержания последующего этапа От- чета из предыдущего, сообщили недостоверные све- дения о представленных ими докладах по заявленной теме на нескольких международных конференциях.
7. Академик Клименко А. В. и соавторы в статьях [1, 2] и в Отчете по соглашению с МИНОБРРФ No 14.574.21.0017 не обосновали новые технические ре- шения и не определили перспективные направления для повышения термодинамической и технико-эконо- мической эффективности объектов распределенной и малой энергетики. Следовательно, академик Клименко А. В. и профессор Агабабов В. С. не выполнили обязательства по данному соглашению.
8. В связи с изложенным весьма странным выглядит подписание Комиссией МИНОБРРФ Акта о выполнении соглашения No 14.574.21.0017, в котором «обязатель- ства по соглашению признаны выполненными надле- жащим образом».
9. Академик Клименко А. В. и соавторы предложе- ли схемы централизованного теплоснабжения на базе ДГА, которые неосуществимы из-за нарушений законов термодинамики.
10. Избрание Клименко А. В. академиком РАН и назначение его главным редактором журнала «Те- плоэнергетика», соучредителем которого явля- ется РАН, являются грубейшими ошибками РАН.

При избрании Клименко А. В. академиком РАН нарушены пункты 22, 24 и 31, е) Устава РАН.

11. При наличии таких «академиков» в РАН невозможно обеспечить прорыв в науке, на который рассчитывает Президент Российской Федерации В. В. Путин в своих ежегодных Посланиях.

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8. Hygrothermal evaluation of half-timbered walls with bonded facing brickwork when retrofitted with interior insulation

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Abstract

This abstract evaluates the hygrothermal behavior of a special outer wall construction, the half-timbered wall with a $\frac{1}{2}$ stone thick facing. The aim is to show the history of architecture and the characteristics of the construction method for the preservation of cultural assets and to evaluate the potential of an energetic renovation.

This construction method was documented during restoration work on the individual monument Drebkau Castle. There was a need for clarification in dealing with special design features and the potential for energy-efficient renovation through the use of interior insulation.

Initially, it was not possible to find any instructions for handling the construction method in the current standards. A publication by the authors Krause and Ahnert is dedicated to building constructions in old buildings, including half-timbered buildings with $\frac{1}{2}$ Stone strong walling.

Further research in the historical specialist literature of the 19th century mentions the application of the 1-stone wall with a framework wall bond design and the brick in of the timber framework. The development is mainly due to design and functional aspects. The castle lost its function with the changes in military technology and slimmer constructions replaced vaults and defensive walls in the baroque era. In rural areas, the visible timber framing is preserved, but the representative castle is given the appearance of a massive building to demonstrate social inequality. The devastating city fires with half-timbered buildings and the desire for an indoor climate with significant temperature differences to the outdoor climate also result in changes in the visible framework. The problems resulting from the building moisture as well as the different drying behavior and the labor-intensive implementation are known at an early stage. With the industrial revolution and a gain in knowledge in masonry construction, the design methods are losing importance in favour of a monolithic wall construction. The design principle of coupling timber and masonry remains valid for parts of the roof structure and timber frame construction until the middle of the 20th century. In other buildings of the 18th and 19th century, such as Rheinsberg Castle, the construction method could be documented.



Figure 1 - Rheinsberg Castle in Brandenburg

As characteristic for the 1 stone thick wall is a latent arrangement of the wooden structure with a $\frac{1}{2}$ stone strong walling. Local resources were available for the building materials used. It was not possible to document a uniform dissemination. with the visual framework. The joints between the wood and the masonry were made with lime and clay mortar and as an air gap. At Rheinsberg Castle, during renovation work in one area a coupling of the masonry to the wooden supporting structure via wall anchors was documented. In connection with a wall thickness of 30 cm - 36 cm, which is slim for the construction period, this is an indication for the application of this construction method. Thermography was used as a method to investigate a damage-free localization of the half-timbered framework at Rheinsberg Castle. Due to different thermal conductivities of truss and masonry, the supporting structure could be well mapped.

One focus of this work was the evaluation of moisture conditions. The strength properties such as the modulus of elasticity, the damage potential for mold growth on the wall behind the interior insulation as well as the fungal growth of wood-destroying fungi on the framework and frost damage to the mineral building materials were considered. The limits were determined on the basis of regulations as well as current knowledge and own investigations. The assessment of the zero damage timber structure is of particular importance. An allocation of the damage areas is essentially based on the fibre saturation range, which is so important for the assessment of wood. It was determined for pine wood from Drebkau Castle with a felling date of 1698. For this purpose, the sorption isotherm up to $\phi_{NH} = 97\%$ was determined exclusively by weighing the test specimens and for the range $\phi_{NH} > 97\%$ by weighing and measuring the change in length based on the material property of shrinkage. The beginning of the length change and the sample mass during drying were determined. When the fibre saturation range is reached, there is a great danger to the serviceability and stability of the construction, depending on the duration and temperature. The moisture required on component surfaces for mold growth is below that required for wood-destroying fungi and is considered a hygiene problem. In an experiment in which the moisture transport within the construction was investigated by diffusion across an air gap, mold growth was confirmed.

On the basis of a replica of the historical wall construction, the influence of building moisture on the wood moisture of the wooden components integrated in the masonry was investigated and documented. A comparison of the execution with a loam joint and an air gap shows that the wood moisture dries much faster into a safe area when the timber frame is executed with a loam joint. There is a risk of damage to the wood and masonry in the first year after construction. A significant influence of the wall anchor on the wood moisture content cannot be documented.

For homogeneous exterior wall constructions, experiences already exists in the application of interior insulation. There is still a need for heterogeneous construction methods in combination with wood. In the castle Drebkau a room for the creation of reference areas was separated from the construction site for this purpose. Experiments with influencing measures were carried out on 3 interior insulation systems with wall temperature control, which have the same construction thickness of $d = 11$ cm. The construction was examined with regard to its resistance to driving rain and an indoor climate with a temporary room air humidity $\phi_i > 60$ %. Two methods were used to determine the moisture content of wood, which were compared on a reference stem. Taking into account the isotropic and heterogeneous wood properties for the directly measured wood moisture and the wood moisture determined by the relative pore humidity, good similarities were found in the course of the moisture

With a wetting of 689 l/m² water on the façade, sufficient driving rain resistance for a conventional plaster finish in P II could be confirmed for a crack-free façade. In the area of a crack, the driving rain experiment resulted in a significant increase in wood moisture. Drying could be achieved by wall tempering, but priority is given to constructive measures in order to avoid the penetration of precipitation water.

With the application of the 3 interior insulation systems, which differ in capillary conductivity and thermal conductivity as well as water vapour diffusion resistance due to their building physics properties, the relative pore air humidity measured in wood is $\phi_{NH} < 85$ % for all surfaces. With regard to the hygrothermal influence on the timber frame construction with facing brickwork, it should be noted that the moisture level introduced dries out and in the long term no critical values of wood moisture are achieved in the timber components. Uncontrolled air exchange via convection between the area of use and the construction has to be strictly avoided. This requirement is intensified by the potential for temporary mold growth within the construction. The evaluation of a cooling system requires further investigations.

On the basis of the numerical simulation the course of temperature and relative pore air humidity were compared and evaluated with measured values of the reference surfaces from Drebkau Castle using the Delphin software. Based on a 2D model and the material database implemented in the software, a horizontal section through the wall with truss stem was simulated. The masonry was realistically depicted with bricks and joints. The temperature curve shows a good similarity for all surfaces. There are significant deviations for the relative pore air humidity, which become apparent when comparing the maximum values in the plane of the levelling plaster. Good similarity between calculated and measured values is achieved in the courses of the relative pore air in the wood, which also confirms an assignment to the measured risk area. The implementation of climate protection goals increasingly requires the inclusion of the existing building fabric in renovation work. The main focus here is on winter thermal insulation to save energy. An increasing role will result from the effects of climate change for summer thermal insulation. Further investigations will show to what extent predicted climate data are taken into account in planning and construction compared to the current statistical weather data of previous years.

9. Effective use of heat energy in the buildings

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Abstract

World energy reserves today are more than one trillion (ton of standard fuel (680 billion tons of coal, 200 billion tons of gas and 220 billion tons of oil). In terms of resource consumption in 2018, these reserves will last for 65-70 years.

Modern thermal energy is characterized by the high efficiency, because it is based on more advanced technologies that usage of fossil fuels, and sources of "green" energy, which provides a significant reduction in the technogenic load on the environment. The conceptual principles underlying the world's heat and energy strategy in the 21st century is based on the need to simultaneously solve three interrelated tasks:

- uninterrupted provision of consumers with high-quality thermal energy, necessary parameters and relevant energy services;
- availability of thermal energy (in terms of price and efficiency);
- environmental friendliness (on environmental impact)

This article analyzes the possibilities of optimal design and management of thermal energy consumption for residential buildings. Effective and efficient methodology and specific recommendations of energy and resources management of the system are clearly expressed.

Keywords: residential buildings, energy resources, thermal energy, operational management, environmental friendliness.

10. Buildings' new methodology of energetic audit

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Abstract

The article is devoted to the methodology for conducting energy surveys for newly built and reconstructed residential buildings.

Currently, special attention is being paid to energy audit issues for residential buildings. The main purpose of the energy audit of buildings is a comprehensive analysis of all energy supply systems to determine the potential for energy conservation and to develop measures to eliminate excess energy resources. It is known that in order to eliminate irrational heat losses and increase the energy efficiency of buildings, as well as to objectively assess the consumption of heat and electric energy, regular energy audits are required. These surveys should be carried out on the basis of regulatory documents and they allow you to develop the best option for technical and organizational measures in order to determine possible savings in energy and energy resources. However, as a rule, many audit companies in practice use their own methods, which do not always characterize the actual state of energy consumption of the building. For an accurate and comprehensive examination of the energy consumption of buildings, as well as to reduce the time for processing data and preparing optimal measures, we propose using technological systems that contain databases structured in a specific way and special programs that implement energy consumption calculations. Based on the data obtained, an energy passport of the building is compiled.

Keywords: *energy audit, energy efficiency, energy saving, energy resources, visual inspection.*

11. Prompt control mode of thermal energy distribution in modern buildings

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Abstract

The growth of housing construction, an increase in quality and improvement of sanitary conditions of the population leads to a significant increase in the consumption of thermal energy. Therefore, the designers and operators of buildings are faced with the task of finding energy reserves. To manage the engineering systems of the modern buildings, it is necessary their design is carried out by taking into account the reliability and controllability, guaranteeing the necessary supply of band and the possibility of rapid changes in the structure and parameters of heat distribution networks. From the point of view of the modern theory of systems, the mode of consumption of thermal energy can be represented as a complex system of interaction of a large number of three types of subsystems: sources of thermal energy, pipelines for transportation and consumers. Obviously, subsystems also have their own complex structure and can be considered as a set of interacting subsystems. On the other hand, the heat supply systems of buildings belong to the class of continuously evolving systems, the development of which is carried out both in time and space. This development is due to the fact that the main functional purpose of the heat consumption process is to provide consumers with thermal energy in the required quantities and under specified parameters. The heat consumption mode is an unsteady stochastic process containing deterministic monotonously increasing trends that characterize the general tendency to increase, as the number of consumers, consumption and parameters of thermal energy. This article is devoted to solve problems in an operational control of the thermal energy distribution by taking into account these requirements.

Keywords: thermal energy, operational management, consumption of thermal energy, engineering systems.

12. Azerbaijan's experience in the energy auditing of school buildings on the case study of Ujar and Lankaran regions

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Abstract

Nowadays energy consumption decrease in the construction industry is essential for the Azerbaijan Republic in order to reach reducing Greenhouse gas emissions up to 30% by 2030 taking 1990 as a base year for all major energy usages: construction sector, transportation and industry. In pursuit of this goal, the analyzing energy issues in school buildings at the operational stage and the offer of recommendations by the implementation the energy-efficient arrangements are crucial. This article makes research to find energy efficiency opportunities in school buildings in three different climate regions of Azerbaijan on the based on the full-scale experiment results. There had been performed energy auditing of three school buildings, the results were processed by software. The outcomes involved some energy-efficient arrangements and retrofits for each building apart. Measurements of the air velocity in the natural ventilation shafts and branches had been carried out by the multi-function measuring instrument Testo 435. All introduced arrangements can be divided into three parts concerning: first- the building enclosure, second- ventilation and heating systems, third- others. The main results are the following: building envelope improvement which includes roof extra insulation and some windows replacement. For southern orientated windows using special shading devices for preventing from overheating is preferable. Natural ventilation shafts and grilles should clean and control properly and permanently at least twice during the year, exploitation of mechanical ventilation and heating systems should provide by the specialist, all radiators ought to be purified before the heating season; LED must be used for lighting, measurement, monitoring and control of all energy demand should be implemented regularly and so forth. The article offers a valuable resource for practitioners. Findings can be used for fulfilling a multi-disciplinary energy audit of the school buildings. The authors are confident that the search for optimal energy auditing of the educational buildings is necessary and it will be further developed.

Keywords: energy auditing; energy efficiency; energy efficient arrangements; recommendations; school buildings.

13. Some aspects of buildings' energy supply

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Abstract

Energy conservation is one of the priority tasks of the 21st century, since energy consumption is one of the main conditions of people's life. Improving energy and environmental safety and the economy of the republic is impossible without realizing the potential for energy conservation, as well as improving energy efficiency through modernization of the construction industry and housing and communal services. Republic of Azerbaijan has a great potential in conservation of energy. This article suggests some alternative measures to save energy and improve the energy efficiency of buildings. These measures can provide a reduction of energy resources and costs for their payment. Some of them can eliminate the obvious over use of thermal energy and can be implemented without prior investment. Events with small investments may have short payback periods. Assessment of the technical feasibility of implementation of the proposed measures must be carried out for each branch of the construction industry, housing and communal services, as well as taking into account local climatic and operational characteristics.

Keywords: *energy conservation, energy efficiency, environmental safety, construction industry, housing and communal services.*

14. RESEARCH ON WEAR AND TEAR OF THE MUD PUMP LINERS

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Abstract

The article tells about the research on wear and tear of mud pump liners, namely: main characteristics that distinguish ceramic liner from the other ones used on the units equipped with the hydraulic system for washing out the drilling wells from cuttings, design of ceramic liners, calculation of the wear rate of ceramic liners, and the positive contribution they made on the modern drilling process. Besides, the research is made on the simplicity of the structure of ceramic liners, a short amount of time consumed to assemble and replace the liners, safety of the work, cost-effectiveness, wearing and corrosion durability, and also compliance with other requirements.

- HP design to prevent friction-free wear • High competitiveness of use -30%

The main features that distinguish ceramic liners from others are as follows.

- High strength metal outer casing
- Perfectly polished, glossy interior
- Intermediate layer with a minimum hardness of -62RC
- HP design to prevent friction-free wear
- High competitiveness of use -30%

As with all mechanical parts, equipment downtime increases as a result of wear due to friction on the liners. Therefore, the research of the friction process of particular importance. The wear of liners is a complex process and by its nature combines all three types of mechanical wear: mechanical, molecular-mechanical and corrosive. The inner and outer layers of the cylinder liners are pressed, which leads to "corrosion due to plastic deformation", "adhesive erosion" when the temperature of the working fluid increases to 110 ° C, more than 12 chemicals and a highly active layer composition in the drilling mud. As a result of the presence of impurities, the process of "wear and tearing under the influence of surface-active substances."

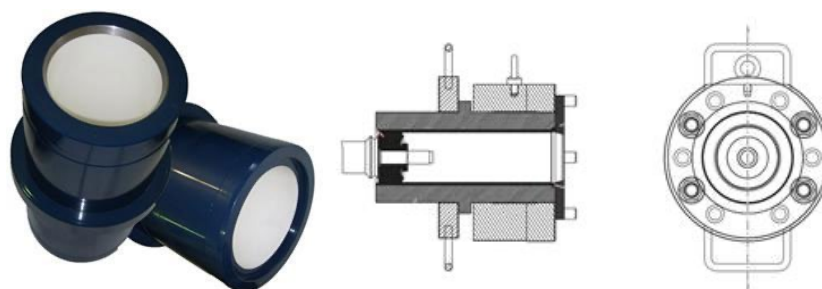


Figure 1. Ceramic liners of the mud pumps.

One of the parameters characterizing wear is the wear rate. It is defined as J_h , the ratio of the thickness of the worn cylinder jacket h_L to the friction path (length of the piston travel path) L .

$$J_h = \frac{h_L}{L}$$

Since friction occurs as a result of periodically repeated contact of the external polystyrene surfaces of the liner and piston, instead of L , it is necessary to write how many times coincides the following point into the contact area or the number of strokes of the mud pump, N_s

$$J_{N_s} = \frac{h_{N_s}}{N_s}$$

Here h_{N_s} - is the thickness of the layer that wears after contact with the number of strokes N of the piston rod, from the point of view of the inner liner layer. Since the wear surfaces of the liners are not lubricated and are exposed to various mixtures, saline water and chemicals are taken, so $m=3$ is obtained. In our dissertation, the main goal is to minimize wear and increase the durability of the liners, therefore it was recommended to replace the solution of the cooling system of the casing with emulsion solution, as a result, has been got $m=1$ and durability has been increased.

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Keywords: mud pumps, mud circulation system, pistons, hydrostatic pressure, friction wear, ceramic liners, tribology.

