Impact Factor:					
	ISRA (India) = 6.317	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 3.939	PIF (India) = 1.940
	GIF (Australia) = 0.564	ESJI (KZ) = 8.771	IBI (India) = 4.260
	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2022 **Issue:** 06 **Volume:** 110

Published: 03.06.2022 **http://T-Science.org**

Issue Article

Dinara Rimovna Khairova
The branch of Russian State University of Oil and Gas (NRU) named after I. M. Gubkin
professor, Ph.D.

Komilakhon Najmiddinova
The branch of Russian State University of Oil and Gas (NRU) named after I. M. Gubkin
Student
Tashkent

THE ECONOMIC EFFICIENCY OF APPLICATION OF COMPOSITE MATERIALS IN GAS TRANSPORTATION

Abstract: *Composite pipes made from materials such as fiberglass, polymers, carbon fiber are becoming one of the most promising for use in the oil and gas industry. Characteristics such as increased reliability, reduced installation and repair costs, and long service life make them the best replacement for metal pipelines. In this paper, an analysis is made of the use of composite materials, in particular fiberglass, in pipeline gas transport using the example of a section of the Dzharkak - Bukhara - Samarkand - Tashkent line. The calculation of economic efficiency from the use of new technologies was carried out using the method of constructing a financial model of the project.*

Key words: *Fiberglass pipes, gas pipelines, transportation, steel pipes, corrosion, financial model.*

Language: *English*

Citation: Khairova, D. R., & Najmiddinova, K. (2022). The economic efficiency of application of composite materials in gas transportation. *ISJ Theoretical & Applied Science, 06 (110),* 35-42.

Soi: http://s-o-i.org/1.1/TAS-06-110-6 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2022.06.110.6

Scopus ASCC: *2000.*

Introduction

Pipeline transport is currently one of the most efficient and affordable means of transporting liquid and gas. It provides delivery of natural gas, oil, products of its processing both at long distances by trunk pipelines, and within the territory of production, storage and processing of products. Thus, 49.8 billion cubic meters of natural gas are produced in the Republic of Uzbekistan, the capacity of gas processing is 50 billion cubic meters. The gas transport system consists of 13,250 km of gas pipelines, 939 gas distribution stations, 25 compressor stations with 250 units [9]. The installation of gas pipeline systems requires large capital investments, and every year the costs of installation, repair and elimination of corrosion effects increase. Due to the prolonged use of pipes exceeding the standard service life, cases of failure and loss of products transported by pipe lines increase, corrosion, paraffin and resin deposits on the internal walls of the pipes are risen, and the capacity of pipes are reduced. These problems require immediate solutions, one of which is the use of fiberglass composite pipes. Moreover, the relevance of this issue is confirmed by the Resolution of the President of the Republic of Uzbekistan 4388 of 09.07.2019 «On measures to provide the economy and the population with energy resources, financial recovery and improvement of the system of management of the oil and gas industry», which emphasizes the need to modernize Uzbekistan's gas transportation system. [1]

One of the most important and old lines of the main gas pipeline is the line Djarkak - Bukhara - Samarkand - Tashkent (DBST). This line was put into operation in 1959 and marked the beginning of the creation of the Central Asian line of gas pipelines. Thus, steel pipes have already been operated for more than 60 years, although their service life is half as much. [2] The capacity is 7 million cubic meters per day, so more than 2.5 billion cubic meters of gas is pumped through these pipes per year.

One of the most promising applications of modern composite materials, in particular fiberglass, is the oil and gas industry. The qualities that distinguish this material among the rest are increased strength, a long service life with correct application, reduced installation and repair costs of pipelines, high protection against the consequences of corrosion. In this work it is proposed to use fiberglass pipes for gas transportation on the section of the main gas pipeline Djarkak - Bukhara - Samarkand - Tashkent Gallyaaral Gas Distribution Station (GDS) - South - Western GDS, the economic effect has been calculated, the advantages and possible problems in the application of new technology have been identified.

Methods

The primary task of calculation of economic efficiency in the application of new technologies is the method of construction of financial model, with calculation of technical and economic indicators. The list of economic indicators includes revenue from sales, capital investments, operating expenses, gross financial result, period costs, net profit, discounted cash flow, pay-back period of the project.

Results and discussion

Currently, the main gas pipelines are made of the following materials: steel, cast iron, high density polyethylene (HDP), polyvinyl chloride (PVC) and fiberglass. One of the most common and affordable types are steel pipes. Steel gas pipelines are divided into two categories: seamless hot and cold transformations and welded pipes. Due to the high exposure of steel pipes to corrosion, there are several ways to protect against it: passive, active and reduced corrosion of the medium. These methods also require certain costs, which should be carried out at least once every 2-3 years.

The passive way involves:

• the use of special methods of laying the highway - between the metal surface of the pipes and the soil, an air gap is left, which prevents the effects of groundwater, salts and alkalis;

• protective coatings - the outer surface of the pipes is painted with compounds that are not destroyed from the effects of soil salts and alkalis, for example, alkyd enamels, protective anti -corrosion mastics.

• processing with special chemical compositions - covering pipelines with a thin layer of phosphates, which form a protective film on the surface of steel pipes.

The active method consists in the use of electric current and electrochemical reactions of the ion - intensive type:

• electroderate protection of pipelines from corrosion - a set of measures that allows you to deal with wandering currents - installation of drainage protection, isolation of flanges and installing electric ones;

• anode protection against corrosion of pipelines - the use of magnesium anodes, which, under the influence of electric currents, secrete magnesium ions, slowing down the processes of metal destruction;

• cathode protection of pipelines from corrosion. The method is based on the phenomenon of cathode polarization of metals under the action of direct current. The object of exposure turns into a cathode with low potential, which eliminates the likelihood of corrosion. [4]

Moreover, low - pressure polyethylene pipes have been very popular. The term “low pressure” applies to the method of production of material and is not related to the characteristics of the pipeline. Such pipes for gas pipelines are suitable for transporting gas under pressure up to 12 bar, safe, reliable and more widely used in the oil and gas sphere.

This work considers the use of fiberglass pipes for gas transportation. Fiberglass is a composite material, which in turn means a material that is obtained by connecting two or more components in the general system in which each component separately retains its properties. Fiberglass are easily mechanical processing, have high strength, resistance to thermal shocks and alternating loads, radio transmission, corrosion resistance. The use of multi - layer fiberglass increases the inter -layer strength of the plastic, simplifies the assembly of the workpiece of the product, reducing the number of manual operations. Such composites are widely used in the oil and gas industry, shipbuilding, aviation, in space equipment, automotive, in the manufacture of some household appliances. [6]

Fiberglass pipes in the oil and gas industry can be used for the following purposes:

• pipes for geological exploration and production of oil and gas;

• pumping and discharge pipeline systems;

• pipelines of transportation of oil and gas, collecting, transportation and pumping of reservoir water;

• pipelines for transporting chemically dangerous fluids and mixtures;

• high -pressure water pipelines of system maintenance systems;

• magistral linear pipelines for transporting oil and gas [7].

Thus, fiberglass covers the entire technological chain of the oil and gas industry, starting from geological exploration to transportation of products to consumers. However, the choice in favor of fiberglass pipes should be carried out taking into account the insignificant probability of damage or in the case when the degree and nature of the destruction is evaluated as insignificant.

Table 1 clearly describes the advantages of pipes depending on the material of manufacture. [10]

Table 1. The advantages of pipes depending on the material of manufacture

Steel	Polyethylene	Fiberglass
High strength indicators	High strength and elasticity	Maintain pressure from 2 to 272 bar
Minor indicators of linear expansion	Corrosive resistance	High corrosion resistance. The life of more than 30 years. High speed and ease of installation
Reliable sealed connection, subject to the rules of the docking and the lack of defects	Does not need special electrochemical protection	Do not require the use of electrical and chemical protection, do not require insulation and related costs
The ability to work with a hot environment having high pressure	Constant throughput	Small coefficient of thermal conductivity. High mechanical strength to shock and bending loads
Long life of pipelines – 30 – 50 years	Chemical resistance, immunity to the transported environment	High resistance to the effects of formation water, gas condensate, acids, alkalis, bacteria, there is no “overgrowing” with salt and other deposits
	Environmental Safety	Ecologically and hygienically safe. Do not require the use of welding. Lack of influence of weather conditions on the installation process (from +50°C to -50°C)

On the basis of the information presented in Table 1, it can be concluded that glass-plastic pipes are practically equal to steel and polyethylene pipes in terms of predominant characteristics. However, each type of pipe also has drawbacks, which are presented in Table 2 [10]

Table 2. Drawbacks of pipes depending on the material of manufacture

Steel	Polyethylene	Fiberglass
Resilience	Combustibility of the material, which makes it impossible to lay pipelines in open areas	Insufficient number of suppliers and manufacturers
Laborious welding installation	Lack of clear regulatory framework for pipe operation and maintenance	Absence of a State regulatory framework regulating the operation of glass-plastic pipes
High susceptibility to corrosion	Pipe fares	High cost of pipes and connecting elements
Condensation due to high thermal conductivity, which, when deposited on the walls of pipes, reduces their capacity	Low pressure limits at which the pipe can be operated	
Mass of pipes causing problems when transporting from production point to operational point		

Comparison of the technical characteristics of the pipes is presented in table 3:

Table 3. Comparison of the technical characteristics of the pipes

Indicator	Fiberglass pipes	Steel pipes with epoxy coating	PVC pipes	Polyethylene pipes
Corrosive stability	Good	An internally epoxy coating, an external coating with a protective layer, cathode protection is required	Bad in the alkaline environment	Good

Service		Not required	Periodic maintenance is required due to peeling of the outer layer	Periodic service is required	Periodic service is required
Lifetime		More than 50 years	Due to corrosion of pipes is 20-25 years, but it is possible to extend	15 - 20 years, depending on operating conditions	20 - 30 years, depending on operating conditions
The weight		A light weight	3-4 times heavier fiberglass	1.5 times heavier fiberglass	1.5 times heavier fiberglass
Tensile strength	3000 - 3750 bar	The minimum 4200 bar	500 bar	350 - 600 bar	
Elastic modulus	35 GPA	210 - 240 GPA	3 GPA	5 GPA	

The production of fiberglass products is engaged in quite a few foreign companies. However, it is worth noting that problems are possible during transportation due to the far arrangement of manufacturing plants from the operation of pipes. A striking example is Future Pipe Industries, the headquarter of which is located in Dubai, is engaged in the design and production of system pipes made of fiberglass and operates in oil and gas, water and industrial sectors. The company has 13 factories scattered around the world, and laid more than 190,000 km of pipelines. In 2021, the company completed 829 projects, 40% of which concerned the oil and gas sphere. [5] One of the examples of the use of fiberglass manufactured by this company is the 2018 project of the Central Production System of Hamlin, which was developed for the large American oil and gas company Surge Energy engaged in exploration and gas production. Future Pipe Industries delivered Surge Energy to more than 8.5 km of pipelines with a diameter of 230 mm with a nominal pressure of 52 bar to support its central production enterprise in Hamlin [11].

Of particular interest for this work is a composite fiberglass pipe produced under the brand Bondstrand. In the product range under this brand are 8 series of pipes that meet the standards of glass plastic pipes, each of them is used in the production of oil and gas, depending on the operational requirements. Bondstrand 2400 series is used for transportation of oil, gas, water, reactive units. Such fiberglass pipe with integrated conical internal connection and projection, integral mechanical connection with internal and external thread for connection with other pipes, available in a wide range and suitable for use in environments with high pressure and higher operating factors. The diameter of the pipes is represented in the range from 50 to 1000 mm, the pressure inside the pipe can be from 10 to 50 MPa, can be used at temperatures from -43°C to 93°C. The length of each pipe is 12m. In order to reconstruct 243 km of the pipeline, 20,250 pieces of pipes will be needed to implement the project.

The diameter of the pipe of the DBST Line Gallaaral GRS South-West GRS is 720 mm, the pressure inside the pipe is 50 MPa, the operation temperature is 20-30°C.

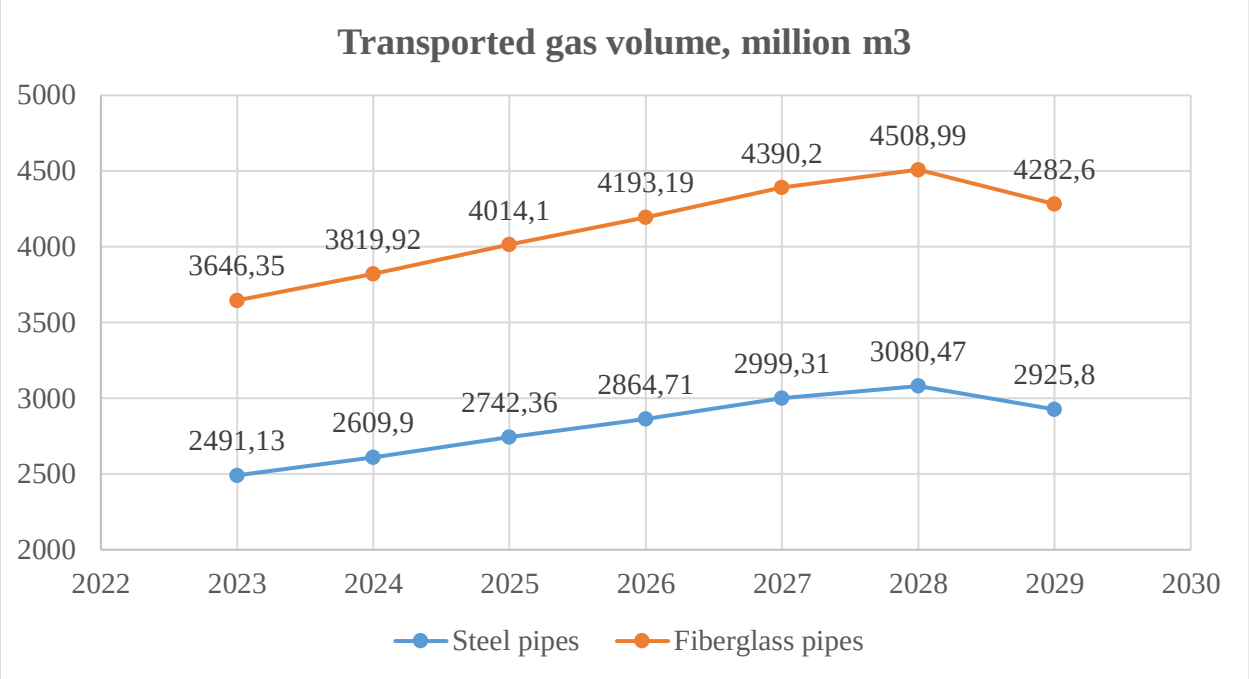

Figure 1. Transported gas volume

The financial model was built for the period from 2022 to 2029. To calculate the forecast volumes of gas transportation, gas consumption has been analyzed over the past 8 years, an annual increase in 5% was revealed. A similar dynamics was projected for the next 8 years.

Analyzing the gas transport volumes shown in Figure 1, it is worth noting that the annual performance when using glass plastic pipes is higher than when using steel pipes by 46.4%. The reason for the growth is the high throughput of fiberglass pipes, which is due to the smooth inner surface of the pipes, which do not accumulate corrosive, paraffin and resin deposits, as well as reduction of regulatory volumes of natural gas on own need and losses up to 0.1%.

Table 4. Projected technical and economic indicators for 2022-2029

Indicators	Steel pipes	Fiberglass pipes	Comparison, %
Capacity, million m^3	44 804,00	64 005,72	43
Own needs and losses, (2,5%; 0,1%), million m^3	505,47	28,88	0,06
Volume of transported gas, million m^3	19 713,48	28 855,34	46,4
Sales revenue, $ million	239,52	350,59	46,4
Capital investments, $ million	0	20,15	-
Structures (fiberglass pipes)	0	12,15	-
Construction and installation work	0	1	-
Equipment	0	1	-
Other (oils, resins, transportation costs)	0	6	-
Operating costs, $ million	92,66	133,44	44
Gross financial result, $ million	146,86	218,79	49

Indicators	Steel pipes	Fiberglass pipes	Comparison, %
Expenditures for the period, $ million	74,47	74,62	0,2
Net profit, $ million	61,52	122,55	99,2
Cash flow, $ million	61,52	115,5	87,7
Discounted cash flow, $ million			
10%	42,26	66,66	57,7
15%	35,90	51,67	44
Project payback period (year)	0	1	

Source: Calculated by authors in MS Excel

Given that the transportation rate remains unchanged at $5 per 1,000 m3 per 100 km, the revenue is calculated as follows:

Sales revenue for 2023 = $5 * Volume of transported gas * Transportation distance / 100000 = $5 * 3646,35 million m^3 * 243 km / 100000 = $44,3 million.

Total revenue is $350.59 million. The total investment will be $20.15 million and will include the following:

Purchase of fiberglass tubes at a price of $500 and connecting elements at a price of $100: $500 * 20250 + $100 * 20250 = $12.15 million.

Cost of construction and installation work = $1 million.

Cost of pipe transportation equipment = $1 million.

Cost of oils, resins required for pipe operation = $1 million.

Transport costs = $ 5 million.

The operating costs for the entire period will amount to $133.44 million. The operating costs for the period are estimated at $13.4 million. In addition, the cost of labour will be reduced by half as a result of the reduction in the number of personnel involved in welding work, as the use of fiberglass tubes does not require them. They also include the depreciation of capital expenditures of $1.64 million each year.

The net profit (Figure 2) in the first year of operation of fiberglass pipes will be 83% higher than that of steel pipes, which in absolute terms is $6.5 million. Then, in the following years, the net profit from the use of fiberglass tubes will be on average twice as high as the net profit from the operation of steel pipes, reaching a peak of $19.37 million in 2028. In 2029, net profit will decrease slightly by 6%, which is due to a decrease in the volume of transported gas by 226.4 million m3. The cash flow obtained by subtracting the capex from net profit and depreciation is $115.5 million. The cash flow discounted at 10% to $66.66 million, at 15% to $51.67 million.

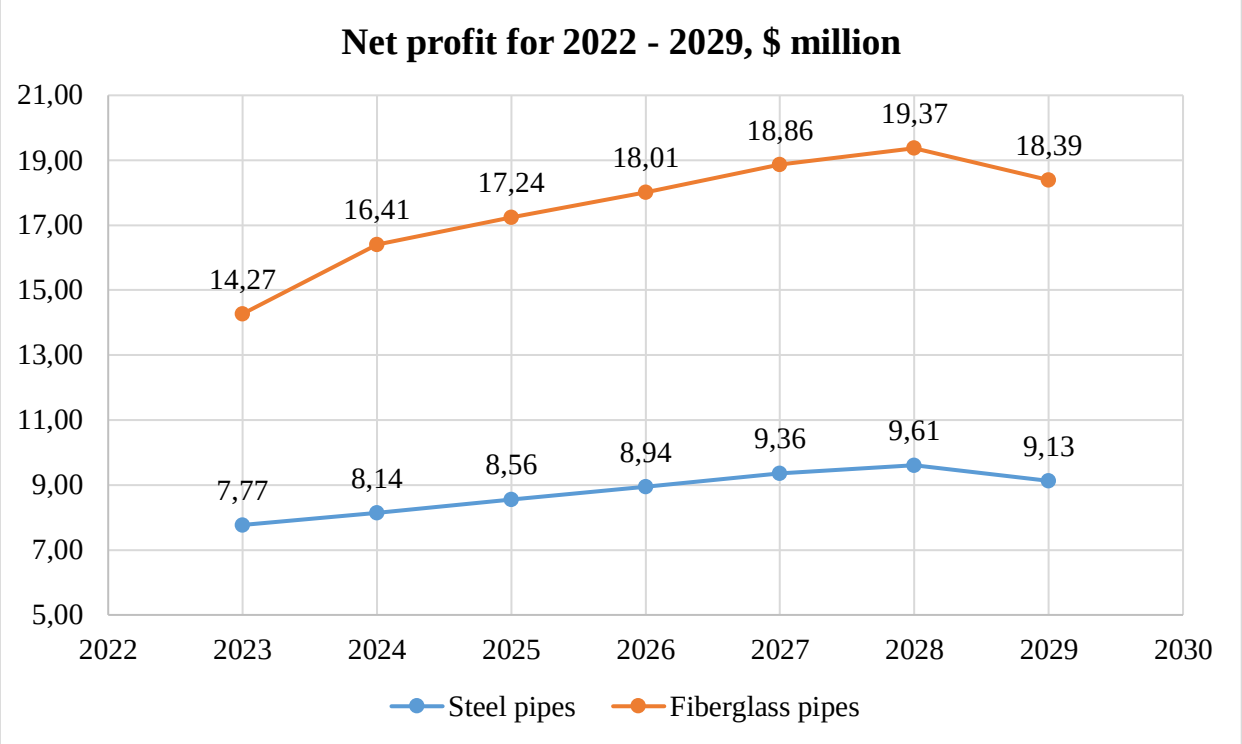

Figure 2. Net profit for 2022-2029

Taking into account that investments will be invested in 2022 and construction and installation works will start, which will take a year, during this period the accumulated cash flow will be negative of $18.51 million. Therefore, the payback period of the project will be one year.

Summing up, it should be noted that the conducted comparative analysis of techno-economic indicators in the operation of steel and fiberglass pipes showed that the revenue from the sale of products will increase by 46,4%; although the share of wages in operating costs will decrease, their total volume will increase by 44%; the net profit will double and the cash flow will increase by 87.7%.

Conclusion

In conclusion, it is worth noting that composite materials increasingly win the market of materials necessary for the manufacture of products used in the oil and gas industry throughout the production chain of oil and gas production, from exploration pipes to oil and gas collection and storage systems. The study concluded that:

1. Steel tubes on the DBST line have been in use for 60 years since 1959 even though the standard life of steel tubes is on average 25-30 years;
2. There are many alternative materials for the production of gas pipeline systems. A comparison of steel, fibreglass, polyethylene and polyvinyl chloride pipes concluded that fiberglass material is an excellent alternative to steel pipes because of similar process parameters;
3. There are many manufacturers and suppliers of pipes made of composite materials, a wide range of products, differing in diameter, pressure, pipe length and other technological features. Most of the plants are concentrated in the United States and China, which may cause problems in the transportation of pipes;
4. Calculation of the economic efficiency of the project to replace steel pipes with fiberglass on the line DBST, from Gallyaral GRS to South - Western GRS (243 km), shows the expediency of the project due to the increase in the volume of transported products by 46,4%, reducing transportation losses to 0.1%, and doubling net profit.

References:

1. (2019). *Decree of the President of the Republic of Uzbekistan "On measures for the stable supply of the economy and the population with energy resources, financial recovery and improvement of the oil and gas industry management system"* dated 07/09/2019. No. PP-

4388 / National Database of Legislation, 07/08/2021, No. 06/21/6258/0651. Retrieved 01/15/2022 from https://lex.uz/docs/4410281

2. Kozlov A. L. (1981). *Natural fuel of the planet.* (p.94). Moscow: Energoatomizdat.
3. Gustov, D. S., & Lyubin, E. A. (2016). Investigation of the possibility of using fiberglass pipes for natural gas transportation. *Indian Journal of Science and Technology*, No. 9, pp. 5-15.
4. Kotov, N. S. (2021). Fiberglass pipes for the oil industry: goals, pluses and production methods. *Sphere. Oil and gas.*, №4, pp. 20-28.
5. Tolmachev, A. A., & Ivanov, V. A. (2019). Prospects for the use of fiberglass and polymer-metal pipes in the oil and gas industry. *News of higher educational institutions. Oil and gas.*, No. 6, pp.132-139.
6. Tskhadaya, N.D., & Yagubov, Z.Kh. (2012). Fiberglass pipe for transportation of oil and gas. *Oil and gas business.*, No. 3, pp. 136-142.
7. Iagubov, E. Z. (2007). Fiberglass pipes - the future of environmentally safe oil and gas pipeline transport. *Environmental Protection in the Oil and Gas Complex*, No. 7, pp.20–23.
8. Iagubov, E.Z. (2006). Fiberglass pipes: problems and prospects of application in the oil and gas industry. *Technologies of oil and gas.*, No. 5, pp. 61–67.
9. (2021). *Key indicators of industry.* Industry of Uzbekistan 2021. (pp.15-16). Tashkent.
10. Gruk, A. G. (2017). *Comparison of fiberglass pipes with pipes from other materials*. *Official website of the company ATTIKA.* – 2017, March 22 [Electronic resource]. Retrieved 12/27/21 from http://attikarus.ru/2017/03/22/207-sravnenie-stekloplastikovih-trub-s-trubami-iz-drugih-materialov/
11. (2022). *Oil and Gas. Official website of the company "Future Pipe Industries"*. [Electronic resource]. Retrieved 12/27/21 from https://futurepipe.com/sectors/oil-gas/