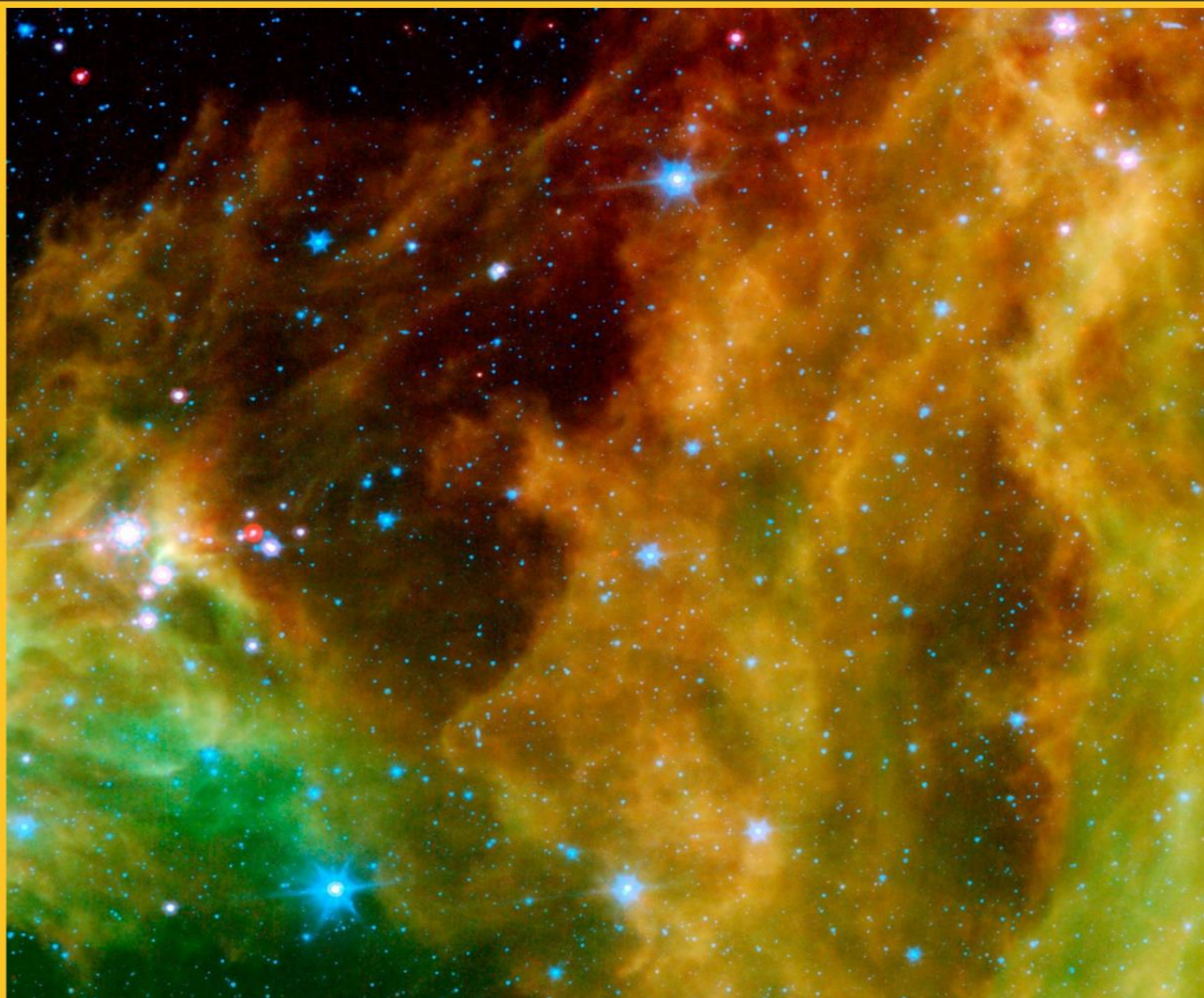


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# APPLIED PEDAGOGY AND PSYCHOLOGY

UDC 159.9

## Simakov A.I. Negotiations as a semantic catalyst for thinking

**Simakov A.I.**

**Abstract.** *The methodology of teaching the human brain almost always encounters such a semantic phenomenon as the brain anticipating the creation of a virtual scenario for the future development of speech communication, which actually distorts the brain's perception of a real (actually) emerging exchange of statements and written messages between real interlocutors in relation to the real subject of discussion. This is the fundamental semantic intrigue.*

*Functional segments in which the human brain creates its own statements, as well as perceives, displays and uses other people's statements, work for each interlocutor according to almost the same unchanging fundamental laws of semantic thinking.*

*Each speech event that occurs in the brain's own information space necessarily affects the success in reaching an agreement with the interlocutor.*

*The advantage of the speech capabilities of the human brain is based on the control of the composition "Meaning-Image-Context" of each created utterance.*

*Negotiations are a semantic catalyst for thinking.*

**Keywords:** *Revelations have a long way to go. From accuracy to distortion. When the essence of intentions is unclear. And with every word, new doubts. When the "meaning" has a plurality of "I". When the "image" has the grace of deception. When in the "context" of the essence of being. When consciousness comes out of the fog. Negotiations as a semantic catalyst for thinking.*

---

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### Semantic essence of the exchange of statements

The universal criterion for the effectiveness of any negotiations is the answer to the question: "How successfully do the revelations of the interlocutors mask their intentions?" There are many different opinions on the topic: "What are negotiations from the point of view of the science of semantic thinking, in the process of which a new reality is created, namely, a written agreement is reached and formalized, which allows you to develop a design documentation for the material production of useful (in-demand) new physical processes and products?"

In this article, the semantic essence of any negotiation process is presented in the artistic form of poetic conciseness. Every speech event that occurs in the brain's own information space necessarily affects the success in reaching an agreement with the interlocutor:

*Revelations have a long way to go, From accuracy to distortion, When the essence of intentions is unclear, And with every word new doubts, When the "meaning" has a plurality of "I", When the "image" has the grace of deception, When the essence of being is in the "context", When consciousness comes out of the fog ...*

*Event #1 (Revelations have a long way to go)*

Speech communication and its most structured form – negotiations, take place in conditions of voluntary and natural exchange of information between interlocutors within the subject of discussion.

Excessive revelations or even natural talkativeness, as well as a demonstration of verbal restraint, alarms the interlocutors, complicates their mutual understanding and requires additional time to reach an agreement.

In the composition of the words of any utterance, additional information always appears about the subject of discussion, intentions, goals, features of speech, the nature of the interlocutor, circumstances, conditions, reasons, etc., which requires a person to control the volume of such information.

This is the "technical task" for the brain to develop an algorithm for managing its "frankness", which penetrates into the "Meaning-Image-Context" composition of the text of each utterance.

In this technical task, the maximum duration (3-7 seconds) of managing the volume of additional information is also set, that is, its inclusion or exclusion, or minimization, before voicing the utterance and perception of the utterance by the interlocutor.

*Event #2 (From accuracy to distortion)*

In the process of creating each utterance in the brain's own information space, all the information activated at the moment falls on a person's speech, and not only that which is directly related to the subject of negotiations.



This becomes a significant semantic hindrance, consisting of information garbage, unrealized prototypes of their previous already voiced statements, information structures that have become available to the brain when perceiving and displaying the statements of the interlocutor, etc.

The brain, in this regard, has a problem – how to remove from the created utterance or at least significantly reduce the amount of such additional information?

The brain actively removes such additional information from its utterance, trying to preserve "accuracy" in the utterance in the face of the appearance of imminent "distortion".

### *Event #3 (When the essence of intentions is unclear)*

When creating each of its statements, the problem of ambiguity of intentions arises in the brain at the stage when internal functional mini semantic search systems have already collected the necessary words (almost like mushrooms in the forest) for the "Idea of the idea" of the statement, but the brain cannot yet create the "Realized idea" of the statement from these words.

The intrigue arises due to the fact that the "Idea of the idea" of the utterance is initially formed by a Semantic personality who does it with active creative verbal grace.

But for a Behavioral personality, the priority is not the semantic elegance of the utterance, but the ability of the utterance to influence the interlocutor as much as possible, in the previously synthesized mode, in preparation for negotiations.

To realize such an impact, each utterance must have a stable "Meaning-Image-Context" composition, which allows for the realization of three types of semantic impact on the interlocutor: a given information, motivation, the presence in his utterances of the ability to complementarily interact with other utterances.

It should be borne in mind that intentions, inseparable, as a rule, from a person's emotional attitude to their needs and their satisfaction, exceed the possibilities of their verbal display.

### *Event #4 (And with every word new doubts)*

The process of creating each utterance is associated with the activation of words individually and uniquely located in their own archive of the information space of each person's brain.

The intrigue arising in connection with the need to achieve, which is virtually impossible due to the influence of various internal and external factors, the functional coincidence of the "Idea of the idea" of the utterance and the "Realized plan" of this utterance has no "resting point".

In the process of creating each utterance, the Behavioral Personality offers the brain variants of specific words with their specific and unchangeable meanings. The brain is obliged to consider each such sentence and make a decision on it – to include or not to include this word, taking into account its invariable meaning, in the composition of the "Realized idea" of the utterance. In the process of creating each utterance, the Semantic Personality offers the brain options for the variety of words used often, far from their specific and unchanging meanings.

Accordingly, the competition between the influence of Behavioral Personality and Semantic Personality on the brain leads the brain to new doubts.

However, such doubts of the brain last no more than 3-7 seconds, during which the Semantic Personality, with the help of its internal functional mini search engines, creates each of its utterances in the information exchange system between interlocutors on a specific subject of negotiations.

#### *Event #5 (When the "meaning" has a plurality of "I")*

When creating utterances, the virtual "Idea of the Idea" of each utterance continuously creates stresses for the brain in connection with its demand for its exact representation in words with their meanings and many uses.

The reasons for such a tense state of the brain are such fundamental semantic patterns as the proactive activity of internal dialogues in the brain's own information space, in which a person, when creating each of his utterances, appears in various functionally significant, but virtual "I", alternately, then under the pressure of a Behavioral personality, then under the pressure of Semantic personalities.

The behavioral personality strives to ensure that the intentions indicated in the "Ideas of the plan" become clear to the interlocutor.

The semantic personality strives to ensure that the "Realized plan" corresponds to the "Idea of the plan".

Only at the stage of creating the "Realized Idea" of the utterance and completing the formation of the "Meaning-Image-Context" composition, which requires activating a much larger number of words in its own information space and selecting them more carefully into



the corresponding semantic segments of the utterance composition, the plurality of "I" disappears from the text of the utterance or, at least, turns out to be less notable.

*Event #6 (When the "image" has the grace of deception)*

When creating the "Realized Idea" of an utterance, the Semantic personality is responsible for the semantic set of words that form the "image" of the composition of the utterance.

The semantic personality strives to ensure that in the process of exchanging statements, as much as possible of the statements of the interlocutors have the ability to complementarily interact with other statements, which makes it possible to draw up, draw up and sign a joint final document, for example, a protocol of negotiations or an agreement, based on the results of negotiations.

The longer the negotiations continue, the more often the interlocutors think about the text of the final document and this disrupts the balance between "Meaning-Image-Context" in the composition of each subsequent statement, which initiates the dominance of the "image".

At some point, the Semantic personality so captivates the brain with the idea of necessarily reaching an agreement with the interlocutor during these negotiations, that the Behavioral personality can no longer actively continue further exchange of statements, objectively assess the impact of his statements on the interlocutor and begins to initiate the completion of negotiations.

However, the more the "image" of the statement differs from the "Idea of the idea" of the author of the statement, the more the statement will meet the expectations of the interlocutor perceiving this statement, which brings the interlocutors closer to reaching an agreement, but ensuring the stability of such an agreement will require either special actions and decisions, or new negotiations and new agreements.

*Event #7 (When the essence of being is in the "context")*

If the words "reaching an agreement" mean the end of negotiations, then the words "reaching a compromise" mean the endless continuation of negotiations.

Unlike, for example, the word "compromise", the word "context" means not only the preservation of the mutual understanding reached in the negotiations, but also the possibility of using coincidental statements to reach an agreement, at a time when other statements that

were supposed to be "coincidental" are destroyed under the influence of new circumstances, omissions of the interlocutors or mistakes they made earlier.

The semantic essence of the concept of "context" is that the idea of "context" is always on the side of an already existing or still only potential agreement. This becomes especially important when negotiations should end with the approval and signing of the final joint document – a protocol or an agreement.

Even when there are no signs of a need to reach an agreement in any of the statements of the interlocutors, such a need is inherent in the human brain from birth, and it is realized automatically, at least in the form of a "context", despite the ongoing semantic struggle of the Behavioral personality and the Semantic personality for the priority of their statements and their version of the text of the final document.

### *Event #8 (When consciousness comes out of the fog)*

The usual rate of exchange of statements allows the human brain to create two statements per minute. In an hour of negotiations, this will amount to 120 utterances, 240 in two hours, 360 in three hours, etc. Each utterance after its voicing clarifies a person's consciousness, as if freeing him from the heavy semantic load of activated words, but not used in the text of the utterance.

This is the exit of a person's consciousness from the semantic "fog" of the meanings of words and their uses, but only for a very short moment of time, which is repeated many times before the conclusion of negotiations.

### **Classical human learning**

The methodology of teaching the human brain almost always encounters such a semantic phenomenon as the advanced creation of virtual scenarios of successful negotiations in the process of internal dialogues, which distorts the brain's perception of the effectiveness of exchanging statements with a real interlocutor already during negotiations.

The training of the human brain in speech communication is based on the creation of a controlled intrigue between the attitude to the subject and the interlocutor of the Behavioral and Semantic personalities of the human brain.

As part of the negotiation intrigue, the Behavioral personality activates its attitude to the subject of discussion and includes, under the control of the brain, an arsenal of competencies necessary for:

analysis of the stability of the semantic content of the exchange of statements with the interlocutor;

formation of algorithms for using the semantic content of the exchange of statements in solving their tasks on the way to reaching an agreement;

timely replacement of selected algorithms with other more efficient ones;

assessments based on feedback information of the result already achieved during the implementation of behavior algorithms invented specifically for this speech communication and/or ready-made and successfully used earlier algorithms from the arsenal of the brain's manifestation of itself as a successful interlocutor.

At the same time, the following management tasks become the most active objects of attention of a Behavioral personality: *removal of psycho-emotional tension; administration of internal dialogues; balance of intentions, rights, obligations; balance of presentation and concealment of information; management of negotiations and change of conversation modes; support of the interlocutor's behavior; speech correction; identification of signs of lies; use and disposal of information garbage; management and neutralization of emotions; semantic logistics; manifestation of illusions and fantasies; manifestation of reasonableness and prejudice; expression of imagination and curiosity; control of forgetting and guessing.*

As part of the negotiation intrigue, the Semantic personality activates its attitude to the subject of discussion and includes, under the control of the brain, an arsenal of competencies necessary for:

creating each utterance and written message with the composition "Meaning-Image-Context" for a comprehensive impact on the interlocutor;

perception, analysis and adequate (without interference of one's internal information) display of the statements and written messages of the interlocutor in the brain's own information space;

ensuring semantic unity and consistency between the "Ideas of the idea" of one's utterance, the "Realized idea" of this utterance using the appropriate keywords, from which the composition "Meaning-Image-Context" of the text of the utterance and the "Reproduced idea" that arises in the interlocutor's brain when he perceives this utterance is formed.

At the same time, the following managerial tasks become the most active objects of attention of the Semantic personality: *the activity of the composition "Meaning-Image-Context" of each utterance; support of the "Idea of the idea" of the utterance; support of the "Realized idea" of the utterance; support of the "Reproduced idea" of the utterance; synthesis of the expected result of the impact of the utterance on the interlocutor and evaluation of the achieved result; management of semantic archive; timeliness of creation of texts of higher order; appeal to the time factor; use of a foreign language; analysis of feedback information; formation of concepts; control of networks of their statements; control of networks of perceived statements of the interlocutor.*

The negotiation intrigue arises in the personal information space of the human brain due to the competition between the Behavioral personality and the Semantic Personality for the priority of influencing the interlocutor and receiving their expected reaction to each statement addressed to him (written message).

This happens in any conversation mode, at any stage of negotiations.

## **Chatbot Machine Learning**

The chatbot training methodology is based on two main principles:

1. unlimited access to billions of informational and functional constructions from words of speech communication of any native (national) language, which in the form of statements and/or written messages have already been repeatedly manifested in real chatbot speech behavior programs and scenarios of speech physical contact communication of numerous categories of people;
2. algorithms for multiple, and in fact infinite, reproduction (copying), sorting and formation by key parameters of typical variants that arise and/or are able to arise in a specific dialog situation during speech communication in order to reach an agreement between a chatbot and a person and/or other chatbots on specific subjects of speech communication.

The processes of improving the speech efficiency of a chatbot have significant and insurmountable barriers that affect the spatial and functional boundaries of the effectiveness of their learning process, for example:

1. the chatbot itself does not create the composition "Meaning-Image-Context" of each of its statements, because it does not understand what it is;
2. the chatbot, using extensive machine learning programs, finds copies (tracing paper) of any ready-made and previously successfully used information structures

containing similar structurally and meaningfully filled configurations of words in the content of previously semantically structured information available to it, each of which resides in semantic texts in their uniquely individual unity of unchangeable recognizable meanings and the variety of their natural, but each time unexpected uses surrounded by a never-repeating set of all other words;

3. the chatbot, repeating in its statements (written messages) the name of an object, event, action, does not use synonyms, even the closest ones, even with repeated repetitions in its statements of these previously used names.

### ***Negotiations are a semantic catalyst for thinking***

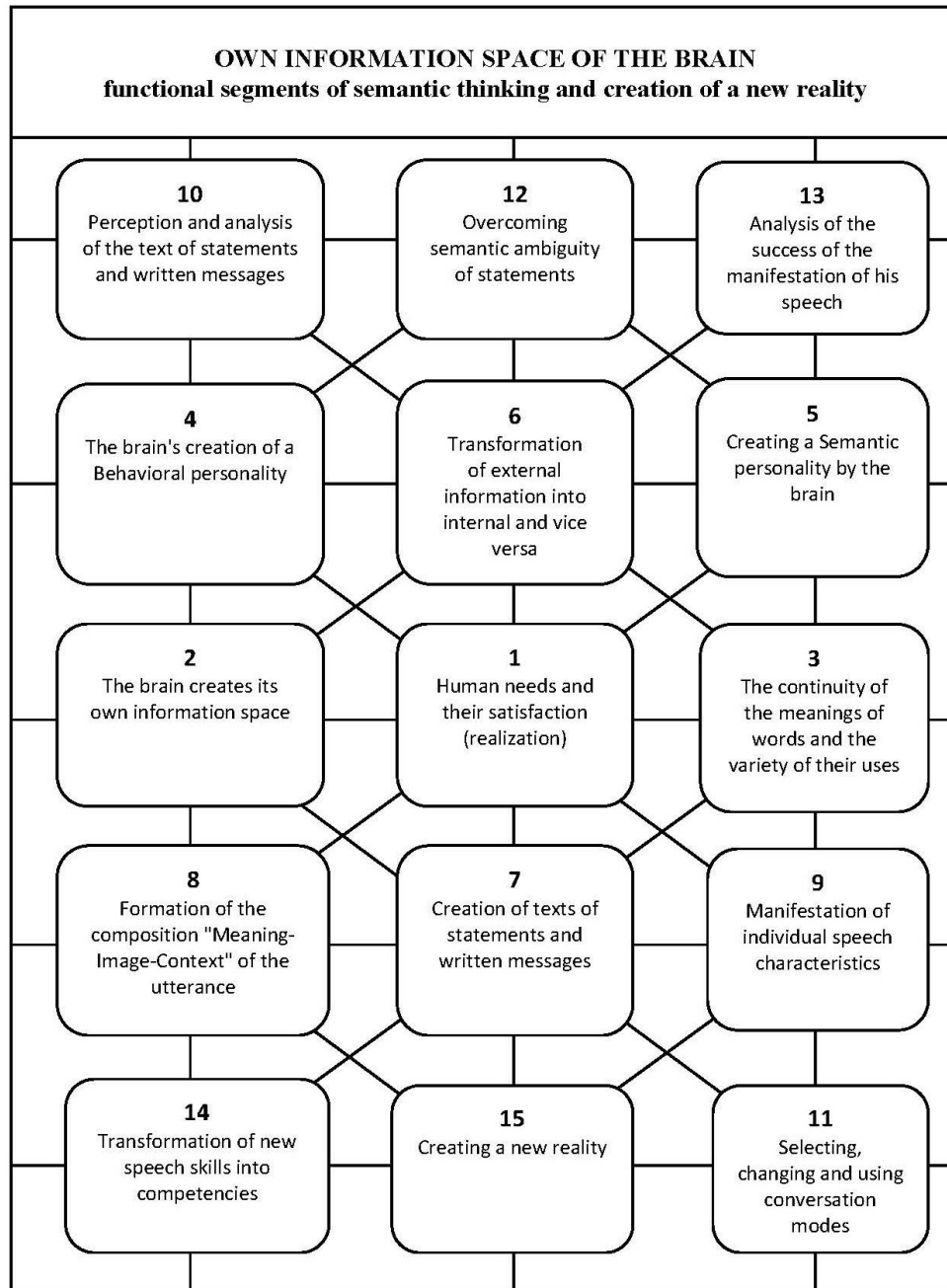
A typical scenario of negotiations was formed in the conditions of the active spread of domestic and foreign trade, which assumed the simultaneous achievement of three main goals:

- to reach an agreement taking into account the conditions of each of the interlocutors;
- to formalize the agreements reached in writing;
- as a result of the negotiations, include the achieved level of motivational influence on the interlocutor of their statements in the complex of their competencies.

Functional segments in which the human brain creates its own statements, as well as perceives, displays and uses other people's statements, work for each interlocutor according to almost the same unchanging fundamental laws of semantic thinking.

All 15 functional segments of thinking participate in the creation of a new reality by the brain, being essentially mini factories for the production of information structures (texts) and their semi-finished products. These semantic specialized mini-factories are combined in their own information space of the brain into a single and continuous technological process of speech, the creation of their statements (written messages), as well as in the process of perception, analysis, decomposition and further use of the statements (written messages) of the interlocutor.

Such segments of semantic thinking, including the continuous activity of their specialized internal mini search engines, include:



Such and/or similar functional segments of thinking, being independent factories for the creation of semantic products, such as ribosomes synthesizing proteins, are located in the information space of each person's brain in their unchanging structural perimeters established by the Behavioral personality in the process of its generation and further continuous development.

The advantage of the speech capabilities of the human brain is based on the control of the Semantic personality of the composition "Meaning-Image-Context" of each created statement (written message).

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UDC 740

## Zak A. Methods for determining the type of planning in younger adolescents

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**Abstract.** *The article presents a scenario for the interaction of fifth-grade students with a computer version of the author's methodology "Repetition" to determine the type of planning used in solving spatial-combinatorial problems. In the conditions of individual experiments with 23 students to test the proposed scenario, the possibilities of the computer version of the "Repetition" method in differentiation were shown types of planning among fifth graders: 65.2% of students used meaningful planning in solving problems, 34.8% used formal planning. In the future, it is planned to test the proposed scenario in work with sixth-graders and younger students, primarily with fourth-graders.*

**Keywords:** *fifth-graders, individual experiments, spatial-combinatorial tasks, types of problem solving planning, computer version of the "Repetition" methodology.*

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### 1.Introduction.

The solution of the problem of the federal project "Digital Educational Environment" is associated with the creation of a modern and safe digital educational environment that ensures high quality and accessibility of education of all types and levels [4].

As part of the solution of the noted task, it is supposed to carry out not only the digitalization of the content of secondary school curricula, but also the development of digital technologies for diagnosing subject and meta-subject results of education, reflecting, in particular, the development of cognitive (cognitive) meta-subject competencies.

The provisions of the Federal State Educational Standard for Basic General Education [8] indicate that meta-subject educational results (including cognitive ones) are formed in primary school students as a result of studying the main educational program. At the same time, it is noted that cognitive meta-subject educational results reflect the development by students of various kinds of universal cognitive actions, associated, in particular, with independent planning to obtain the required result.

Studies show (see, for example, [1], [2], [7]) that problem solving can be planned in different ways. In one case, the first part of solution planning is a complete analysis of the conditions of the problem in order to determine all the specific executive actions necessary to achieve the desired result. In the second part of planning, a program is developed to achieve the desired result, in which all the necessary actions are included in a certain sequence. Only after this is the problem solved. In this case, planning is carried out as a meaningful action associated with programming the solution of the problem as a whole.

Otherwise, planning is done differently. Firstly, there is no complete analysis of the conditions of the problem and clarification of the composition of all actions necessary to obtain the required result, and, secondly, there is no independent part associated with drawing up a program for the implementation of all necessary actions.

With this implementation of planning, one or two actions to solve the problem are first planned, then carried out, then again there comes a stage where actions are planned, and a stage where these actions are performed. In this case, in the course of planning, there is no construction of the entire sequence of necessary actions before their implementation, since first one part of the required sequence is outlined and carried out, then another part, and so on. Such planning is carried out as a formal action associated with programming the solution of a problem in parts.

## **2. Materials and methods.**

The purpose of this study was to characterize the possibilities of the computer version of our technique "Repetition" [1, 5] in determining the type of planning in younger adolescents.

It was assumed that the developed scenario for the interaction of students with the computer version of the "Repetition" method really allows you to determine the type of planning (meaningful, in general or formal, in parts) when solving problems. In this, we proceeded from the fact that the computer version of the methodology was developed in such a way as to create conditions for solving problems that are as identical as possible to those conditions in which problems are solved in the original methodology (when developing this methodology, modern approaches to information and communication technologies for diagnostics of educational achievements of schoolchildren were taken into account [6 ]).

In the first part of working with the computer version (as in the original method, see [ 1 ]), students learn the names of the cells of the playing field. To do this, appropriate texts and images are placed on the computer screen.

Each cell is labeled with a letter and a number:

2			
1			
	A	B	C

	△	

The bottom cells in each rectangle are called A1, B1 and C1.  
 The top cells are A2, B2 and C2.

What is the triangle cell called? Choose (click) the correct answer:

A1 ☐    B2 ☐    A2 ☐    C2 ☐    B1 ☐    C1 ☐

If the student chooses the wrong answer, the program informs him about it and offers the same question, but in this case the triangle is already in a different cell. And so it continues until the student gives two correct answers in a row.

In the second part of the work (the same as in the original method, see [1]), students solve training problems.

Problem 1

In which two cells do you need to swap the figures so that the same figures are in the same cells where there are the same numbers?

2	○	△
1	○	△
	A	B

-----  
1 action

7	7
4	4

By pressing the buttons, write the names of two cells, for example,

like this: A1 ↔ B2

A

1

B

2

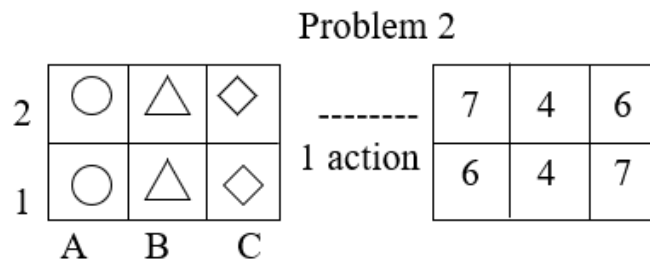
In what other two cells can you change pieces?

Find these cells and write their names ? ↔ ?

If the student chooses the wrong answer, the program informs him about it and offers the same question, but in this case the triangle is already in a different cell. And so it continues until the student gives two correct answers in a row.

If the student gives the wrong answer (writes down the wrong action), the program informs him about this and offers the second version of this task, where you also need to mentally place two pairs of identical figures in one action in such cells in which there are identical numbers. If the second version of the problem is solved incorrectly, then the experiment ends in this case.

In the case when the student (a) correctly solves the first option of the proposed problem or (b) the first option solves incorrectly, and the second one correctly, then he is offered the second (more difficult) training problem, with three pairs of figures and numbers. At the same time, just like the first task, it is required to find out in which two cells it is necessary to swap the figures in one action so that the same figures are in the same cells where there are the same numbers.



In the same way (presentation of one or two options), the solution of the third and fourth training tasks was programmed.

**Problem 3**

What two exchanges are needed so that the same figures are in the same cells, where there are the same numbers?

2	○	△	◇
1	△	◇	○
	A	B	C

-----

2 actions

7	7	4
4	6	6

Press the buttons, write the names of the two cells of the first and second steps:

A

1

B

2

C

1) ? ↔ ?

2) ? ↔ ?

**Problem 4**

2	○	△	○	△
1	◇	□	□	◇
	A	B	C	D

----

8	5	9	9
4	8	5	4

In the third part, students are invited to solve the same four main tasks as in the original methodology: Nos. 1 and 2 - in two actions, Nos. 3 and 4 - in three actions. Just as in solving training problems, students must find and write down the required actions by pressing the buttons with letters and numbers. The program does not report the result of solving each main task.

## Main problems

3	△	□	○	△	№1	5	7	6	5	3	□	◇	□	◇	№2	5	6	7	5
	○	△	□	○		6	5	7	5		□	◇	□	◇		5	7	5	6
	△	□	□	○		7	7	6	6		□	◇	◇	◇		6	6	7	7
2					actions														
1																			
	A	B	C	D							A	B	C	D					

3	□	△	◇	□	№3	8	5	5	7	3	△	◇	○	◇	№4	8	6	6	7
	△	○	○	□		5	6	8	7		□	△	□	◇		8	5	7	5
	△	◇	○	◇		8	6	6	7		△	□	○	○		5	7	8	6
2					actions														
1																			
	A	B	C	D							A	B	C	D					

### 3. Results.

In individual experiments with a computer version of the "Repetition" methodology, 23 fifth-graders participated in 4 and 5 grades. 15 people (group A, - 65.2%) successfully solved all the main tasks with the help of meaningful planning of their actions. The remaining eight people (Group B. - 34.8%) could not solve the main tasks in three actions (Nos. 3 and 4): four of them (subgroup B1) were able to correctly solve the first and second main tasks (in two actions), the other two (subgroup B2) - only the first main task.

Observations of the actions of students in both groups made it possible to characterize the features of solving problems with the help of meaningful and formal planning to achieve the desired result. It is important to note that the students were asked to think aloud, telling and explaining what and how they intend to do.

Thus, the students included in group A acted as follows. When solving each problem, the students, as could be understood from their words and actions, first found out the nature of the correspondence between the location of the figures (on the left side of the condition) and the location of the numbers (on the right side of the condition). In the first task, for example, they determined the following: the arrangement of triangles is most consistent with the arrangement of "fives", the arrangement of circles - the arrangement of "sixes", the arrangement of squares - the arrangement of "sevens"; in the second task: the location of rhombuses - the location of "sevens", the location of squares - the location of "sixes", the location of pentagons - the location of "fives".



After that, they figured out which two actions (two mutual movements of two figures) must be performed in order to solve the problem. Seven students of this group (subgroup A1) as the first action chose the exchange of places of a circle from cell D2 with a triangle from cell A1, two students (subgroup A2) chose to exchange places of a square from cell C1 with a circle from cell D2, one student (subgroup A3) chose as the first action, exchange the square from cell C1 with the triangle from cell A1.

When asked by the students of subgroup A1 about why they chose the intended first action, the students usually answered as follows: "... because three triangles are already in the places of the "fives", and one triangle in cell A1 is in the place of the "seven" .. .. so you need to move this triangle to the place of the "five", in the cell D2 ... ".

When asked by the students of subgroup A2 about why they chose the exchange of places of the square from cell C1 with the circle from cell D2 as the first action, the students answered: "... because the circles should be where the "sixes" are, ... three circles already are in the places of the "sixes", and one circle in the D2 cell is in the place of the "five", ... therefore, put this circle in the place of the "six", in cell C1 ... ".

In the same way, the student who made up the subgroup A3 answered the question about the choice of the first action: "... it is necessary that all the squares be in the places of the "sevens" ...".

Then, based on the definition of the first action, the students of group A indicated a possible second action. For students of subgroup A1, this action was the exchange of places of a circle from cell A1 with a square from cell C1, for pupils of subgroup A2 – exchange of places of a triangle from cell A1 with a square from cell D2, for a student of subgroup A3 - exchange of places of a circle from cell D2 with a triangle from cell C1.

In a similar way, first determining the correspondence between the location of the figures and the location of the numbers (finding out in which places the largest number of certain numbers is located), then determining the content of the first and second actions, the students of group A acted in solving problem No. 2, and also and more complex main tasks (Nos. 3 and 4) – in three steps.

The noted actions of students of group A in solving basic problems of varying complexity give reason to believe that they carried out a meaningful cognitive action of planning a solution, associated with a complete analysis of the conditions of the problem and the definition of all the required actions in general before their implementation.

The students who made up group B acted differently. The students who solved correctly only the first and second main problems (group B1) did not find out (unlike the students of

group A) the full correspondence between the location of the places (cells) occupied by the figures and the places occupied by the numbers.

When solving the first main problem, they immediately said that they needed to swap the circle from cell D2 with the square from cell C1. When asked why it was necessary to do this, they usually answered "... where there are two "sixes", there should be two circles ...". Then they wrote down this action: D2 – C1.

Next, they tried to determine what the second action might be. For a long time they examined and compared the arrangement of figures and the arrangement of numbers. As a result, they noticed that where two sevens are nearby (cells A1 and C1) there are a triangle and a square, and that it is necessary to put a square from cell D2 in place of the triangle in cell A1, so that, as they explained, "... the squares were in place "sevens" ... Having found this solution, they wrote down the second action: A1 - D2.

As a result of performing these two actions, it turned out, unexpectedly for the students (as could be seen from their reaction), that the problem was solved: after the first action, all the circles were in the places of "sixes", and after the second action, all the squares were in the places of "sevens". "And all the triangles are in the places of the "fives".

In a similar way, the students of subgroup B1 solved the main problem No. 2.

When solving the main problem No. 3 (in three actions), the students of subgroup B1 acted in the same way as when solving the main problems No. 1 and 2. In particular, without finding out which figures correspond to the location of certain numbers, they immediately determined the first action. Seeing that in cells B3 and C3 there are two "fives", and in their places - a triangle and a rhombus, they considered it right to move the rhombus from cell B1 to cell B3, so that, as they explained: "... two rhombuses were there, where the two digits are 5...". After recording this action, they exchanged a rhombus from cell D1 and a triangle from cell A2: "... so that all the rhombuses are where the "fives" are...".

After recording the mentioned second action as the third action, she considered it necessary to move the square from cell A3 to cell D1, explaining: "... so that the squares are where the "sevens" are...".

By the next action, they were going to move the triangle from cell A2 to cell B2: "... so that all the triangles are where the "eights" are...". However, the experimenter reminded that this problem can be solved in three steps and offered to check what result was obtained after performing the found three mutual exchanges of figures in places. Checking the record of three actions showed that not all the figures are in the places of the corresponding numbers.

New attempts to solve this problem were as unsuccessful as the first attempt. When solving the fourth main problem, the students acted in the same way as when solving the previous (third) problem. As a result, it was solved incorrectly.

The actions of the students of subgroup B2 in solving the first main task were the same as those of the students of subgroup B1. It could be observed that the students do not find out the correspondence between the location of all the figures and the location of all the numbers and immediately write down the found variant of the interchange of two figures in order to have two identical figures in the places where two identical figures were found.

After the correct solution of the first main task, the second task was solved by them unsuccessfully.

The noted actions of the students of group B in solving the simplest basic tasks (Nos. 1 and 2) give reason to believe that they carried out a formal cognitive action of planning the solution of the problem, associated with a partial analysis of its conditions, with the definition and implementation of only one of the actions required for problem solving.

#### **4. Conclusion.**

So, our research, related to the conduct of individual experiments, consisted in approbation of the capabilities of the computer version of the "Repetition" method in determining the type of planning in solving problems in younger adolescents.

As a result of the experiments performed with 23 fifth-graders, it was shown that some students (65.2%) solve the problems of the computer version of the "Repetition" methodology using meaningful planning associated with a complete analysis of the conditions and determination of all required actions before they are performed.

Another part of the students (34.8%) used formal planning in solving problems, associated with a partial analysis of the conditions and the definition and implementation of each of the required actions.

Thus, the approbation showed that the computer version of the "Repetition" method allows you to determine the type of planning in younger adolescents, in particular, among schoolchildren studying in the fifth grade.

As further steps in testing this computer version of the "Repetition" methodology, it is planned to conduct a series of individual experiments with sixth graders.

Based on the analysis of the results obtained in experiments with pupils of the fifth and sixth grades, it will be possible to organize a survey of a relatively large number of pupils of the fifth and sixth grades. Such a survey is necessary to determine the age dynamics of the cognitive action of planning, the development of which is the content of a meta-subject

educational result associated with independent planning of solving problems to obtain the required result.

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# ECONOMY, ORGANIZATION AND MANAGEMENT OF ENTERPRISES, INDUSTRIES, COMPLEXES

UDC 658

**Batkovskiy A.M., Batkovskiy M.A., Omelchenko A.N. Assessment of  
profitability of the production diversification project taking into  
account the risk of its implementation and the liquidity factor**

Оценка доходности проекта диверсификации производства с учетом риска его  
реализации и фактора ликвидности

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**Abstract.** *Currently, there are various models for choosing the optimal options for production diversification projects, but in practice many of them are not used, since, due to the considerable complexity of the modeled process, they are usually illustrative in nature. Many of the procedures for this assessment are not formalized, and therefore, in the process of managing the diversification of production, the tools of expert evaluation of projects are often used at present. The article presents a formalized formulation of the problem of choosing the optimal diversification project based on an assessment of the profitability of the project, taking into account the risk of its implementation and liquidity. The use of the obtained research results in practice will help to optimize the process of diversification of production.*

**Keywords:** *evaluation, project, diversification, production, risks, tools.*

**Аннотация.** В настоящее время существуют различные модели выбора оптимальных вариантов проектов диверсификации производства, но на практике многие из них не применяются, так как, ввиду значительной сложности моделируемого процесса они носят, как правило, иллюстрационный характер. Многие процедуры данной оценки не формализованы и поэтому в процессе управления диверсификацией производства в настоящее время часто используются инструментарий экспертной оценки проектов. В статье представлена формализованная постановка задачи выбора оптимального проекта диверсификации на основе оценки доходности проекта с учетом риска его реализации и ликвидности. Использование полученных результатов исследования на практике будет способствовать оптимизации процесса диверсификации производства продукции.

**Ключевые слова:** *оценка, проект, диверсификация, производство, риски, инструментарий.*

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## **Введение**

Оценка диверсификационных мероприятий должна базироваться, с нашей точки зрения, на использовании методического инструментария, применяемого в инвестиционном менеджменте, который необходимо доработать применительно к специфике рассматриваемого объекта исследования [1; 2]. До настоящего времени отсутствует единая точка зрения по вопросу его использования при решении рассматриваемой задачи. Кроме того, применение на практике данного инструментария при оценке проектов диверсификации производства затруднено ввиду недостаточного объема необходимых для этого исходных данных; значительных рисков их реализации; сложности решаемых управленческих задач, требующих учета не только стоимостных, но и временных факторов, а также конкурентоспособности создаваемой диверсификационной продукции. Для преодоления негативного влияния отмеченных обстоятельств, снижающих оптимальность управленческих решений, необходимо дальнейшее развитие инструментария оценки проектов диверсификации производства продукции.

## **Методы и методики**

Результаты анализа зарубежного и отечественного опыта решения рассматриваемой задачи свидетельствуют, что существует достаточно широкий спектр

возможных методов и моделей оценки проектов диверсификации производства, каждый из которых может иметь свою область рационального применения [3; 4; 5; 6]. В качестве основных методов расчета показателей оценки проектов диверсификации производства используются экономико-статистические методы и методы экспертных оценок. Экспертные методы оценки проекта диверсификации производства продукции целесообразно использовать в случае, если информации, которая необходима для проведения расчетов на основе экономико-статистических методов, недостаточно [7]. Они базируются на результатах опросов высококвалифицированных специалистов с последующей обработкой итогов их оценок. В рамках опроса специалисты оценивают возможный показатель оценки по различным балльным шкалам.

### Результаты исследования

Используя различные методы оценки проекта диверсификации производства, можно рассчитать требуемый уровень показателя доходности бюджетных, внебюджетных и заемных средств, необходимых для его осуществления с учетом риска. С этой целью следует определить [8; 9]:

- значение показателя премии за риск, т.е. прибыли, которую инвестор требует помимо уровня дохода от инвестиций с нулевым риском:

$$P^{\rho} = (\bar{R} - R) \cdot \beta, \quad (1)$$

где  $P^{\rho}$  – показатель значения премии, в случае возникновения риска при реализации рассматриваемого проекта;  $\bar{R}$  – средняя величина показателя уровня нормы доходности проекта;  $R$  – безрисковый показатель уровня нормы доходности.

- общий показатель уровня нормы доходности по выбранному проекту, учитывающий фактор возникновения риска:

$$P_{NPV}^{\rho} = I \cdot P^{\rho}, \quad (2)$$

где  $P_{NPV}^{\rho}$  – показатель суммы премии, в случае возникновения риска;  $I$  – стоимость рассматриваемого проекта.

- общий показатель уровня нормы доходности по анализируемому проекту диверсификации с учетом фактора возникновения риска:

$$NPV^{\rho} = R + P^{\rho}, \quad (3)$$

где  $NPV^{\rho}$  – общий показатель уровня нормы доходности рассматриваемого проекта диверсификации с учетом фактора риска.

- показатель избыточной доходности для всех проектов диверсификации производства продукции, включаемых в производственную программу предприятия:



$$S = \frac{\sum NPV - R}{\sigma(\sum NPV - R)}, \quad (4)$$

где  $S$  – коэффициент, который показывает избыточную доходность бюджетных, внебюджетных и заемных средств, который характеризуется среднеквадратическим сдвигом показателя уровня избыточной доходности;  $\sum NPV$  – совокупный уровень доходности производственной программы предприятия, в которую включаются проекты диверсификации производства продукции.

- будущую стоимость бюджетных, внебюджетных и заемных средств с учетом возможности возникновения риска при реализации проекта диверсификации производства продукции:

$$FV^p = PI \cdot [(1 + R) \cdot (1 + P^p)]^n, \quad (5)$$

где  $FV^p$  – будущая стоимость бюджетных, внебюджетных и заемных средств, с учетом возникновения риска его реализации;  $PI$  – изначальная стоимость бюджетных, внебюджетных и заемных средств, необходимых для реализации проекта.

- настоящую стоимость бюджетных, внебюджетных и заемных средств с учетом возможности возникновения риска реализации проекта:

$$PV^p = \frac{FV^p}{[(1 + R) \cdot (1 + P^p)]^n}, \quad (6)$$

где  $PV^p$  – показатель, характеризующий настоящую стоимость финансовых средств, учитывая риск реализации проекта диверсификации производства продукции.

Процедура снижения рисков реализации проекта диверсификации может проводиться путем разделения рисков, их страхования и создания денежных резервов [10; 11]. Страхование рисков является инструментом защиты процесса диверсификации производства продукции путем использования фондов, которые формируются из сумм страховых взносов. Создание денежных резервов направлено на покрытие, неожиданных затрат в случае наступления рисков событий.

Вторым важным направлением развития инструментария оценки проектов диверсификации производства продукции является определение требуемого уровня нормы доходности с учетом фактора ликвидности как в абсолютных, так и в относительных показателях [12]. Ключевым абсолютным показателем оценки уровня ликвидности проекта, которая означает его способность обслуживать все имеющиеся денежные обязательства, считается совокупный временный промежуток вероятного

осуществления рассматриваемого проекта диверсификации производства продукции. Для расчета указанного показателя можно использовать следующую формулу:

$$P_l = P_{k1} - P_{k2}, \quad (7)$$

где  $P_l$  – совокупный временной промежуток показателя ликвидности проекта диверсификации производства продукции;  $P_{k1}$  – вероятный временной промежуток перерасчета вкладываемых в данный проект бюджетных, внебюджетных и заемных средств;  $P_{k2}$  – временной промежуток перерасчета вкладываемых в анализируемый проект финансовых средств с абсолютным показателем уровня ликвидности.

Основным относительным показателем рассматриваемой оценки является коэффициент ликвидности, который определяется с использованием следующей зависимости:

$$K_l = \frac{P_{k2}}{P_{k1}} \quad (8)$$

Естественно, при разработке производственной программы предприятия в нее необходимо включать высоколиквидные проекты диверсификации. При этом реализация проектов с низкими и средними показателями ликвидности должна стимулироваться возможностью получения дополнительных доходов в результате их осуществления [13]. Так, уровень ликвидности проекта с низким значением данного показателя должен быть обратно пропорционален размеру показателя доходности от его реализации или премии за ликвидность данного проекта. Показатель премии за ликвидность можно определить, используя следующую формулу:

$$P^l = \frac{P_l \cdot IRR^i}{360}, \quad (9)$$

где  $P^l$  – необходимый показатель уровня премии за ликвидность проекта диверсификации, в %;  $IRR^i$  – средний показатель годовой нормы уровня доходности по оцениваемому проекту диверсификации с абсолютным показателем ликвидности, в %.

При определении общего показателя уровня нормы доходности бюджетных, внебюджетных и заемных средств, необходимых для реализации проекта диверсификации с учетом фактора ликвидности, предлагается использовать следующую зависимость:

$$IRR^l = IRR^i + P^l, \quad (10)$$

где  $IRR^i$  – необходимый общий показатель уровня нормы доходности бюджетных, внебюджетных и заемных средств, необходимых для реализации проекта диверсификации производства продукции с учетом его ликвидности, в %.

Использование предлагаемого инструментария оценки стоимости бюджетных, внебюджетных и заемных средств с учетом показателя уровня ликвидности проекта дает возможность оптимизировать финансовое обеспечение процесса диверсификации производства продукции. С этой целью целесообразно использовать следующую формулу:

$$FI^l = PI \cdot [(1 + IRR^i) \cdot (1 - P^l)]^n, \quad (11)$$

где  $FI^l$  – будущая стоимость бюджетных, внебюджетных и заемных средств, с учетом показателя уровня ликвидности;  $PI$  – первоначальная стоимость этих ресурсов;  $n$  – число периодов финансирования.

Оценку настоящей стоимости бюджетных, внебюджетных и заемных средств с учетом ликвидности следует проводить, используя следующую зависимость:

$$PI^l = \frac{FI^l}{[(1 + NPV^i) \cdot (1 + P^l)]^n}, \quad (12)$$

где  $PI^l$  – показатель, характеризующий настоящую стоимость бюджетных, внебюджетных и заемных средств с учетом уровня ликвидности проекта диверсификации производства продукции.

### **Заключение**

Задача оценки проектов диверсификации производства является сложной, что обусловлено значительной степенью неопределенности в отношении будущего результата их реализации. Основной задачей количественной оценки рисков их реализации является получение информации о вероятностях случайного события, которая может быть определена объективным или субъективным методом. Наряду с традиционным пониманием риска как объективной или субъективной вероятности, существует подход к созданию математической модели риска реализации проекта диверсификации производства продукции. Однако по мере усиления неопределенности классические вероятностные описания риска уступают место, субъективным вероятностям, основанным на экспертной оценке.

Факторами риска реализации проекта диверсификации производства продукции выступают различные внутренние и внешние причины. В настоящее время нет единой классификации рисков реализации проектов диверсификации производства

продукции. Каждый из них уникален и поэтому создать универсальную классификацию данных рисков сложно. Однако, несмотря на уникальный характер каждого проекта диверсификации производства продукции, существует некоторый ограниченный перечень факторов, анализ которых можно применить ко всем проектам. В статье представлен инструментарий расчета необходимых для этого показателей.

Расчет необходимого уровня доходности бюджетных, внебюджетных и заемных средств, требуемых для реализации проекта диверсификации производства с учетом фактора ликвидности, предложено основывать на анализе взаимосвязи показателей, которые определяют шкалу «доходность – ликвидность».

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## Popov Y.A. Current trends and prospects of economic development of the Russian leather and haberdashery sector of the light industry

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**Abstract.** *This scientific work reveals the causes and current trends in the Russian light industry on the example of the leather and haberdashery industry. The prerequisites that served as the basis of the current state of the analyzed industry are described. Statistical data indicating the state of the industry as a whole are presented. The key trends in the course of increasing the profitability of modern manufacturing enterprises are considered. Positive examples of the activities of Russian companies in the current conditions are reflected. The potential prospects for the development of the entire leather and haberdashery industry are described.*

**Keywords:** *light industry, manufacturing, leather and haberdashery industry, raw materials, processing technologies, product range, competitiveness, production capacity.*

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The modern light industry of the Russian Federation is a set of specialized economic sectors that involve the production of mass consumption goods and services from different types of raw materials. The textile, leather, fur, footwear, apparel and innovation groups included in it have every reason to become the engine of the country's economic development.

Light industry is a strategic industry for Russia. According to the methodological documentation in the sphere of light industry development strategy - the main competitive advantages of the Russian Federation are the presence of developed oil and chemical industries and the presence of developed industries-consumers of industrial textile products, but these advantages are not yet realized. Against the background of the ever-increasing role of chemical materials in the light industry, Russia has a significant potential for development in this area. In the aggregate, the implementation of development directions will make it possible to increase the volume of the industry one and a half times (by 0.5% of GDP). In addition, it will be possible to overcome the natural reduction of employment in the industry

and create up to 245-330 thousand new jobs [5]. This fact determines the relevance of the topic under consideration.

One of the main branches of the light industry under consideration are the leather and haberdashery industries and, consequently, their overall economic sphere. Despite the rich history and centuries-old experience of creating the highest-class products, these industries after a significant, almost fatal decline in the 90s of the last century, as well as already modern pandemic Covid-19, which had a significant impact on the entire world economy, and against the background of the current foreign policy crisis have serious prospects and opportunities for development. However, there are also a number of difficulties and problems. For example, the negative consequences of Covid-19 led to a supply shock to a certain extent. IMF experts have highlighted problematic aspects in economic development during the spread of the virus. They are expressed in the reduction of labor supply, as well as the absence of workers at their places for various reasons. Reduction of both demand and supply in the crisis economic situation in the country led to a drop in the income of enterprises.

The current situation of political and economic relations with other countries, and the consequent withdrawal of a number of brands and suppliers, has also provided the groundwork that could allow for a significant leap forward.

According to a number of studies by analytical agencies, the critical point of decline in leather goods production in the Russian Federation over the past 10 years was in 2020. According to ACG estimates, the production of leather goods and haberdashery goods decreased by 20.7% compared to the same indicator in 2019. The production of suitcases, handbags, ladies' bags and similar articles made of genuine leather, combinations of leather, plastic sheets, textile materials, vulcanized fibers or cardboard decreased by 7.6% [7].

The fact that the industry in question is supplied with raw materials deserves special attention. For example, from 2014 to 2018, sales of raw hides and skins of cattle in Russia decreased by 5.2%. The domestic market experienced a deficit due to the high profitability of their export. Raw materials were sold abroad for foreign currency, which was a more preferable payment option [2]. However, today in the Russian Federation, tanneries are striving to work on domestic raw materials.

It should be noted that production growth rates are limited precisely by the volume of raw material base. The main criterion for assessing the volume of raw materials for leather goods is quantitative, i.e., the number of livestock at the enterprise. Thus, according to Federal State Statistics Service, in the first quarter of 2020, the number of cattle in Russia decreased by 2.2% compared to the same period of 2019, pigs – by 4.5%, goats and sheep – by 2.4% [9].



The previously mentioned Covid-19 pandemic was the very factor when there was an increase in the volume of purchases of natural leathers on the domestic market. Most companies began to plan their own strategies to strengthen their market position in a difficult economic environment.

Along with this, it is important to note that the tannery industry has many production features that affect the location of the company, due to the strong impact on the environment. Tanneries are the fourth most polluted industries in the world [4]. This imposes additional constraints and increases production costs. For example, tannery production requires a large amount of water at many stages of raw material processing, and the chemical and organic substances used pollute water. This includes elements such as chromium, aluminum and others used in leather processing. Large amounts of sodium chloride, which is used as a preservative for raw hides, as well as particles of fat, meat, sinew and wool also pollute the environment.

Analyzing this branch of light industry in the first 20 years of the XXI century, experts recorded the fact of equipment obsolescence, which could not process raw materials in the required volume and high quality, as well as the lack of technologies for the production of elite varieties of leather, and, consequently, incentives to improve the quality of raw materials and increase prices for them. Small farms are unable to organize raw material supply, as they cannot always afford to hire highly qualified specialists and ensure delivery of raw materials to the place of their processing. In turn, the lack of productivity growth leads to the inability to increase purchases of raw materials on the domestic market at favorable prices for livestock breeders.

At the same time, it is important to note that the rates of development of domestic production and demand differ markedly. Thus, according to average estimates, the growth rate of production is about 4%, which is twice less than the growth rate of demand. This indicates that the growing demand can be satisfied by import supplies, and their growth would outpace production [3].

It is logical that the solution to such problems is the creation of domestic well-equipped and modern production facilities, which at the same time, of course, must be profitable.

The analysis of technical processes at the enterprises of the industry under consideration, as well as a number of studies allows us to identify several key trends in the course of improving the profitability of production:

- introduction of modern processing technologies for the production of more expensive leather grades with subsequent import substitution in the domestic market;

- improving the quality of hides at the initial stage, before they go directly to the factory. A large number of defects on the leather significantly reduces its value and makes it unsuitable for the production of high-quality and elite grades of leather;
- use of additional equipment to reduce processing time at intermediate stages, thus speeding up the production process;
- increasing the assortment of products of various shapes and colors, which will constantly increase the number of customers;
- minimizing the environmental impact through the use of various cleaning and recycling systems. As a consequence, the choice of location for the plant will increase significantly, thus saving on logistics costs;
- improving water treatment systems for industrial waste. Fines for violating environmental safety standards can make production unprofitable. There is also an opportunity to reuse chemical reagents for processing hides. At the same time, the fight for the state of ecology has been given quite serious attention in recent years. In turn, non-environmental enterprises may find themselves under strong pressure from the state and the public [6].

Thus, it becomes possible to note that the domestic leather goods industry has undergone serious negative changes, in particular, the reduction of conditions for stable supply and demand for goods and services. However, new prerequisites for its development have emerged, primarily in the domestic market. The main ones can be considered to be the spread of widespread introduction of robotics and artificial intelligence into production and household chains, trends of digital presence of leather goods and haberdashery products and services on the Internet, increase in platforms for online training of employees and incentives for the educational process with further employment, and many others.

As a result, in the strategy for the development of light industry in the Russian Federation for the period until 2025, the leather and haberdashery industry occupy one of the 4 main places: "Creating in Russia the production of tanning materials for both clothing and footwear, as well as for the furniture and automotive industries, increasing the degree of processing and utilization of tannery waste, the organization of associated production of biocomponents and bio-additives" [8].

Achieving the development goals will require addressing the issues of increasing the production potential on the basis of technical re-equipment and modernization of production, it is necessary to introduce new technologies, as well as to reduce the technological and commodity dependence of industries on other countries. It is necessary to ensure economic efficiency of production, significant growth of labor productivity. It is necessary to strive to

constantly improve the environmental safety of technological processes, resource conservation, and production culture. It is necessary to fight against shadow production and illegal import of footwear in order to increase the share of goods produced in Russia in the domestic market. It is necessary to establish inter-regional and intersectoral commercial ties with CIS countries, to improve integration and develop inter-territorial and intersectoral interaction of industrial entities and small businesses, to develop systems of reproduction of labor resources, training of workers, managers and managerial personnel capable of successfully conducting production process and business in a market economy. The state policy should provide sufficient funding for small and medium-sized businesses, as well as legislatively ensure the stable position of domestic producers in the domestic market, improve customs and credit policies, and stimulate the export of Russian footwear.

Russian tanneries aim to implement modernization, digitalization and the latest technical equipment. According to Federal State Statistics Service, these trends are supported by the state: investments for this industry amount to about 1.5 billion rubles [9]. This factor is also interrelated with the increased competitiveness of Russian haberdashery products not only in the domestic market, but also in the foreign market.

Among the most successful prospects for the development of the leather and haberdashery industry in the Russian Federation are:

- transition to the latest technological base. Its main advantage should be a well-established process of low-waste production (or, if possible, zero-waste production).
- improvement of the processes of labor organization and management of the working staff at the enterprise. The main factor for development is the improvement of the educational process in the industry in question.
- the use of environmentally friendly leather production techniques (e.g. chrome-free tanning).
- expansion of the range of leather goods, development of domestic brands, etc.

At the moment, the leather goods industry in Russia is undergoing a number of technological changes that set a new vector of development. The high potential of this branch of light industry requires state support in the development of manufacturing production, creation of domestic technological and material base, as well as implementation of the strategy of import substitution of products. In its turn, the state in the realization of these prospects tends to occupy one of the main roles, as it systematically carries out stimulation of the development of the domestic raw material base by subsidizing the increase in the number of livestock and improving the quality of hides harvesting, as well as seeks to apply a flexible customs and tariff policy.

The competitiveness of Russian goods in the foreign market has increased. Currently, the Russian light industry is a highly competitive industry with a high share of small and medium-sized enterprises. There are more than 29 thousand enterprises and 49 thousand individual entrepreneurs in the industry [1].

The increase in demand for Russian products has caused additional pressure on production capacity. This has led many domestic enterprises to actively develop their production, which declined significantly during 2020. The Russian light industry accounts for 0.9% of GDP, which is 2.4% of industrial production or 3.6% of total manufacturing [5].

One of the positive examples in the development of the light industry is the leather industry, namely the production of leather for haberdashery and footwear. While the quality of Russian leather used to be questionable and production volumes were insufficient, over the last 10-15 years there have been positive changes. Russian leather is not inferior to generally recognized analogues and is now used not only for the production of clothing and footwear, but also for other industries - automotive, aviation, furniture.

Russian raw materials are used by many companies, such as those producing footwear. The Faraday company produces new types of special-purpose footwear, Bris-Bosfor is creating a new footwear production facility with a capacity of up to 12 million pairs per year. Some of the largest footwear production facilities are JSC "Ralf Ringer Footwear Factory" (Moscow), JSC "Egorievsk-Obuvvie" (Egorievsk), JSC "Unichel Footwear Factory" (Chelyabinsk), LLC "Pskov-Polymer" (Pskov), LLC "Lel Footwear Factory" (Kirov). All these productions buy leather from large tanneries, such as JSC "Russkaya Kozha", JSC "Verkhnevolzhskiy tannery", JSC "Khrom", LLC "Arsenal". Russian Leather" company has a rapid pace of development, it actively introduces the direction of production of environmentally safe leathers that have no domestic analogues.

As of today, the growth rate of the leather industry and reorientation towards raw material processing contributes to its further development. Therefore, the main goal laid down in the light industry development strategy is to increase the share of Russian goods in the domestic market.

Summarizing, it should be noted that despite the outlined positive trends, the development of the domestic light industry was complicated in 2020, mainly due to the introduction of quarantine restrictions and, as a consequence, the growth of unemployment. This affected the purchasing power of consumers seeking to save cash. Retail stores of shoes and clothes were closed for a long time, so online sales increased. Due to the foreign policy circumstances of the last two years, it is difficult to give accurate long-term economic forecasts, but the potential associated with the development of import substitution in the light

industry is quite high. According to statements by the Ministry of Industry and Trade, for example, the production of footwear in Russia grew by 7.3% in January-June 2022 compared to the same period in 2021 [5].

Competition with other countries sets goals for Russia in the light industry, the achievement of which is necessary for the state to remain one of the main participants in the world market. For the sake of meeting the needs of buyers, its constituent industries must constantly develop and have different levels of production, differing in types of products, volumes of processed data, new materials, technologies, etc. In turn, the organization and modernization of modern tannery production is impossible without the introduction and use of modern technologies and equipment. Special attention should be paid to the following aspects: the impact of the enterprise on the environment, active expansion of the range of products, improving the quality of raw materials.

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# TECHNOLOGY, ENGINEERING

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## Shiryaev A.D. Research of production technologies and analysis of prospects for the use of liquefied natural gas

Исследование технологий производства и анализ перспектив применения сжиженного природного газа

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**Abstract.** Liquefied natural gas (LNG) is an important and promising type of energy resource that is produced from natural gas by cooling it and compressing it to a liquid state. LNG production is a complex and technologically advanced process that requires specialized installations and equipment. This article analyzes the LNG market, discusses the main stages of LNG production, technologies and difficulties associated with this industry.

**Keywords:** liquefied natural gas (LNG), LNG production, expander, Claude liquefier, deep cooling cycle, throttling, regasification.

**Аннотация.** Сжиженный природный газ (СПГ) является важным и перспективным видом энергоресурса, который производится из природного газа путем его охлаждения и сжатия до жидкого состояния. Получение СПГ является сложным и технологически продвинутым процессом, который требует специализированных установок и оборудования. В данной статье произведен анализ рынка СПГ, рассмотрены основные этапы производства СПГ, технологии и трудности, связанные с этой отраслью.

**Ключевые слова:** сжиженный природный газ (СПГ), производство СПГ, детандер, ожижитель Клода, цикл глубокого охлаждения, дросселирование, регазификация.

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Сжиженный природный газ (СПГ) - это природный газ, охлажденный до жидкого состояния при температуре около -160 градусов Цельсия для транспортировки и хранения. Объем природного газа в жидком состоянии примерно в 600 раз меньше его объема в газообразном состоянии [1]. Этот процесс позволяет транспортировать

природный газ туда, куда не доходят трубопроводы. Сжижение природного газа - это способ транспортировки природного газа на большие расстояния, когда транспортировка по трубопроводу невозможна. Данный процесс был впервые открыт в 1820 году британским ученым Майклом Фарадеем, который успешно охладил природный газ, чтобы превратить его в сжиженную форму. Около 100 лет спустя в Западной Вирджинии был построен первый завод по производству СПГ. Первый проект завода СПГ в России появился в 1945-1947 гг., когда остро стал вопрос о регулировании суточной неравномерности потребления газа из газопровода Саратов-Москва.

На данный момент Российская Федерация является вторым по величине производителем природного газа в мире после США и обладает крупнейшими в мире запасами газа. Россия является крупнейшим в мире экспортером газа. В 2021 году РФ произвела 762 млрд кубометров природного газа и экспортировала по трубопроводу около 210 млрд кубометров. «Газпром» и «Новатэк» являются основными производителями газа в России, но многие российские нефтяные компании, в том числе «Роснефть», также эксплуатируют объекты по добыче газа.

Кроме того, Россия расширяет свои мощности по производству СПГ, чтобы конкурировать с растущим экспортом из США, Австралии и Катара. В 2021 году правительство опубликовало долгосрочный план развития СПГ, предусматривающий экспорт СПГ на уровне 110–190 млрд кубометров в год к 2025 году. В 2021 году Россия экспортировала 40 млрд кубометров СПГ, что сделало ее четвертым крупнейшим экспортером СПГ в мире и обеспечило примерно 8% мировых поставок сжиженного природного газа. Производство СПГ за 2022 год составило 21,6 млн тонн, что на 13,5% больше, чем в 2021 году [2].

В связи с событиями, происходящими в мире, ожидается, что мировой спрос на природный газ останется невысоким до 2025 года. Стремительное желание Европы к применению сжиженного природного газа с целью поэтапного отказа от поставок по трубопроводам из России и ограниченное расширение глобальных экспортных мощностей по производству СПГ повышают риск продолжительной напряженности на рынках [3].

В «компактной» жидкой форме природный газ может доставляться в специальных танкерах на терминалы по всему миру. На этих терминалах СПГ возвращается в газообразное состояние и транспортируется по трубопроводам к распределительным компаниям, промышленным потребителям и электростанциям.

Для создания СПГ природный газ должен пройти несколько стадий переработки на заводах по производству сжиженного природного газа.



Первым шагом является очистка природного газа на заводе по сжижению. Природный газ чаще всего состоит из метана, однако он может включать другие соединения и газы, такие как бутан, пропан,  $\text{CO}_2$  и даже нефть и воду. Чтобы природный газ всегда соответствовал высоким стандартам, составляющим около 85-99% метана, и его можно было безопасно использовать и транспортировать, его необходимо очищать.

Существует ряд процессов, используемых для удаления различных загрязняющих газов, которые могут присутствовать в исходном сырьевом газе (природном газе). Однако не все удаляемые газы и соединения тратятся впустую. Ненужные пропан и бутан можно удалить, а затем восстановить и переработать для создания пригодных для использования продуктов

Следующим этапом является сжижение очищенного газа. Процесс охлаждения газа подобен тому, который используется в холодильниках. Отдельный газообразный хладагент сжимается, охлаждается и конденсируется. Этот газ обычно является одним из газов процесса очистки, который рекупируется и используется повторно. После конденсации газа давление снижается, что приводит к падению температуры за счет эффекта Джоуля-Томсона. Затем этот охлажденный газ используется для охлаждения исходного газа до температуры, необходимой для сжижения тяжелого газа метана, около  $-160$  градусов Цельсия.

СПГ намного плотнее природного газа и занимает  $1/600$  часть объема. Это позволяет транспортировать большие объемы цистернами, а не по трубопроводам [4]. Однако, чтобы СПГ оставался жидким, любое транспортное средство должно быть соответствующим образом оборудовано для поддержания низкой температуры. Для использования СПГ, его необходимо повторно нагреть, чтобы вернуть в газообразную форму, этот процесс называется регазификацией.

В настоящее время существует множество видов заводов по сжижению природного газа. Одним из основных критериев классификации заводов СПГ является производительность по жидкому газу [5]:

1. Малотоннажные заводы по СПГ - до 1 млн т СПГ в год;
2. Среднетоннажные заводы по СПГ - от 1 до 2 млн т СПГ в год;
3. Крупнотоннажные заводы по СПГ - более 2 млн т СПГ в год.

В России крупнотоннажный СПГ производят заводы "Сахалинская Энергия", "Ямал СПГ", также СПГ производят среднетоннажный завод на компрессорной станции "Портовая". Среднетоннажное производство СПГ дает возможность гибко подстраиваться под рыночный спрос, не создавая избыточных мощностей, и в

наибольшей мере отвечает современным рыночным реалиям, обеспечивая относительно короткий период в овозврата инвестиций.

Для сжижения газа необходимо охладить его до низких температур. В настоящее время для получения весьма низких температур для сжижения природного газа применяют циклы глубокого охлаждения: дроссельный; детандерный; азотный [6]. Также для сжижения газов и выделения определенных газов из смесей используют каскадный цикл; этот цикл является одним из самых эффективных, но, в то же время, он имеет самую сложную конструкцию и требует наличия нескольких хладагентов, что уменьшает его экономичность.

Основой дроссельного цикла является дросселирование-расширение газа без совершения работы. Этот метод сжижения газа также называется метод Линде. Схема данного цикла и его изображение на  $T-S$  – диаграмме показаны на рисунке 1. Газ при температуре, близкой к окружающей среде, и низком давлении поступает в компрессор КМ, где его давление повышается, затем охлаждается в охладителе ОХ до первоначальной температуры. На  $T-S$  – диаграмме процесс 1–2 сжатия и охлаждения газа показан условно как изотермический. Далее через регенеративный теплообменник РТ газ подается к дроссельному вентилю ДВ. В первый момент пуска сжатый газ дросселируется в ДВ, и его температура снижается. Охлажденный газ через испаритель И, тепло к которому еще не подводится, поступает в регенеративный теплообменник, в котором нагревается, охлаждая следующую порцию газа. Газ с этой температурой также используется для охлаждения сжатого газа перед ДВ, тогда после дросселирования достигается более низкая температура и т.д. Через некоторое время газ охлаждается настолько, что дросселирование будет заканчиваться в области влажного пара.

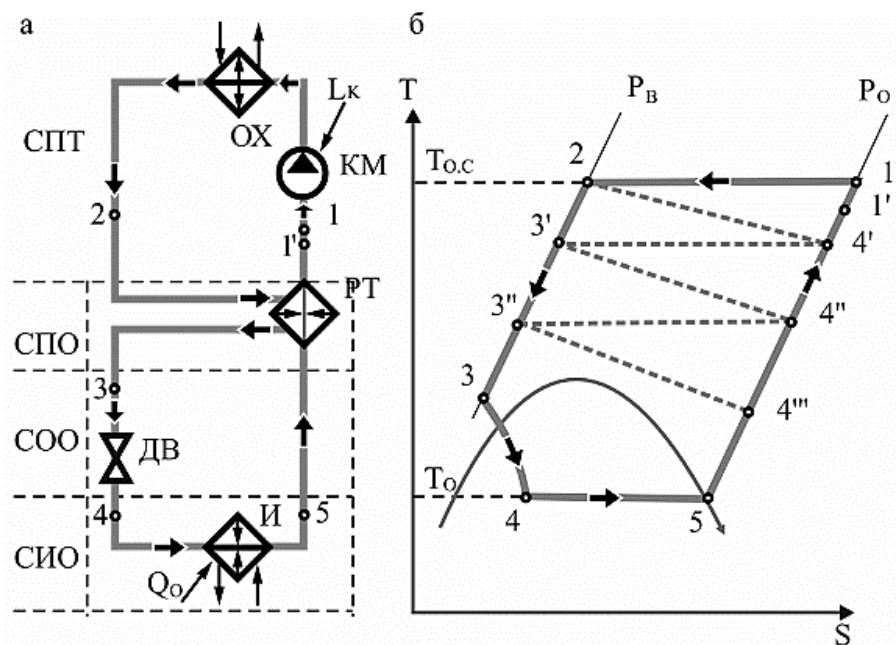


Рисунок 1. Цикл Линде: а – схема цикла; б – T-S-диаграмма цикла [7]

Холодопроизводительность цикла Линде характеризуется параметром - изотермический эффект дросселирования, который равен разности энтальпий между газом высокого и низкого давления при одинаковой температуре. Преимущество цикла Линде – простота, недостаток – неэкономичность. Если использовать цикл Линде с циркуляцией, то такой цикл будет более экономичным.

Основа детандерного цикла – адиабатическое расширение газа с отдачей внешней работы. Также метод сжижения называют циклом Клода. Схема и изображение процессов на T-S-диаграмме метода Клода приведены на рисунке 2. Сжатый газ после компрессора KM и охладителя ОХ поступает в предварительный теплообменник ПТ, где охлаждается обратным потоком расширенного газа, после чего газ разделяется на два потока. Часть газа (1– M) проходит через промежуточный теплообменник ПмТ, основной РТ и после охлаждения дросселируется. Полученная после дросселирования доля жидкости выводится из отделителя жидкости ОЖ. Отвод некоторой части M прямого потока в детандер ДТ позволяет охладить оставшееся (1–M) количество сжатого газа в теплообменниках ПмТ и РТ до более низких температур, чем в квазицикле Линде. Это приводит к уменьшению разности температур в этих теплообменниках.

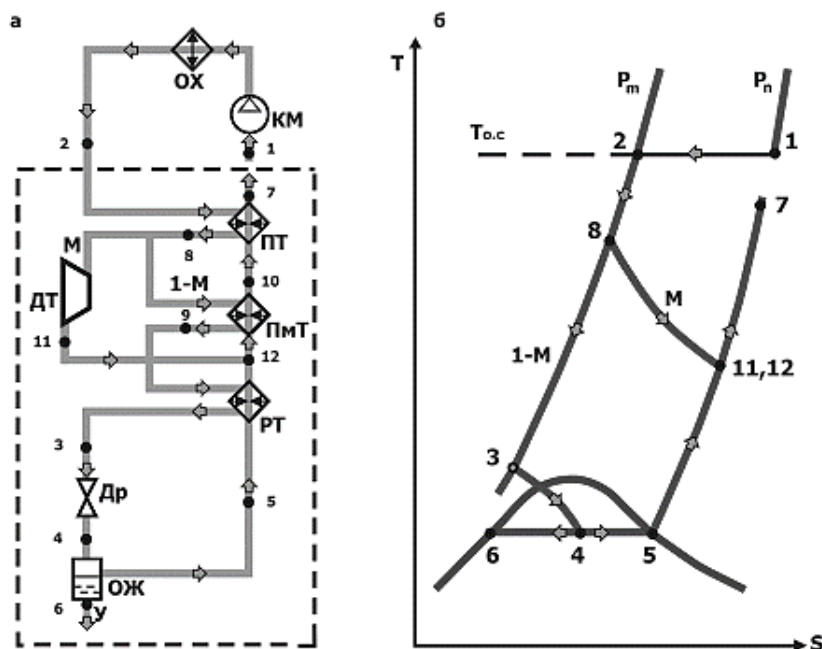


Рисунок 2. Цикл Клода: а – схема цикла; б – T-S-диаграмма цикла [7]

На практике находят применение также другие схемы квазициклов ожижения газов с внутренним охлаждением в СПО посредством детандера, например, установка Капицы.

Выбор схемы сжижения природного газа зависит от ряда параметров, таких как: состав, температура, давление газа, наличие и концентрация примесей, производительность установки, требования к составу СПГ. Цикл Линде с однократным дросселированием отличается своей относительной простотой, но подходит только для установок небольшой производительности по жидкому газу. Цикл Линде с предварительным охлаждением, цикл Линде с циркуляцией, и комбинация этих циклов более применимы для установок большой производительности, но целесообразнее использовать установки Клода, так как они более экономичны и имеют более простую конструкцию. Детандерный цикл ожижения среднего давления сочетает в себе относительную простоту конструкции по сравнению с азотным циклом и большую производительность по СПГ по сравнению с циклом Линде.

В соответствии с рисунком 3 существует несколько направлений использования СПГ. Сжиженный природный газ может быть использован для генерации электроэнергии в газотурбинных установках, а также для работы парогазовых установок, что позволит диверсифицировать источники энергоснабжения и снизить

зависимость от угля и нефти. Также СПГ может быть использован для обеспечения теплоснабжения в жилых и промышленных комплексах. Это особенно актуально для удаленных районов, где нет доступа к газопроводной инфраструктуре.

Практическое применение сжиженного природного газа возможно в качестве топлива для автомобилей и железнодорожного транспорта. Данный вид топлива позволит снизить выбросы вредных веществ и улучшить экологическую обстановку в городах. Кроме того, СПГ может быть использован в процессах химического производства, таких как производство удобрений, пластмасс и других химических продуктов [8].

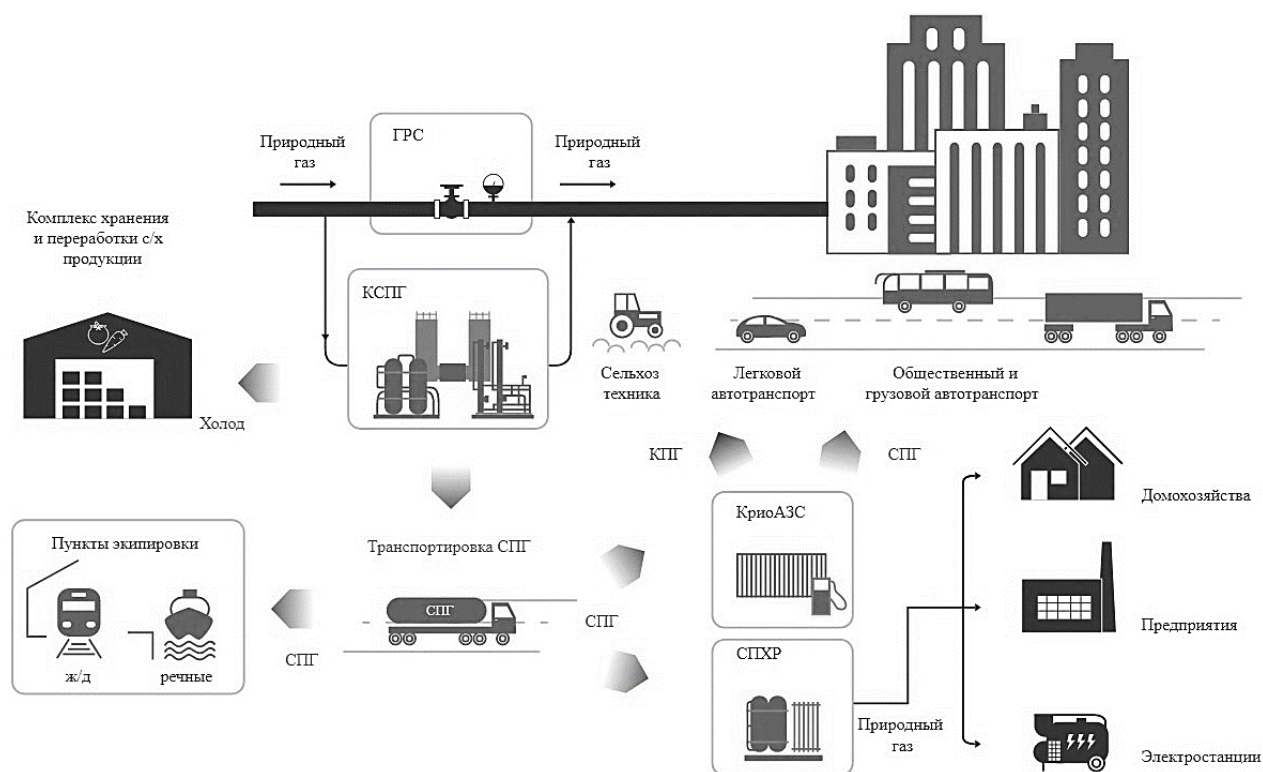


Рисунок 3. Сферы применения СПГ [9]

СПГ имеет ряд коммерческих, экологических и энергетических преимуществ перед традиционными видами топлива при применении как в качестве моторного топлива, так и топлива энергоустановок. СПГ является одним из самых чистых видов топлива, сравнимым с энергией, получаемой из возобновляемых источников. Он содержит меньшее количество вредных выбросов, таких как диоксид углерода и оксиды азота, что способствует снижению загрязнения окружающей среды и

улучшению качества воздуха. СПГ является негорючим и не взрывоопасным материалом в жидком состоянии, что делает его более безопасным для хранения и транспортировки по сравнению с другими видами топлива [10]. Также одним из основных преимуществ сжиженного природного газа является его высокая энергетическая плотность.

Практическое применение сжиженного природного газа имеет огромный потенциал для устойчивого развития и снижения вредного влияния на окружающую среду. Производство СПГ является сложным и технологически продвинутым процессом, который требует специализированных установок и оборудования. Он представляет значительный потенциал для обеспечения энергетической безопасности, снижения выбросов вредных веществ и диверсификации источников энергоснабжения. Производство СПГ может стать способом для уравнивания экспорта природного газа в разных направлениях, изменения структуры экспорта и открытия новых рынков для Китая в обход третьих стран.

Современные тенденции на мировом рынке природного газа требуют развития отечественной отрасли СПГ. Высокое качество, чистота и соответствие всем требованиям, связанным с экологической чистотой продуктов на рынке энергосырья, а также отсутствие ограничений при транспортировке, характерных для обычного газа, способствуют росту интереса именно к этому виду топлива.

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