ARPN Journal of Engineering and Applied Sciences

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PROJECT OF MULTI-PURPOSE RESEARCH NUCLEAR INSTALLATION ON FAST NEUTRONS IS TO ENSURE THENATIONAL ECONOMY SAFETY

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ABSTRACT

The article considers some opportunities of perspective nuclear power development which being guarantee of branch competitiveness in the internal and external markets, make essential impact on formation of national economy safety potential. In the conditions of an unstable environment of the raw markets the nuclear power strengthens the priority in system of instruments of increase of an economical and political statehood in the world community. Accumulation of construction speed of nuclear power plants around the world actualizes problems of search of nuclear fuel rational use ways. At the same time reduction of highly profitable fields of uranium and a suspension of development of uranium mining assets by leading enterprises is observed now. Besides, there is a problem of ensuring safe storage of spent fuel. As one of the most perspective modern innovative projects of the development of nuclear power directed to the specified problems solution, authors of article consider creation and operation of multi-purpose research nuclear installation on fast neutrons (MBIR) in the long term. The work represents advantages of this project intended for carrying out a wide range of the researches directed to scientific and experimental search of opportunities and results of use of perspective types of fuel, closed nuclear cycle strategy, researches with use of radioactive radiation, etc. It is proved that use of opportunities of MBIR Reactor will allow to solve problems of resource provision, economic security, competitiveness increase of not only branch productions, but also national research platforms. The research, technological and economic advantages of this installation allowing to create the safe highly effective research reactor that will significantly increase the level of knowledge intensity of nuclear branch production are opened and systematized and will provide economic efficiency of the project.

Keywords: safety of national economy, nuclear power, the energy carrier, the closed nuclear cycle, MBIR reactor.

1. INTRODUCTION

The domestic nuclear power is referred to the number of the boom knowledge-intensive branches of the national economy. One of the main tasks of the State Nuclear Energy Corporation “Rosatom” is a modernization and technological re-equipment, based on its own developments and human capacity and also cooperation with external strategic partners. Increasing amounts of financing research to 4,5 % of the Rosatom’s revenue by 2020 is focused on creating conditions for the efficiency in the performance of an international battle on energy capacity by 2030.

The modern negative dynamics of Russia’s economic and political relationship with its chief foreign partners (the USA and Western Europe) deforms an interaction strategy in the nuclear power (20% of Uranium is mined at the territory of the USA under the Russian control (Uranium One)). It will actualize search problems of directions about enhancing the national security and independence. The innovation technologies, directed to nuclear power development, become that strategic superiority, which provides not only the highest country rating in the global power market, but it creates a special political atmosphere of nuclear country. It makes a favourable influence on the dynamics of the foreign economic and political relations and it also serves as a considerable support for the development of the national economy.

2. THE MAIN PART

In the conditions of increasing instability in energy world market conjuncture, developing the Russian nuclear power becomes a top-priority factor for promoting economic redevelopment and national security. It leads to actualizing the problems about supplying nuclear power plants (NPPs) with fuel material, preserving and increasing raw materials strategic potential and also minimizing the probability of accident situation occurrence, causing the great environmental and economic damages. The problem of radioactive waste explosion, having a considerable destructive effect, is of key importance.

NPPs use uranium as a nuclear fuel, whose main mining is centered in the 10 countries of the world [2] (Table-1).

Table-1. The top ten country -leaders in the field of uranium mining in 2007 and 2014 [2].

Rating	The year of 2007		The year of 2014	
	Country	**Uranium mining, million tons**	**Country**	**Uranium mining, million tons**
1	Canada	9,476	Kazakhstan	23,127
2	Australia	8,611	Canada	9,134
3	Kazakhstan	6,637	Australia	5,001
4	Russia	3,413	Niger	4,057
5	Niger	3,153	Namibia	3,255
6	Namibia	2,879	Russia	2,990
7	Uzbekistan	2,320	Uzbekistan	2,400
8	USA	1,654	USA	1,919
9	Ukraine	0,846	China	1,500
10	China	0,712	Ukraine	0,926

Today nuclear power resumes its development after the recession, resulted in the accident at the Japanese NPP “Fukushima-1”. In general, the positive dynamics for all countries is predicted, but the center of activity will be displaced from Western Europe, Japan and the USA towards China, Russia, Korea, India and the Middle East [1]. Constructing the new NPPs and increasing their capacity will continue a tendency to the growth in fuel demand. However, the level of the world prices for natural uranium did not increase after falling in 2011 that led to decreasing the profitability of its mining and ceasing developing uranium mining assets by many companies, including the Russian holding “Atomredmetzoloto”. However, the major deposits, which have a low cost-price for uranium mining, will have been depleted by 2030 and developing the inaccessible deposits will result in cost price development and cause further decline in nuclear fuel export.

According to the experts, demands for the fuel of the Russian NPPs are not in full covered due to their own mining, and Rosatom meets a deficit by using weapon-grade uranium reserves [3]. Therefore, there arises a contradiction between the necessity to strengthen development of the Russian nuclear industry and the worldwide tendency to reduce offers in the nuclear fuel market. One can resolve this contradiction and neutralize the negative consequences of the political and economic diversities by means of searching for the alternative ways of meeting the demand for uranium.

In spite of the fact that it is still economic to mine uranium and it is still rather cheap, it is necessary to think over the preventive measures, aimed at forming a strategic potential of the nuclear industry by strengthening its innovative development. Introducing new technologies and approaches must not only allow overcoming the above-stated problems of resource provision, but it must also serve as a basis for the national state’s competitive ability in the longer term. It will create conditions for increasing the safety level of the national economy and its independence from the political and economic interests of the partner countries. Meanwhile, the potential of the state’s nuclear power depends not so much on constructing the new NPPs as the technologies, directed to optimizing and increasing the efficiency and safety of the NPPs operation.

The above-noted tasks include the questions about using the spent nuclear fuel and increasing the safety and efficiency level of its storage. These questions have been decided for a long time and must become a new processing area for developing the domestic nuclear power and create the conditions for society sustainability [4]. Many studies are known to be devoted to the advantages of introducing the strategy of the closed nuclear cycle and constructing fast nuclear reactors [5, 6]. The expediency of refusing neutron moderator was proved by I.V. Kurchatov and the Soviet scientists developed and implemented the idea of the power fast nuclear reactor (FNR). Du to the FNR there appears a possibility of breeding nuclear fuel and increasing energy production from ton of natural uranium 20-30 times. The necessity for placing the FNR into operation was repeatedly emphasized at the beginning of the new millennium and remains topical in view of implementing the strategy for intensive development of the nuclear industry long term up to 2020 [7, 8]. According to the expert evaluation, made within the INPRO project (International Project on Innovative Nuclear Reactors and Fuel Cycles), the share of the nuclear industry increases, the Russian FNR technologies are at a commercialization stage and the level of developing the strategy of the closed nuclear cycle is high in the country against the background of the growing world need for the electric power [9]. It shows existence of the effective processing area for further innovative development of this industry.

2.1 Developing the alternative reactor technologies

Developing the alternative reactor technologies requires power engineering industry enterprises being

VOL. 12, NO. 2, JANUARY 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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involved in solving this task. One of the leading and perspective participants of the noted strategy is the branch of JSC "AEM-technology" "Atommash" in Volgodonsk (further -Atommash), the leader of the domestic atomic power plant engineering that was recognized in the Soviet period with an accurate smooth- running production of nuclear installations. The strategic task of developing and mastering the production of generator units and the FNR was set before the plant early in the 90s years of the past century, intended to solve the scientific and technical problems of power ascension is implemented and integrated into the system of the modern state priorities.

Now a design engineering preparation for producing the major components of design-technology preparation of production of the main knots of the multi-purpose research nuclear installation on fast neutrons (MBIR) is being made at Atommash. The reactor facility (RF MBIR) includes the MBIR and a complex of systems, elements and experimental devices, which are placed in the territory, determined by the project and intended for using neutrons and ionizing radiation in the research purposes.

2.2. The reactor facilities and testing

The reactor facility MBIR is intended for ensuring performance of a wide range of research and experimental works by using reactor radiation by areas of activity [10]:

- radiation tests of the perspective types of fuel absorbing and constructional materials;
- for nuclear reactors of various type, including the innovative reactor and thermonuclear facilities, in the conditions of intensive neutron radiation with a current density (2 - 5)·1015 cm-2s -1;
- reactor tests of fuel elements, fuel assembly (FA), absorber elements (AE) and other elements of an active zone in the stationary, transitional and emergency operating regimes for the innovative reactors of the next generation with perspective types of the heat carrier (sodium, heavy metal, gas, liquid saline ones, etc.); it is congruent with the second scenario of the strategy for developing the Russian nuclear technologies of the new generation up to 2020, according to which it is necessary for risk minimization, besides reactors with a lead heat carrier, to carry out additional developments of reactors with sodium and lead-bismuth heat carriers;
- to conduct complex computational and experimental studies for obtaining the necessary information for accounting code development and verification;
- to research the closed nuclear fuel cycle (CNFC);
- to mature the manufacturing techniques of the radionuclide products of various purpose and the result of the modified materials;
- to conduct applied research by using reactor radiations;
- to use reactor heat energy for central heating and power generation.

The reactor facility MBIR construction is presented in Figure 1 [11].

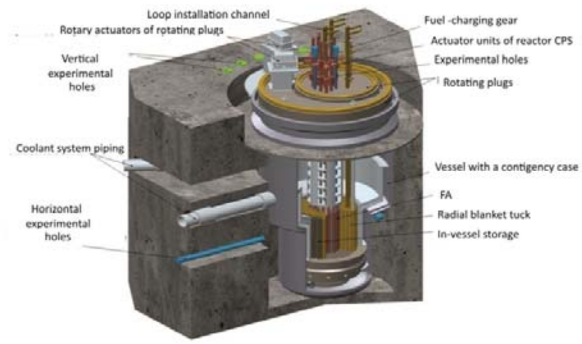

Figure-1. The MBIR construction.

2.3. Expected results

The opportunities of the MBIR Reactor can be as follows:

a) Research opportunities, which make a serious starting of the export-dependent high technologies, allow satisfying the state's internal needs for research and development work (the R&D work) and promote implementing the interests of foreign partner investors (the MBIR program is open for foreign cooperation, in particular, the agreement with France and the USA is signed); RF MBIR gives an opportunity to research in the field of hylology reactors physics, safety control, reactor core testing, check and diagnostics, etc., to increase the relative density of innovative products and services, created by implementing the measures of the Federal Targeted Programme "Nuclear Energy Technologies of the New Generation for the duration of 2010 - 2015 and long term up to 2020" (further - FTP) in total sales of industry products and services up to 10% and to provide the efficiency of the state investments into the R&D work according to the FTP in the sum of 48712,36 million roubles [8];

b) Technological opportunities, determined by

- the capability of nuclear fuel burnup from uranium-238 core by interaction with fast neutrons, absorbing which uranium-238 is turned into plutonium-239 - effective nuclear fuel [12];
- substituting the heat carrier from water for sodium that leads to rectifying the problem of neutron absorption and moderation;
- increasing the efficiency of using the natural uranium as a nuclear fuel by 31,8% [8];
- decreasing the volume of the spent nuclear fuel and radwastes storage by 31,1 % by 2020 (as compared to the year of 2009) [8];
- the correctness of selecting the operation of the reactor facility primary equipment that allows cooling the reactor smoothly in any emergency actions, thus, to ensure the RF safety;

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

- the fact that the used intermediate sodium loop gives an opportunity to level a possible hit of sodium resultant with the heat carrier of the third circuit in the reactor and the radioactive sodium in the steam circuit when the steam generator leaking (Figure-2 [13]); considering the loop layout of the RF, the whole first circuit is a security system, as it participates in emergency cooling [10];

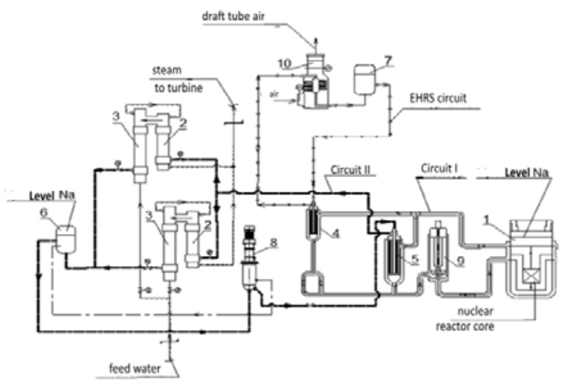

Figure-2. The layout diagram of the reactor facility MBIR (the second loop is not shown):*1* - reactor; *2* - reheater module; *3* - evaporimeter module; *4* - emergency heat exchanger; *5* - intermediate heat exchanger; *6* - buffer sodium vessel; *7* - expansion vessel; *8* - MCR -2; *9* - MCR -1; *10* - air heat exchanger

c) Economic opportunities, among which are as follows:

- to save costs for expensive steel in reactor vessel production, as sodium is warmed up with a smaller pressure than water is, and its warm temperature exceeds water warm temperature twice (600 ˚C);

- to decrease costs for constructional material repair and replacement, as sodium does not cause their corrosion practically, as compared to water [12];

- the capability of luring foreign investments in the MBIR program with a high payback, as according to the preliminary forecasts, the cost of 1% of stocks, offered to sale for 1 mln. dollars, will have increased to 36 mln. dollars by 2020 [14, 15];

- the capability of preserving and maintaining the strategic level of uranium resources for providing the leading positions of the state in the world market of energy carriers long term (it is achieved by using the technology of the closed nuclear cycle in uranium separation from the spent nuclear fuel in a chemical way and its further radiation in the fast neutron for plutonium preparation and nuclear reactor fuel manufacturing on thermal neutrons).

Creating and operating the MBIR Reactor becomes an important stage of fast neutron reactors construction that allows taking a step towards ensuring the competitiveness of the national nuclear industry long term up to 50 years. According to the experts, during this period the cost of uranium mining will have increased, owing to its deposit depletion considerably and there will come the period of the “fast energy industry”.

The MBIR project will make a special influence on the national security of the state. Firstly, it is an increase in the level of nuclear infrastructure safety by overcoming the problems of the growing quantity of the unsafe spent nuclear fuel and radwaste reserves and the inefficient use of natural uranium stocks. Secondly, it is an ensuring economic security of the state on the basis of increasing the rates of technologic progress and the level of the competitiveness of the domestic nuclear products in the foreign market.

3. CONCLUSIONS

The noted advantages of the MBIR Reactor will be entirely coordinated with the priority directions of developing the Russian nuclear power [9] and economy, and they become the effective tool for establishing and upholding the nuclear country status in the world arena.

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