Limiting efficiency of deuterium plasma based fusion neutron source

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The prospect of fusion energy production in high-temperature plasma is now considered practically only on the basis of the reaction of deuterium and tritium (D–T) in tokamak type magnetic containment devices. To realize the reactor, it is necessary that the plasma power gain factor reach a value of *Q* = 5–10. The problem of creating a reactor is the lack of structural materials with the necessary radiation resistance under conditions of neutron fluxes of 1 MW/m2. Another direction is the source of fusion neutrons. This is a less powerful and relatively compact device with a reduced level of neutron fluxes and a gain of *Q* = 0.1–1 depending on the purpose (driver of a hybrid “fusion–fission” reactor, a radioactive waste burner, a material testing device, etc.). The use of the D–T reaction involves the production of tritium, which is also associated with significant technological difficulties. Therefore, we consider the possibility of using the D–D reaction, among which the products contain tritium. Its burning can produce a noticeable yield in fast neutrons.

The problem of D–D reaction is low reactivity. Possible increase of the reactivity will be achieved due to the powerful neutral beam injection (NBI) into the plasma [1–4]. For deuterium-based plasma, the gain can be *Q* = 0.2–0.5 at injection energies of 1–2 MeV. The fraction of energy in fast neutrons is more than 50%. The effect of additions of lithium isotopes to deuterium plasma was analyzed [5]. The calculations show possibilities to realize the essential neutron yield from the tritium-lean deuterium-based plasma. The estimates of the parameters needed for the realization of a source of tokamak based fusion neutrons are presented. Requirements to different magnetic confinement systems are discussed respectively with the proposed concept.

The efficiency of the power plant is considered taking into account the conversion of thermal energy. The use of a gas-cooled blanket with a solid raw material makes it possible to use one circuit with a closed gas-turbine installation similar to the scheme with a high-temperature gas-cooled reactor with spherical fuel elements. Helium is preferred as a heat carrier, but the use of other gases is not excluded.

References

1. Chirkov A.Yu. Optimal parameters of fusion neutron sources with a powerful injection heating // Journal of Fusion Energy. 2015. V. 34. P. 528–531.
2. Chirkov A.Yu. Evaluation of the operational parameters for NBI-driven fusion in low-gain tokamak with two-component plasma // Nucl. Fusion. 2015. V. 55. 113027. (8 p)
3. Almagambetov A.N., Chirkov A.Yu. Power and sizes of tokamak fusion neutron sources with NBI-enhanced reaction rate // Journal of Fusion Energy. 2016. V. 35. P. 845–848.
4. Vesnin V.R., Chirkov A.Yu. Parameters estimation for fusion neutron source based on deuterium plasma // Problems of Atomic Science and Technology. Ser. Thermonuclear Fusion. 2018. Vol. 41, no. 2. p. 34–40.
5. Chirkov A.Yu., Vesnin V.R. Deuterium-lithium plasma as a source of fusion neutrons // Journal of Physics: Conf. Series. 2017. V. 891. 012306 (4p) <http://iopscience.iop.org/article/10.1088/1742-6596/891/1/012306>.