Simulation of a thermonuclear neutron source based on an axially symmetric mirror trap for a thorium hybrid reactor [[1]](#footnote-1)\*)

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Over the past few years Tomsk Polytechnic University has been developing a project of a high-temperature gas-cooled thorium reactor [1]. Possible design of such a device is a hybrid reactor with a subcritical fuel assembly and a plasma neutron source (NS) based on an open axially symmetric mirror trap [2]. The results of NS calculations are presented in this paper for a plasma of 50% deuterium and 50% tritium mixture. Tritium usage allows to significantly increase the neutron yield compared to the pure deuterium case.

Calculations were performed by DOL code [3]. The theoretical model underlying it assumes the division of the ion distribution function into two parts. The first is fast ions, which have a low collision frequency. Their distribution function is found from the solution of the kinetic equation averaged over the period of longitudinal motion. The second is warm ions with a model distribution function. Their confinement is determined by the equations of balance of particles and energy.

The main cell of NS has a length of 15 m and ends by mirror coils with a field of 15‑20 T. The cell is conventionally divided into two parts. Heating atomic beam injectors are placed in the first part. The magnetic field here is almost constant and the lowest in the main cell (about 0.8 T). The second part is surrounded by a fuel assembly and has a length of about 3 m. The field slowly increases here from 2 T to 2.5 T providing a fairly uniform emission of neutrons. The results of three calculation series with different values of injection power are presented in the table.

|  |  |  |  |
| --- | --- | --- | --- |
| Injection power, MW | 20 | 30 | 40 |
| Injection energy, keV | 50 | 70 | 70 |
| Temperature of warm ions and electrons, keV | 0.4 / 0.6 | 0.6 / 0.7 | 0.7 / 0.8 |
| Densities of warm and fast ions, 1013 cm-3 | 1.7 / 8.6 | 2.2 / 11 | 4.1 / 13 |
| Neutron yield in the fuel Assembly region, 1017 n/s | 0.6 | 1.8 | 2.6 |

Three constraints were used to select the acceptable configurations. The first is *tkin* / *tgd* < 1, where *tkin* and *tgd* are the confinement times of warm ions in the kinetic and gas-dynamic modes. This is a conservative condition under which micro-instability on warm ions does not arises. The second is *Ti* / *Einj* > 0.01, where *Ti* is the ion temperature and *Einj* is the energy of the atoms in the injected beams. The two-humped instability is suppressed under this condition. And the third is *nw* / *nf* > 0.1, where *nw* and *nf* are densities of warm and fast ions. If this condition is violated, drift-cone cyclotron (DCLC) instability can be driven by fast ions.

References

1. I.V.Shamanin, S.V.Bedenko, Yu.B.Chertkov, Thorium-loaded low-power reactor installation operated with super-long fuel residence time. Izvestiya Wysshikh Uchebnykh Zawedeniy, Yadernaya Energetika 2, 121–132 (2016) (in Russian).
2. A.Arzhannikov, S.Bedenko, V.Shmakov, V.Knyshev, I.Lutsik, V.Prikhodko, I.Shamanin. Gas-cooled thorium reactor at various fuel loadings and its modification by a plasma source of extra neutrons. NUCL SCI TECH (2019) 30:181. DOI: 10.1007/s41365-019-0707-y
3. D.V.Yurov, V.V.Prikhodko, and Yu.A.Tsidulko. Nonstationary Model of an Axisymmetric Mirror Trap with Nonequilibrium Plasma. Plasma Physics Reports, v. 42, n. 3, pp. 210-225 (2016).

1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLVII/Cm/ru/KC-Prikhodko.docx) [↑](#footnote-ref-1)