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システムダイナミクスによる核融合炉における トリチウムフローに関する研究

Study on stock and flow of tritium in fusion reactor system by system dynamics

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In order to prepare the initial loading of tritium that was believed to be indispensable in the past, the authors have proposed an innovative fuel scenario to produce tritium by DD reaction which occurs mainly between neutral beam and plasma, and following neutron reaction in breeding blanket. Then tritium will be burned as fuel of DT operation; so-called DD start-up scenario [1,2].

In the previous study [3], we developed a system dynamics (SD) model to describe the stock and flow of tritium in fusion reactor system. The SD model was analyzed by a commercial simulation software STELLA™ v10.0.2 (isee systems, Inc). A simplified stock and flow diagram of tritium in the fusion reactor plant model is shown in Fig. 1 [3]. As one of the results, with an assumption of local tritium breeding ratio (TBR=T/n) in the blanket as 1.20 by DT neutron and 0.84 by DD neutron, the required extension period to reach normal DT burning operation without initial tritium is estimated as 90 days. Further results are summarized in Fig. 2 that suggests small amount of initial tritium significantly reduces the required period. These results reveal that launching DT fusion projects without initial tritium is possible when it uses external electricity for DD operation that will be usually needed for commissioning of the plant.

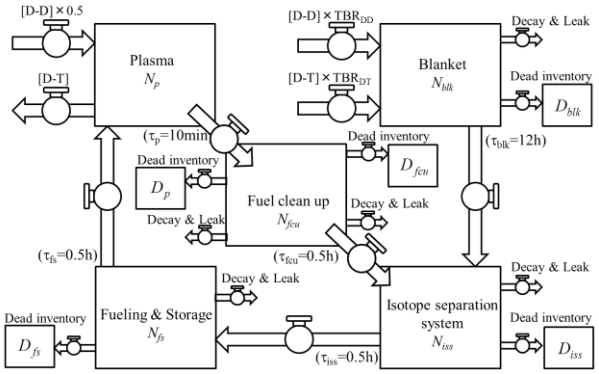

Fig. 1 Tritiun stocks & flow diagram of the fusion reactor plant model in this study (simplied) [3].

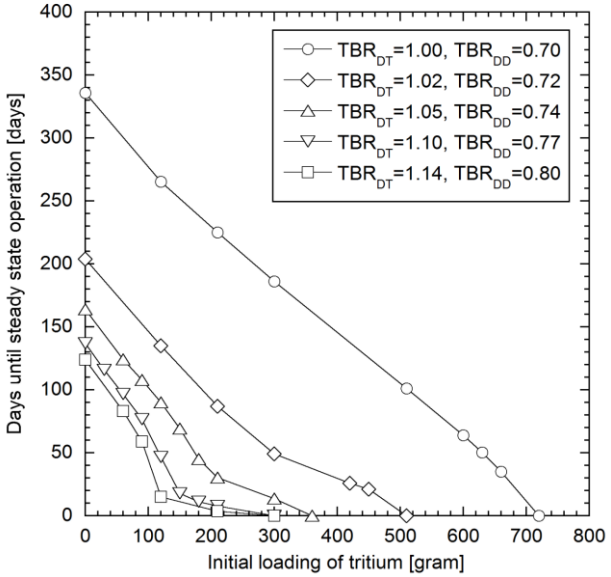

Fig. 2 Calculated results of relationship between initial loading of tritium and days until steady state DT operation.

Using this model, the present study points out that tritium breeding system will need to control the TBR because of the possible excess stock that is unavoidable consequence of the TBR>1.0 blanket operation.

[1] S. Konishi, Y. Asaoka, R. Hiwatari, and K. Okano, J. Plasma Fusion Res., vol. 76, pp. 1309–1312, 2000.

[2] Y. Asaoka, S. Konishi, S. Nishio, R. Hiwatari, K. Okano, T. Yoshida and K. Tomabechi, 18th IAEA Fusion Energy Conf. PDP-08, 2000.

[3] S. Kwon, R. Kasada, S. Konishi, “Operation Scenario of DT Fusion Plant Without External Initial Tritium”, Proceedings of SOFE2013, IEEE.