Development and Applications of the System Analysis Program for Parameter Optimization and Economical Assessment of Fusion Reactor (SYSCODE)

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The System Analysis Program for Parameters Optimization and Economic Assessment of Fusion Reactor (SYSCODE) has been developed since 2006 and was used to evaluate the economic efficiency of fusion reactor and fusion-fission hybrid reactor concepts developed by FDS Team [1-2]. In this contribution, the development and applications of the new version of SYSCODE (SYSCODE3.0) will be presented. The main functions of SYSCODE3.0 include: (1) Plasma physics calculation for ensuring the parameters of configuration, physics, performance, powers of core plasma and so on. (2) Engineering calculation for ensuring the heat and neutron loads on plasma facing components, and to build main structure model of tokamak reactor. (3) Economic calculation for assessing cost and economic efficiency of fusion reactor and related power plant. (4) SYSCODE3.0 also provides an optimization tool for system parameters analysis and optimization.

Up to now, SYSCODE3.0 has been verified through series of international benchmarking cases: its calculation was tested and verified based on one example of ARIES System Code (ASC), design of ITER, as well as the IAEA system codes benchmark which was reported on the 2nd IAEA DEMO workshop and includes other 6 international fusion system codes [3].

In this contribution, several typical preliminarily applications of SYSCODE3.0 will be presented: (1) Cost assessment of China Fusion Engineering Test Reactor: Based on the concept designs of two proposed options which include full superconducting tokamak and water-cooling Cu magnets tokamak, the cost of the two options was assessed and compared. (2) Economic assessment and system parameter optimization of fusion power plant: A steady fusin power plant with long pulsed fusion reactor driven by inductive plasma current and heated by helium ions power was proposed. Its system parameters was optimized and its economic efficiency was compared with steady state operated tokamak fusion reactor. (3) New concept research of tokamak: A tokamak with negative triangularity plasma configuration was proposed as an innovative concept for a fusion reactor in order to reduce divertor heat flux and improve plasma stability. A typical configuration with large radius of 7m, minor radius of 2.7m, triangularity of -1.0 was analyzed by using SYSCODE3.0 to gain the global physics parameters and its cost with same component material of ITER.

[1] Y. Wu, J. Jiang, M. Wang, M. Jin, FDS Team. A fusion-driven subcritical system concept based on viable technologies. Nuclear Fusion, 51 (2011) doi:10.1088/0029-5515/51/10/103036.

[2] Y. Wu, FDS Team. Conceptual design activities of FDS series fusion power plants in China, Fusion Engineering and Design, 81(2006) 2713-2718.

[3] D. J. Ward, et.al., International Systems Code Benchmark for DEMO, 2nd IAEA DEMO Programme Workshop, December 16-20, 2013, Vienna, Austria.