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Comparative Study of Cost Models for Tokamak DEMO Reactors
トカマク型核融合原型炉のコストモデルの比較検討

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To prove the economical feasibility of the nuclear fusion power plant, cost evaluation analysis for tokamak-typed demonstration reactor DEMO using the PEC (Physics Engineering Cost) system code is carried out. By using the PEC code, plasma parameters which can achieve the target value of the net electrical power are decided, and the capital cost based on the calculated radial build can be obtained. Several concerns about assumptions for the design and cost calculation, or choice of the rate of currency conversion emerge to compare the calculation results to previously proposed cost evaluations.

1. Introduction

To prove the feasibility of the nuclear fusion power plant, various designs of tokamak-typed demonstration reactor DEMO have been proposed [1,2]. One of the tasks of DEMO includes establishment of the economical perspective after realization of fusion power plants. Therefore, an attractive design of DEMO requires the assessment of the economical evaluation. Especially, appropriate choice of the cost model in the studies of the system codes for the optimization of the reactor design is necessary to show the economical validity of the DEMO or commercial reactors.

In the present study, the construction cost of a tokamak DEMO reactor is calculated by using a system code. The calculated cost is compared to that of previously proposed reactor design study. Then, establishment of the cost model which is appropriate to be included in the system code is a main purpose of this study.

2. Methods of Cost Calculation

A reactor designing system code PEC (Physics Engineering Cost) is used for the cost evaluation [3]. Figure 1 shows the calculation flow of PEC code. Firstly, the target electrical power (1080 MW_e in this study) and parameters of plasma shapes are decided as input parameters. The plasma parameters such as plasma major radius, fusion output power, current drive power, plasma current are calculated using input parameters. If the net electrical power matches the target value, the major radius and associated radial build are decided. The amount of materials used in the fusion island is employed as fundamental data of cost evaluation. The cost of the balance of plant will be considered corresponding to the thermal output power.

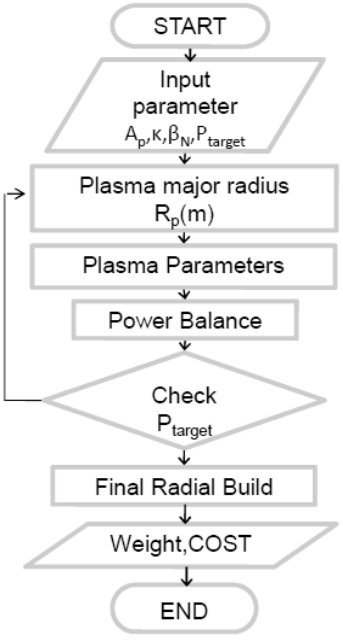

Fig.1. Calculation flow of PEC code

3. Results

Table 1 shows the plasma parameters of a tokamak DEMO reactor designed by PEC code. It is designed so that plasma parameters are similar to those of the SSTR DEMO reactor [1]. Parameters

Table I. Plasma parameters of a DEMO reactor designed by PEC code and those of SSTR as references

	PEC	SSTR [1]
Major Radius R_p	6.96 m	7.0 m
Aspect Ratio A_p[a]	4.1	4.1
Ellipticity κ[a]	1.85	1.85
Triangularity δ[a]	0.4	0.4
Maximum field B_{max}[a]	16.5 T	16.5 T
Toroidal field B_t	9.07 T	9.0 T
Normalized beta β_N[a]	3.1	3.3
Safety factor q_{95}[a]	5.0	5.0
Plasma current I_p	11.3 MA	12.0 MA
Central ion temperature $T_i(0)$[a]	34 keV	34 keV

[a] Input.

Table II. Capital cost and its breakdown of a SSTR-like DEMO reactor designed by PEC code

Breakdown	Cost [M$]
Total direct cost	2921.0
Fusion island	1224.2
FW/blanket/reflector	124.5
Shield	307.6
Magnets	341.7
Current drive & heating	207.8
Primary structure & support	60.4
Vacuum systems	103.6
Power supply, switching	67.6
Impurity control & divertor	11.1
ECRH breakdown system	4.9
Balance of plant	1696.7
Land & land rights	12.7
Structures & site facilities	431.8
Main heat transport systems	468.5
Auxiliary cooling system	5.6
Radioactive waste management	9.9
Fuel handling and storage	108.2
Other reactor plant eqt.	9.0
Instrumentation and control	46.8
Turbine plant equipment	339.3
Electric plant equipment	168.3
Misc. plant equipment	81.9
Heat rejection system	0.0
Special materials	14.6
Construction services & eqt.	350.5
Home office engr. & services	151.9
Field office engr. & services	175.3
Owners cost	539.8
Process contingency	0.0
Project contingency	715.9
Interest during construction	801.9
Total capital cost	5656.3

of SSTR are shown together in this table. Although there are small differences in the normalized beta and plasma current between two designs, the size of torus can be almost reproduced by the calculation of PEC code. The cost for the construction of the reactor designed by PEC code is shown in Table 2. Values in this table are priced in dollars in 2003. To compare this result to other cost evaluation study, appropriate conversion rate from dollar to yen is needed. If the exchange rate of 116 Yen/$ or the purchasing power parity calculated for GDP comparison of 140 Yen/$ (both in 2003) is employed, the total capital cost in Table 2 is 656 billion Yen or 792 billion Yen, respectively. These are in the same order of the total capital cost shown in the previously proposed cost evaluation of SSTR, which is 720 billion Yen in 1991 [4]. If it is necessary to clarify the reason of small difference between the calculated costs and previously obtained one, more detailed comparison of assumptions for the design and cost calculation is needed, which might be one of approaches to propose an appropriate cost model.

4. Summary and Future Plans

Cost evaluation analysis of the fusion DEMO reactors using the PEC system code is under progress to establish the cost model to be included in the system code for reactor design and cost calculation. There remain several concerns to be studied to compare the calculation results to other cost evaluation study, such as concretization of the difference of assumptions for the design and cost calculation between each study, choice of the rate of currency conversion, and so on. As a future view, it will be useful for the parameter survey study to optimize the cost using the system code having the appropriate cost model.

Acknowledgments

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