Neutronic Analysis of PeLUIt Reactor with Heavy Metal Loading and Power Variations in the OTTO Refueling Scheme

Ahmad Muzaki Mabruri[1]*, Nuri Trianti[2], Zaki Su'ud[1,3], Dwi Irwanto[1,3], Topan Setiadipura[2]

[1]*Department of Nuclear Science and Engineering. Bandung Institute of Technology, Bandung, Indonesia*
[2] *Nuclear Reactor Technology, National Research and Innovation Agency (BRIN), Bandung, Indonesia*
[3] *Department of Physics, Bandung Institute of Technology, Bandung, Indonesia*

ABSTRACT

The PeLUIt reactor is a high-temperature reactor (HTR) of the pebble-bed type that uses helium coolant and is being developed by Indonesia to support energy independence based on the Net-Zero Emission principle. The reactor design began in 2015 as part of the National Medium-Term Development Plan to meet the increasing national energy demands in the electricity generation and industrial sectors. The latest PeLUIt design features a flexible operational power range between 5 MWt and 30 MWt and adopts the OTTO fuel-loading scheme. The PeLUIt is planned to use U-235 enrichment reduced from 17 wo% to 8–11 wo% to improve economic feasibility; however, this reduction leads to a decrease in fuel criticality. Since PeLUIt fuel pebbles are typically undermoderated, criticality can be enhanced by adjusting the Heavy Metal Loading (HML) per pebble. This study analyzes the neutronic performance of the PeLUIt using UO_2 fuel in pebble-bed design based on the commercial HML values of HTR-10 and HTR-PM. Optimization results indicate that a minimum U-235 enrichment of 16 wo% is required for both fuel specifications to achieve operational conditions with a burn-up of 80 MWd/kgHM at power variations of 10, 20, and 30 MW. Under standard 10 MW operation, the required refueling rate is 25 pebbles/day for HTR-10 fuel and 15 pebbles/day for HTR-PM. Additionally, the fissile plutonium production rate under all three optimum power conditions reaches approximately 1.35 grams/day for HTR-10 fuel and 1.43 grams/day for HTR-PM. Based on these results, HTR-10 fuel, with its lower heavy metal loading, is considered more efficient and economical for use in the PeLUIt reactor.

Keywords: HTR, Indonesia, OpenMC, Pebble-bed, PeLUIt.

I. Introduction

PeLUIt (Industrial Power and Steam Generator or *Pembangkit Listrik dan Uap Industri*) is an advanced generation reactor of the High Temperature Reactor (HTR) type that has been developed by Indonesia since 2015 and continues to be improved to this day. It serves as part of the implementation of Indonesia's National Medium-Term Development Plan to meet the growing national energy demand in both the power generation and industrial sectors. The development of this reactor is part of the national energy transition strategy and aims to support industrial downstreaming schemes based on the principle of net-zero emission [1], [2]. With the capability to operate at high temperatures above 900°C, the PeLUIt reactor is highly suitable for industrial applications and hydrogen production as a form of co-generation.

PeLUIt is designed as a High Temperature Reactor (HTR) with a pebble-bed fuel type, in which uranium dioxide (UO_2) fuel is encapsulated in TRISO (tristructural-isotropic) particles and formed into fuel pebbles. These pebbles are then loaded into the reactor core and undergo circulation during operation. This system allows for continuous fuel reloading, supporting long-term reactor operation. PeLUIt is planned to operate using a One-Through-Then-Out (OTTO) scheme, in which the fuel pebbles undergo burnup until reaching a certain threshold before being discharged from the reactor core ([3], [4]

The use of two types of commercial pebble-bed fuels previously applied in HTR-10 and HTR-PM reactors should be considered in the development of PeLUIt to achieve operational efficiency and economic viability. The HTR-10 reactor uses fuel with a heavy metal loading (HML) of 5 grams per pebble and a U-235 enrichment of 17 wo%, while HTR-PM uses a higher HML of 7 grams per pebble and a U-235 enrichment of 8.5 wo%. Although both are pebble-bed HTRs, differences in design, operational power, and fuel quantity result in non-uniform fuel specifications [5], [6]. PeLUIt itself is designed with a flexible power output ranging from 5 MW to 30 MW, making the selection of an appropriate fuel type critical to both reactor performance and cost-effectiveness [7]. In addition, the availability and affordability of commercially supplied fuel are also important factors in ensuring long-term operational sustainability.

Research related to PeLUIt reactor fuel has been conducted from various perspectives in previous studies. A study by [8] indicated the potential to reduce both heavy metal loading (HML) and uranium enrichment levels without altering the reactor's operational specifications. This potential arises due to the under-moderated condition of the current fuel system. However, the reduction in U-235 content results in increased production of fission products such as plutonium and minor actinides (MA), which require particular attention in terms of safety and radioactive waste management. In response to these findings, a study by [9], developed an optimization approach by enhancing graphite moderation effects within the pebble fuel to compensate for reactivity loss due to the decrease in fissile material. This approach successfully maintained reactor performance comparable to standard PeLUIt fuel conditions and demonstrated the potential for reduced plutonium production as a fission byproduct. Additionally, [10], [11] indicated that PeLUIt's fuel reloading scheme could still be optimized, either through the OTTO approach or a multi-pass scheme, to achieve optimal performance across various operational aspects.

The latest PeLUIt design plans to use pebble fuel with U-235 enrichment reduced to around 8–11 wo% to improve economic feasibility by lowering uranium fuel costs. The reduction of fissile U-235 enrichment plays a crucial role because it directly affects total fuel expenses and supports more competitive reactor operation. However, lowering enrichment may reduce fuel criticality and shorten the operational lifetime [8], [9]. This research takes two existing commercial pebble fuels as references: the HTR-10 fuel, which originally used about 17 wo% U-235, and the HTR-PM fuel, which uses about 8 wo% U-235. This study evaluates and optimizes both fuel types by adjusting their enrichment, while keeping the original Heavy Metal Loading (HML) unchanged to ensure their suitability for PeLUIt operation. Since PeLUIt fuel pebbles are typically under-moderated, criticality can be improved by adjusting the Heavy Metal Loading (HML) per pebble, but the suitability of existing HML specifications must be assessed for compatibility with the PeLUIt reactor. Therefore, this study aims to identify and optimize two types of commercial pebble fuels from HTR-10 and HTR-PM reactors for application in PeLUIt under various operational power schemes using the OTTO method. Once the optimal design is determined, a neutronic performance and plutonium production analysis is conducted to assess efficiency, safety, and proliferation risk. Through this approach, the study is expected to provide recommendations for the most suitable pebble fuel specifications for PeLUIt, supporting the development of a more competitive, safe, and sustainable national HTR design.

II. Method

This study was conducted using a Monte Carlo method approach, based on criticality, burn-up, and depletion calculations using the OpenMC code. This code is an open source neutronic analysis tool that employs a constructive solid geometry (CSG) modeling system and is capable of calculating material interaction characteristics with neutrons and photons [12]. OpenMC has been widely used and verified for modeling and analyzing reactor designs such as MSRs, GFRs, PWRs, and several other reactor types efficiently [13], [14], [15], [16], [17], [18]

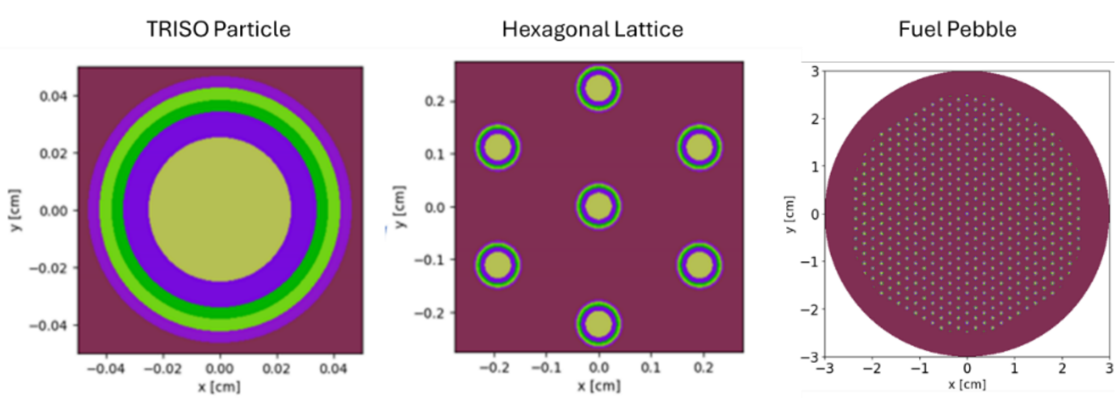

FIGURE 1. TRISO and Fuel Pebble Design

The reactor modeling in this study comprised three main levels: TRISO particle, pebble, and full core. The TRISO particle was modeled as a fuel element containing uranium dioxide (UO_2), placed at the center of the fuel kernel, and subsequently coated in sequence with graphite (buffer), inner pyrolytic carbon (IPyC), silicon carbide (SiC), and outer pyrolytic carbon (OPyC), as shown in Fig. 1. These TRISO particles were then arranged within a graphite matrix and shaped into solid spherical fuel elements or pebbles. The arrangement of TRISO particles within the pebble, which is in reality randomly distributed during fabrication, was simplified in this study by using a hexagonal lattice pattern to improve computational efficiency. The spacing between TRISO particles in hexagonal lattice distribution was set to 0.20847315 cm to maintain the packing fraction and ensure the total number of TRISO particles per pebble remained around 8335, in accordance with the commercial fuel design of the HTR-10 [19]. As for the HTR-PM, since it contains more heavy metal (HM), the total number of TRISO particles per pebble was increased. Therefore, to represent a value of 7 g/pebble, the TRISO spacing for this fuel was set to 0.18604819 cm.

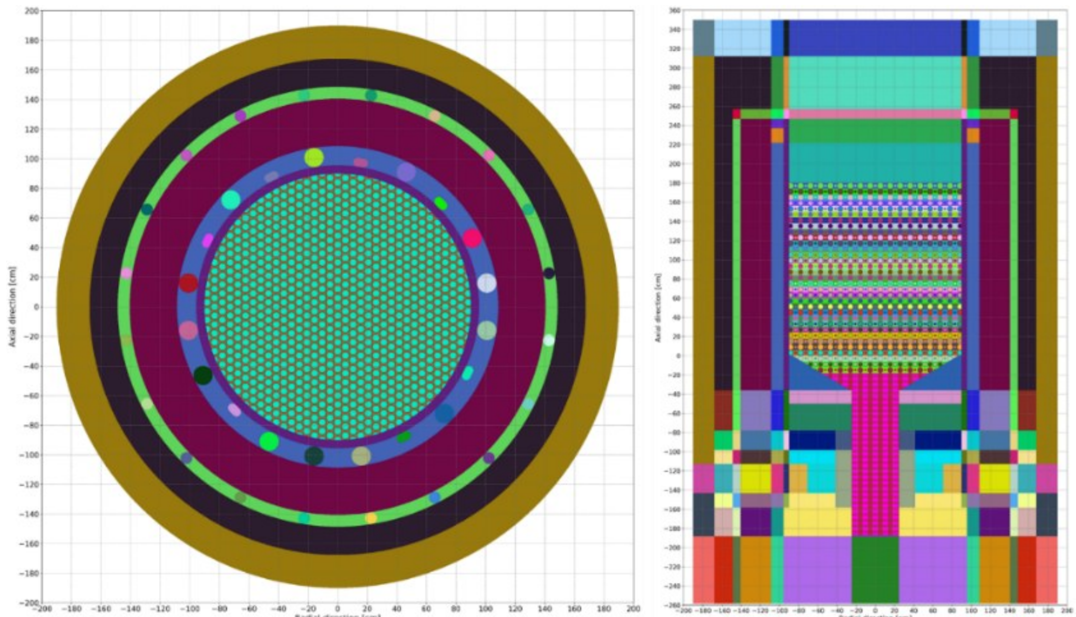

FIGURE 2. Reactor Design

The modeling of pebbles within the reactor core was simplified using a hexagonal lattice configuration, as illustrated in Fig. 1 and Fig. 2. This approach referred to a previously verified model by [19], which has been proven effective in representing fuel distribution efficiently within the geometry of a pebble-bed reactor. The hexagonal configuration was chosen due to its ability to closely approximate the actual arrangement of pebbles inside the reactor, as well as its ease of spatial representation in homogenized cell-based calculations. This simplification also aimed to enhance computational efficiency without compromising the accuracy of neutron and thermal distribution within the fuel.

TABLE I. Reactor Design Parameter [5], [6], [19]

Parameter	Specification
Pebble Diameter	6.00 cm
Fuel Zone Diameter	5.00 cm
Density of Graphite on Matrix and Outer	1.73 g/cm^3
Uranium Enrichments	17.0wt%
Fuel Kernel	
Fuel Kernel Radius	0.25 cm
UO_2 Density	10.4 g/cm^3
Coating	
Coating Material	Buffer/IPyC/SiC/PyC
Thickness (mm)	0.09/0.04/0.035/0.04
Density (g/cm^3)	1.1/1.9/3.18/1.9
Active Core Diameter / Height	180 cm / 180 cm
Picking Factor in Core	0.61
Number of Pebble	24720
Pebble in 1 layer	824
Total layer	30
Layer Height / Diameter	6 cm / 180 cm

TABLE II. Pebble Fuel Design Parameter

Pebble Type	HTR-10 (5SQ)	HTR-PM (7SQ)
Number of TRISO	8335	11669
Initial Enrichment	17%	8.50%
HML	5 gr	7 gr
TRISO Space	0.20847315 cm	0.18604819 cm
1 Layer Refueling Time (10MW/20MW/30MW)	33/22/11 days	46/23/15 days

The reactor design parameters, including the geometric dimensions of each element, material densities, and other detailed specifications, are comprehensively presented in Table 1. This study modeled two commercial fuel pebble types based on the data in Table 2. The HML values and the number of TRISO particles per pebble for both fuel pebble types were kept constant according to the values in Table 2 for all cases, with only the enrichment values varied to achieve fuel pebbles with optimal operating conditions. In this model, each layer was represented by 824 pebbles. Axially, the height of a single layer was set at 6 cm, meaning each layer consisted of a single, tightly packed row of pebbles in the vertical direction. To achieve the desired active core height of 180 cm, a total of 30 layers was required from the bottom to the top of the fuel zone. With this configuration, the packing fraction (pf) could be maintained at approximately 0.61, which remains within a reasonable range and is consistent with actual pebble filling conditions in pebble-bed reactors.

$$t = \frac{Burnup \times mHM}{Power \times CF} \tag{1}$$

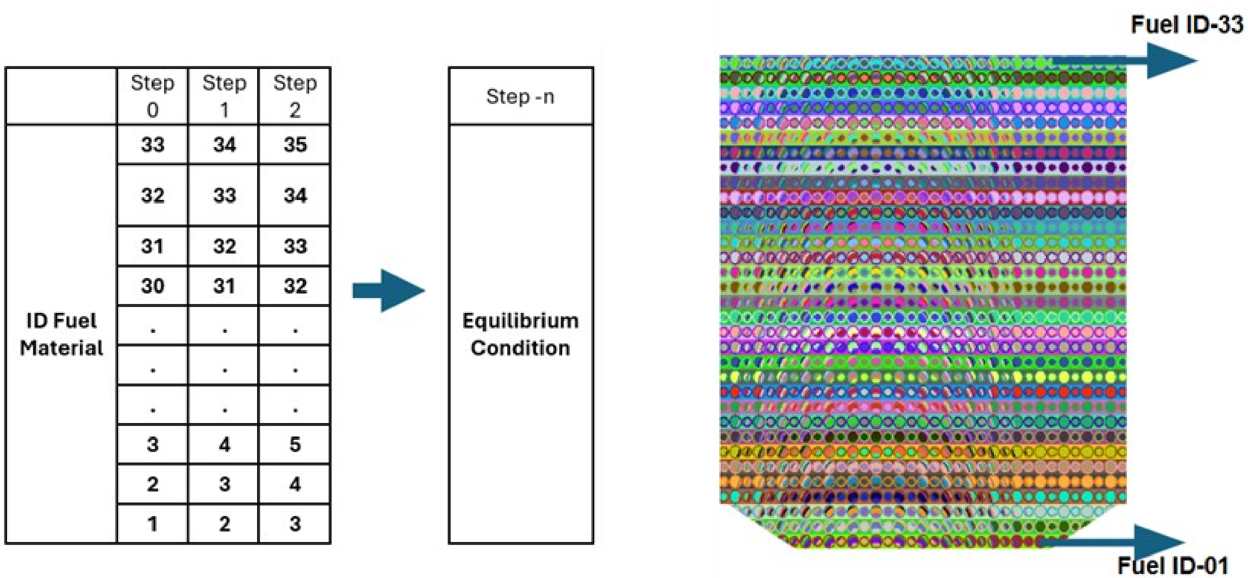

FIGURE 3. OTTO Scheme

The fuel operation scheme using the OTTO method was implemented based on the material ID shifting mechanism for pebble fuel, as illustrated in Fig. 3. As shown in the figure, the highest ID number always represented the position of a newly inserted pebble into the core, i.e., a pebble containing fresh fuel. At each simulation time step (n-step), the pebbles shifted axially downward, numerically represented by the shifting of material IDs for each fuel element. This process represented an open circulation, in which pebbles that reached the bottom of the core were discharged, and new pebbles were added from the top. The refueling time in this scheme was determined using a simplified burn-up equation, i.e., Eq. (1), under the assumption of a 100% capacity factor (CF). In all analyzed scenarios, the maximum burn-up value was set at 80 MWd/kgHM as the operational limit for the fuel. By calculating the heavy metal mass per layer (mHM), the refueling time for certain Power values (10, 20, and 30 MW) can be determined using Eq. (1) (see Table 2). Based on the calculations with these parameters, the operation and fuel reloading cycle can be carried out periodically, in which each fuel layer will continuously shift according to the scheme illustrated in Fig. 3.

III. Result and Discussion

The calculation began with the verification of the criticality value (k-eff), which serves as the main basis for determining the optimal operational conditions of the PeLUIt reactor in this study. The k-eff value was first verified at the point where the core was filled with fuel pebbles and moderator pebbles in a ratio of 53:47, following the initial operational reference of the HTR-10 reactor. Table 3 presents the verification results, showing that the hexagonal lattice distribution used for the pebble arrangement in the core in this study was able to calculate the k-eff value with a relative difference of less than 1.0% compared to the three reference calculation sources.

TABLE III. Code verification

Verivication Code	k-eff
OpenMC (Hexagonal lattice)	1.12214 ± 0.00033
OpenMC (Random lattice)	1.12125 ± 0.00054
MCNP6 (BCC lattice) [20]	1.12864 ± 0.00015
VSOP [6]	1.11956

III. A. U-235 enrichment optimization

Calculations using the OTTO method were performed on the commercial standard fuels of HTR-10 (5SQ) and HTR-PM (7SQ). These calculations optimized the U-235 enrichment in UO_2 and analyzed the results through the effective multiplication factor (k-eff), as shown in Fig. 4. The k-eff value represents the ratio of neutron production—dominated by the fission process—to neutron losses due to absorption and leakage, and serves as an indicator of criticality robustness, which must be greater than 1 for sustainable reactor operation. Fig. 4 shows the difference in timesteps for both cases, which reflects the different refueling time schemes applied in the OTTO refueling approach. The 7SQ pebble has a higher total heavy metal loading per pebble compared to the 5SQ pebble, resulting in a longer refueling duration according to Eq. (1). This indicates that, if the reactor operates at the same power level and burn-up limit (80 MWd/kgHM), the 7SQ pebble will reach its equilibrium point more slowly. Based on the calculated k-eff values, only the commercial fuel from HTR-10 with 17 wo% U-235 enrichment fully meets the criticality requirement for application in the PeLUIt reactor at a power level of 10 MWt and a burn-up of 80 MWd/kgHM, which shows that higher enrichment contributes significantly to maintaining stable fission reactions and achieving the desired operation cycle.

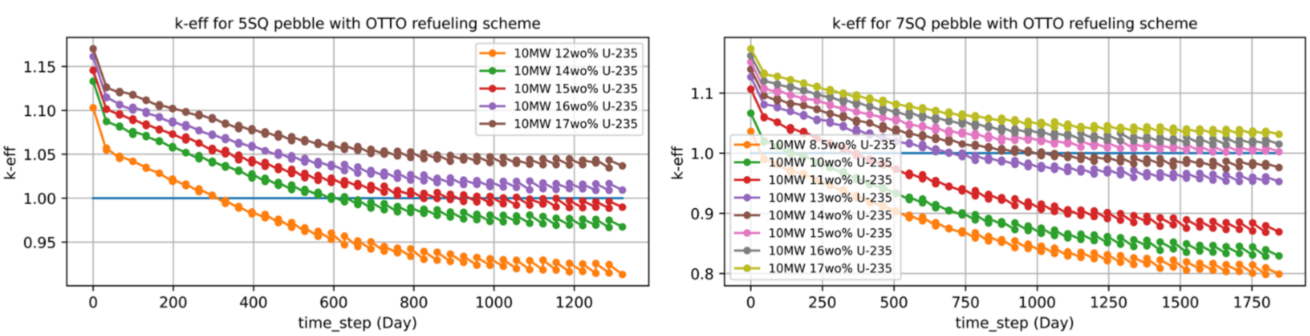

FIGURE 4. Effective multiplication factor values for pebble fuel 5SQ and 7SQ in the OTTO refueling method

Fig. 4 shows that the 7SQ fuel with 8.5 wo% U-235 enrichment, commonly used in the HTR-PM reactor, cannot be applied to the PeLUIt reactor under the assumption of 10 MWt power and 80 MWd/kgHM burn-up. This inability is caused by significant differences in core dimensions between HTR-10, HTR-PM, and PeLUIt. Although the 7SQ fuel has a better moderation ratio per pebble and higher heavy metal (HM) content, the total number of pebbles and fissile material available within the PeLUIt reactor core is insufficient to generate an optimal fission reaction. The k-eff data in Fig. 4 reinforces this finding, showing that for the 7SQ case, the desired operating conditions can only be met if the U-235 enrichment is increased to at least 16wo%. Conversely, the 5SQ fuel type, originally used in the HTR-10 reactor and having core dimensions more comparable to PeLUIt, can still operate stably even when the U-235 enrichment is reduced to 16wo%. The resulting k-eff values under these conditions remain above 1, thus supporting safe and sustainable reactor operation.

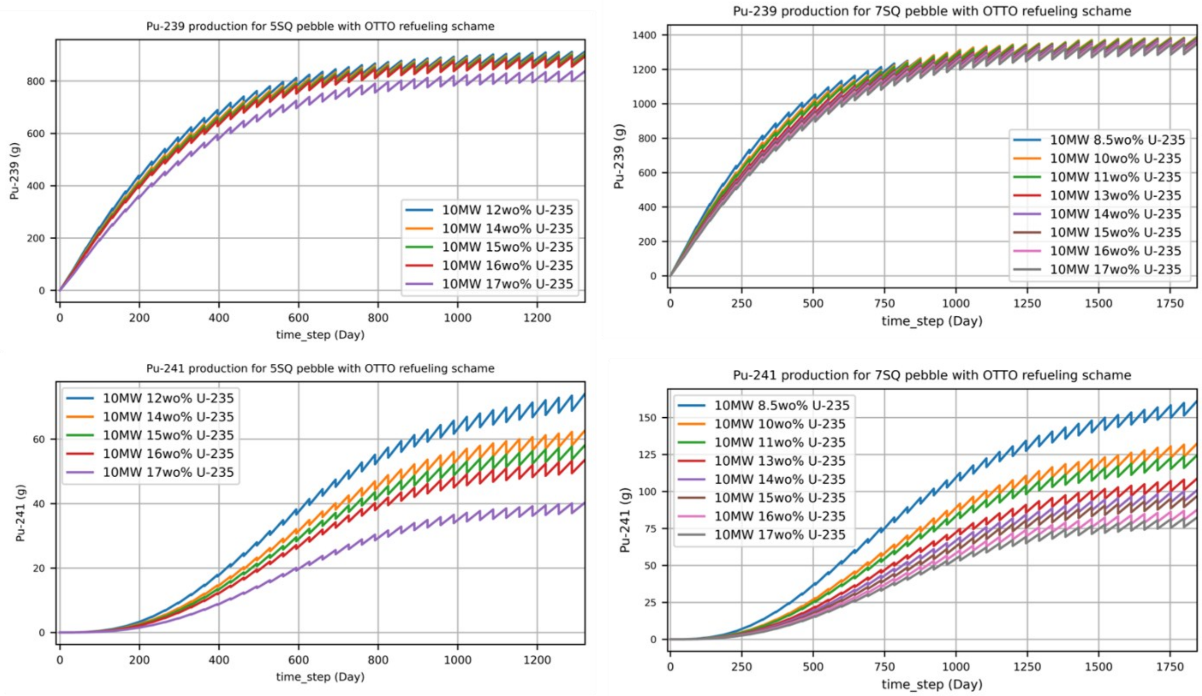

FIGURE 5. Fissile plutonium production for pebble fuel 5SQ and 7SQ in the OTTO refueling method

Equilibrium conditions, as shown in Fig. 4, were reached after the OTTO refueling scheme had been in operation for more than 1089 days for the 5SQ fuel and more than 1716 days for the 7SQ fuel. Based on Eq. 1 and the results presented in Fig. 4, the refueling time per layer was calculated to be 33 days for 5SQ and 46 days for 7SQ. Accordingly, the daily pebble insertion rate (pebbles per day) at 10 MWt power and 80 MWd/kgHM burn-up was 25 pebbles/day for 5SQ and 18 pebbles/day for 7SQ. The lower pebble per day value for 7SQ is due to the higher heavy metal loading (HML) per pebble. Nevertheless, to maintain k-eff above the critical limit, the 7SQ fuel still requires higher U-235 enrichment. Therefore, although fewer pebbles are needed, the economic effectiveness of this fuel requires further evaluation.

Fig. 5 shows the production of fissile plutonium material over the reactor operation period with the OTTO refueling scheme, which is also an important parameter in selecting effective fuel. According to Fig. 5, fissile plutonium production tends to increase as U-235 enrichment decreases. When comparing the two optimal conditions from Fig. 4 (i.e., at 16 wo% U-235 enrichment), during the same equilibrium period, fissile plutonium production (Pu-239 and Pu-241) in the 7SQ fuel tends to be higher than in 5SQ. This is likely due to the higher HML content in the 7SQ pebble, resulting in a larger fraction of U-238. However, when viewed on a daily average basis, the total fissile plutonium production amounts to 1.35 grams/day for 5SQ and 1.43 grams/day for 7SQ.

III. B. Power Variation at Optimal Enrichment

Variations in reactor operating power at 10 MW, 20 MW, and 30 MW were analyzed using the previously determined optimal enrichment values. The evaluation results are presented in Fig. 6, which shows that both fuel types (5SQ and 7SQ) were able to achieve the specified power targets, with the maximum burn-up remaining limited to 80 MWd/kgHM. As the power increased, the time required to reach equilibrium conditions shortened. This was due to the increased fuel burn rate, which directly accelerated the pebble refueling demand. This phenomenon demonstrates a linear relationship between reactor power, fuel consumption rate, and fuel reload frequency, which is a crucial factor in designing the refueling system for pebble-bed reactors.

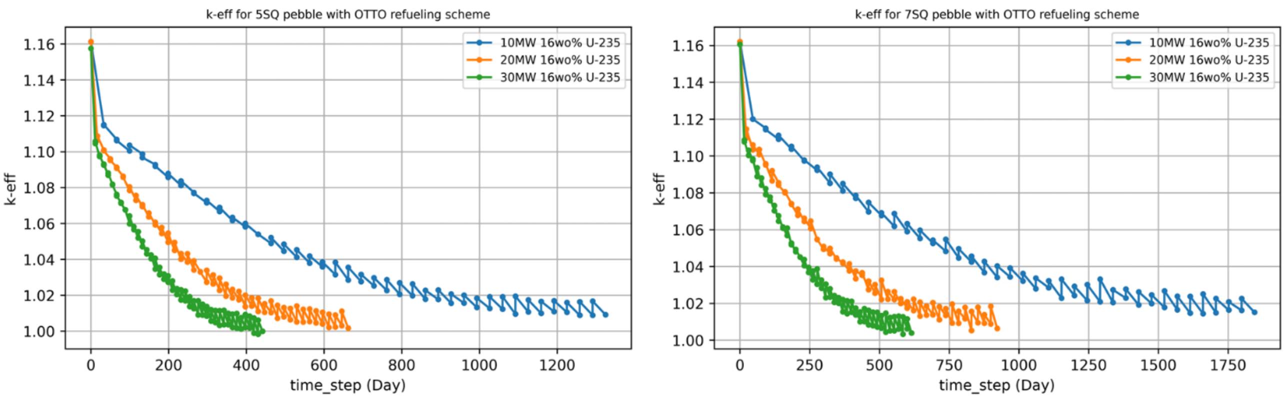

FIGURE 6. Effective multiplication factor value for optimal enrichment of 5SQ and 7SQ pebble fuel in OTTO refueling method with power variation.

For the 5SQ fuel, the number of pebbles required per day increased sequentially to 25, 51, and 75 pebbles per day for power levels of 10, 20, and 30 MW, respectively. Meanwhile, the 7SQ fuel required 18, 36, and 54 pebbles per day to achieve the same power levels. Although both fuel types were able to reach the target power, it was observed that at the operating powers of 20 MW and 30 MW, the k-eff value decreased significantly and approached the critical limit (k-eff ≈ 1). This condition indicates that at higher power levels, the criticality margin becomes narrower, potentially reducing the stability of reactor operation. Therefore, under higher power operating conditions, it is recommended that the refueling process be accelerated so that the burn-up per pebble can be reduced. By doing so, the availability of fissile material in the core is maintained, and the k-eff value can be kept above the critical threshold, thus supporting a more stable and safe reactor operation.

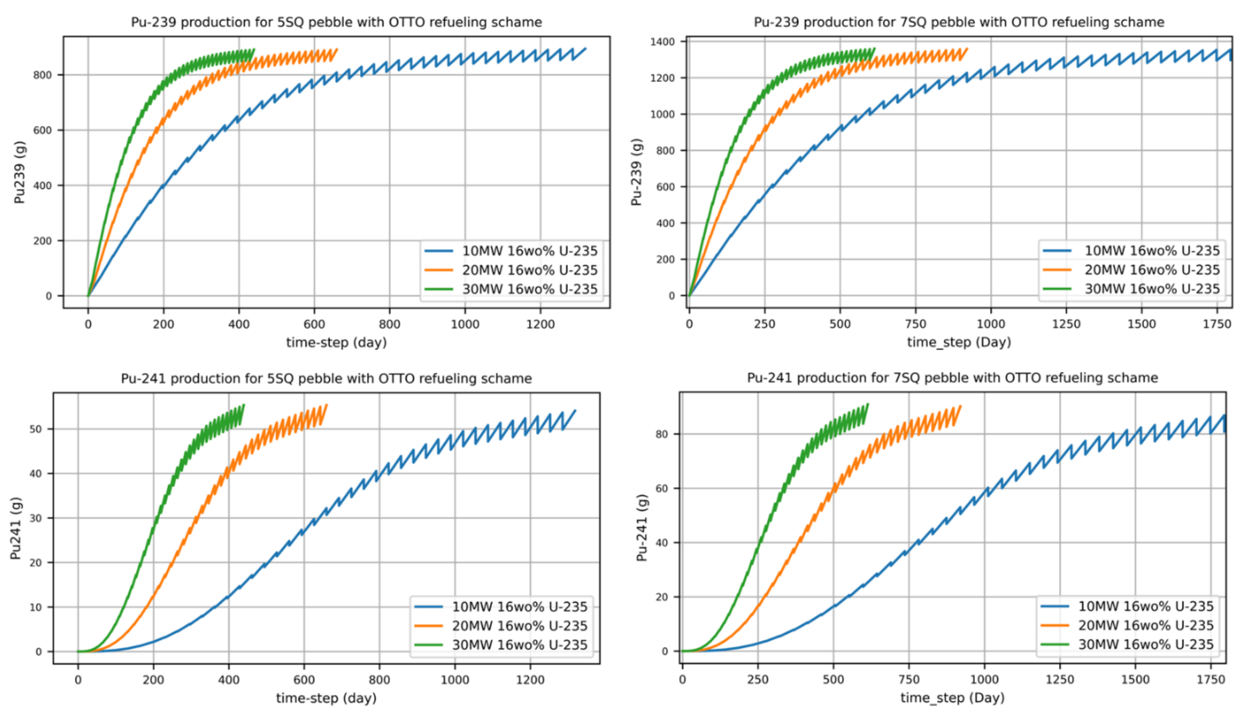

FIGURE 7. Fissile plutonium production for optimal enrichment of 5SQ and 7SQ pebble fuel in OTTO refueling method with power variation.

Fig. 7 illustrates the trend of fissile plutonium isotope production resulting from variations in reactor power using two types of pebble fuel (5SQ and 7SQ). Based on the graph, it can be concluded that increasing reactor power accelerates the accumulation rate of plutonium until equilibrium is reached. The higher the operating power, the faster the fuel undergoes burnup, producing conversion of U-238 into Pu-239 and Pu-241. However, when observed during the equilibrium phase, the amount of plutonium produced per refueling cycle tends to remain constant across different power levels. This indicates that as long as the burnup per refueling cycle is maintained (in this case, 80 MWd/kgHM), the quantity of plutonium generated per cycle is not significantly affected by the reactor power level. In other words, despite variations in operating power, as long as neutron efficiency and burn-up level per cycles are consistently controlled, plutonium production per cycle remains within a comparable range.

IV. CONCLUSIONS

Pebble fuel with standard specification HTR-10, based on the method and results of this study, has been proven to be the most suitable for use in PeLUIt reactors at all three operating power levels: 10 MW, 20 MW, and 30 MW. Furthermore, the neutronic calculation results in this study indicate that, under the assumed maximum burn-up target of 80 MWd/kgHM, this fuel can still be optimized by reducing the enrichment from 17 wo% to 16 wo% while maintaining sufficient criticality. In terms of fissile plutonium isotope production, power variations only affect the speed at which equilibrium is reached but do not significantly influence the amount of plutonium produced per refueling cycle, provided the burn-up value is maintained. According to calculations, the 5SQ fuel type produces about 1.35 grams of fissile plutonium per day, while 7SQ produces approximately 1.43 grams per day. Additionally, both fuel types require the same enrichment level to exceed the specified operational targets. Therefore, due to its lower heavy metal loading (HML), 5SQ is considered superior in terms of design and economic efficiency compared to 7SQ pebble fuel.

ACKNOWLEDGMENTS

The authors would like to acknowledge the Bandung Institute of Technology and the National Research and Innovation Agency of the Republic of Indonesia for their support in this research and publication activity.

REFERENCES

[1] S. Permana, N. Trianti, and A. Rahmansyah, "Nuclear energy contribution potential to secure electricity demand with low carbon emission and low risk of power plant in Indonesia," in IOP Conference Series: Earth and Environmental Science, IOP Publishing Ltd, Jun. 2021. doi: 10.1088/1755-1315/753/1/012048.
[2] S. Permana, N. Trianti, and A. Rahmansyah, "Nuclear Energy Contribution for Net Zero Emission and National Energy Mix 2060 in Indonesia," in Journal of Physics: Conference Series, Institute of Physics, 2022. doi: 10.1088/1742-6596/2243/1/012066.
[3] F. Miftasani et al., "Investigating geometry adjustments for enhanced performance in a PeLUIt-10 MWt pebble bed HTGR with OTTO refueling scheme," Nuclear Engineering and Design, vol. 422, Jun. 2024, doi: 10.1016/j.nucengdes.2024.113163.
[4] C. Wulandari et al., "Optimization of uranium and uranium-thorium fuel utilization in pebble bed for PeLUIt-10 reactor using PEBBED code," Nuclear Engineering and Design, vol. 433, Mar. 2025, doi: 10.1016/j.nucengdes.2025.113873.
[5] D. She et al., "Prediction calculations for the first criticality of the HTR-PM using the PANGU code," Nuclear Science and Techniques, vol. 32, no. 9, Sep. 2021, doi: 10.1007/s41365-021-00936-5.
[6] IAEA, Evaluation of high temperature gas cooled reactor performance : benchmark analysis related to initial testing of the HTTR and HTR-10. Vienna, Austria : International Atomic Energy Agency, 2003.
[7] N. Trianti et al., "Neutronic And Thermal-Hydraulic Analysis of HTGR-Based PELUIT-40 Reactor with PANGU-DAYU Code," China, Oct. 2024.
[8] D. Mulyana, T. Setiadipura, and I. W. Ngarayana, "Heavy metal loading effects on special nuclear material and waste of an uprated Indonesian Reaktor Daya Eksperimental," Nuclear Engineering and Technology, Jul. 2024, doi: 10.1016/j.net.2024.07.031.
[9] A. M. Mabruri, N. Trianti, Z. Su'ud, and R. D. Syarifah, "Optimizing Micro-PeLUIt reactor with UO2-ThO2 fuel mixtures and improved graphite moderation," Nuclear Engineering and Design, vol. 438, Jul. 2025, doi: 10.1016/j.nucengdes.2025.114051.
[10] N. Trianti et al., "Optimum power determination and comparison of multi-pass and OTTO fuel management schemes of HTGR-based PeLUIt reactor," Nuclear Engineering and Design, vol. 415, Dec. 2023, doi: 10.1016/j.nucengdes.2023.112696.

[11] D. Mulyana and S. S. Chirayath, "The impact of refueling schemes on the proliferation resistance of a pebble bed reactor," Ann Nucl Energy, vol. 170, Jun. 2022, doi: 10.1016/j.anucene.2022.109010.
[12] P. K. Romano and B. Forget, "The OpenMC Monte Carlo particle transport code," Ann Nucl Energy, vol. 51, pp. 274–281, Jan. 2013, doi: 10.1016/j.anucene.2012.06.040.
[13] R. D. Syarifah, F. Prasetya, A. M. Mabruri, A. Arkundato, and N. Trianti, "The Effect of Adding Minor Actinide Fuel Rods on GFR Reactor in Radiopharmaceutical Waste Production Using OpenMC Program," Science and Technology Indonesia, vol. 9, no. 4, pp. 857–865, Oct. 2024, doi: 10.26554/sti.2024.9.4.857-865.
[14] A. M. Mabruri, R. D. Syarifah, I. K. Aji, A. Arkundato, and N. Trianti, "Validation of OpenMC Code for Low-cycle and Low-particle Simulations in the Neutronic Calculation Criticality k-eff Low-cycle MSR FUJI-12 OpenMC Corresponding Author," Jurnal Ilmu Fisika, vol. 16, no. 2, pp. 107–117, 2024, doi: 10.25077/10.25077/jif.16.2.107-117.2024.
[15] A. M. Mabruri, R. D. Syarifah, I. K. Aji, Z. Hanifah, A. Arkundato, and G. Jatisukamto, "Neutronic analysis on molten salt reactor FUJI-12 using 235U as fissile material in LiF-BeF2-UF4 fuel," Eastern-European Journal of Enterprise Technologies, vol. 5, no. 8(119), pp. 6–12, 2022, doi: 10.15587/1729-4061.2022.265798.
[16] F. Prasetya, A. M. Mabruri, I. Karomah, R. D. Syarifah, I. K. Aji, and N. Trianti, "Validation of OpenMC Code Criticality Value Calculation for GFR Reactor with UN-PuN Fuel," in Journal of Physics: Conference Series, Institute of Physics, 2024. doi: 10.1088/1742-6596/2734/1/012065.
[17] R. D. Syarifah et al., "Analysis of variation minor actinide pin configurations Np-237, AM-241, AND Cm-244 IN UN-PuN fueled pressurized water reactor," EUREKA, Physics and Engineering, vol. 2024, no. 1, pp. 36–46, Jan. 2024, doi: 10.21303/2461-4262.2024.003048.
[18] R. D. Syarifah, B. A. Putri, I. K. Aji, and A. M. Mabruri, "Neutronic Analysis on Molten Salt Reactor (MSR) Using OpenMC Code With Variations of Geometry Core Fueled By LiF-BeF2-UF4," El-Cezeri Journal of Science and Engineering, vol. 11, no. 2, pp. 152–159, Jul. 2024, doi: 10.31202/ecjse.1364028.
[19] A. M. Mabruri, N. Trianti, Z. Su'ud, E. Umar, and R. D. Syarifah, "Comprehensive evaluation of nuclear data library variations and TRISO distribution methods on neutronic properties of HTR-10 pebble-bed fuel using OpenMC," Nuclear Engineering and Design, vol. 441, Sep. 2025, doi: 10.1016/j.nucengdes.2025.114168.
[20] O. Kabach, A. Chetaine, A. Benchrif, and H. Amsil, "The use of burnable absorbers integrated into TRISO/QUADRISO particles as a reactivity control method in a pebble-bed HTR reactor fuelled with (Th,233U)O2," Nuclear Engineering and Design, vol. 384, Dec. 2021, doi: 10.1016/j.nucengdes.2021.111476.