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HEAT TRANSFER SIMULATION ON HTGR PEBBLE BED USING ATHLET CODE

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1. INTRODUCTION

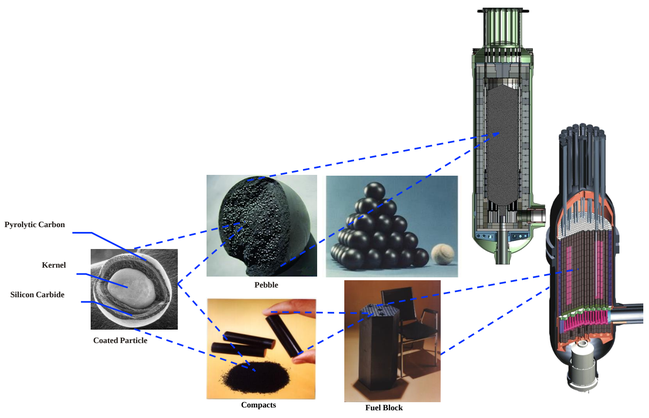

FIG. 1. Modular HTGR(s) design from the bottom up [1].

2. METODOLOGY

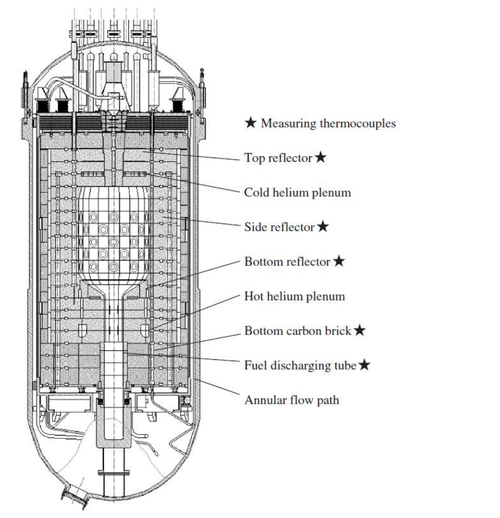

FIG. 2. Vertical cross section of MHTGR reactor [8].

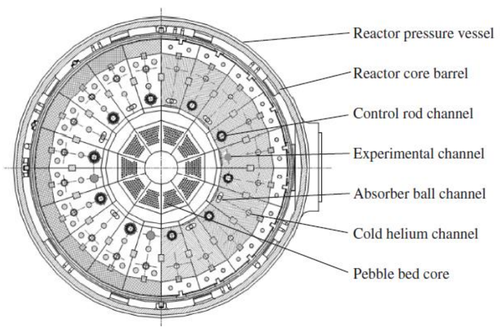

FIG. 3. Horizontal cross section of the MHTGR-10 reactor [8].

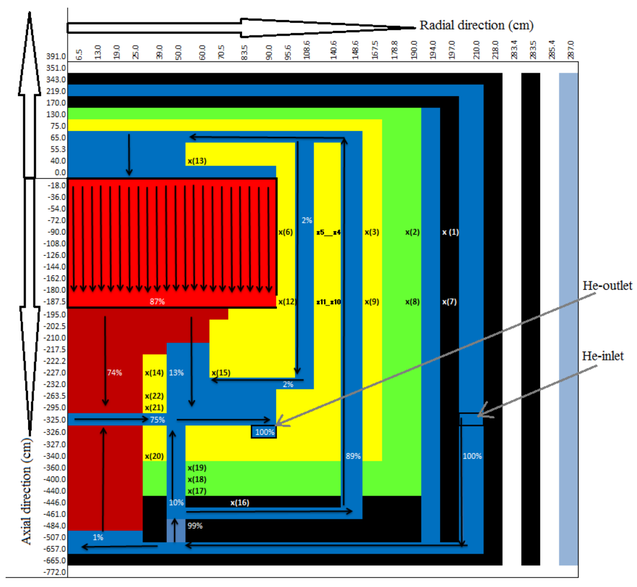

FIG. 4. Mass flow distributions in the reactor primary system and the locations of 12 of fixed thermocouples in the reactor internals of side reflector [7].

ATHLET Code as Metodology calculation

The main features of the ATHLET program are [9]:

1. advanced modeling of thermohydraulics (fluid, vapor and liquid phases);
2. fluids such as light water, helium, sodium and lead;
3. heat generation, heat conduction and single-phase or two-phase heat transfer by considering geometric shapes such as cylinders or balls; And
4. Couple Interface with 3-dimensional neutron kinetic software numerical models and 3-dimensional CFD software

The following are the basic modules used for modeling in ATHLET [9]:

1. Thermo-Fluiddynamics (TFD)
2. Heat Conduction dan Heat Transfer (HECU)
3. Neutron Kinetics (NEUKIN)
4. Control and Balance of Plant (GCSM)

3. SCOPE OF DISCUSSION

ATHLET Model for Modular HTGR Pebble Bed Reactor

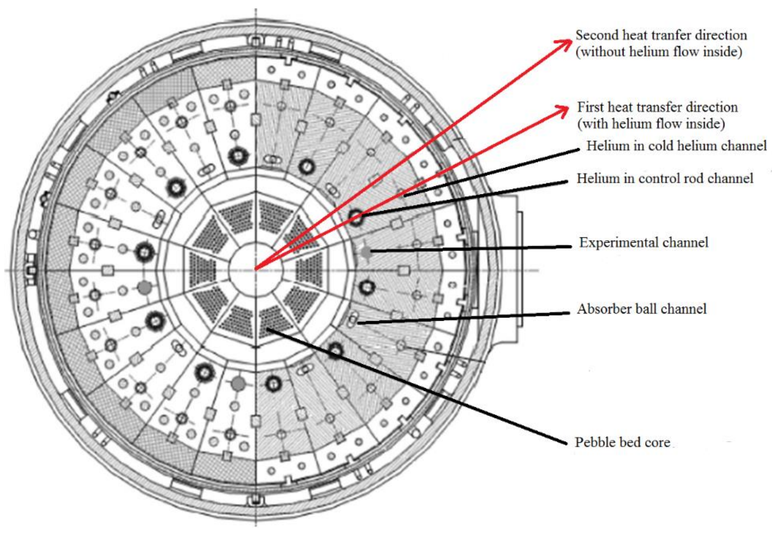

FIG. 5. Horizontal cross section of the HTR-10 reactor for two heat transfer directions

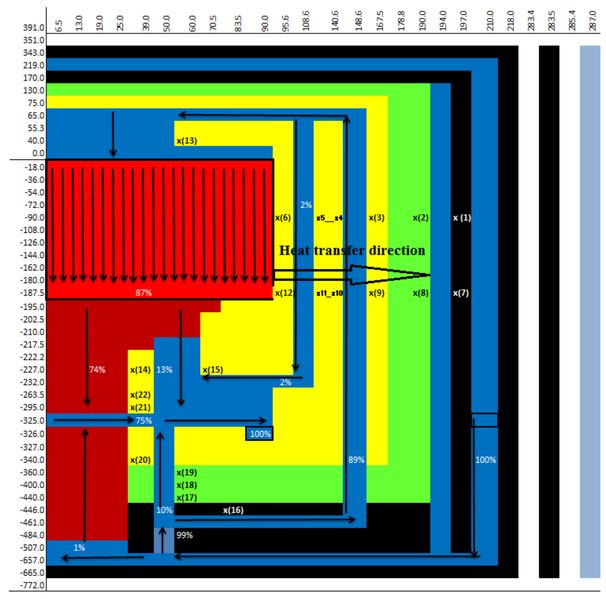

FIG. 6. First heat transfer direction through the channels

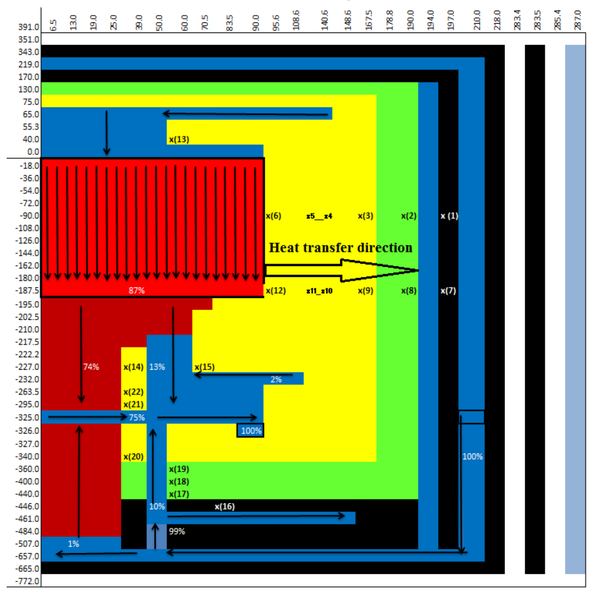

FIG. 7. Second heat transfer direction through solid structure only

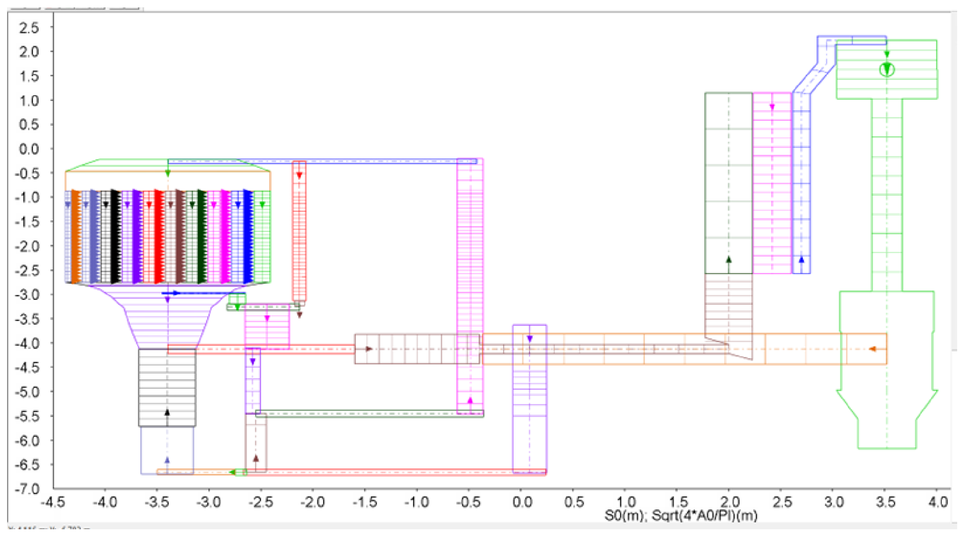

FIG. 8. Modular HTGR reactor core model in ATHLET for 10 parallel core Channels including Steam Generator

4. RESULTS AND DISCUSSION

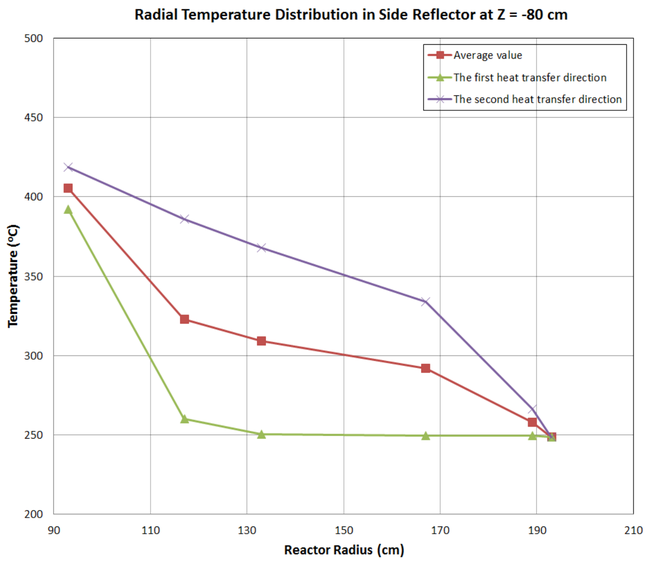

FIG. 9. The 2 models of heat conduction for side reflector

The methodology calculation of the 2 models of heat conduction for side reflector is shown in figure 9. The heat conductions for side reflector models are generated by 2 models. The first heat transfer direction which is across the control rod channel and the cold helium channel is shown in green color, the second heat transfer direction which is going through graphite and carbon brick heat conduction objects only is shown in blue color and the average value is shown in red color. However, ATHLET cannot model the heat transfer in azimuthal directions.

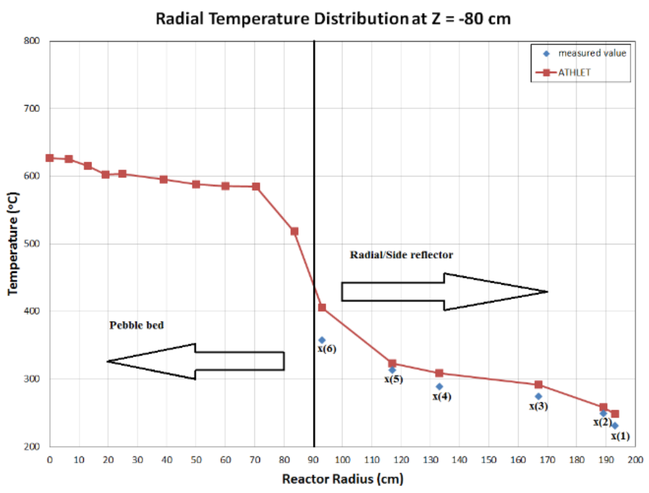

FIG. 10. Radial temperature profile at Z = -80 cm ATHLET vs Measured value

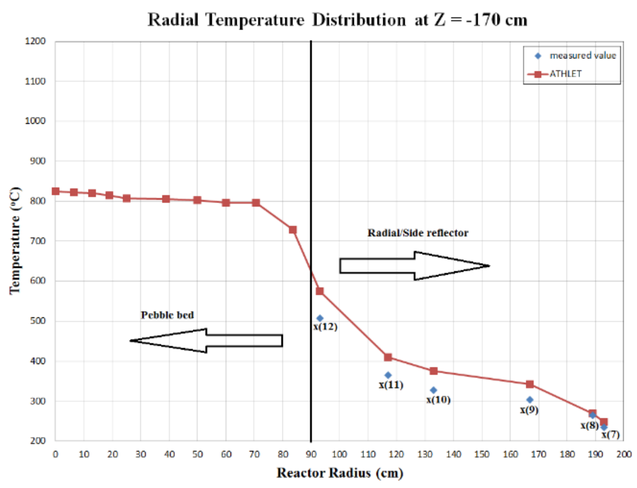

FIG. 11. Radial temperature profile at Z = -170 cm ATHLET vs Measured v

5. CONCLUSIONS

The steady-state temperature distribution in upper and lower of the Modular HTGR side reflector internals is already simulated by ATHLET. The various calculation results correspond well with the experimental results. However, some discrepancies still exist between calculations and measurements.

For the upper part, Z = -80 cm, the comparison between calculations and the measurements for the six measuring points show in good agreement. Similarly with upper part, the lower part, Z = -170 cm, results show in good agreement. Only at one position is slightly higher with maximum relative deviation is about 13%.

According to the comparison results, ATHLET reproduces relatively good results. Furthermore, the next calculations need more investigation to use not only radial heat transfer direction but also axial heat transfer direction. Then the temperature distribution calculation of the Modular HTGR can be simulated reasonably using this code.