Effect Of Changing The Outer Fuel Element Diameter On Thermophysical parameters of RITM-200 Reactor unit

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Abstract

The thermophysical calculations on the RITM-200 reactor unit is conducted to ascertain the possibility of optimizing the fuel element diameter without compromising the thermal constrains. These calculations included temperature distribution profile of the fuel rods at various fuel diameters, average coolant velocities and critical heat flux for nucleate boiling crisis analysis. It is demonstrated from the results achieved that an inverse relationship exists between the fuel rod diameter and the maximum fuel temperature. The average coolant velocity is observed to be directly proportional to the fuel rod diameter at a constant flowrate of G =9.38 kg/s. It is also determined that decreasing the fuel rod diameter below 6.9 mm which is the design fuel rod diameter will lead to boiling crisis.

Keywords: RITM-200 reactor, Pressurized water reactor, departure from nucleate boiling, Thorium-uranium fuel cycle, Uranium-plutonium fuel cycle.

Introduction

The heat released in the reactor as a result of the fission reaction takes place in several forms. These include the release of heat as a result of the kinetic energy of fission neutrons, as well as from gamma rays of rapid fission, from gamma rays and rays generated during the decay of fission products and, possibly, from neutrino radiation [1]. Since these various forms of heat generation are carried out by radiation particles, their energy turns to be weakened in various ways, which leads to the deposition of their energy in different places [2]. The thermophysical calculations conducted in this article takes account of the neutronic calculations already performed on the RITM- 200 reactor unit [3].

In this research, we consider several analysis of the thermophysical properties of the fuel, thus:

- Temperature and coolant velocity distribution profile,
- Critical heat flux for nucleate boiling crisis analysis,

Nucleate Boiling

In preventing the occurrence of heat transfer crisis in the reactor unit which is moderated and cooled with water, the critical heat flux is determined. Also, the ratio of critical heat flux to heat flux for all fuel diameters under study thus between 3.9 – 9.9 mm with interval of 1 mm is determined. When , it implies that fuel element at that diameter will experience some sort of heat transfer crisis. The critical heat flux calculation is determined from the equation below [11]:

$$q^{crit} = 41300(v.p)^{0.5}t^{0.33}(V^i/(V^{ii} - V)) \quad (1)$$

Results 2

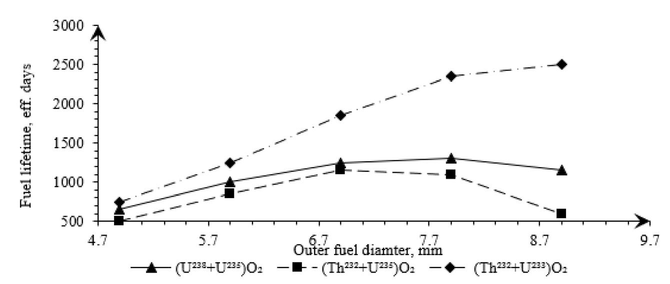


Figure 2: Dependence of the duration of the nuclear fuel lifetime on the diameter of fuel rods with different dispersion fuels

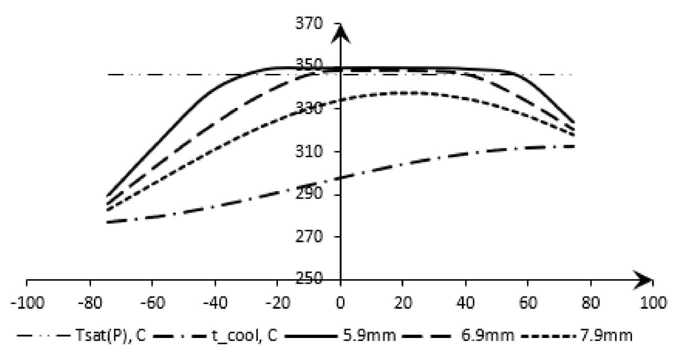


Figure 3: Temperature distribution profile.

Results 1

The analysis of the coolant velocity across the fuel assembly through the different fuel element diameters show increase in average coolant velocity with increase in fuel element diameter.The velocity profile of the various fuel element diameters demonstrates a linear relationship with fuel element diameter.

d,mm	3.9	4.9	5.9	6.9	7.9	8.9
v,m/s	2.04	2.22	2.48	2.89	3.56	4.84

Table 1: Coolant velocities at different diameters

The application of the Thom's correlation was used in the evaluation of the boiling crisis in the various fuel element diameters. The results showed that boiling crisis will occur in the fuel element diameters less than 6.9 mm. This result implies that increasing the fuel diameter will not lead to boiling crisis, hence endorsing the recommendation of the neutronics calculations which proposed increase in fuel diameter to optimize fuel campaign. Fig. 4 below shows the result of the boiling crisis on the various fuel element diameters between 3.9 to 9.9 mm

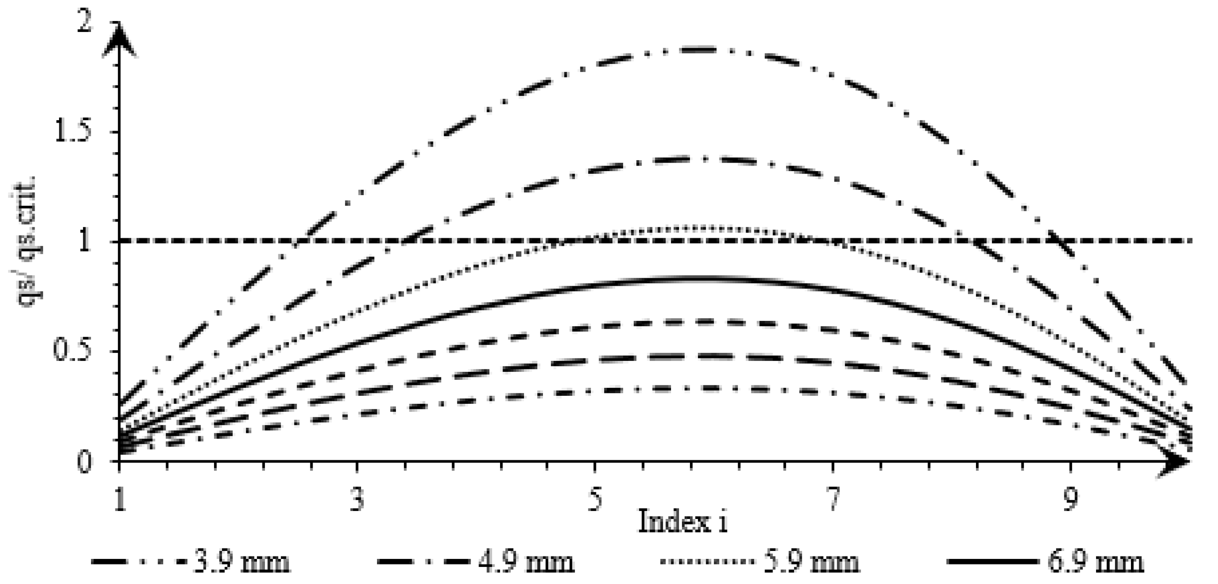
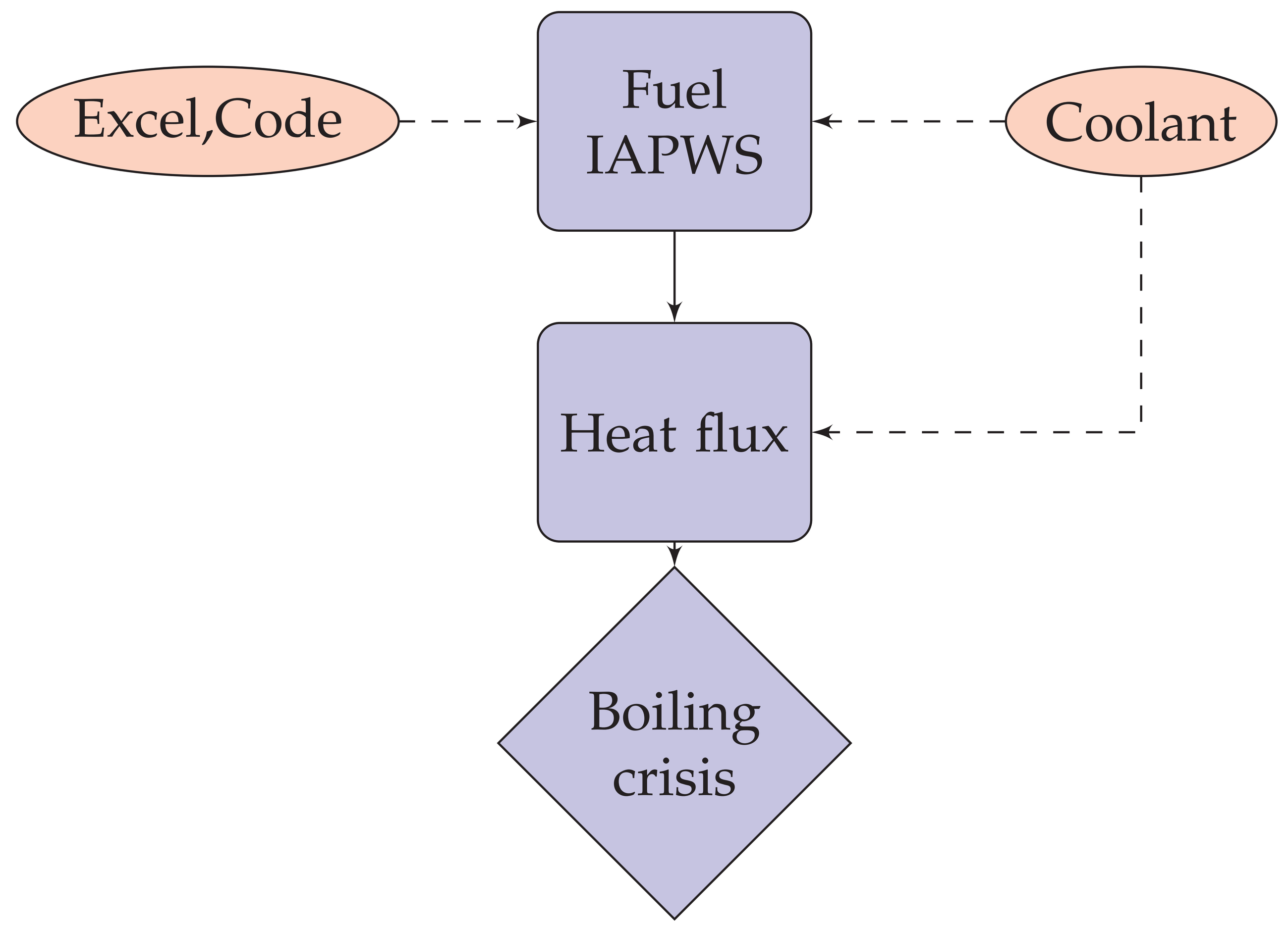


Figure 1: A graph of Dependence of heat flux on the fuel assembly section

Conclusion



- The heat transfer calculations conducted on the RITM-200 reactor unit showed that the temperature of fuel increases as the fuel element diameter decreases. This can be explained from the fuel burnup which is inversely proportional to diameter.
- It is also established that the coolant velocity is proportional to the fuel element diameter which implies that increasing the fuel element diameter will lead to a higher heat removal by the coolant from the outer surface of the fuel clad.
- There will be no boiling crisis as a result of heat removal from the system.

References

[1] J. R. Lamarsh et al. Introduction to nuclear engineering. *Upper Saddle River, NJ: Prentice Hall, Vol. 3. -P. 783*, 2001.

Future Research

Employ the use of modern computational fluid dynamics codes to study the heat transfer mode as a result of fuel diameter changes.

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