УДК 621.039.53

NUCLEAR REACTOR MODELING USING «COMSOL MULTI-PHYSIC» FOR NUCLEAR FUEL ELEMENT

Y. Ghoneim
Scientific Supervisor: PhD. A.G. Karengin
Tomsk Polytechnic University, Russia, Tomsk, Lenin str. 30, 634050
E-mail: youmnasami24@gmail.com

МОДЕЛИРОВАНИЕ ЯДЕРНОГО РЕАКТОРА С ИСПОЛЬЗОВАНИЕМ «COMSOL MULTI-PHYSIC» ДЛЯ ЯДЕРНОГО ТВЭЛА

У. Гхонеим
Научный руководитель: к.т.н. А.Г. Каренгин
Национальный исследовательский Томский политехнический университет,
Россия, г. Томск, пр. Ленина, 30, 634050.
E-mail: yloumnasami24@gmail.com

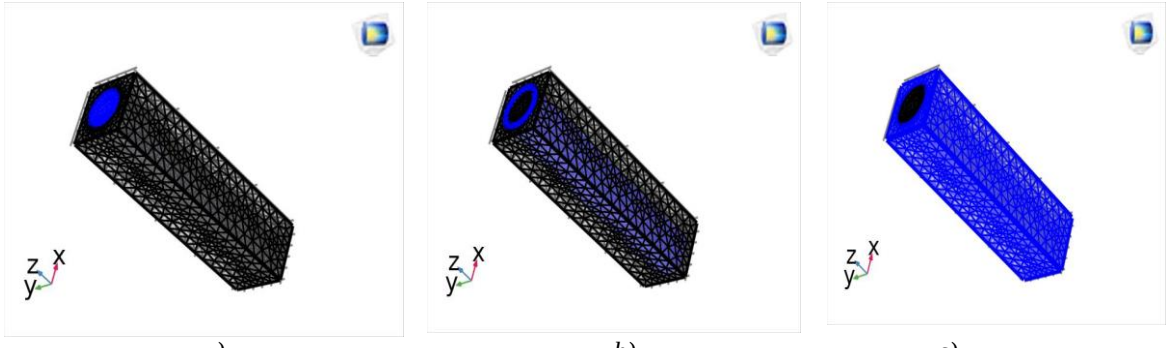
Аннотация. *Программа COMSOL используется для моделирования температурного анализа твэлов и оболочек с водой в качестве замедлителя, распределения тепловых напряжений.*

Introduction. Energy is released from fission within the fuel tube and then moved to the fuel's surface and through the cladding by heat conduction. Convection transfers heat from the cladding surface to the coolant, which travels from the core to the external heat exchangers where steam is produced.

The source of nuclear energy in a reactor is a nuclear fuel rod, based on the type of reactor, nuclear fuel is produced in various ways and serves as the reactor's main source of energy. The majority of operational commercial nuclear reactors employ uranium oxide (UO_2) pellets as fuel [1].

Research methods. In this modeling, a fuel rod is made up of many pellets that are stacked and sealed at both ends inside metallic zirconium alloy (zircalloy) thin tubes (or cladding) measuring 0.018 m in thickness, using water as a moderator material [2].

A fine mesh produces precise numerical results in accordance with the finite element method's guiding principle. As a result, the fuel rod, cladding, and moderator block in the cylinder geometry were included in the finite element analysis, as illustrated in Figure 1. [2].



a) *b)* *c)*

Fig. 1. Mesh analysis for a) fuel rod, b) cladding, c) moderator

There are three modules of physics (heat transfer in solids, solid mechanics module, and multi-physics coupling) used to proceed with the modeling process using COMSOL multi-physics simulation program.

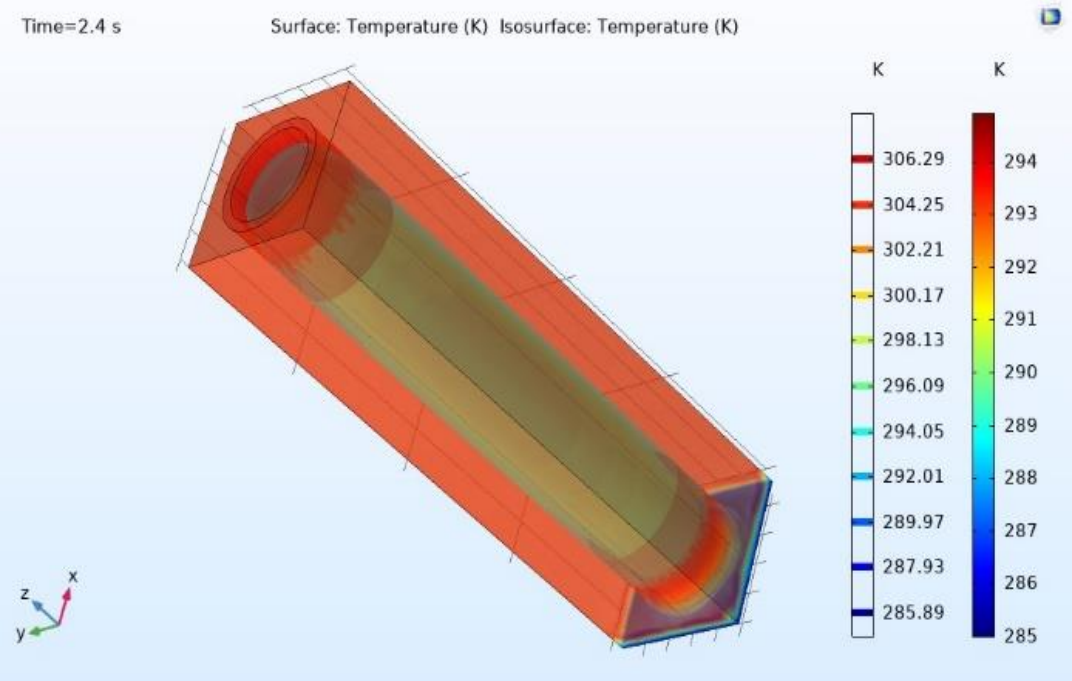


Fig. 2. Temperature COMSOL animation scan

In this study, a heat-generating cylinder is put through a hybrid analytical-numerical thermal study with temperature-dependent thermo-physical properties similar to high-burn-up nuclear fuel rods. [3].

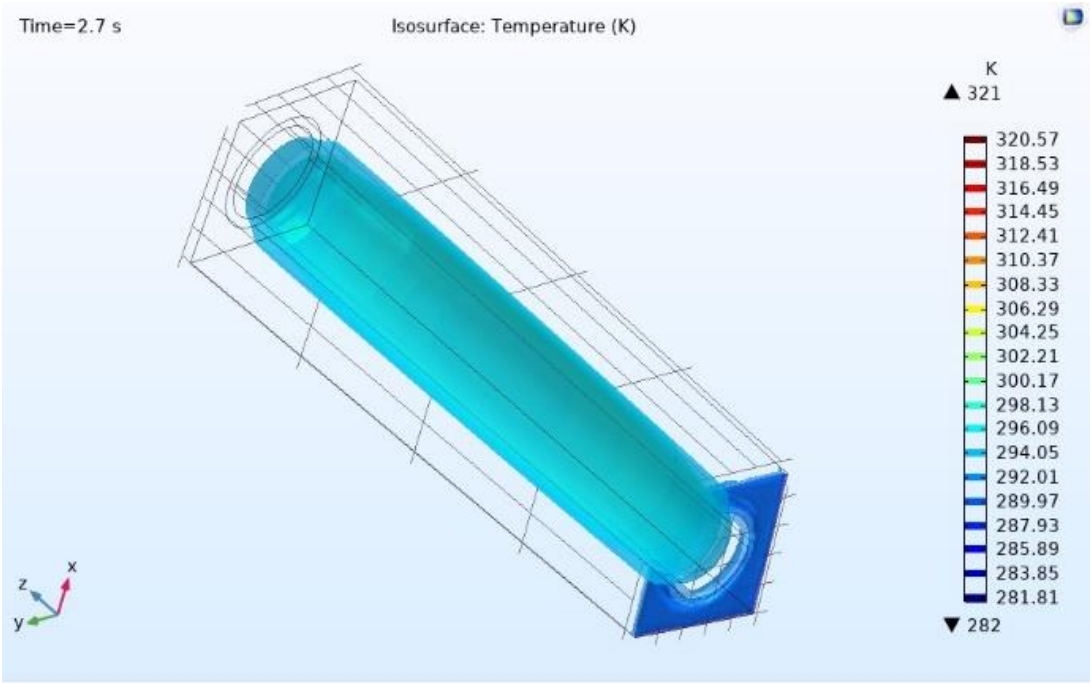


Fig. 3. Iso-surface temperature COMSOL animation scan analysis

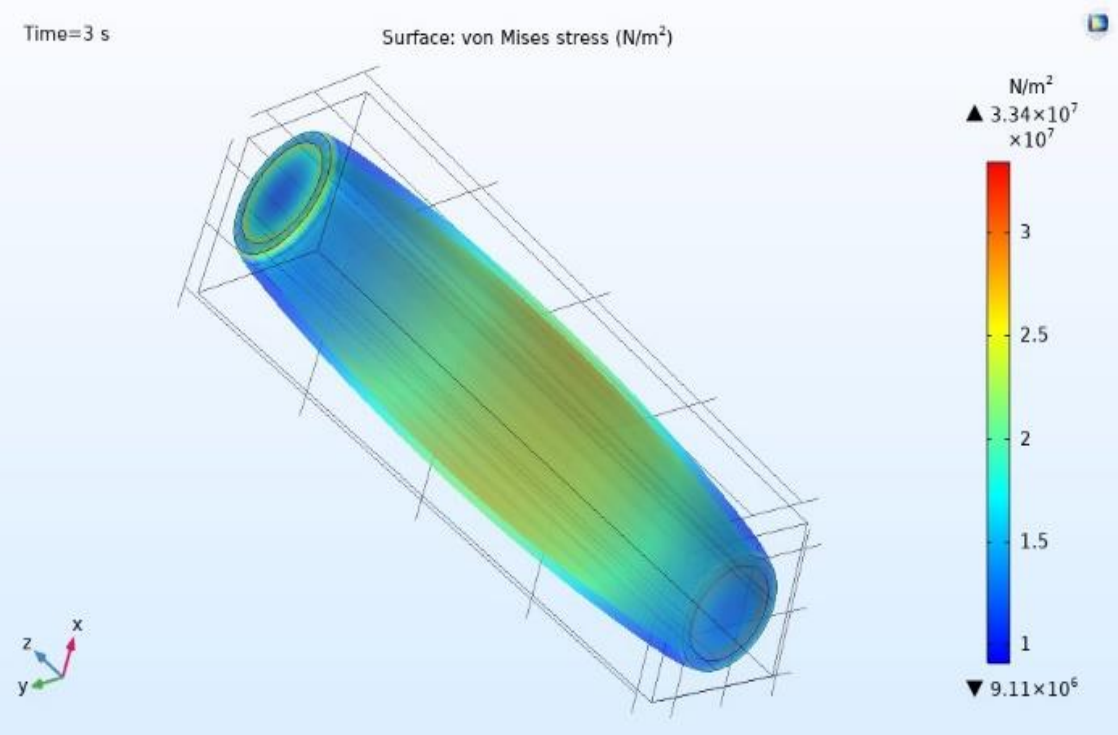


Fig. 4. Thermal stress COMSOL analysis for the entire geometry of a nuclear fuel element

Results. The temperature changes shown in the simulation results are corresponding to different neutron interactions throughout the entire geometry of the fuel sample.

Conclusion. It has been observed that the pellet bias has a significant impact on the temperature of the pellet center but little impact on the difference in temperature between the cladding tube's interior and exterior walls.

REFERENCES

1. Eskandari, M.R., Bavandi, A., Mihandoost, A. Studies on nuclear fuel rod thermal performance // Energy Procedia. – 2012. – P. 1-6. doi.org/10.1016/j.egypro.2011.12.909.
2. Linghong, S., Yunqiao D. Finite element analysis of temperature field of nuclear fuel cladding tube // Article. Retrieved, 2021, from *Ser.* 1985 012061 DOI 10.1088/1742-6596/1985/1/01206.
3. Pontedeiro Auro, C., Renato M. Cotta (2007). Thermal analysis of high burn-up nuclear fuel rod using generalized integral transform technique, Article, Retrieved, 2007, from ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR ABEN ISBN: 978-85-99141-02-1.