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Selection of materials for a nuclear rocket engine

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Selection of materials for a nuclear rocket engine

Purpose: This assignment will help you analyze several options to outline an engineering solution to a technological problem: the selection of materials for a nuclear rocket engine. Whichever your educational background is, it is important that you learn how different professionals make decisions in a collaborative project such as the buildup of a nuclear propulsion system. This will help you broaden your perspective, sharpen your analytical skills, and approach any problem with an open mind in your future professional endeavors.

Skills: The purpose of this assignment is to help you practice the following skills that are essential to your success in this course:

- Define the parameters that constrain an engineering problem.
- Compare different alternatives, and (potentially) be able to sketch some initial drawings of the solution at hand.
- Analyze the advantages or disadvantages of choosing a given solution.
- Defend an original design of a nuclear propulsion concept.

Knowledge: This assignment will also help you to become familiar with the following important content knowledge in this discipline:

- Materials used in nuclear rocket engines.

Tasks: You are required to select which materials will be used in the construct of a nuclear reactor for a space rocket. The reactor parts under consideration are four: the fuel, the moderator, absorber, and structural material. It is initially assumed that the fuel elements are the hexagonal prisms used in NERVA. However, if you consider that this configuration should be changed to better match the requirements, feel free to change it. The solution should not match NERVA project, and you need to justify the decisions you make. It is recommended to follow the scheme below:

1. Make a brief historical introduction to nuclear propulsion in space, in no more than 300 words.
2. Make an estimate of the dimensions and the operational temperature of the reactor. You could infer some values from a given space mission you would like to fly. Remember that space mission parameters are a given in this project, they do not need to be calculated.
3. Decide which parameters are important to consider for each of the parts, and which range of values would be acceptable. Do not forget to consider aspects such as manufacturability, acquisition and production costs, safety considerations (see chapter 17 in the book for initial references) or operational efficiency. Add as many parameters that you may consider. Remember that the set of parameters may vary for each part. For instance, large absorption cross-sections are only applicable for the control material (absorbers).

4. Make a selection of the materials available. A minimum of two are required for each part. For the fuel, one in addition to ^{235}U is necessary.
5. Make a chart for each pre-selected material, which shows in a snapshot which material is most appropriate for the nuclear reactor.
6. Draw some conclusions based on the materials selected. Would the alternatives result in cheaper cost? Would that have an impact on safety aspects? Which geometries (if any) would favor the use of certain materials?

Criteria for success: The final product should be in the form of a report following APA style guidelines (7th edition). A cover page would include the title, the author's information and a brief abstract (50 words maximum). Special attention is brought to the adequate usage of references and in-text citations. Suggested length: about 1,500 words, excluding references and cover page.

Some of the following sources may be useful:

Konings, R. J. M., & Stoller, R. E. (Eds.) (2020). *Comprehensive nuclear materials*. Elsevier.

Dewar, J. A. (2004). *To the end of the solar system: the story of the nuclear rocket*. University Press of Kentucky.

Emrich, W. Jr. (2023). *Principles of Nuclear rocket propulsion*. Elsevier.

Feel free to explore other sources!