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Analysis of Lobe Power Calculator and Indication System with Physics and Cycle Based Models

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Introduction

The research goal of this experiment is to study the effects of physics and cycle based power calculations. This will focus on the algorithm for the lobe power calculation and indication system (LPCIS), which utilizes 10 radiation detectors within the Nitrogen-16 (N-16) system. These detectors, in relation to the 5 power lobes, will form power equations which utilize coefficients and multipliers. The objective of this study is to determine if physics and cycle based coefficients and multipliers will output more accurate readings than the current traditional calibrating method.

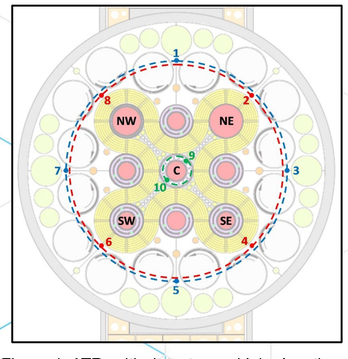

Figure 1. ATR with detector and lobe locations.

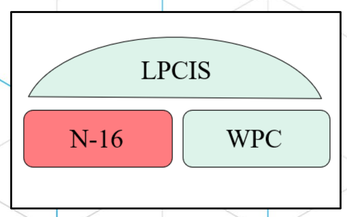

Figure 2. ATR LPCIS and Water Power Calculator (WPC) power measuring systems.

Methods

Two methods are observed to compare and contrast the impact of coefficients and multipliers. Both methods are observed with constrained and unconstrained effects. Constrained will operate under safety measures of the WPC and unconstrained will operate under independently of WPC. Weighting factors varying from 10, 100, and 10000 are utilized only for constraint power calculations since unconstrained has a weighting factor of 1. For this experiment the methods were applied to the 166-A cycle.

Original least squares method

- This is the current method being used to calculate the reactor power.
- This system is based on empirical adjustment of multipliers and coefficients.
- Has been implemented for decades and is reliable.

New physics and cycle based method

- This method utilizes INL's high-power computer (HPC) to calculate coefficients and multipliers.
- Coefficients and multiplier results vary the longer the HPC calculates cycles.
- For this experiment 3 different sets of values are produced by the HPC. The sets consist of 23-hour, 11 day, and 40-day calculations.

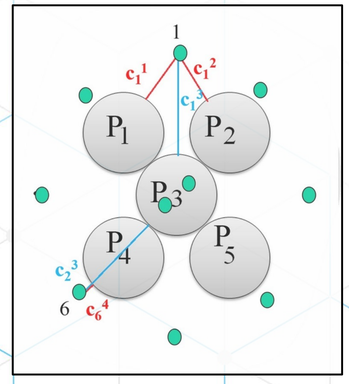

Figure 3. Detector and lobe positions that determine magnitude equations.

Results

The results of this experiment did compare constrained and unconstrained results of both methods.

Constrained

- The most favorable results produced are the following
  - 40-day HPC physics with weighting factor of 10000
  - Original method with weighting factor of 10000
- The least favorable results produced are the following
  - 23-hour HPC physics with weighting factor of 10
  - Original method with weighting factor of 10

Unconstrained

- The most favorable results produced are the following
  - 40-day HPC physics
  - Original method
- The least favorable results produced are the following
  - 23-hour HPC physics
  - Original method with weighting factor of 10

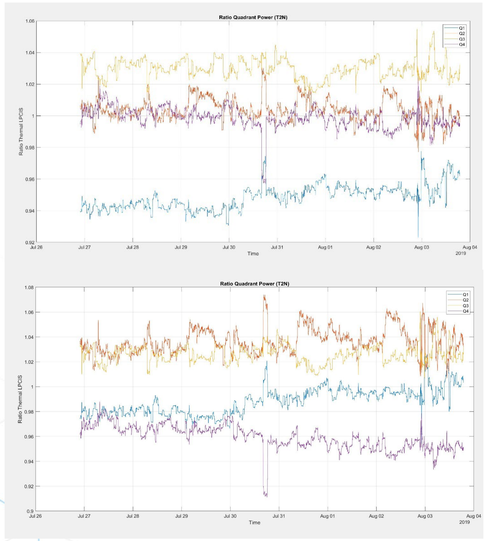

Fig 4. Results of 40-day physics and least squares method with a weighting factors of 10k.

Conclusion

Based on the evidence collected.

- HPC calculations are effective for calculating coefficients and multipliers. The longer HPC calculates the more effective the results.
- Physics based HPC calculations outperformed the current least squares method. This is only accurate for the applications of the 166-A cycle.
- The physics and cycle based method doesn't hold up for different cycles. Implementation of 166-A coefficients and multipliers on 169-A resulted with the least squares. method outperforming the physics-based method.
- The tested physics method isn't 100% possible without the ability to change coefficients in real time for each cycle.
- A machine learning method could potentially be implemented in the near future to also produce coefficients and multipliers.

Fig 5. ATR core during operation.