PEARLS™: The Next Generation Loading Pattern Search Tool from Westinghouse

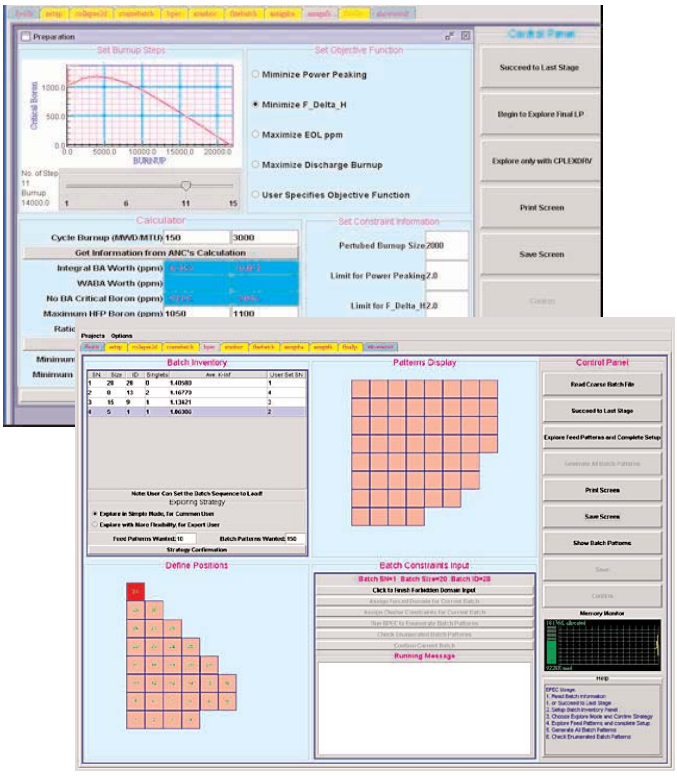
Engineering Services

Background

Perfect loading patterns (LPs) are the ultimate goal for all core designers. With PEARLS (Pattern Enumeration and Refinement for Loading Search), the most advanced search tool available from Westinghouse, core designers have a unique tool to achieve this goal. PEARLS delivers:

- Improved economy
- Accuracy and consistency
- Reduced neutron leakage
- Extended cycle length
- Enhanced margin usage
- Decreased waste volume

A typical PEARLS search will examine or eliminate by bounding 10^{20} to 10^{24} of possible candidate patterns—many orders of magnitude more than the "step-by-step" search tools currently available. PEARLS gives veteran designers the tools needed to quickly converge on the ideal LP and guides less experienced designers through the search process, arriving at relatively the same result. Set the design criteria, and PEARLS finds the optimum pattern. Change the criteria, and PEARLS will find the new optimum pattern. This control gives designers the power to meet the current plant needs and the confidence to know that they have the best LP to meet those needs.



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PEARLS combines the highly theoretical concepts of branching-and-bounding batch patterns enumerated under constraints (B3PEC), the enumeration technique, and the branch-and-bound (B&B) technique of integer programming into a real-world, practical engineering solution that results in a deterministic and comprehensive search process.

PEARLS is further grounded in its practical approach by using the Westinghouse Advanced Nodal Code (ANC) for spatial calculations, resulting in the direct applicability of its results to design calculations. For ease of use and adoption into any user environment, PEARLS is driven by a graphical user interface (GUI) that can be installed onto current generation workstations.

PEARLS provides a tool for fuel and utility managers who need to demonstrate that they are meeting their fiduciary duty to use the best possible LPs. Analysis on random cores demonstrates that PEARLS, fed with the appropriate criteria, produces results better than or equal to those developed by an expert core designer who "tweaked" the results from earlier generation search code methods.

Benefits

The benefits of using PEARLS to find your "best" core LP include:

- **Improved LP quality**
  For a given set of input search parameters and constraints, PEARLS evaluates all alternatives to find the best one and has the capability to find the equivalent of 0 to 10 extra effictive full-power days (EFPDs). LP search is, of course, a go/no-go operation. Many plant cycles teeter on the brink of acceptability with N-4 feeds but are loaded with N feeds. In these situations, PEARLS can be the catalyst that enables the designer to find the acceptable LP that saves four assemblies.
- **Reduced time to final LP**
  More candidate LPs are analyzed in less time.
- **Design-grade accuracy**
  Accuracy is ANC-equivalent.
- **ANC-consistent models**
  Resulting PEARLS model is inherently consistent with ANC, having been generated and depleted with ANC.
- **Less variability in LP quality**
  LP quality is less heavily dependent upon the core designer's level of experience and skill.
- **Increased confidence in the final LP**
  PEARLS' exhaustive search leaves little doubt about the final, best LP.

PEARLS Methodology

- **B3PEC**
  B3PEC interactively generates all the batch patterns with a variety of flexible position constraints that the user can impose. Each batch pattern later sprouts into numerous patterns via in-batch shuffle and burnable absorber loading. A user can repeatedly run B3PEC to define the search problem and assess its solution space size before starting any spatial calculations.
- **3-D/2-D ANC**
  Direct depletion calculations generate the sensitivity matrix (S-matrix) for burnable absorber loading adjustments and for in-batch assembly shuffles.
- **Mixed-integer linear programming (MILP)**
  An advanced MILP code uses the S-matrix and the B&B technique to evaluate all the patterns sprouting from each of the batch patterns. The B&B method takes advantage of the fact that the best continuous-variable solution always bounds the best integer-variable solution. If the best continuous-variable solution is not acceptable, then no permutation, i.e., shuffling, for generating integer-variable solutions is needed. An enormous shuffling problem can be solved quickly for the best solution using this method.

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