



Axiomatic Design Produces Seismic Improvements in Nuclear Rod Assembly

Context: The nuclear plant industry is highly regulated when it comes to safety, but since price deregulation the price of nuclear fuel has become a driving market force. Criteria for shut down during seismic activity are strictly enforced such that ground vibration exceeding certain levels requires immediate cessation of nuclear reactions. In addition, the financial challenge facing nuclear industry is to continue to produce quality nuclear products while at the same time reducing costs to stay competitive.

Problem: The largest volume nuclear product is a support structure to hold the nuclear fuel rods. One nuclear facility needed a new design of the fuel rod assembly in its pressurized light water reactor (PWR) for the following major objectives:

- Better secure safety of the core and fuel against vibration
- Reduce manufacturing costs
- Maximize product life/operation
- Trace design changes for compliance with governmental agencies

Solution: The spacer grid is a main component of the fuel assembly. The grid supports the fuel rods, guides cooling water, and guides control rods that control reactor power. The grid must maintain its structural integrity when subjected to impacts such as those from an earthquake and must tolerate high structural stress during thermo-nuclear reactions within the core. The design needs of the reactor environment drew from many disciplines, such as structural analysis, metallurgy, thermal-hydraulics, and manufacturing technologies. AD provided a systematic way of focusing on core Functional Requirements (FRs) in order to avoid the difficulties of basing the complex design process solely on experience and engineering analysis. Though the redesign included sophisticated analyses, the AD process guided the use of those analyses such that the final design resulted in a significant change in the shape of the spacer grid to achieve the following gains:

- Improved stress toleration over longer durations
- Less stress on the spacer during nuclear reactions
- Decreased spacer perturbation during seismic events
- Improved design for manufacturing
- Better traceability to specific requirements for regulatory compliance
- Improved design flexibility for easy modification as requirements change

Axiomatic Design Solutions is a business and technology consultancy that delivers measurable results and value through the application and support of axiomatic design methods as a basis for quality-driven design processes.

The Axiomatic Design Process

- Improves the quality of designs
- Facilitates the creative process
- Requirements driven
- Captures design intent and traceability
- Provides early phase risk assessment
- Gives objective metrics for design evaluation
- Reduces the Design-Build-Test-Design Cycle
- Scalable from small projects to very large
- Fully compatible with:
 - Six Sigma
 - QFD
 - Lean Process