Studsvik

EXPANSION IN THE STUDSVIK SOFTWARE SYSTEM

Jeffrey Borkowski, Studsvik Scandpower
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STUDSVIK SCANDPOWER TODAY

● President/CEO: Robert Whittle

Rob comes to Studsvik with extensive Business Development experience at GE and Motorola. Rob most recently served as the President of Astron Aerospace which is developing a revolutionary new and efficient rotary engine for aircraft as well as many other applications. Rob has global experience with high-tech software companies and has worked for several years in the nuclear industry at Los Alamos National Laboratory.

● Sr. VP, Global Sales & BD: Alina Reyzelman

Alina comes to Studsvik as a Senior Corporate executive with 14 years SaaS Enterprise software/information services sales experience. Alina has previous successful development positions at Wood Mackenzie and other positions in Enterprise Software sales and leadership.
BENEFITS OF STUDSIK PRODUCTS

● Modern Numerical Methods

● Direct Acquisition of Nuclear Data

● Nuclear Data Available Everywhere in Cycle

● Core Cycle Update Highly Automated

● Real-Time Execution On Conventional Hardware And Operating Systems

● Long-Time Partnership with the principals of Corys
ADDITIONAL BENEFITS FOR DIGITAL SYSTEMS

Cannot use Plant Digital Systems in the simulator with poor “measured” data from the simulator core.

Core monitoring system

Digital control system
**CORE MANAGEMENT SYSTEM 5 (CASMO5 + SIMULATES)**
- True Physics / True Geometry
- Models complicated mixtures of fuel enrichment zones, control rod zones, and spacer grids
- Automation to reduce engineering time and rapidly deliver results for design and planning
- Reduces time needed to perform the analysis for restart
- More accurate calculation of shutdown cooling

**CASMO**
State-of-the-art 2D lattice physics code for modeling square and hexagonal LWR nuclear fuel. CASMO5 reaches far beyond any other lattice physics codes.
- Incorporates the latest nuclear data library
- Substantially expands modeling capability
- Models new, more complicated fuel designs like Atrium-11™, Triton-11™, and GNF3

**SIMULATE**
3D, steady-state, multi-group nodal simulator for the analysis of LWRs.
- Developed specifically for modeling modern, more complicated fuel designs
- Microscopic depletion model with more than 50 explicit nuclides
- 3D, pin-by-pin power and exposure distributions
- Automatic sub-meshing for improved accuracy
- Advanced thermal-hydraulic models
- Accelerates the management of failed fuel

**CMSBUILDER**
Point-and-click graphical loading pattern design tool. Allows core designers to design and evaluate multiple loading patterns in a short period of time.

**S3K**
Advanced, two-group nodal code delivers neutronic and thermal-hydraulic analysis to perform transient analysis with licensing-grade accuracy over a wide range of dynamic applications.

**GARDEL**
An advanced on-line core monitoring suite with built-in reactivity management tools. GARDEL reduces uncertainties and conservatism that limit reactor efficiency.

**S3R**
Enables the training simulator to run using cycle-specific, real-time core modeling. Integrates with simulators from CORYS, GSE Systems, WS Carey, and L-3 MARPS.

**MARLA**
Automates safe movement and accountability of all Special Nuclear Materials on a plant site. MARLA optimizes fuel shuffles, dry cask storage campaigns, and spent fuel storage pool configurations.

**SNF**
Leverages extended isotope chains in CASMO5 to perform highly accurate, best estimate analysis of spent fuel for the fuel pool, interim dry cask storage and permanent repositories for up to 100,000 years.
**S3R V2.08.00**

- First Sale In China
  - Licensed Re-distribution
  - v2.08.00
  - Generic W3L base model

- New License Prototype
  - S3R Client Application
  - Minimal, Standard Interface Source

- Basis for CMS5-Compatible S3R
VALUE OF LICENSE CMS5 TO TRAINING

- The information presented in the TR demonstrates that the CMS5 codes are acceptable for performing all core physics analyses as the licensing code of record separately from the fuel vendor including:
  - Reload Design
  - Safety Analysis Input
  - Startup Predictions
  - Plant Physics / Operator Data Books
  - Reactor Protection and Monitoring System Updates
- No “two clock” problem with computed reference data
- Same level of compatibility with S3R
# CRITERIA FOR SIMULATOR FIDELITY

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<th>Difference (pcm)</th>
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![Assembly ID](image1.png)  
![Boron Concentration](image2.png)
\[ \phi(z) = \frac{\int \Sigma(r)\phi(z) dV}{\int \phi(z) dV} \]
Following Fukushima, U.S. Department of Energy to focus on developing enhanced accident tolerant fuel and cladding
"Tolerate loss of active cooling for a considerably longer time period, while maintaining or improving fuel performance (relative to standard UO$_2$)"

Three-phase plan:
- Phase 1: Feasibility and down selection
- **Phase 2: Development and qualification**
  - FY 2017 – 2022
  - Industry-led supported by labs and academia
- Phase 3: Commercialization
THREE APPROACHES TO ATF

Modify current cladding
- Near-term
- Apply coating
- Reduce oxidation/hydriding
- Example: Cr-coat

Replace current cladding
- Long-term
- Very low oxidation/hydriding, PCI
- High-strength at high T
- Examples: FeCrAl, SiC

Improve or replace
- Improved fission gas retention
- High thermal conduct.
- Examples: Cr-doped, $U_3Si_2$, LightBridge

ATF MODELING WITH CMS5

- **CASMO5**
  - ATF material compositions present in the ENDF/B VIIIr0 library
  - Verification of library group structure and resonance self-shielding calculation

- **SIMULATE5**
  - Define properties for new materials: FeCrAl, SiC, U$_3$Si$_2$
  - Develop new fuel/cladding gap models
  - Create the intra-pellet power profile tables with **CASMO5**
  - Review the Doppler temperature for cross-section evaluation

From [http://www.nei.org]
INCREASED ENRICHMENT & BURNUP

- Burnup (Peak Pin or equivalent)
  - 62 GWD/MTU to 75 GWD/MTU

- Enrichment (max pellet)
  - 5 w/o 235U to 10 w/o 235U
  - Near term actual designs need smaller increase
A BIT MORE ON INCREASED ENRICHMENT

- Larger $^{235}$U Content is a Licensing Consideration, Not A Technological Leap
- BUT this higher enriched fuel is not necessarily cast in UO$_2$ pellets
- Thermal And Mechanical Performance At High Temperature Presents More Issues
  - Thermal Expansion
  - 2D Conduction
  - Basic Material Properties
WHAT DOES THAT MEAN TO WHOM?

• Fuel (Vendor/Plant Site)
  • Qualification of Methods for application to higher burnup
  • Fuel Management
  • Longer Cycle Lengths
  • 24 months for high power PWR
  • Higher neutron absorber loadings

• Power Peaking
  • Reactivity
  • Fuel storage/transportation requirements
  • More Decay Heat

• Core Designer Options
  • Fuel Lattice Optimization
  • More Types of Fresh
  • Optimization
• Startup Physics Testing
• More Core Lives
• At power Testing
• Power Distribution Accuracy
• Time in Life Reactivity Coefficients
• Core Follow Program
• Core Reactivity
• Power Distribution Accuracy
PREPARATION FOR HEX CORES

2020

• Strategic Decision for Complete Offering to Hex Owners
• Other Dynamic Modules from S3R
• “Computer Science” Interface as in S3R
• External T/H

2021

• Significant Progress
• Completion Early 2022
SUMMARY: WE WORK HARD SO YOU DON’T HAVE TO

- S3R Continues To Provide High Fidelity Operations Training
- S3R Capitalizes On the Design Methods of CMS
- The Scope of Studsvik’s Real-Time Capabilities Are Expanding