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Activities in the field of Fast Reactors Research and Technology Developments in Mexico

49th Meeting of the TWG-FR

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26.05.2016

Outline

- Introduction.
- Activities 2015.
- Recent activities.
- National and international nuclear energy policies.
- Conclusions.

Introduction

- Mexico was accepted as observer in the TWG-FR in 2014.
- Two Mexican representatives:
  - Armando Gomez and Federico Puente
- As a first step, together with IAEA, a Fast Reactors education and training seminar was organized.
- The mexican universities doing academic studies have been identified and the creation of a Mexican Fast Reactors research group as part of the AZTLAN project is ongoing.

Activities 2015

Education and training seminar on Fast Reactors

Activities 2015

Education and training seminar on Fast Reactors

Activities 2015

Visit of experts to ININ after FR seminar

Activities 2015

- In 2014, a common research national project led by ININ was approved.
- In 2015, a subgroup on Fast Reactors have been created and all organizations are working together.

Mexican platform for nuclear reactor's simulation and design

FONDO
DE SUSTENTABILIDAD
ENERGÉTICA

CONACYT

AZTLAN Platform

ININ

UNAM

Casa abierta al tiempo
UNIVERSIDAD AUTÓNOMA METROPOLITANA

Activities 2015

The research ongoing in the institutions:

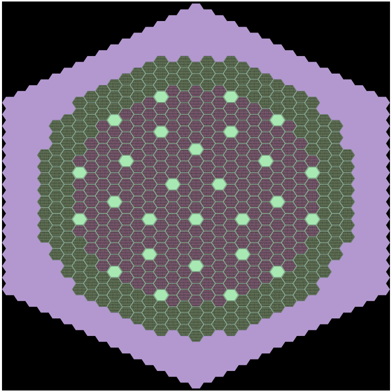
- National Institute for Nuclear Research (ININ): Neutronics with SERPENT and own tools, participation in the UAM-SFR Benchmark.
- National Polytechnic Institute (IPN): Neutronics with SERPENT and development of own tools.
- National Autonomous University of Mexico (UNAM): Neotronics with SERPENT, MCNP and KNEXT
- Metropolitan Autonomous University (UAM): Thermalhydraulics with own tools.

Recent activities

ININ

As a result from a visit to CEA Cadarache and thanks to Dr. Alfredo Vasile, Dr. Christian Latge and Dr. Gerald Rimpault, ININ was accepted to participate in the UAM-SFR Benchmark.

First calculations have been done with SERPENT



Recent activities

ININ

Benchmark for Neutronic Analysis of Sodium-Cooled Fast Reactor Cores with Various Fuel Type and Core Sizes.

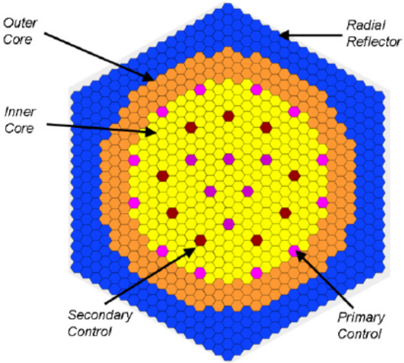
Cores included in the benchmark:

- CAR-3600
- MOX-3600
- MET-1000
- MOX-1000

Recent activities

ININ

CAR-3600 Core

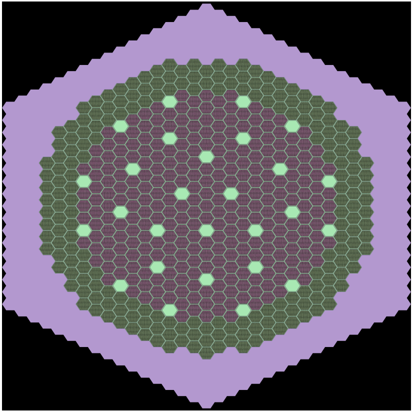


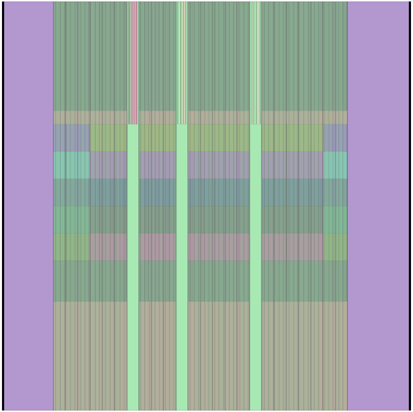
- (U,Pu)C Fuel
- 487 fuel assemblies in two zones (286 + 201)
- 270 radial reflector assemblies
- 27 control assemblies in two independent systems (18 + 9)

Recent activities

ININ

3600-CAR Core in Serpent





Preliminary Results 3600 MW Cores

MOX-3600			
XS Library	AZTLAN K-EFF	Benchmark Av. K-EFF	Benchmark Std. Dev
JEFF 3.1.1	1.03428	1.0138	0.00405
ENDFB7	1.02932	1.0138	0.00405

CAR-3600			
XS Library	AZTLAN K-EFF	Benchmark Av. K-EFF	Benchmark Std. Dev
JEFF 3.1.1	1.00913	1.0090	0.0062
ENDFB7	1.00326	1.0090	0.0062

Recent activities

ININ

Preliminary Results 3600 MW Cores

MOX-3600			
XS Library	AZTLAN* Void Worth	Benchmark Av. Void Worth	Univ. Illinois** Void Worth
JEFF 3.1.1	1423.9	1937	1559
ENDFB7	1423.9	1937	1569

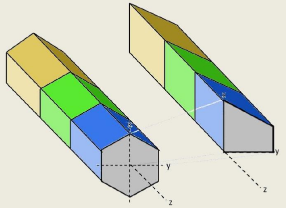
CAR-3600			
XS Library	AZTLAN* Void Worth	Benchmark Av. Void Worth	Univ. Illinois** Void Worth
JEFF 3.1.1	1577	2120	1464
ENDFB7	????	2120	1750

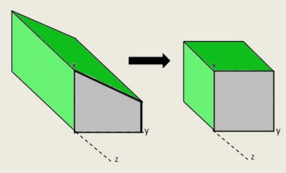
* AZTLAN Team used SERPENT 2.1.20 with setpot 1000000 330 30 and fixed seed.

** No information about version of SERPENT, setpop or seed used.

Recent activities
IPN

- Development of a 3D diffusion module AZNHEX, solves numerically the time dependent neutron diffusion equations in Hexagonal-Z geometry.



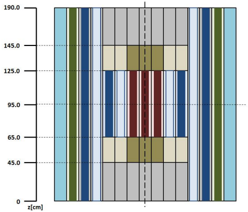


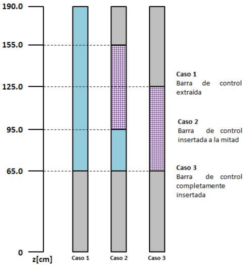
- Gordon-Hall transfinite interpolation to each one of the four quadrants to transform it in a cube.

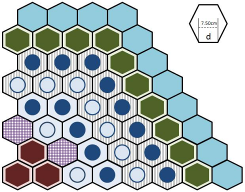
Recent activities

IPN

- Benchmark for Reactor FBR (KNKII).



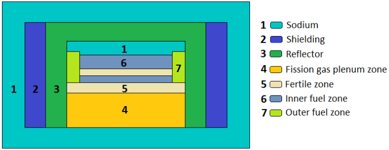


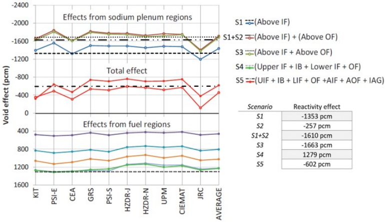


	AZNHEX	PARCS	PCM
Case 1	1.048129	1.074046	2413.0
Case 2	0.957055	0.958441	144.6
Case 3	0.843969	0.844319	401.4

Neutronic Study of a Sodium cooled Fast Reactor

- At the National Autonomous University of Mexico a validation of a developed ASTRID-like nuclear reactor model has been developed with accurate results.
- Reactivity at End of Cycle, Doppler constants and sodium void worth were analyzed with successful results.



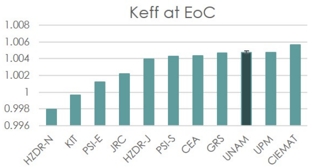


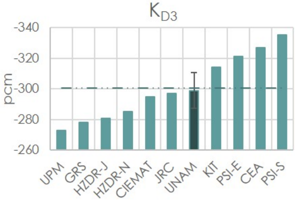
Scenario	Reactivity effect
S1	-1353 pcm
S2	-257 pcm
S1+S2	-1610 pcm
S3	-1663 pcm
S4	1279 pcm
S5	-602 pcm

Recent activities

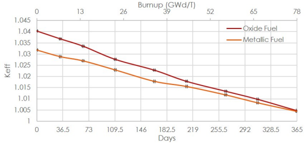
UNAM

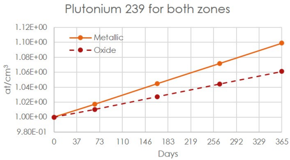
Neutronic Study of a Sodium cooled Fast Reactor





Metallic vs. Oxide fuel in ASTRID design



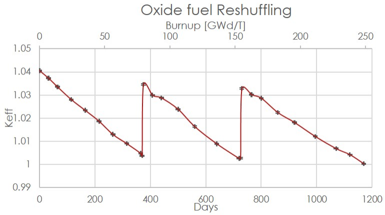


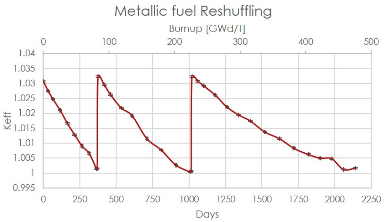
Recent activities

UNAM

Breed and burn strategies

- Different strategies for enhancing the fuel utilization are analyzed, such as the reshuffling fuel strategy.
- Different core configurations without loading fresh fuel are studied.

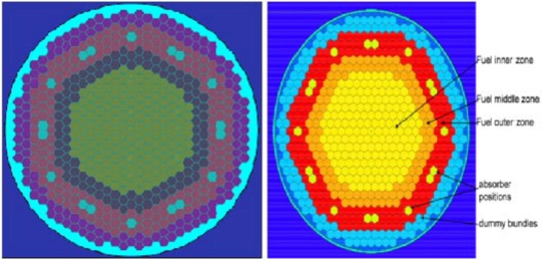




Recent activities
UNAM

Neutronic Study of a Lead cooled Fast Reactor

- Analyze the breeding capability and MA transmutation, comparing the MOX base fuel with Nitride fuel, using SERPENT.



Keff at BoC	
Taget value	Serpent value
1.0136	1.0134

Recent activities

UNAM

Transmutation analysis of nuclear waste in a Gas Fast Reactor

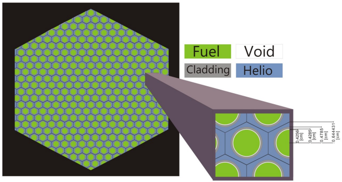
- Minimize nuclear waste via transmutation of minor actinides

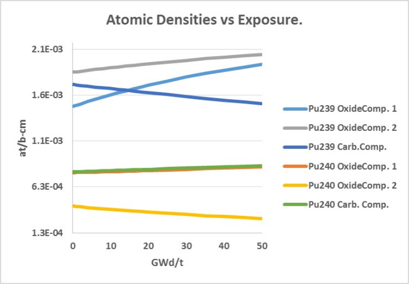
Nuclide	[at/b-cm]		
	Oxide Composition 1	Oxide Composition 2	Carbide Composition
U235	5.42E-05	4.97E-05	5.67E-05
U238	2.14E-02	1.96E-02	7.94E-03
Np237	1.70E-04	2.05E-04	0.00E+00
Pu239	1.51E-03	1.88E-03	1.75E-03
Pu240	7.85E-04	1.33E-03	7.93E-04
Pu241	3.10E-04	4.20E-04	3.34E-04
Pu242	2.38E-04	4.67E-04	1.51E-04
Am241	1.43E-04	3.16E-04	0
Am243	5.93E-05	1.23E-04	0
Cm244	1.96E-05	6.50E-05	0
Oxigene	4.95E-02	4.94E-02	0
Graphite	0	0	8.531E-02

	Final (at 50 GWd/t) - Initial (at 0 GWd/t)		
	Oxide Composition 1 Delta (at/b/cm)	Oxide Composition 2 Delta (at/b/cm)	Carbide Composition Delta (at/b/cm)
U235	-2.42E-05	-1.81E-05	-1.71E-05
U238	-1.64E-03	-1.21E-03	-3.76E-04
Np237	-5.58E-05	-5.47E-05	1.61E-06
Pu239	4.55E-04	1.88E-04	-2.11E-04
Pu240	6.36E-05	-2.05E-05	6.66E-05
Pu241	-1.17E-04	-1.33E-04	-9.09E-05
Pu242	-5.84E-06	-2.15E-05	6.43E-06
Am241	-2.84E-05	-6.09E-05	3.79E-05
Am243	2.06E-06	-3.60E-08	1.13E-05
Cm244	1.28E-05	1.14E-05	1.53E-09

Recent activities
UNAM

Transmutation analysis of nuclear waste in a Gas Fast Reactor





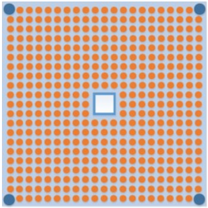
Paper presented in PBNC 2016: Transmutation analysis of nuclear waste in a Gas Fast Reactor, Ricardo Reyes Ramírez, et. al.

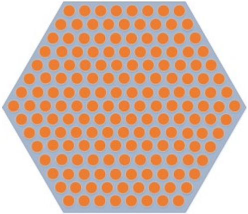
Recent activities

UAM

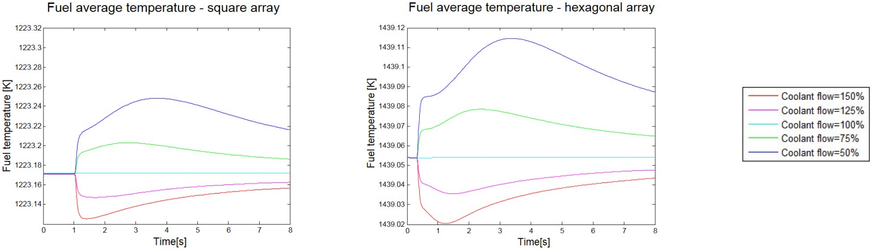
Simulation of thermal-fluid process in lead-cooled fast reactors

- Using as a reference the reactor ELSY (European Lead-cooled System)
- Development a code to describe the process in the core
- Reproduction of analysis in the core and compare between square and hexagonal arrays:





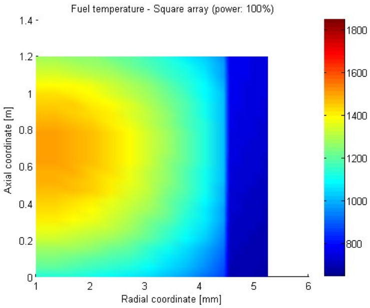
Fuel average temperature comparisons between square and hexagonal array with different coolant flow

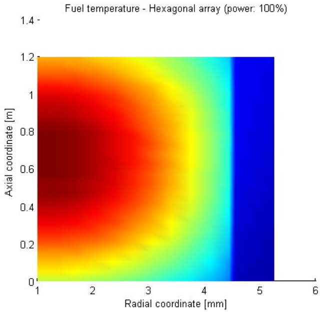


Recent activities

UAM

Fuel temperature comparison between square and hexagonal array, nominal power of 100 %





National and international nuclear energy policies

Nuclear status in Mexico

- One Nuclear Power Plant "Laguna Verde" with two BWR-5 reactors.
  - 4 % of installed capacity.
  - 3-5 % of generated electricity.

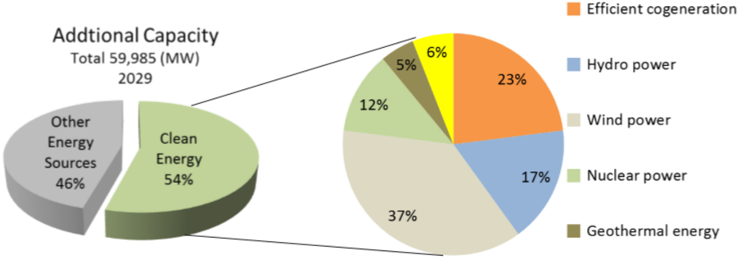
- One national research centre: ININ.
- The regulatory body: CNSNS.
- Five academic institutions with nuclear programs.

National and international nuclear energy policies

Nuclear status in Mexico

- In 2013, the national energy strategy pointed out that Nuclear Power would play an important role in electricity production.
- In 2014, a big energy reform in Mexico opened the electricity production in Mexico to the private sector (Energy sector was exclusive from state).
- However, nuclear energy remains being exclusive from state.
- Thus, decisions on increasing nuclear power still are taken by the government.

The PRODESEN 2015-2029 established three new reactors, this will represent 12% of total clean energy.



Conclusions

- The acceptance of Mexico in the TWG-FR is a great opportunity to extend the knowledge of the nuclear research institute in Fast Reactors (traditionally focused on light water reactors).
- After one year, significant steps have been done in the Fast Reactors area.
- In the short term, Mexico, and particularly the institutions taking part on the AZTLAN platform project, will be able to participate much more actively in the international Fast Reactors community.
- The seminar and the Mexican Fast Reactors group will contribute to the human resources with background on Fast Reactors in Mexico

END

Thanks a lot for your attention