July 27, 2023

Sunming Qin, Gerhard Strydom
Department of Advanced Reactor Technology & Design
Idaho National Laboratory

HTGR Validation: NEUP Survey and Database

Database Development for HTGR Thermal-Fluid Experiments

DOE ART Gas-Cooled Reactor (GCR) Review Meeting
Virtual Meeting
July 25 – 27, 2023

ART
Advanced Reactor Technologies

Introduction

- From FY2009 to FY2023, there are in total 35 DOE NEUP [1] projects focusing on the thermal-fluid experiments related with High-Temperature Gas-cooled Reactor (HTGR), producing **a large amount of high-quality validation data**, however,
  - data is distributed at universities and *has not been disseminated to the HTGR community well*,
  - final reports are now only available on the OSTI webpage.
  - This is a missed opportunity for the HTGR research community needing code validation data.
- Our work is aimed to improve access to the HTGR validation data and optimize the return on the significant investment made by DOE. Supported by the Advanced Reactor Technologies (ART) Gas-Cooled Reactor (GCR) program [2], we conducted a survey to:
  - **Assess completed and ongoing NEUP-funded HTGR-TH projects,**
  - **With the aim to develop a public-accessible data platform** that can be used to retrieve code validation data and guide future NEUP investments.

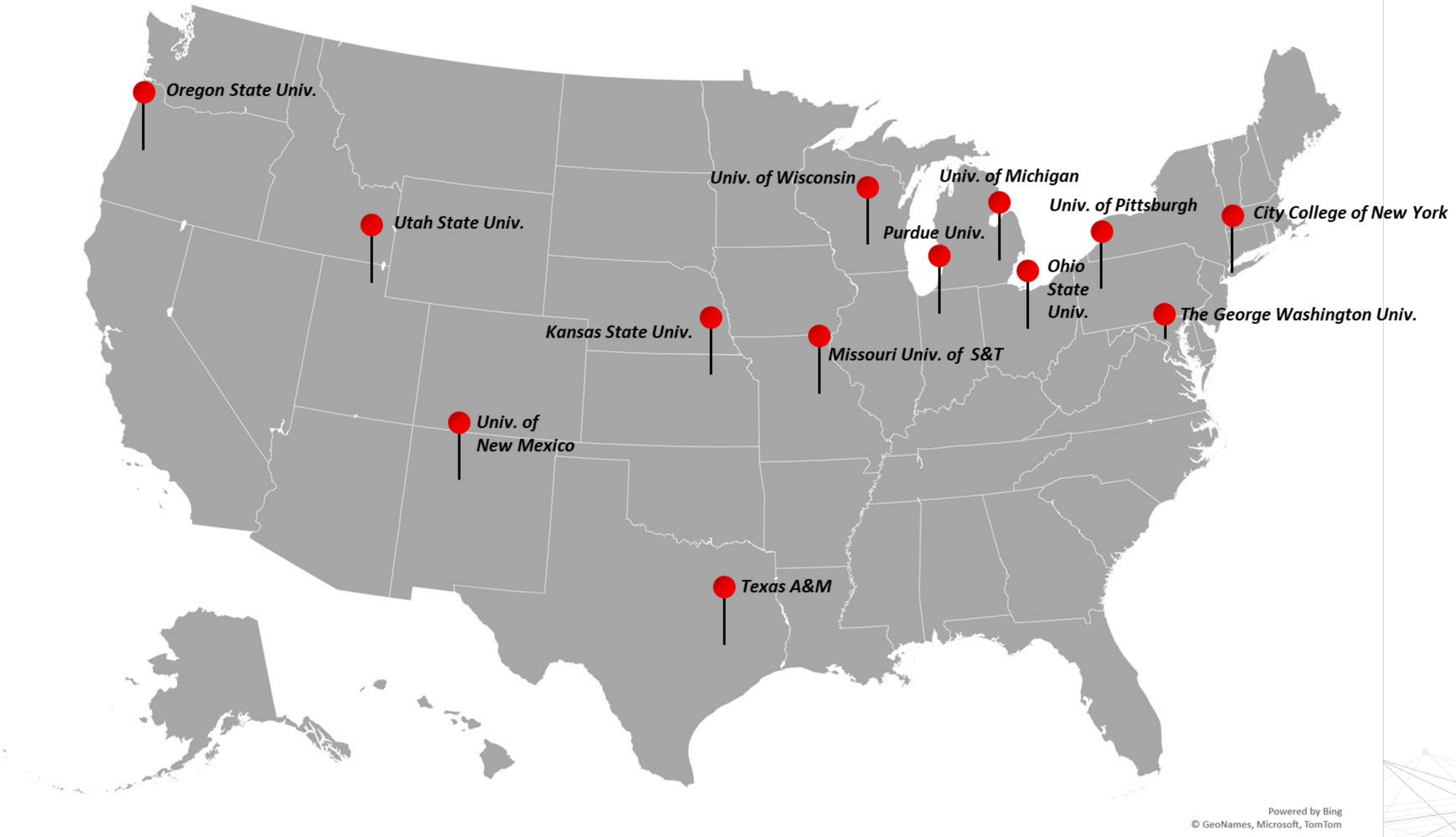
DOE NEUP Project List for HTGR-TH (FY09 – 23)

Project No.	Project Name	Project Instructors and Affiliation
09-771	Creation of a Full-core HTR Benchmark with the Fort St. Vrain Initial Core and Assessment of Uncertainties in the FSV Fuel Composition and Geometry	William Martin (University of Michigan)
09-781	Experimental Studies of NGNP Reactor Cavity Cooling System With Water	Michael Corradini (University of Wisconsin)
09-784	Investigation of Countercurrent Helium-air Flows in Air-ingress Accidents for VHTRs	Xiaodong Sun (Ohio State University, now at UMich)
09-817	CFD Model Development and Validation for High Temperature Gas Cooled Reactor Cavity Cooling System (RCCS) Applications	Yassin Hassan (Texas A&M University)
09-830	Graphite Oxidation Simulation in HTR Accident Conditions	Mohamed El-Genk (University of New Mexico)
09-840	Investigation on the Core Bypass Flow in a Very High Temperature Reactor	Yassin Hassan (Texas A&M University)
11-3079	Thermal-hydraulic analysis of an experimental reactor cavity cooling system with air	Michael Corradini (University of Wisconsin)
11-3081	Transient mixed convection validation for NGNP	Barton Smith (Utah State University)
11-3218	Experimental Investigation of Convection and Heat Transfer in the Reactor Core for a VHTR	Masahiro Kawaji (City College of New York)
12-3582	Experimentally Validated Numerical Models of Non-isothermal Turbulent mixing in High Temperature Reactors	Mark Kimber (University of Pittsburgh, now at TAMU)
12-3759	Experimental and CFD Studies of Coolant Flow Mixing within Scaled Models of the Upper and Lower Plenum of a NGNP Gas-Cooled Reactors	Yassin Hassan (Texas A&M University)
13-4884	Validation data for depressurized and pressurized conduction cooldown, validation data acquisition in HTTF during PCC events	Philippe Bardet (The George Washington University)
13-4953	Experimental and Computational Investigations of Plenum-to-Plenum Heat Transfer and Gas Dynamics under Natural Circulation in a Prismatic Very High Temperature Reactor	Muthanna Al-Dahhan (Missouri University of Science & Technology)
13-5000	Model Validation using novel CFD-grade experimental database for NGNP Reactor Cavity cooling systems with water and air	Annalisa Manera (University of Michigan)
14-6435	Fluid stratification separate effects analysis, testing and benchmarking	Andrew Klein (Oregon State University)
14-6786	Experimental Investigation and CFD Analysis of Steam Ingress Accidents in HTGRs	Xiaodong Sun -> Richard Christensen (Ohio State University)
14-6794	Scaling Studies for Advanced High Temperature Reactor Concepts	Brian Woods (Oregon State University)
15-8205	Experimental investigation of forced convection and natural circulation cooling of a VHTR core under normal operation and accident scenarios	Masahiro Kawaji (City College of New York)
15-8627	Experimental validation data and computational models for turbulent mixing of bypass and coolant jet flows in gas-cooled reactors	Mark Kimber (University of Pittsburgh, now at TAMU)

DOE NEUP Project List for HTGR-TH (cont'd)

Project No.	Project Name	Project Instructors and Affiliation
16-10244	Integral System Testing for Prismatic Block Core Design HTGR	Brian Woods (Oregon State University)
16-10509	CFD and system code benchmark data for plenum-to-plenum flow under natural, mixed and forced circulation conditions	Barton Smith (Utah State University)
17-13115	Experimental Determination of Helium Air Mixing in Helium Cooled Reactor	Victor Petrov (University of Michigan)
18-15058	High-resolution experiments for extended LOFC and Steam Ingress Accidents in HTGRs	Xiaodong Sun (University of Michigan)
19-17037	Investigation of HTGR Reactor Building Response to a Break in Primary Coolant Boundary	Shripad Revankar (Purdue University)
19-17183	Mixing of helium with air in reactor cavities following a pipe break in HTGRs	Masahiro Kawaji (City College of New York)
20-19896	Progression of High Resolution SET and IET Benchmarks on PCC and DCC events in HTGRs	Izabela Gutowska (Oregon State University)
20-19968	Experimental Investigations and Numerical Modeling of Near-wall and Core Bypass Flows in Pebble Bed Reactors	Thien Nguyen, Victor Ugaz, Yassin Hassan (Texas A&M University)
20-20074	Characterization of Plenum to Plenum Natural circulation flows in a high temperature gas reactor (HTGR)	Masahiro Kawaji (City College of New York)
21-24104	Thermal Hydraulics Investigation of Horizontally Oriented Layout micro HTGRs Under Normal Operation and PCC Conditions Using Integrated	Muthanna Al-Dahhan (Missouri University of Science and Technology)
21-24111	Experimental Investigations of HTGR Fission Product Transport in Separate-effect Test Facilities Under Prototypical Conditions for Depressurization and Water-ingress Accidents	N.K. Anand (Texas A&M University)
21-24156	Experimental thermofluidic validation of TCR fuel elements using distributed temperature and flow sensing	Hitesh Bindra (Kansas State University → Purdue University)
21-24287	Investigating Heat Transfer in Horizontally Oriented HTGR under normal and PCC conditions	Hitesh Bindra (Kansas State University → Purdue University)
22-26607	An Innovative Monitoring Technology for the Reactor Vessel of Micro-HTGR	Lesley Wright (Texas A&M Engineering Experiment Station)
23-29598	Uncertainty Quantification of Model Extrapolation in Neural Network-informed Turbulent Closures for Plenum Mixing in HTGRs	Som Dutta (Utah State University)
23-30994 (IRP)	Exascale Simulation of Thermal-Hydraulics Phenomena in Advanced Reactors and Validation Using High Resolution Experimental Data	Taehun Lee (City College of New York)

NEUP-Related HTGR Projects – Universities Participated



List of NEUP-Related HTGR Projects (FY09 – 23)

UNIVERSITY PARTICIPATING IN NEUP

FINISHED NEUP PROJECT # in RED

ONGOING NEUP PROJECTS # in BLUE

- **Univ. of Michigan, Ann Arbor**: 09-771, 13-5000, 17-13115, 18-15058
- **The Ohio State University**: 09-784, 14-6786
- **Texas A&M University**: 09-817, 09-840, 12-3759, 20-19968, 21-24111, 22-26607
- **University of New Mexico**: 09-830
- **University of Wisconsin, Madison**: 09-781, 11-3079
- **Utah State University**: 11-3081, 16-10509, 23-29598
- **City College of New York**: 11-3218, 15-8205, 19-17183, 20-20074, 23-30994
- **University of Pittsburgh**: 12-3582, 15-8627
- **The George Washington University**: 13-4884
- **Missouri University of S&T**: 13-4953, 21-24104
- **Oregon State University**: 14-6435, 14-6794, 16-10244, 20-19896
- **Purdue University**: 19-17037
- **Kansas State University**: 21-24156, 21-24287

Thermal-Fluid Phenomena and Operating/Accident Scenario – Studied in NEUP HTGR Projects

- **Thermal-Fluid Phenomena**
  - Plenum Mixing / Jet Impingement
    - Lower plenum
    - Upper plenum
    - Plenum to plenum
  - Ingress
    - Air ingress
    - Steam/Water ingress
  - Conjugate Heat Transfer
    - Forced convection
    - Natural convection
  - RCCS Performance
  - Core Bypass Flow
  - Fluid Stratification
  - Multi-physics (Fission product, safety analysis, thermal-mechanical etc.)

- **Various Scenarios**
  - Normal Operation
  - Pressurized loss of forced cooling (PLOFC);
  - Depressurized loss of forced cooling (DLOFC);
  - Load Change (Transient)
  - Steam Generator Accident (Tube break)

Thermal-Fluid Phenomena and Accident Scenario – Database Matrix

FINISHED NEUP PROJECT # in RED		ONGOING NEUP PROJECTS # in BLUE	SCENARIOS				
			NORMAL OPERATION	PRESSURIZED LOSS OF FLOW	DEPRESSURIZED LOSS OF FLOW	LOAD CHANGE (TRANSIENT)	STEAM GENERATOR TUBE BREAK
PHENOMENA	PLENUM MIXING / JET IMPINGEMENT	LOWER PLENUM	12-3582 15-8627	16-10244	16-10244		
		UPPER PLENUM	12-3759	18-15058	18-15058		
		PLENUM TO PLENUM	13-4953 16-10509 23-29598	20-20074	20-20074	23-29598	
	INGRESS	AIR INGRESS		15-8205 20-19896	09-784 15-8205 13-4884 17-13115 14-6435 20-19896		14-6786 19-17183
		STEAM/WATER INGRESS		18-15058	18-15058 21-24111		14-6786

Thermal-Fluid Phenomena and Accident Scenario – Database Matrix (Cont'd)

FINISHED NEUP PROJECT # in RED

ONGOING NEUP PROJECTS # in BLUE

			SCENARIOS				
			NORMAL OPERATION	PRESSURIZED LOSS OF FLOW	DEPRESSURIZED LOSS OF FLOW	LOAD CHANGE (TRANSIENT)	STEAM GENERATOR TUBE BREAK
PHENOMENA	CONJUGATE HEAT TRANSFER (CORE)	FORCED CONVECTION	09-771, 11-3081, 16-10509, 21-24104, 21-24287	11-3218, 21-24104, 21-24287	11-3218, 21-24156		
PHENOMENA	CONJUGATE HEAT TRANSFER (CORE)	NATURAL CONVECTION	14-6794, 16-10509	14-6794	14-6435, 21-24156		
PHENOMENA	RCCS PERFORMANCE		09-781, 09-817, 11-3079, 13-4953, 20-19896	20-19896	20-19896	09-781, 11-3079, 09-817, 13-5000	
PHENOMENA	CORE BYPASS FLOW		09-830, 15-8627, 20-19968	15-8205	09-840, 15-8205		
PHENOMENA	FLUID STRATIFICATION				14-6435		
PHENOMENA	MULTI-PHYSICS (FISSION PRODUCT, SAFETY ANALYSIS, THERMAL-MECHANICAL, ETC.)		20-19896, 22-26607	20-19896	19-17037, 21-24111, 20-19896, 21-24156	22-26607	

FINISHED NEUP PROJECT # in RED

ONGOING NEUP PROJECTS # in BLUE

PHENOMENA		SCENARIOS: NORMAL OPERATION	PRESSURIZED LOSS OF FLOW	DEPRESSURIZED LOSS OF FLOW	LOAD CHANGE (TRANSIENT)	STEAM GENERATOR TUBE BREAK
PLENUM MIXING / JET IMPINGEMENT	LOWER PLENUM	12-3582 15-8627	16-10244	16-10244		
PLENUM MIXING / JET IMPINGEMENT	UPPER PLENUM	12-3759	18-15058	18-15058		
PLENUM MIXING / JET IMPINGEMENT	PLENUM TO PLENUM	13-4953 16-10509 23-29598	20-20074	20-20074	23-29598	
INGRESS	AIR INGRESS		15-8205 20-19896	09-784 15-8205 13-4884 17-13115 14-6435 20-19896		14-6786 19-17183
INGRESS	STEAM/WATER INGRESS		18-15058	18-15058 21-24111		14-6786
CONJUGATE HEAT TRANSFER (CORE)	FORCED CONVECTION	09-771 11-3081 16-10509 21-24104 21-24287	11-3218 21-24104 21-24287	11-3218 21-24156		
CONJUGATE HEAT TRANSFER (CORE)	NATURAL CONVECTION	14-6794 16-10509	14-6794	14-6435 21-24156		
RCCS PERFORMANCE		09-781 09-817 11-3079 13-4953 20-19896	20-19896	20-19896	09-781 11-3079 09-817 13-5000	
CORE BYPASS FLOW		09-830 15-8627 20-19968	15-8205	09-840 15-8205		
FLUID STRATIFICATION				14-6435		
MULTI-PHYSICS (FISSION PRODUCT, SAFETY ANALYSIS, THERMAL-MECHANICAL, ETC.)		20-19896 22-26607	20-19896	19-17037 21-24111 20-19896 21-24156	22-26607	

Urgent Need for NEUP-HTGR Data Platform

- NEUP projects have produced valuable results with both computational and experimental studies, but detailed information is not always available, including:
  - Detailed facility description;
  - Instrumentation locations;
  - Boundary conditions;
  - Resulting experimental data (raw/processed), etc.
- It is crucial and urgent to construct a more transparent, sustainable, and equitable process for the community to harvest important HTGR thermal fluid validation data created with U.S. taxpayer funding.
  - ART-GCR program will create a central data platform at INL to *identify, organize and store* the results of these valuable research projects, and
  - provide future guidance for storage and transmission of important project documentations for later NEUPs.

Online Data Platform for NEUP HTGR (in progress)

- Organized by FY and NEUP project number.
- Each entry currently has its resultant scientific publications:
  - Project abstract
  - Final report
  - Journal publications
  - Conference proceedings, etc.
- Methods and possibilities under investigation to include experimental data matrices.
- This will be integrated into the ART-GCR official webpage later.

DOE-ART | NEUP Website | **NEUP Prj Files**

NDMAS

NEUP LIBRARY

Version: 0.20
Status: Checked in and viewable by authorized users.

Name	Document Title	PI/Authors	Doc Type	Awarded University (PI affiliated)	Year	Project ID / Title
Project ID / Title : 23-30994-IRP / Exascale Simulation of Thermal-Hydraulics Phenomena in Advanced Reactors and Validation Using High Resolution Experimental Data (1)						
IRP 23-30994	Exascale Simulation of Thermal-Hydraulics Phenomena in Advanced Reactors and Validation Using High Resolution Experimental Data	Taehun Lee	Abstract	City College of New York	2023	23-30994-IRP / Exascale Simulation of Thermal-Hydraulics Phenomena in Advanced Reactors and Validation Using High Resolution Experimental Data
Project ID / Title : 23-29598 / Uncertainty Quantification of Model Extrapolation in Neural Networkinformed Turbulent Closures for Plenum Mixing in HTGRs (1)						
23-29598_Technical Abstract	Uncertainty Quantification of Model Extrapolation in Neural Networkinformed Turbulent Closures for Plenum Mixing in HTGRs	Som Dutta	Abstract	Utah State University	2023	23-29598 / Uncertainty Quantification of Model Extrapolation in Neural Networkinformed Turbulent Closures for Plenum Mixing in HTGRs
Project ID / Title : 22-26607 / An Innovative Monitoring Technology for the Reactor Vessel of Micro-HTGR (1)						
22-26607 Technical Abstract	An Innovative Monitoring Technology for the Reactor Vessel of Micro-HTGR	Lesley Wright	Abstract	Texas A&M Engineering Experiment Station	2022	22-26607 / An Innovative Monitoring Technology for the Reactor Vessel of Micro-HTGR
Project ID / Title : 21-24287 / Investigating heat transfer in horizontal micro-HTGRs under normal and PCC conditions (2)						
21-24287 Technical Abstract	Investigating heat transfer in horizontal micro-HTGRs under normal and PCC conditions	Hitesh Bindra	Abstract	Kansas State University	2021	21-24287 / Investigating heat transfer in horizontal micro-HTGRs under normal and PCC conditions
Ross et al. 2023	Passive heat removal in horizontally oriented micro-HTGRs	Molly Ross, T-Ying Lin, Isaiah Wicoff, Broderick Sieh, Piyush Sabharwal, Donald McEligot, Hitesh Bindra	Article	Kansas State University	2023	21-24287 / Investigating heat transfer in horizontal micro-HTGRs under normal and PCC conditions
Project ID / Title : 21-24156 / Experimental thermofluidic validation of TCR fuel elements using distributed temperature and flow sensing (1)						
21-24156 Technical Abstract	Experimental thermofluidic validation of TCR fuel elements using distributed temperature and flow sensing	Hitesh Bindra	Abstract	Kansas State University	2021	21-24156 / Experimental thermofluidic validation of TCR fuel elements using distributed temperature and flow sensing
Project ID / Title : 21-24111 / Experimental Investigations of HTGR Fission Product Transport in Separate-effect Test Facilities Under Prototypical Conditions for Depressurization and Water-ingress Accidents (1)						
21-24111 Technical Abstract	Experimental Investigations of HTGR Fission Product Transport in Separate-effect Test Facilities Under Prototypical Conditions for Depressurization and Water-ingress Accidents	N.K. Anand	Abstract	Texas A&M University	2021	21-24111 / Experimental Investigations of HTGR Fission Product Transport in Separate-effect Test Facilities Under Prototypical Conditions for Depressurization and Water-ingress Accidents
Project ID / Title : 21-24104 / Thermal Hydraulics Investigation of Horizontally Orientated Layout Micro HTGRsunder Normal Operation and PCC Conditions Using Integrated Advanced Measurement Techniques (1)						
21-24104 Technical Abstract	Thermal Hydraulics Investigation of Horizontally Orientated Layout Micro HTGRsunder Normal Operation and PCC Conditions Using Integrated Advanced Measurement Techniques	Muthanna H. Al-Dahhan	Abstract	Missouri University of Science & Technology	2021	21-24104 / Thermal Hydraulics Investigation of Horizontally Orientated Layout Micro HTGRsunder Normal Operation and PCC Conditions Using Integrated Advanced Measurement Techniques

Ongoing V&V Efforts
- Ranking Table Development for Experimental Facilities

- Incorporated the HTGR-related projects:
  - NEUP projects
  - Available experimental facilities, such as ANL NSTF, OSU HTTF, etc.
- Identified investigation topics and phenomena of interest.
- Collected information for data resolution and time scheme.
- Ranking parameters:
  - Raw data availability;
  - Data uncertainties;
  - Scientific publications;
  - Computational models;
  - Integral vs. Separate effect test.

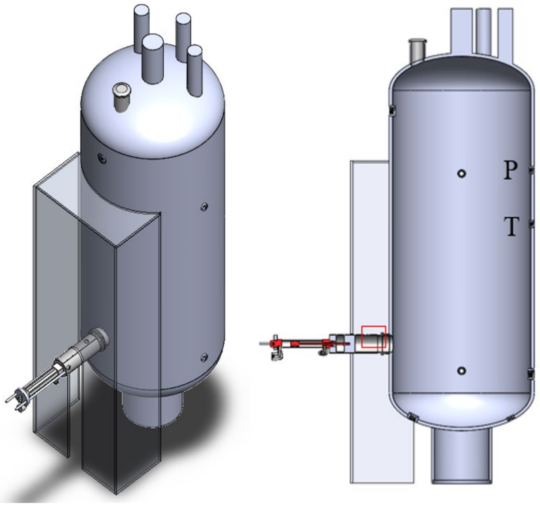
Ranking Table Development for HTGR-related Experimental Facilities

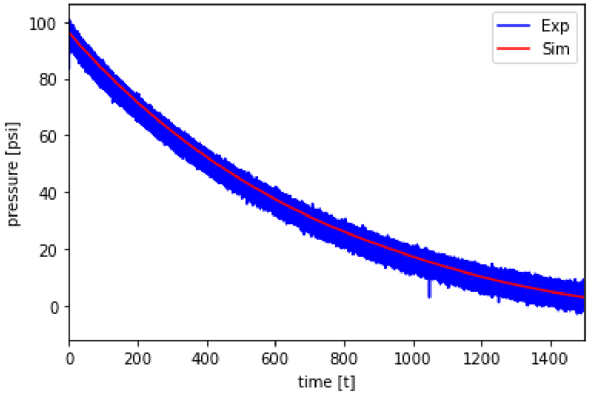
Facility/ NEUP Project	Location	Point of Contact (PI)	Phenomena of Interest / Purpose	Data Resolution (Description)	Time scheme: [SS, Transient]	Topic Type: [TH, Neutronics, Chemical, Multi-physics]	Raw Data (#)	Data Uncertainties (#)	Report/ Publications (#)	Computational Models (#)	Integral? (#)	Score
NEUP 17-13115	Univ. of Michigan	Victor Petrov	He/Air mixing behavior during the HTGR DLOFC and Air Ingress accidents for small and medium sized breaks.	Jet velocity data (PIV and LDV), mass flow rate, temperature, pressure	Transient	TH	80	70	60	70	70	**350**
NEUP 11-3081	Utah State University	Barton Smith	PIV vs CFD data validation for a heated flat plate	Heat flux, Velocity field (PIV)	SS	TH	80	70	50	60	80	**340**
NEUP 12-3759	TAMU	Yassin Hassan	(Jet) Flow mixing at upper/lower plenum	Velocity field (PIV), Temperature	SS	TH	80	70	60	60	70	**340**
NEUP 18-15058	Univ. of Michigan	Xiaodong Sun	High-resolution data on jet interaction at HTGR upper plenum; Moisture absorption of heated graphite.	Velocity field (PIV and LDV)	SS, Transient	TH, Chemical	70	70	60	70	70	**340**
NEUP 15-8627	Univ. of Pittsburgh	Mark Kimber	Flow interaction between core bypass and coolant jet flows	Velocity Field (PIV), Reynolds Stress, Turbulent kinetic energy, vorticity	SS	TH	70	70	70	60	70	**340**
NEUP 13-5000	Univ. of Michigan	Annalisa Manera	RCCS at upper plenum and turbulent jet mixing	Velocity field (PIV and LDV)	SS	TH	80	70	50	60	70	**330**
NEUP 09-817	TAMU	Yassin Hassan	RCCS in VHTR	Temperature (k-type TC) and mass flow rate (flow meter)	Transient	TH	70	60	60	60	60	**310**
NEUP 09-781	UW, Madison	Michael Corradini	Water RCCS performance	Temperature and mass flow rate (time resolved)	SS, Transient	TH	70	60	70	60	50	**310**
NEUP 16-10509	Utah State University	Barton Smith	Buoyancy driven/opposed flow measurements	Velocity field (PIV), temperature (TC), pressure, mass flow rate	SS, Transient	TH	70	70	50	50	70	**310**
NEUP 12-3582	Univ. of Pittsburgh	Mark Kimber	Turbulent jet mixing in the lower plenum	Velocity field (PIV), temperature (TC, IR camera for field)	SS	TH	70	70	50	60	60	**310**
Natural Convection Shutdown Heat Removal Test Facility (NSTF)	ANL	Darius Lisowski	RCCS performance using both water and air	Mass flow rate, temperature, pressure	SS, Transient	TH	70	60	70	70	30	**300**

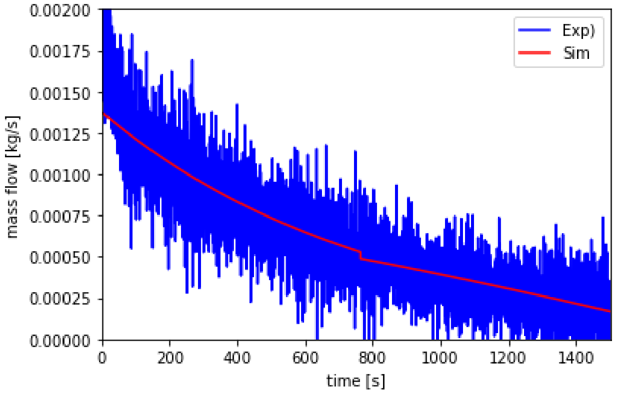
(to be continued)……

ART-NEUP Collaborations with INL LDRD projects

- Project Title: A Causal Approach to Model Validation and Calibration
- Lead PI: Dr. Diego Mandelli
- Selected collaboration project NEUP 17-13115: Helium Air Ingress gas Reactor Experimental (HAIRE) facility at Univ. of Michigan.







Proceedings of the ASME 2023
International Mechanical Engineering Congress and Exposition
IMECE2023
October 29-November 2, 2023, New Orleans, Louisiana

IMECE2023-112430

A CAUSAL APPROACH TO MODEL VALIDATION AND CALIBRATION

D. Mandelli Idaho National Laboratory Idaho Falls, ID

R. Gonzales Idaho National Laboratory Idaho Falls, ID

C. Wang Idaho National Laboratory Idaho Falls, ID

M. Abdo Idaho National Laboratory Idaho Falls, ID

Z. Welker University of Michigan Ann Arbor, MI

P. Balestra Idaho National Laboratory Idaho Falls, ID

S. Qin Idaho National Laboratory Idaho Falls, ID

V. Petrov University of Michigan Ann Arbor, MI

A. Manera University of Michigan Ann Arbor, MI

ABSTRACT

All current developed methods for model validation are based on standard statistical analysis (to measure statistical differences between data populations) or machine learning (to identify response surface from data) methods. Both classes of methods have in common to be purely data driven, i.e., they provide quantitative comparison measures between data sets (e.g., simulated vs. measured data) without explicitly considering the hypothesis behind them (e.g., boundary conditions) and the structure of the employed models. This generates sometimes the erroneous conclusion that when two data populations are "close enough" then the models that have generated them are "similar". In addition, when simulated and experimental data differs beyond the acceptance criteria, model calibration techniques are used to "tweak" simulation model parameters to reduce the gap between simulated and experimental data. This gives the false expectation that a simulation model matches reality. The goal of this paper is to move away from currently employed purely data-driven methods for validation and calibration toward more robust model-driven methods based on causal inference. The presented methods are designed to capture the causal relationships between data elements (e.g., simulated and experimental data) rather than looking at their associations, and they employ these relationships to measure differences between simulated and measured data. These causal differences then directly inform the calibration process rather than relying on the analyst educated guess.

Keywords: validation, causal inference, calibration

1. INTRODUCTION

Currently, advanced simulation models are not only used in the design and licensing of systems, but are also an integral part of their operation and control (e.g., in system autonomous operation or in a digital twin context). These simulation models are designed to mimic aspects of the real world as closely as possible to correctly capture the evolution and the properties of those aspects. Creation of these simulation models begins by defining their constituent laws, as represented through a set of mathematical equations (e.g., conservation laws, equations of motion, thermodynamic laws, etc.). Note that, at this stage, the causal relationships between variables defined within the model are totally lost due to the nature of the mathematical formalism being used. Causal relationships are regained when the developed mathematical equations are coded into a simulation model.

Once the coding process is completed and verified, these models require a validation process that tests whether they can model aspects of the real world, by comparing simulated results with experimental real-world observations under similar initial/boundary conditions. Current methods for model validation are based on standard statistical analysis (to measure statistical differences between data populations) or machine learning (ML) (to identify response surfaces from data) methods. Both classes of methods are purely data driven, meaning that they provide quantitative comparison measures between datasets (e.g., simulated vs. measured data) without explicitly considering the hypotheses behind them (e.g., boundary conditions) or the structure of the employed models. This can lead to the erroneous conclusion that, if two data populations are close enough, then the models that generated them are similar. In

1

Conclusion

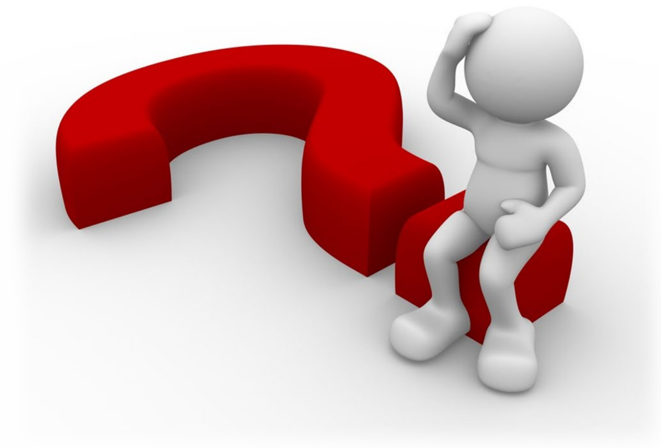
- Updated the matrix for Thermal-Fluid Phenomena and Accident Scenario with new projects.
- Communicating with several awarded universities and gathering experimental data as well computational models.
- Collaborating with INL research team through LDRD project
  - Ranking table of code V&V for experimental facility.
- Online data platform in development.

Future Work

- Collaborating with university PIs to gather more detailed information for experimental and computational work.
  - Refining the HTGR phenomena summary chart continuously.
- Finalizing the data platform and keeping it updated with new funded NEUP-HTGR projects.
- Choosing 1-2 projects and performing benchmark studies for code verification and validation (V&V) during next fiscal year.

Thank you for your attention!

Questions?



Reference

1. U.S. Department of Energy, Nuclear Energy University Program (NEUP). [cited 2023 July]; Available from: https://neup.inl.gov/SitePages/Home.aspx.
2. INL Advanced Reactor Technologies (ART) Program. [cited 2023 July]; Available from: https://art.inl.gov/SitePages/ART%20Program.aspx.
3. Qin, S., Song, M., Vietz, S. H., T Pham, C. B., Plummer, M. A., & Strydom, G. (2022). *High-temperature gas-cooled reactor research Survey and Overview: Preliminary data Platform construction for the nuclear energy university Program* (No. INL/RPT-22-68771-Rev000). Idaho National Lab.(INL), Idaho Falls, ID (United States). Available from: https://doi.org/10.2172/1887092.