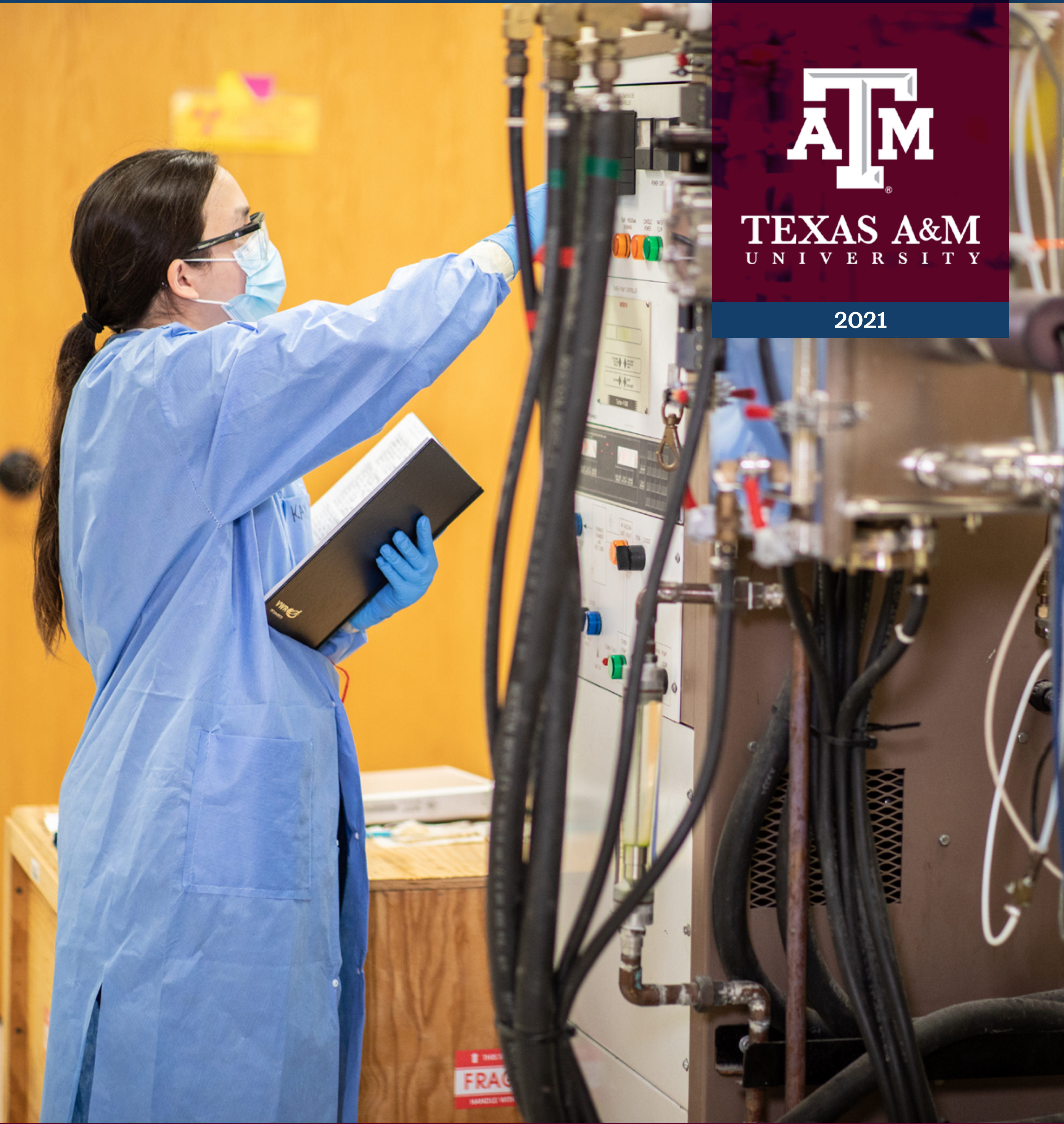


TEXAS A&M UNIVERSITY

2021

DEPARTMENT OF

NUCLEAR ENGINEERING

LETTER FROM THE
DEPARTMENT HEAD

The Department of Nuclear Engineering at Texas A&M University has continued to grow and evolve throughout these unprecedented times. Our year was remarkable in many ways and this year holds great promise for the future of the department.

Our faculty and former students continue to conduct remarkable research and meet unchartered milestones. Dr. Lin Shao, who collaborated with researchers at Los Alamos National Laboratory and Hokkaido University, helped create the next generation of high-performance oxide-dispersion strengthened alloys. So far, they are some of the strongest and best-developed metals in the field.

Dr. Jean Ragusa and Dr. Mauricio Eduardo Tano Retamales investigated pebble-bed reactors, a very-high temperature, fourth-generation reactor. Together, they developed a Coupled Computational Fluid Dynamics-Discrete Element Model to study bypass flow in these reactors. This model can now be applied to all types of pebble-bed reactors, as well as assist vendors in designing safer and more efficient reactors in the future.

As we approach 2022, I am thankful for the faculty, staff and students who are paving the way toward excellence. I hope you enjoy hearing about the innovative and award-winning research conducted in the department of nuclear engineering.

Thanks and Gig 'em!

Dr. Michael Nastasi

Professor and Department Head of Nuclear Engineering
Sallie and Don Davis '61 Professorship in Engineering

TEXAS A&M UNIVERSITY
Department of
Nuclear Engineering

BY THE NUMBERS

RANKING (2022)

#3 Graduate Program
Ranked No. 3 (Public)
(*U.S. News & World Report*)

ENROLLMENT* (FALL 2021)

**preliminary, 5th class day*

272 Bachelor's

48 Master's

81 Ph.D.

FACULTY (2020-21)

16 Tenure-Track Faculty

6 Academic Professional Track

RESEARCHERS

129 Graduate Students

11 Research Staff

DEGREES AWARDED*

(AY 2020-21) **preliminary*

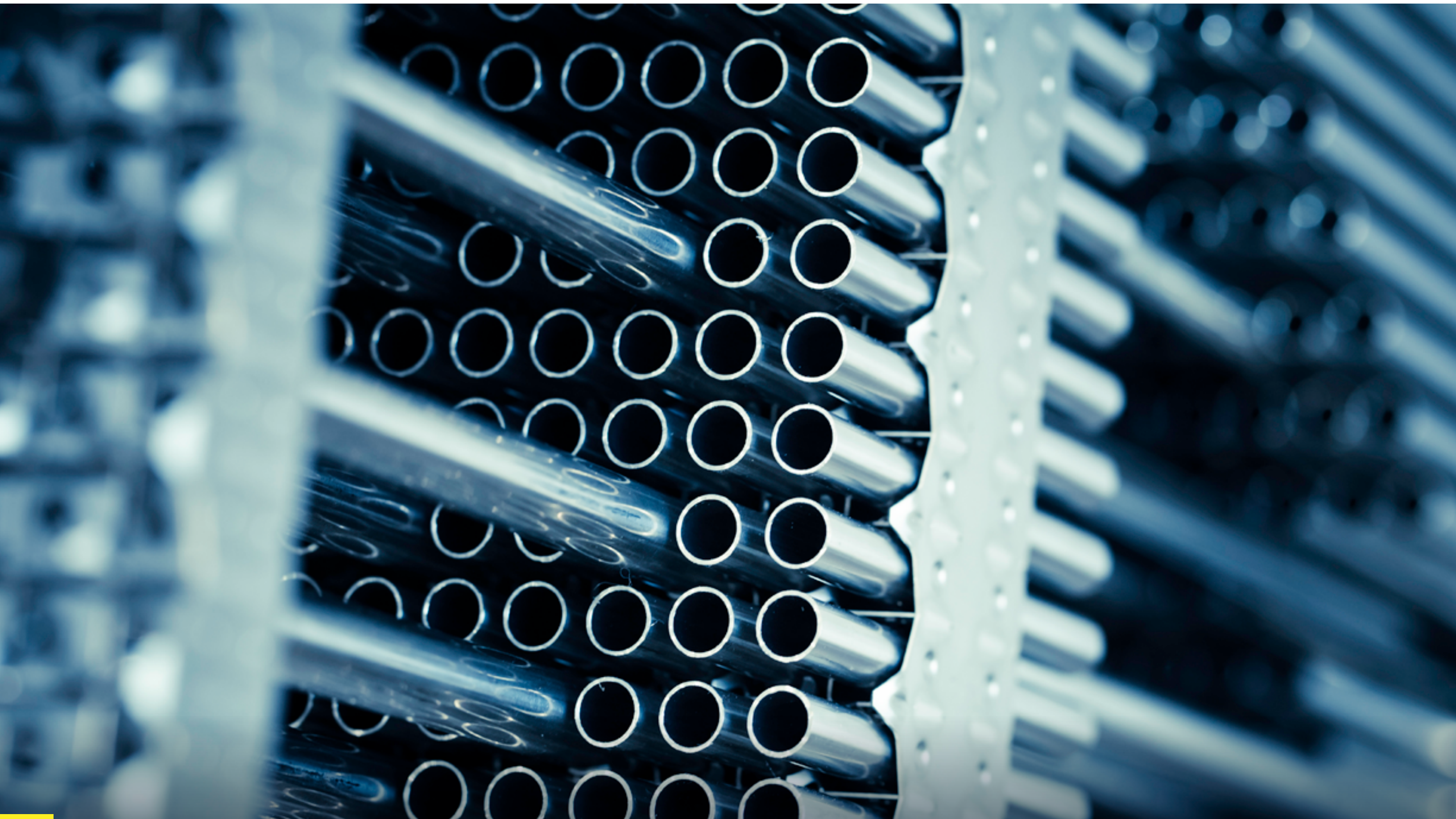
59 Bachelor's

31 Master's

10 Ph.D.

RESEARCH FUNDING

$16 MILLION
(FISCAL YEAR 2019-20)



RESILIENT OXIDE DISPERSION STRENGTHENED ALLOY

Texas A&M researchers have shown superior performance of a new oxide dispersion strengthened (ODS) alloy they developed for use in both fission and fusion reactors.

Dr. Lin Shao worked alongside research scientists at the Los Alamos National Laboratory and Hokkaido University to create the next generation of high-performance ODS alloys.

ODS alloys consist of a combination of metals interspersed with small, nanometer-sized oxide particles and are known for their high creep resistance. As temperatures rise, the materials keep their shape instead of deforming.

Nuclear engineering researchers like Shao consistently seek to identify quality creep-resistant and swelling-resistant materials for their use in high-temperature reactors. The material in the core components of reactors must be high strength, radiation tolerant and resistant to swelling. Unfortunately, the majority of commercial ODS alloys are problematic because they are based on the ferritic phase. While ferritic alloys have proper ductility and high-temperature strength, they are weakest in resistance to swelling.

"We decided to explore a new design principle in which oxide particles are embedded in the martensitic phase, which is best to reduce void swelling, rather than the ferritic phase," said Shao.

The resulting alloys can survive up to 400 displacements per atom and are some of the most successful alloys developed in the field, both in terms of high-temperature strength and superior-swelling resistance.

Details of the complete project were published in the *Journal of Nuclear Materials* along with the most recent study. The team has since conducted multiple studies and attracted attention from the U.S. Department of Energy and nuclear industry. The project resulted in a total of 18 journal papers and two doctoral degree dissertations.

FEATURED RESEARCHER

Dr. Lin Shao

Professor

PROFESSORS AWARDED IN COLLABORATIVE RESEARCH PROGRAM

Dr. Shikha Prasad and Dr. Jean Ragusa are recipients of development fellowships from the 2020-21 edition of the Texas A&M University System National Laboratories Office Collaborative Research Program with Los Alamos National Laboratory (LANL). Development fellowships are awarded to researchers who have the skills, knowledge and interest in developing lasting, collaborative relationships with LANL researchers.

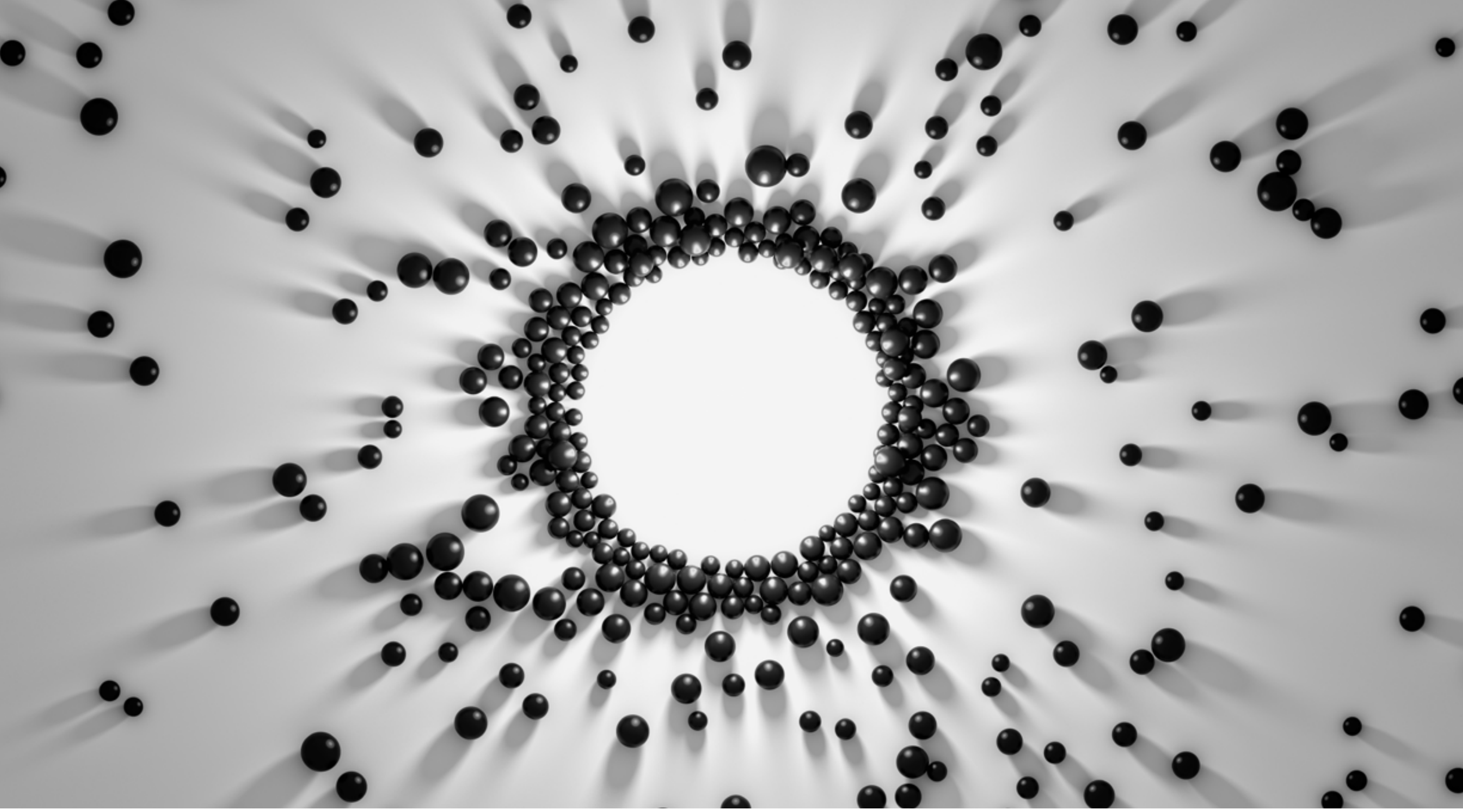
Prasad focuses primarily on nuclear security and nonproliferation. Prasad will work alongside Matthew Devlin and Andrea Favali from LANL to measure neutron multiplicity from spontaneous fissions of plutonium-240, a human-made isotope and major constituent of several proposed advanced reactor designs.

“Despite such promising efforts, there is a lack of plutonium-240-measured nuclear data,” said Prasad. “The plutonium-240 measurements will help improve our understanding of reactor safety parameters, used nuclear fuel and other derivative man-made isotopes (plutonium-241 and americium-241).”

Ragusa researches computational and data sciences applied to national security and nuclear engineering. He received his fellowship for his computational research in high-energy-density physics.

Due to the interactions of coupled physical phenomena and large systems of equations involved, running these simulations requires the use of leadership-class supercomputers. Ragusa and his team will investigate machine-learning approaches to speed up thermal radiative transfer simulations.

“With Dr. Andrew Till and Dr. Pete Maginot, I will investigate several data-science approaches to significantly reduce the computational complexity of thermal radiative transfer simulations,” said Ragusa. “Our goal is to enhance algorithmic efficiency and build accurate surrogate models for faster simulations.”



NEXT-GENERATION REACTOR SAFETY

Dr. Jean Ragusa and Dr. Mauricio Eduardo Tano Retamales are studying a new fourth-generation reactor, pebble-bed reactors, which use spherical fuel elements and a fluid coolant.

“There are about 40,000 fuel pebbles in such a reactor,” said Ragusa. “Think of the reactor as a really big bucket with 40,000 tennis balls inside.”

During an accident scenario, a process known as natural convection cooling occurs. Fuel pebbles are made from pyrolytic carbon and tristructural-isotropic particles, making them resistant to temperatures as high as 3,000 degrees Fahrenheit. As a very-high-temperature reactor, pebble-bed reactors can be cooled down by passive natural circulation.

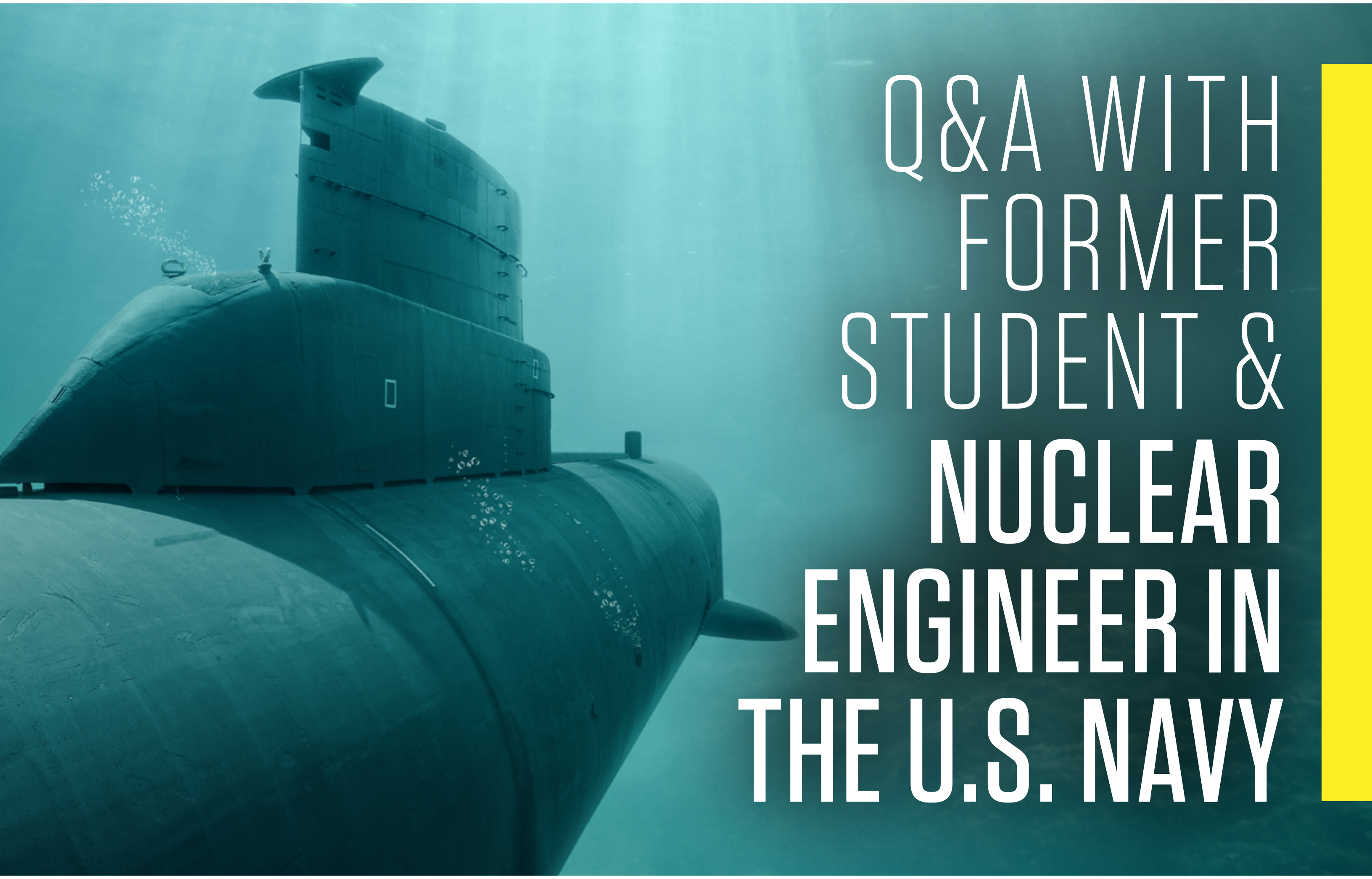
During normal operation, a high-speed flow cools the pebbles. This flow creates movement around and between the fuel pebbles, similar to the way a gust of wind changes the trajectory of a tennis ball. But, how do you account for the friction between the pebbles and the influence of that friction in the cooling process?

This is the question that Ragusa and Tano aimed to answer in their most recent publication in the journal *Nuclear Technology* titled “Coupled Computational Fluid Dynamics–Discrete Element Method Study of Bypass Flows in a Pebble-Bed Reactor.”

“We solved for the location of these ‘tennis balls’ using the Discrete Element Method, where we account for the flow-induced motion and friction between all the tennis balls,” said Tano. “The coupled model is then tested against thermal measurements in the SANA experiment.”

As a result, their teams developed a coupled Computational Fluid Dynamics-Discrete Element Methods model for studying the flow over a pebble bed. This model can be applied to all high-temperature pebble-bed reactors and is the first computational model of its kind to do so. It’s very-high-accuracy tools such as this that allow vendors to develop better reactors.

“The computational models we create help us more accurately assess different physical phenomena in the reactor,” said Tano. “As a result, reactors can operate at a higher margin, theoretically producing more power while increasing the safety of the reactor.”



Q&A WITH FORMER STUDENT & NUCLEAR ENGINEER IN THE U.S. NAVY

Former nuclear engineering student Alex Rubin offers a glimpse into his career in the United States Navy, what he has learned and his future endeavors.

Q: You're currently employed with the United States Navy — a promising option for many nuclear engineering students due to the nuclear-powered submarines. What has the job-hunting industry been like?

A: I became interested in the Navy when I was a sophomore. I learned about the nuclear power prototype schools they offered and the opportunities I would have to operate a reactor or go work on either a submarine or aircraft carrier. They had a lot of incentives and benefits, and it was a no-brainer for me.

Q: What are you learning right now?

A: I'm at prototype, which means we visit a training submarine to learn the ins and outs of everybody's job on the ship. Submarines are very different from a commercial power plant — for example, the ship takes in water from the ocean. So, making sure that our water is pure and clean is paramount.

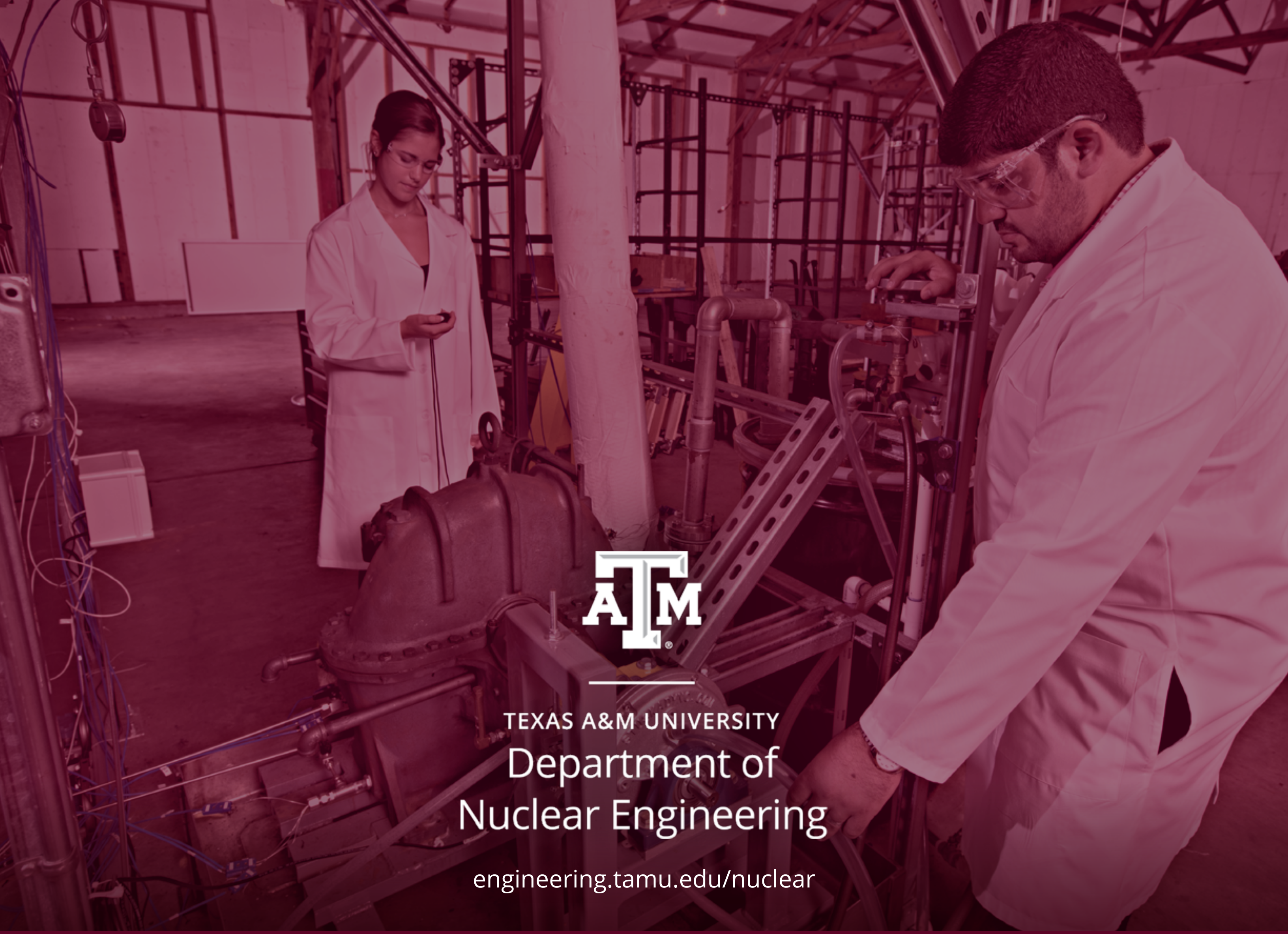
Q: What's your favorite part about your job?

A: My favorite part is truly the dynamic lifestyle — you're never doing one thing for too long. As soon as you learn one skill and get comfortable doing that, you're moving on to the next thing. I've learned a lot of life lessons in a very short amount of time.

Q: What advice would you give to nuclear engineering students considering pursuing careers in the Navy?

A: I would advise them to do as much as possible to learn about things you want to do.

There's a lot of things to consider that they don't always tell you about: what sort of lifestyle do you want to live? Do you want to travel? What sort of hours are you looking to invest? Of course, joining the Navy is a very big commitment. So, be aware of the decisions you're making and the type of commitments they may carry too.



DEPARTMENT OF NUCLEAR ENGINEERING

AREAS OF FOCUS

- Advanced Nuclear Reactors
- Computational and Data Sciences Applied to National Security and Nuclear Engineering
- Fuel Cycles and Materials
- Health Physics, Radiation Biology and Medical Physics
- Nuclear Power Engineering
- Radiation Transport
- Security, Safeguards and Nonproliferation
- Thermal Hydraulics