THE 10,000 YEAR PLAN

Pallavi Pharkya thinks a lot about the future.

Pharkya, a Ph.D. candidate in materials science and engineering, works in the area of corrosion science, predicting how materials will perform over extended periods of time. Her particular focus is a nickel-chromium-molybdenum alloy called C-22, a highly corrosion-resistant metal. Pharkya's aim is to help determine whether containers made from C-22 can be used to store high-energy nuclear waste – for 10,000 years and longer.

Pharkya's work is part of a plan by the U.S. Department of Energy to consolidate the country's nuclear waste in a single proposed repository. The proposed repository is in Yucca Mountain located in a remote Nevada desert. Currently about 70,000 metric tons of spent nuclear fuel and high-level radioactive waste are divided between approximately 100 sites around the country.

The undertaking, Pharkya emphasizes, is massive. To study just the corrosion aspects of the packaging, Case is collaborating with eight other universities, five national labs and Atomic Energy of Canada Limited. Even with so many players, the study will likely take several years to complete.

Heading the entire group is Joe Payer, a professor of materials science and engineering at Case and Pharkya's mentor.

"I came here to have the opportunity to work with Dr. Payer, an expert in corrosion, but I didn't know specifically what I would be working on," Pharkya recalls. "I was pretty thrilled when I learned about the vastness of the project – my research would be just a small part of this huge topic – and the impact of the research we would be doing."

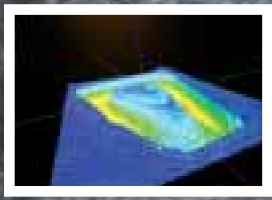
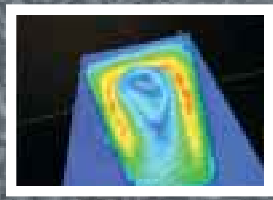
Agressively Researching Passive Films

The "small part" is in itself a huge undertaking.

Pharkya studies the durability of passive films on C-22 under conditions applicable to the proposed Yucca Mountain repository. Passive films are thin layers of protective metal oxides that form spontaneously on the surface of corrosion-resistant materials, such as titanium and nickel alloys, when exposed to normal conditions of pH and oxygen concentration. Generally no more than nanometers thick, these films protect the metals against corrosion. When the film breaks due to chemical exposure or physical damage, the key to high performance is whether the film will repassivate or remain damaged and permit corrosion to proceed.

By running electrochemical tests, Pharkya is able to study the nature of the film formed on the metal under different conditions, any breakdown of the film and, finally, the repassivation potential, or the potential that the film will repair itself.

Temperature, humidity and electrolyte composition and concentration are some of the variables she considers. To evaluate the effects of moisture moving through the mountain, metal samples are exposed to chloride waters and other solutions of varying concentrations, and the current is measured to determine the rate of corrosion. Varying the potential applied also drives the process.

Lined up on a workbench, the tests look like sophisticated versions of potato-growing experiments from grade school, with samples suspended in beakers of liquid and sprouting numerous wires.

Once Pharkya has determined the upper and lower limits of corrosion, other researchers will put these parameters into models to predict how the metal will behave over 10,000 years and longer of changing climate conditions, long enough for the waste to become benign.

Pharkya admits that her work is sometimes overwhelming. “There are so many different aspects that I have to study. I have to come up with techniques to predict what I want to predict. Sometimes I get to the point where I’m ready to do the experiment and I realize the technique just won’t work.”

Luckily, she has plenty of people to turn to. As the director of the co-op, Payer maintains a keen interest in her work, passing through the lab at least twice daily to talk with her and answer questions. Her colleagues at the other 14 institutions provide important feedback, as well. Once or twice a month, all of the faculty, postdoctoral researchers and students participate in a virtual conference where, connected by conferencing software with video capabilities, they present their work and open the floor for discussion.

Pharkya says, “It’s helpful to have so many people looking at your work. Regardless of what kind of criticism they give, it’s going to be good when you’re back in the lab at the end of the day.”

Looking (Not So Far) Ahead

Pharkya is trying to make short-term predictions as well: She wants to complete her degree in the next two years. By that time, she hopes to have finished her project, but she allows that this goal may not be feasible. “With research,” she says, “you never know. Repassivation is such a huge topic. One study could take a lifetime.”

Still, she is satisfied that what she’s doing has far-reaching consequences. Nuclear energy, she predicts, will be around to some degree for many years and will play a key role in meeting the world’s increasing energy demands. Although other technologies such as fuel cells are emerging, a viable alternative does not yet exist. The importance of safely isolating these spent nuclear fuels is obvious.

Payer emphasizes this importance. “Public acceptance of nuclear power as an important energy source depends upon developing acceptable solutions to the back-end of the nuclear fuel cycle. Carefully engineered solutions are more likely to gain public acceptance.”

After leaving Case, Pharkya intends to study further as a postdoctoral researcher and then apply her knowledge in industry. With her skills, she will have plenty of positions to choose from. The prediction of materials performance is crucial to a broad range of industries and systems. There is great economic incentive, for example, to prevent the degradation of infrastructure such as highways, buildings and the pipelines used to transport water. Other applications of corrosion science are found in the chemical processing industry, which often deals with corrosive substances such as acids and high temperature solutions.

After working in industry for a few years, Pharkya plans to return to her native India to pursue an academic career.

For the time being, though, she continues to be rewarded by her work. “I’m still at the stage when I’m learning every day.”