Interest revived in the ORNL- developed molten salt reactor

(As published in The Oak Ridger's Historically Speaking column the week of March 12, 2018)

The Molten Salt Reactor technology is identified with Alvin Weinberg. There is substantial interest developing across the nation and in Europe in reviving the technology. There is a "Weinberg Foundation" that is leading the effort. This is the first in a series of articles by Carolyn Krause on the history of the molten salt reactor developed at the Oak Ridge National Laboratory.

This is the first of a three-part series by Carolyn Krause on the Molten Salt Reactor history.
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Sometimes the federal funding winds in Washington shift quickly.

On July 5, 1971, Karl Z. Morgan, the director of the health physics division at Oak Ridge National Laboratory and founder and first president of the Health Physics Society, was scheduled to give a talk to an international scientific meeting of radiation physicists in Neuherberg, Germany, near Munich. The topics of his talk were the dangers of the newly developed liquid metal fast breeder reactor (LMFBR) and the evidence that the ORNL-developed molten salt thermal breeder (MSTB) "provided a safer and more acceptable approach to nuclear power."

So, wrote Morgan in his memoir "The Angry Genie: One Man's Walk through the Nuclear Age." It was published in 1999, the year Morgan died in Oak Ridge at age 91.

Morgan stated that he had written a paper approved at ORNL on how terrorists could make an atomic bomb from the plutonium-239 bred from uranium-238 if numerous LMFBRs were operating throughout the world. "I intended to point out that our MSTB with its uranium-233 (bred from thorium-232) presented a more difficult target for terrorists," he wrote.

After he and his wife Helen vacationed in Zermatt in Switzerland, they took a train to Zurich and a taxi to the Zurich airport, from which they flew to Frankfurt, Germany, on their way to the conference. "I checked us in on the flight to Frankfurt," Morgan wrote. "When the ticket agent recognized my name, she exclaimed in her limited English, 'Go to phone – call this number – our police and your FBI looking everywhere to find you.' "

Morgan called the number and Floyd Culler, the deputy director of ORNL, answered, saying, 'Thank goodness, Karl, we've finally reached you. After you left Oak Ridge we reviewed your Neuherberg paper once again. Some changes must be made. I phoned the chairman of the meeting and told him I was sending 250 revised copies and asked him to destroy the copies you had sent.'"

Morgan was stunned. Only two weeks before, he wrote, ORNL Director Alvin Weinberg and others had promoted the MSTB as the future power reactor. "Culler revealed the real reason management wanted to muzzle me. The LMFBR had reached top priority in Washington (and ORNL coveted large contracts for its development). He told me, in effect, 'Don't say anything about the superiority of the MSTB over the LMFBR. Don't you realize the president has decided to allocate $30 million of extra money to expedite building a demonstration LMFBR? You are jeopardizing the welfare of the laboratory.' "

Morgan was led to believe that if he had delivered his original speech, hundreds of people at Oak Ridge, including himself, would lose their jobs. So, in his talk he described the risks of exposure to plutonium without mentioning the MSTB or the LMFBR.

As it turned out, the Atomic Energy Commission announced plans to build a demonstration LMFBR in Oak Ridge, where its former rivals for federal funding, the molten salt reactor and molten salt breeder, had been invented. Congress terminated funding for the Clinch River Breeder Reactor Project in Oak Ridge in 1983.

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Fast breeder reactors have never been built in the United States, owing in part to high construction costs and concerns about diversion of plutonium fuel for bombs by terrorists and rogue nations. France, which produces 75 percent of its electricity using nuclear power, operated the fast breeder reactor Superphoenix until the mid-1990s when it was shut down; it had been plagued by many technical, political and administrative problems, and by then uranium was more abundant for use as reactor fuel than previously believed.

In the 1950s and 1960s the concept of the molten salt reactor (MSR) was identified with ORNL only. The molten salt reactor experiment (MSRE) was built at ORNL using technology developed for the successfully built and tested Aircraft Reactor Experiment. The nuclear-propelled aircraft bomber project was canceled in 1961. Besides the project's significant technology problems, the ICBM missiles that were being built were considered a better method for delivering nuclear warheads to enemy nations.

The MSRE was first operated with uranium-235, the fissile isotope in enriched uranium burned in light-water reactors in nuclear power plants. Later the MSRE became the first reactor to run on uranium-233 fuel, starting on October 8, 1968, almost 50 years ago. AEC Chairman Glenn Seaborg, who co-discovered U-233 with ORNL chemist Ray Stoughton, was given the honor of starting up the MSRE on the U-233 fuel. ORNL's Dick Engel, who died recently, showed Seaborg how to operate the controls.

How does a molten salt reactor work? The liquid fuel salt (such as fluorides of lithium, beryllium, and uranium) is circulated through a heat exchanger where it is cooled by another molten salt loop that is free of radioactive fuel and fission products. The heat from this second loop can do work, such as boiling water to turn a steam turbine to generate electricity. In the molten salt breeder, additional uranium-233 is produced by exposing a blanket of thorium-232 to neutrons in the reactor.

Except for a small amount of research by ORNL, China, India, Japan and Russia in the latter half of the 20th century, interest in the MSR concept was dormant for decades. Fast forward to the 21st century when interest and research efforts were revived partly because the MSR has been viewed as a passive, safer reactor with less radioactive waste.

According to David Holcomb, a technical advisor for the Department of Energy's molten salt reactor program at ORNL, a number of national governments, universities, companies (including utilities), DOE national labs and other organizations are supporting development of various molten salt reactor concepts with research programs, training and funding.

The countries include China, Canada, Czech Republic, Singapore, South Korea, the United Kingdom and U.S. The academic institutions involved currently include Texas A&M and the universities of California at Berkeley, Massachusetts, New Mexico and Wisconsin.

The companies include Alpha Tech Research Corporation, Duke Energy, Elysium Industries, Exelon, FliBe Energy, Kairos Power, MicroNuclear, Muons Inc., NuVision Engineering, Southern Company, Terrestrial Energy USA, ThorCon and Transatomic Power.

The DOE national labs and other organizations involved are Argonne, Idaho and Oak Ridge, as well as the Electric Power Research Institute and Nuclear Energy Institute Advanced Reactor Working Group.

Most important, DOE Nuclear Energy's Office of Advanced Reactor Technologies, DOE's National Nuclear Security Administration and the U.S. Nuclear Regulatory Commission are providing support through funding, development of regulations and personnel training.

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Like Weinberg, Karl Morgan would be happy to know that the future of the MSR and MS breeder technology continues to be much brighter than that of the liquid metal fast breeder reactor.

NEXT: The birth and life of the molten salt reactor in the 20th century.

Almost 50 years ago, in 1968, AEC Chairman Glenn Seaborg was given the honor of starting up the Molten Salt Reactor Experiment at ORNL by following instructions given him by Dick Engel, who helped develop the MSRE. The MSRE was the only reactor to run on uranium-233. Engel, who died recently, appears in a documentary on MSRs, the topic of the third article in this series.

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Syd Ball, a retired ORNL engineer, discusses a component of a molten salt reactor design with Lou Qualls, an ORNL engineer who was recently appointed national technical director of the molten salt reactor program. It was given elevated status among advanced reactor programs within DOE's Nuclear Energy Office. Ball appears in a documentary on MSRs.

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Karl Morgan, a founder of the field of health physics, was prepared to promote ORNL's invention of the molten salt thermal breeder abroad when he received a phone call about a change in funding priorities.

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Ray Stoughton co-discovered uranium-233 with Nobel Laureate Glenn Seaborg in California. Stoughton moved to ORNL and worked in its chemistry division.