DYNAC Systems
partnered with
Idaho National Laboratory

RFA-17-14639, Dynamic Natural Convection System

YEARS AWARDED: 2017

TOTAL PROJECT VALUE: $100K (DOE funding, $80K; awardee cost share, $20K)

STATUS: Completed

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DESCRIPTION: This Gateway for Accelerated Innovation in Nuclear voucher paired DYNAC Systems with Idaho National Laboratory to evaluate the company's Dynamic Natural Convection (DNC) system. DNC is a trade name for an engineered solution to mitigate the effects of a loss of AC power to a nuclear power plant and remove decay heat from the reactor to a heat sink. It is based on a physical effect, using a uniquely designed condensing ejector, called a conjector, that creates an innovative form of natural circulation in a closed pressurized piping system. Operation of the system is independent from electric power. It can mitigate most losses caused by random equipment failures common to light-water reactors. Work with INL involved creating a RELAP5-3D model of the DNC system and adding it to an existing model of the Surry Power Station's pressurized-water reactor near Richmond, VA. The Surry model was used to simulate the performance of the DNC system during quasi-steady operation after a reactor shutdown, during a station blackout, and following two small-break loss-of-coolant accidents. This scoping analysis showed that the DNC system is capable of removing the decay heat from the reactor plant safely during a station blackout as well as small-break loss-of-coolant accidents.

BENEFIT: The technology has the potential to substantially benefit the nation's economy, environment and stakeholders, including the nuclear industry, the United States electric power system, and its consumers by reducing the risk, cost, and complexity of nuclear power plants.

IMPACT: Initial results showed that, following a station blackout in a three-loop pressurized-water reactor outfitted with DNC systems, reactor pressures and temperatures decrease slowly and continuously without ever opening the safety valves. Consequently, no water is lost from the reactor coolant system or the steam generators throughout the event, and the nuclear plant can be safely shut down without the need for electric power, diesel generators, or other active equipment.

LESSONS LEARNED: One issue identified by the review of the DNC system design is that degraded heat transfer conditions may occur when the water inventory of the ultimate heat sink is too low, partially uncovering the tubes of its heat exchanger and reducing heat removal. This problem can be alleviated by increasing the water inventory of the heat sink. The crucial aspect of the heat sink design in a DNC system is its *location at ground level*. In contrast, current passive heat sinks are located high in the containment where space is limited and only a small amount of coolant can be stored. The DNC design prevents a loss of cooling even in the event of complete loss of electric power without using moving parts and in a cost-effective way.

SIGNIFICANT CONCLUSIONS: The results were very encouraging. However, the calculated DNC system performance in a simulation depends on available conjector correlation data. An analytical model of the conjector has to be validated based on test results generated by operating the 1-MW test loop currently under construction with support of the Department of Energy at the NuVision test facility in Mooresville, NC.

NEXT STEPS: NuVision, in collaboration with DYNAC Systems and Mississippi State University, has proposed to characterize the performance of a 1-MW conjector. This will be accomplished by designing, procuring, and assembling a test loop and performing a series of tests with varying inputs and operating conditions to refine models that can be used to design full-scale conjectors to be deployed in operating nuclear power plants.