Establishment of an integrated, advanced manufacturing and data science driven paradigm for advanced reactor systems

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ABSTRACT:

BWX Technologies, Inc.-Nuclear Energy (BWXT) and Oak Ridge National Laboratory (ORNL) propose to develop a process for nuclear design and manufacturing through the integration of advanced software with additive manufacturing (AM) processes. Both technologies (advanced software and AM) have matured during the previous decade and, when applied to qualify material and geometries for nuclear reactor systems and subsystems, will provide reactor components with enhanced performance that are safer and more economical. A project of this ambition can be accomplished only by leaders with expertise in nuclear design and manufacturing, made possible through industry-led funding initiatives by the Department of Energy.

AM technologies can be transformational for the nuclear industry because they are capable of geometries not possible with conventional manufacturing techniques. In addition, proving the ability to AM advanced materials, such as Hastelloy® X and molybdenum (Mo), will enable designs that are more energy efficient, safer, and more economical. The result will be the creation of novel component geometries, usually reserved for research and test reactors, which can then be rapidly prototyped and tested, significantly reducing the projected time to market for advanced reactor designs.

We will use a combination of in-situ process monitoring technologies, modeling, and data analytics (1) to rapidly develop the processing conditions for Hastelloy® X and Mo used in reactor core and other primary system components and (2) to demonstrate component-level qualification, leading to certification of nuclear materials configured in complex geometries.

Currently, new proposed reactor designs often are hindered by costs associated with the ability to qualify and license based on the availability of legacy test data, applicable software, and models. Only when the models and methods have been extensively verified is the risk considered acceptable to proceed with plans for fuel and component manufacturing. In addition, the geometries in reactor designs are limited by current manufacturing methods. AM would allow an expansion of geometries, if a solution can be found to ensure AM-manufactured components could be inspected. We propose that through the use of advanced software that monitors AM manufacturing as it is occurring, we can take full advantage of AM methods to design and produce new geometries and reactor components equally as safe and more cost effective than current conventional methods. Once fully tested and qualified, our process can be applied to the commercial market, greatly reducing overall development and fabrication costs of future nuclear reactors.

Our approach shifts the paradigm to minimize the time to testing and fabrication for unique and advanced components by employing parallel design and manufacturing processes that are tracked and validated using data

science, providing insights to the materials we are processing and the resulting performance beyond conventional manufacturing methodologies. This coupled with developing the ability to AM advanced materials such as Hastelloy® X and Mo will provide a pathway to commercialization. The future of nuclear energy in the United States depends on the advancement of innovative methods that will provide a turning point in the economics associated with the development of new commercial nuclear builds.

Our program will be led by BWXT, a respected high-consequence nuclear manufacturer in the United States with a proven record for delivery of more than two nuclear reactors every year for the federal government. BWXT is joined by ORNL, the largest DOE multi-program, science and energy laboratory, which is engaged in a wide range of activities that support DOE's mission of ensuring security and prosperity by addressing energy, environmental, and nuclear challenges.