Modularity of the MIT Pebble Bed Reactor

For Use by the Commercial Power Industry

By

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Abstract

The Modular Pebble Bed Reactor is a small high temperature helium cooled reactor that is being considered for both electric power and hydrogen production. Pebble bed reactors are being developed in South Africa, China and the US. To make smaller 120 Mwe reactors economically competitive with larger 1500 Mwe traditional light water reactors changes in the way these plants are built are needed. Economies of production need to be sufficiently large to compete with economies of scale. MIT (Berte) has been working on developing a modular design and construction strategy for several years. This thesis builds on that work by demonstrating the technical feasibility of implementing the modularity approaches previously developed.

The MIT approach uses “space frames” containing all the components, piping, valves and needed cables, instrumentation in a specified volume. These space frames are built in a factory to assure high quality in manufacture. They are then shipped by train or truck to the site and assembled “lego” style. It is expected that with the improved quality in the factory setting, and rapid assembly at the site that the total time and cost of construction of the plant will be greatly reduced (Kadak). To make this process work, it is vitally important to assure that when the space frames and internal components are manufactured, they are done to rigid tolerances to assure line up when assembled in the field. By using many advanced three dimensional measurement technologies, including the use of digital photography, lasers, and photogrammetry, companies are now capable of fabricating pieces to extremely precise specifications at a relatively affordable cost.

This thesis evaluates the feasibility of manufacture of space frames and internal components to the required tolerances, the accuracy control needed and how the plant can be assembled with details of each space frame interfaces. A global reference system was determined and a basic plant map for space frame placement developed. Deviations from exact placement from this map due to tolerance allowances were factored in and methods and techniques for overcoming any variations was developed. In order to enable each frame and it’s respective components to be accurately fabricated to ensure interfacing parts will mate, a local coordinate system was developed for each frame and used to describe the exact location of the required interfaces for each specific frame. Crucial concepts of accuracy control and “best fit” are outlined and incorporated.

Based on independent verification of the processes and the design proposed, this modularity approach appears to be feasible. A comparative economic analysis was also performed to assess the potential cost savings of the modularity approach compared to traditional "stick build" approaches presently being used in nuclear construction. Manhour, learning curve and overall cost savings of over 30 % can be expected which suggests that if modularity approaches as those proposed are used, smaller reactors can compete with larger economies of scale plants.

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