

FBNR Letter

FIXED BED NUCLEAR REACTOR – FBNR

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Dear coworkers and potential coworkers around the world,

As the number of coworkers is increasing, we are issuing a circular letter to communicate about the matters of general interest to the FBNR project. Please consider this as a personal letter to yourself. Those who are not involved in the project as yet may participate at any appropriate moment. The project has manifold aspects including scientific, technological, economical, political, and sociological.

A new era of nuclear energy is emerging. The International Atomic Energy Agency has committed itself to “Help to ensure that nuclear energy is available to contribute in fulfilling energy needs in the 21st century in a sustainable manner; and to bring together both technology holders and technology users to consider jointly the international and national actions required to achieve desired innovations in nuclear reactors and fuel cycles.”- IAEA-TECDOC-1362.

The objective is to develop an innovative nuclear reactor to be inherently safe, passively cooled, small, modular, and simple in design with integrated primary circuit. Safety is achieved by design, and has reduced adverse impact on environment. It is to meet the requirements of GEN IV and IAEA-INPRO as being economic, safe, proliferation resistant and sustainable.

The FBNR may be called People’s Reactor. It is intended to be developed by the peoples for the peoples of the world in the spirit of cooperation and service to humanity. It is intended to be a near term deployment project. Let us form an international consortium to develop this reactor where all members are stakeholders.

An IAEA Coordinated Research Project (CRP) includes FBNR in its program.

Participate in the project and make a proposal on a particular activity of your interest.

FBNR Letter 10 September 10, 2004

Some suggestions concerning the research problems of FBNR.

Dear coworkers and potential coworkers around the world,

Here are some suggestions about the problems that you may become interested to solve. For details please feel free to contact me.

Cordially Yours,
Sefidvash

1. **Construction of the hydraulic module of the reactor** to simulate the reactor behavior. The module is to be made from a transparent material such as Plexiglas and the use of glass balls having similar densities as fuel elements made from coated particles, in order to observe the behavior of the core under different flow conditions. Also to measure the pressure loss as a function of coolant velocity in such a system. This research is fundamental to the development of the FBNR concept. It goes to meet the recommendation of the Consultancy Meeting in March 2004 where was said, *“In particular, the Consultancy noted that the innovative approach proposed in the Fixed Bed Nuclear Reactor (FNBR) concept relating to hydraulically supported column of spherical fuel elements offers a good potential to serve as a method of passive control of core reactivity. This concept needs to be further developed and polished for its possible implementation in small reactors.”* [Related to the activities 1,4, & 6]
2. **The Particle Image Velocimetry (PIV) technique** is to be used to make flow visualization of the coolant in the core module and study the moving behavior of the fuel elements. In PIV, the images are captured by a camera and digitalized by an acquisition board installed in a PC. The velocities are measured by image processing, evaluating the trajectory distance of the particles traveled in the fluid and the time for the displacement is determined by camera shutter. The velocity vectors are calculated and the flow charts are plotted. [Related to the activities 1, 4 & 6].
3. **Design the three dimensional components of the reactor** to show the conceptual design of the reactor using the Pro-Engineering FireWork code. Two conceptual designs are to be produced; namely, the design of a single module reactor, and the design of a multi-module reactor. [Related to the activities 1 & 2]
4. **Study of the method for the development of the 15 mm diameter spherical fuel elements** made from coated particles and cladded by SiC (or other materials) to be compatible with water coolant. [Related to the activities 1,4 & 6].
5. **The feasibility of the use of coated particles directly** (without fabricating larger spherical fuel elements) with water forming a suspended core in the FBNR concept by using a supporting weight in the module. The real coated particles is to be used to make a realistic experiment. A vibration machine is also is utilized

in order to simulate the hydraulics vibrations in the reactor. [Related to the activities 1 & 6]

6. **Calculation of temperature distribution in the fuel.** The heat generated in the UO₂ region of the micro sphere is transferred by conduction through two layers of graphite with different densities and then crossing the SiC cladding is conducted through the graphite matrix until reaches the SiC clad of the fuel element. Thereafter, the heat is transferred by convection to the water flowing around the fuel element. The maximum temperature in each region should be calculated to verify that they will not exceed the permitted temperature limits of any particular material.
7. **Passive cooling of the fuel chamber.** In this work the passive cooling characteristics of the FBNR are to be analyzed. Any reactor incident or accident, causes the small spherical nuclear fuel elements fall into the cylindrical fuel chamber by gravity. Calculations are to be made on the cooling of the fuel elements inside a double walled cylindrical tube by natural convection in order to verify the passive cooling characteristics of this reactor concept.[Related to the activity 6].
8. **Development of a simplified analytical model** to simulate reactivity behavior of the FBNR reactor as function of height, for the purpose of qualitative analysis of reactivity behavior. [Related to the activities 1 & 6]
9. **The conceptual design of an innovative control system** for the FBNR to contribute to its “fail safe” and “inherent safety” characteristics. [Related to the activity 6]
10. **Preliminary structural calculations** determining the thicknesses of tubes in the core, the fuel chamber, and other components. Calculation of the structures that support the reactor modules. [Related to the activities 1 & 2]
11. **Neutronics calculations of FBNR.** Neutronics modeling and the choice of computer codes for the reactor core calculations. The reactor core is composed of fuel elements made from coated particles. Calculations such as fuel burnup, criticality as a function of core height and fuel enrichment, neutron flux distribution, peaking factors, effect of entering new fuel into the core, kinetics calculations, etc. Study of the method of securing reserve reactivity by fresh fuel insertion and utilization of burnable poison.
12. **Study of the integrity of the fuel and cladding** materials at very high fuel burnup using coated particle fuel.
13. **Thermal-Hydraulics calculations of the FBNR core.** Thermal hydraulics modeling and the choice of computer codes for the reactor core composed of fuel elements made from coated particles cooled by water. Calculations of fuel and coolant temperatures under different operating conditions.

14. **Safety Evaluation.** Safety analysis under various accident scenarios including loss of coolant accident, loss of flow accident, loss of power accident, anticipated transient without scram, and the safety against terrorist's actions.
15. **Study of the various forms of reactivity control** are to be made such as using fine control rod in the centre of the module, use of absorber shell insertion, fixed bed level limiter, coolant pump flow controller, or using the coolant valve flow controller option.
16. **Comparative assessment of several passive decay heat removal systems.** Study of passive cooling of fuel chamber being cooled by natural convection to air. Study of fuel chamber being cooled by natural convection to water. Study of the fuel in the fuel chamber being cooled by the water from an accumulator.
17. **Research and development on coated particle type fuel for water-cooled reactors.** Determination of the optimum size of the fuel element made from the coated particles for utilization in FBNR. Method of fabrication of the large diameter fuel elements from the coated particles. Testing of the irradiated and non-irradiated fuel elements.
18. **To devise an administrative-economic plan** in order to be able to attract financial investments for the project and that can administer research and development activities internationally. There are many financial resources and possibilities around the world that can be utilized. For example, the European Community under certain conditions will contribute to nuclear energy projects. Many countries subsidize their clean energy programs. Others provide funds for innovative research that will help elevate the level of science and technology in their countries. There exist many visionary private investors who may provide risk capitals. The nuclear industry and research institutions can make investments by supplying equipments, use of their facilities, manpower, and technology. In this manner, the necessary funds can be raised. The research project concerns establishing a consortium. The investments in it can be in the form of service, equipment, or money.
19. **To devise a political scheme** to bring about an adequate global governance in relation to numerous such small reactors being deployed around the world. To guarantee the safeguard of nuclear reactors and materials. Also produce a shift in paradigm in the public perception of nuclear energy, showing the world community how the new safety philosophy and new criterias will bring about innovative reactors that will produce energy in a sustainable and safe manner at the service of humanity.

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