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April. 2, 2002

Dr. Mori
JAIF. Inc.
Vice President

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JAIF.
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Dear Dr. Mori,

I should have come to you in JAIF to apologize in person for my great mistake, regarding the date of my lecture, but I write you instead since I did not have the opportunity. I truly regret having missed the opportunity to give my lecture at JAIF during my stay in Japan and hope that you will forgive me.

Thank you also for your kind suggestion. I contacted Mr. Takeda at Dowa Co. who came to Sokendai at Hayama, and we had a fruitful discussion about the deep underground reactor. He taught me about the practice of civil and mine engineering and gave me many valuable suggestions.

After the Sokendai symposium. I visited the Kamioka mine company which built the super-kamiokande site and got a great deal of information about the construction of big vaults in the Kamioka mine. Mr.K.Tsurumi who is the Directing General Manager at the Kamioka Mine & Smelting Company kindly agreed to meet with me on a national holiday, and gave me valuable information along with a videotape on the mine and super kamiokande.

Visiting the super-kamiokande gave me even greater confidence in the concept of a deep-underground reactor. Although the idea may not be readily accepted by the public, building a reactor deep underground would be more economical than building one on the earth's surface.
Future reactors, not only high conversion light water reactors but also many other types of reactors, such as HTGR which has been promoted recently, should be placed deep underground.

I am enclosing a copy of the paper, which I plan to submit to the upcoming ANS meeting in Florida, and others. I would appreciate it very much if you would read it, and give me your comments.

During my stay in Tokyo, I had the opportunity to participate in a conference on the foundation of quantum mechanics held at Waseda Unviversity. Prof. Ojima and Prof,

Takahashi of the architecture department have been active for the last 20 years in metropolitan underground city planning. I visited them and discussed the deep underground reactor with them. They felt that my proposal of a 500-1000m depth was too deep for their purpose.

As you are working on the new initiative for metropolitan city planning, this is extremely important for future of Japan. I am going to continue on this subject more than my efforts to accelerator driven reactor proposed decade ago.

I hope you will continues to support this enterprise for creating a peaceful civilization which uses nuclear energy wisely.

Thank you for all your help, and I am looking forward to see you in the not distant future.

Sincerely,

Hiroshi Takahashi

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PS. I will sent this by mail and E-mail.

Embedding Materials and Economy for a Deep Underground Reactor

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Abstract - I proposed embedding the high-conversion LWR, studied in the NERI program, about 500-1000 meters deep underground. At such depths, the earth's gravity force passively removes heat using the natural circulation of the reactor coolant; then, even a nuclear-power plant with very tight-lattice fuel assembly can be operated safely. Safety is ensured by embedding the reactor vessel and other components, such as coolant ducts, in casing containers and filling the space between the container and the vessel with embedding material. I describe suitable embedding materials that can be easily removed to allow access to the reactor and coolant components. , Finally, I discuss the key economic aspects of building a reactor deep underground.

I. INTRODUCTION

In NERI program, we highlighted the value of a high-conversion light water reactor (LWR) that uses a high concentration of tight-lattice Pu fuel [1][2]. This reactor, with its hard neutron-energy spectrum close to a Na-cooled fast reactor, ensures a high burn-up of fuel. The reactor with uranium fertile material has positive water-coolant void coefficient, so to get a negative void coefficient, a pancake-type flat core configuration must be used, or a fuel assembly with a neutron-streaming void section that reduces the neutron economy. Using thorium fertile material provides the negative void coefficient without the need to have a neutron-leaky core configuration. Also, the neutron economy is improved and the burn-up of fuel is higher than in the reactor with uranium fertile materials. However, the pumping power of the water coolant must be substantially increased to remove the high-density heat from tight-latticed-fueled core. In the steady operation, coolant flow can be maintained by increasing pumping power several times above that of the regular LWR. During emergencies, such as outage of on-site power or loss of coolant, the removal of heat becomes serious problem. Detailed analyses of this accident scenario have been made, and experimental studies of heat removal from a tight lattice are planned in Japanese program.

The high pressure-difference between the inlet and outlet in the narrow water channel of the tight lattice is provided by the difference in gravity force between the low density of boiled water and the high density of the water condensed after the steam passes through out the steam turbine. To get this high-pressure difference, the vacuum condenser is located far above. The pumping-pressure difference circulating water in the regular BWR and PWR are, respectively, 2 atm and 1.5 atm which is equivalent to a 20 –15 meter difference in water height .For the high conversion (HC) LWR with a tight lattice, the difference must be several times greater: here, a difference in water height of more than 80-60 meter is needed to naturally circulate coolant water. By putting the reactor deep underground, enough space can be provided to get a satisfactory high-pressure difference between the inlet and outlet, steam turbine and condenser, both of which are located far above the reactor vessel.

By locating the reactor deeper, the pressure imposed on the pressure vessel is increased by the gravitational force of surrounding earth. At a depth of 400 meters and 600 meters, the earth's pressure generated a water pressure of 100 atm and 150atm, suitable for a BWR and a PWR, respectively. .

In the conventional model proposed for a passive cooling system using natural circulation. it is operated in an environment where the pressure is insufficient, the state of the steam is not well defined, instability is created, and so, it is not necessarily a safe operation, even though it is a passive one. . By operating at a high enough pressure, these nonlinear effects are eliminated, and the reactor can be safely operated deep unde ground. From this point of view, there are many advantages in the concept of the deep underground reactor. Due to pressure from earth's gravity, the walls of the pressure vessel can be thin;