Design Concept Description

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This document is approximately 1,700 words long.

Disclaimer

So far as I'm aware, this design concept for a nuclear power reactor has never been previously described or documented by any other party and is my own original concept. I originally documented the idea on Tuesday, December 19, 2000.

Patent Status

It's my intention that this idea should be a part of the public domain and should never be patented or monopolized in any way whatsoever. I intend that it shall be available for use by any party who wants to use it and who's capable of doing so. I first posted this idea on the internet, and first declared it to be public domain, on Saturday, July 30, 2005.

Scope

This document describes only the design concept for this reactor design and that only very generally. Detailed calculations will be necessary to assess the feasibility of the design. Further calculations will be necessary to determine optimum design configurations.

I suggest frequent reference to the sketch during the study of this written description.

Pressure Vessel Conditions

I believe that the reactor should be a pressurized water reactor (PWR) instead of a boiling water reactor (BWR). I believe that the reaction will be more stable and easier to control if the reactor is a PWR. There are also some other possible advantages that I'll mention later in this document.

Fuel

Feasibility studies will be needed to determination if the fuel should be an oxide with Zircaloy or glass cladding, an unclad metallic alloy of uranium, a ceramic of some sort, or some other form.

The reactor might operate with enriched uranium and natural water moderator or with natural uranium and heavy water moderator. That decision would probably be based as much on politics as on technical considerations. Heavy water reactors can be an important part of the process of breeding and extracting plutonium. Incidentally, the use of heavy water would be another reason for using a PWR design. The simpler PWR primary coolant loop will result in fewer opportunities for leaks, and the consequent loss of heavy water.

The fuel pellets will be free-floating in the coolant and will not be mechanically constrained to any specific fuel array. Instead, the fuel will operate suspended in the coolant in a Reaction Zone Plenum. Each fuel pellet should probably be spherical. Feasibility studies might suggest a better shape. I expect that solid pellets will be easier to manufacture than hollow pellets, and provide higher fuel density. There might be a reason to use hollow pellets but I don't know what it would be. The optimum size and shape of the pellets will be a function of several related parameters. For example, smaller pellets will require less coolant flow for their suspension in the coolant. However, they'll sink more slowly, increasing the time to shut-down. There might even be reasons to use pellets of different sizes and shapes at the same time. The determination of the optimum pellet configuration will be a complex calculation taking into consideration the effects of many parameters.

Reaction Zone Plenum

The Reaction Zone Plenum is the volume enclosed by the Reaction Zone Boundary Structure. That structure will be situated in the upper portion of the Reactor Pressure Vessel. I've shown it in the sketch to be a cone-shaped structure with the large end below and the small end above. That shape is adequate for purposes of illustration. However, studies will be necessary to determine if better performance might be provided by a different shape. There are various other shapes that might provide advantages or avoid problems. I also recommend that glass be considered as the material from which to construct the Reaction Zone Boundary Structure. It might seem unlikely to someone who hasn't investigated the matter but glass is equal to or superior to Zircaloy in such properties as corrosion resistance, elasticity, high temperature integrity, and parasitic thermal neutron absorption.

Shutdown Zone Plenum

The Shutdown Zone Plenum is the volume inside the lower portion of the Reactor Pressure Vessel but outside of the Shutdown Zone Boundary Structure. As with the Reaction Zone Boundary Structure, I've sketched the Shutdown Zone Boundary Structure as a cone. Studies should be undertaken to investigate the possible advantages of other shapes. I recommend that glass containing Boron or a similarly effective poison should be examined as a possible material from which to construct the Shutdown Zone Boundary Structure. As an alternative, such poison could be located near the Circumferential Shutdown Groove, mentioned later.

Controlling the Reaction Rate

The nuclear reaction rate will be easily controllable by variation of the coolant flow rate. At a low coolant flow rate, the fuel (lacking buoyancy) will settle away from the small end of the Reaction Zone Plenum. It will sink toward or into the Shutdown Zone Plenum. As the pellets move into the larger volume and drift apart the reactivity rate will decrease. If boron or some other poison is used in or near the Shutdown Zone Boundary Structure, that will increase the effectiveness of the shutdown process. The dreaded loss of flow accident will simply shut down the reactor. That is, in response to a loss of flow the pellets merely disperse and the reaction stops. At a higher coolant flow rate, coolant flow will force the fuel pellets upward into the small part of the Reaction Zone Plenum resulting in a more dense mass and an increased reaction rate.

The Shutdown Condition

The lower edge of the Shutdown Zone Boundary Structure will have a Circumferential Shutdown Groove into which the fuel pellets will settle after they drop into the Shutdown Zone Plenum. When the pellets are dispersed into the Circumferential Shutdown Groove, fuel pellet dispersal will be such that the nuclear reaction will be terminated.

Fuel Processing and Refueling

Using appropriate plumbing, fuel pellets can be transferred through the Reactor Pressure Vessel wall during full power operation or at any other time. In the sketch, I've shown an orifice that would be capable of inserting pellets any time but removing them only during shutdown conditions. However, other orifices at other appropriate locations in the Pressure Vessel could remove or insert fuel during other operating conditions.

It might be a good idea if all fuel management responsibilities are subcontracted. The fuel might even be owned by the subcontractor. The owner of the reactor could be responsible for reactor operations only and lease the fuel and all fuel management services from the subcontractor. The way the world is developing, that subcontractor will probably be the International Atomic Energy Agency. Administrative controls and reactor design could assure that only the subcontractor would have access to the fuel. If it's the international agency, then you can bet that will be the case.

Some Anticipated Advantages

The reactor will seldom need to be shut down. All fuel processing and refueling activities can be accomplished during reactor operation. Fuel can be loaded or withdrawn in any quantity and at any time. All necessary reactor management operations can be performed far more simply and reliably that in a conventional reactor. Structurally, the reactor will be far simpler than a conventional reactor. It will be cheaper to design, build, and operate. It will be inherently more stable, reliable, and safe. It will have an essentially unlimited life expectancy and will be far easier to repair and maintain. Although the design might lend itself to lower power densities and lower power levels than conventional reactors, I believe that in the long run the political and bureaucratic advantages of having many small facilities rather than a few large ones will easily offset the so-called economies of scale usually used to justify monster facilities.

Some Operational Considerations

I believe that there are some advantages to be obtained from designing the reactor as a PWR rather than as a BWR. As a PWR, the primary coolant loop can be subdivided into two parallel branches each with its own steam generator. One steam generator will drive a turbine and electric generator. The reactor will be operated at 100% of rated power 100% of the time. Load following will be accomplished by redirecting surplus steam to the second branch of the primary coolant loop and thus to the second steam generator. The purpose of the second steam generator will be to boil sea water or contaminated water to generate fresh water. The fresh water can be used for any purpose for which distilled water is appropriate. With world population growing endlessly and with the available supply of fresh water being depleted or polluted, the fresh water produced by the reactor might eventually be more valuable than the electricity that the reactor produces. Maybe we can save a few water tables in the world from depletion. The residue from the distillation of sea water will be replete with the minerals and other chemicals that are dissolved in sea water and might become a treasure-trove of unexpected value.

Deployment Suggestions

I want to see this design developed and put to use. I'd like for as many different developers as possible to do so. That's one reason why I'm placing the idea into the public domain. I believe that the widespread use of this reactor design by many different parties, for many different purposes, will result in an abundant source of electricity, fresh water, chemicals, and other things.

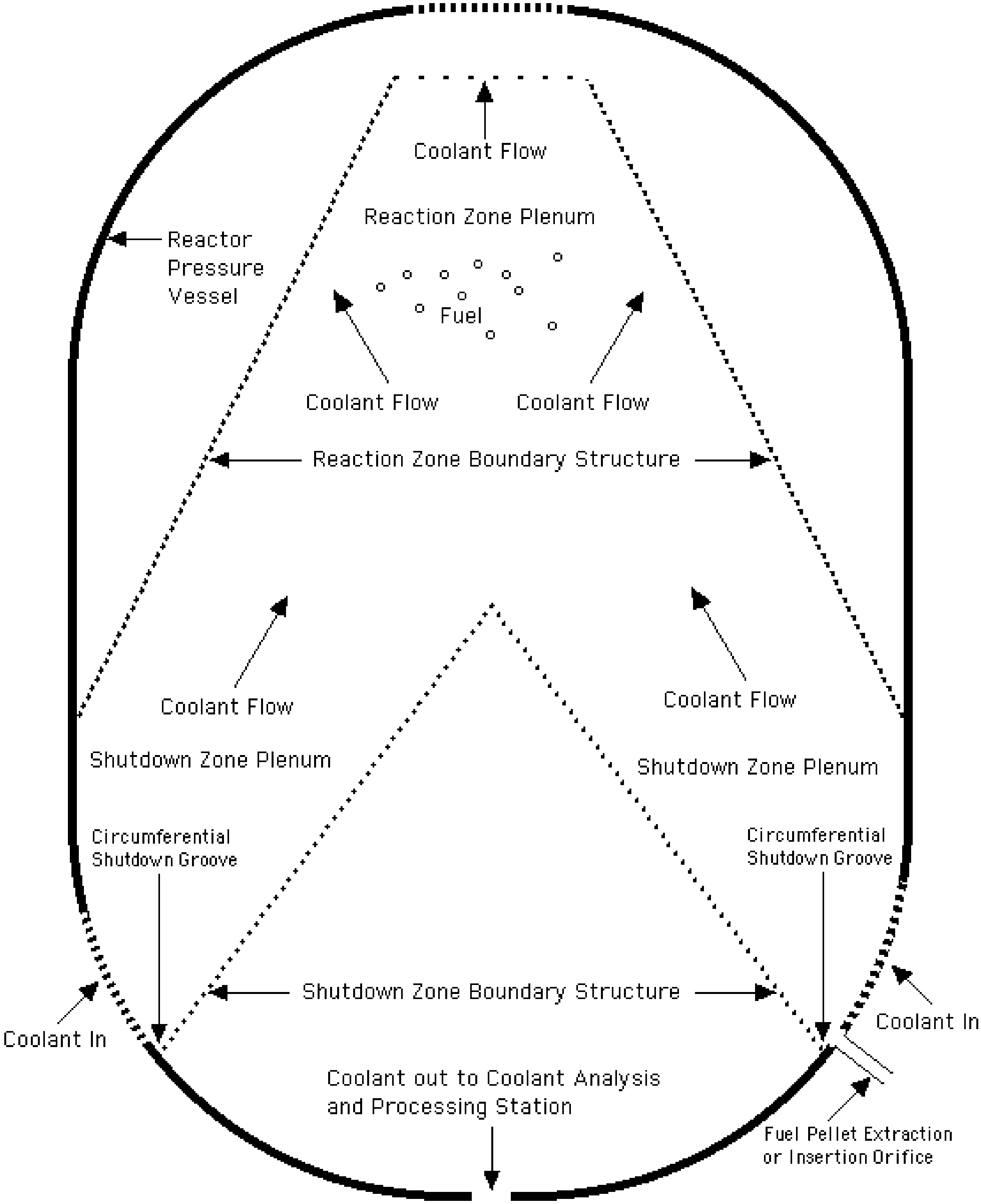
For example, with transportation costs escalating, I believe that there is a future for rail transportation. If a railroad company owns many small reactors of this type, located at appropriate intervals along electrified railroads, then trains could be operated very cheaply.

Reactors along rivers or coastlines could produce as much fresh water as people wanted.

Every town or county could own a small version of such a reactor. Electrical coops could be formed, and buy small reactors. Even a neighborhood could own its own reactor. Electricity could be very inexpensive.

Fuel companies could use such reactors as sources of energy to produce hydrogen for automotive fuel.

Etc. Use your imagination.


Coolant Flow
Reaction Zone Plenum
Reactor
Pressure
Vessel
Fuel
Coolant Flow
Coolant Flow
Reaction Zone Boundary Structure
Coolant Flow
Coolant Flow
Shutdown Zone Plenum
Shutdown Zone Plenum
Circumferential
Shutdown Groove
Circumferential
Shutdown Groove
Shutdown Zone Boundary Structure
Coolant In
Coolant In
Coolant out to Coolant Analysis
and Processing Station
Fuel Pellet Extraction
or Insertion Orifice

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