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Basic Science

Mathematical Analysis of Poisoning Effect

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ABSTRACT [ENGLISH/ANGLAIS]

Since Xenon poisoning denominates nonpareil a too high Xenon- Concentration in one Reactor, which during an achievement throttling and when interchanging the reactor off arises. Therewith Fission develops 135(I). Through the expressions obtained we can find the physics characteristics of reactor restarted up in iodine pit comprehensively and essentially. This is integrates with one Radioactive half-life of 6,6 hours through Beta decay to likewise radioactive 135(Xe). The capture cross section for during the nuclear fission developed and for the nuclear chain reaction postulated neutrons quantity to for 135(Xe) 2.65 million barn implements to thermal neutrons with energy of 0.025 eV. The fission products that accumulate in a reactor core act as long-term heat sources through their radioactive decays and parasitic neutron absorbers or poisons that, over time, decrease the thermal utilization factor and introduce negative reactivity into a core. In this paper, poisoning decay of Xenon and Samarium has discussed.

Keywords: Poisoning, Samarium, Xenon, Reactivity, Equilibrium

RÉSUMÉ [FRANÇAIS/FRENCH]

Depuis l'empoisonnement au xénon dénomme nonpareil une trop haute concentration de xénon dans un réacteur, ce qui au cours d'une limitation de la réalisation et quand échangeant le réacteur hors pose. Fission y développe 135 (I). Par les expressions obtenues, nous pouvons trouver les caractéristiques physique du réacteur renouvelées en fosse iode globale et essentiellement. C'est s'intègre avec une demi-vie radioactive de 6,6 heures par désintégration bêta de même radioactifs 135 (Xe). La section efficace de capture au cours de la fission nucléaire mis au point et de la réaction nucléaire en chaîne postulé quantité de neutrons pour 135 (Xe) 2650000 grange en œuvre pour les neutrons thermiques avec une énergie de 0,025 eV. Les produits de fission qui s'accumulent dans un acte du cœur du réacteur en tant que sources de chaleur à long terme à travers leurs désintégrations radioactives et absorbeurs de neutrons parasites ou des poisons qui, au fil du temps, de diminuer le facteur d'utilisation thermique et d'introduire de la réactivité négative dans un noyau. Dans cet article, la décomposition de l'empoisonnement au xénon et le samarium a discuté.

Mots-clés: Intoxication, le samarium, Xenon, Réactivité, équilibre

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INTRODUCTION

The promising conveyable of nuclear waste material from nuclear reactors and defense amenities to a repository is the essence concern in the present eon. The aspiration of waste treatment is of grave importance now in order to handle nuclear waste transportation issues at the local, tribal, state, regional and national levels [1]. For fossil fuel burning power plants, solid waste is primarily a trouble for coal-based power. Approximately 10% of the substance of coal is ash. Ash often includes metal oxides and alkali. Such residues necessitate disposition, generally burial, though some reprocessing is possible, in a manner that limits migration into the general environment. Volumes can be substantive. When burned in a power plant, oil also yields residues that are not entirely burned and thus conglomerate [2], [3]. These residuals must also be disposed as solid wastes. Natural gas does not produce significant volumes of combustion based solid wastes. Nuclear does produce spent fuels. Once the fission operation has decelerated, the fuel rods are supplanted. The spent fuel rods hold extremely radioactive fission products and must be stored safely [4], [5]. These used fuel rods are regarded as high level nuclear waste. Currently all high level nuclear waste is stored in large pools of water at the power plants where it was generated [6]. In a reactor core the fission products that accumulate are of concern for two explanations. First, they play long-term ignite origins through their

disintegrations. Second, they act as penthetic neutron absorbent or toxicants that, over time, decrease the thermal utilization factor and, thus, bring in electronegative reactivity into a core. For fission products acquired from the fission of 235U, it is often presumed that each fission produces 1 atom of static poisonous substance with an concentration Cross section of 50 barns. While this simplistic rule-of-thumb exploits for long-term reckonings of burn up effectuates, the two particular poisons 135Xe and 149Sm have such prominent absorption cross sections that they must be tempered on an individual basis. The fission products that accumulate in a reactor core act as long-term heat sources through their radioactive decays and parasitic neutron absorbers or poisons that, over time, decrease the thermal utilization factor and introduce negative reactivity into a core. In this paper, poisoning decay of Xenon and Samarium has discussed.

POISONING: DECAY CHAIN

Poison Reactivity

To determine the reactivity transient caused by a particular fission product poison, $N_p t/\sum f$, buildup equations for the poison decay chain and a quantity that is found from the decay. The reactivity p_P introduced by a fission product poison is directly proportional to its average concentration Np in the core.

$$\rho_P = \frac{k'_{eff} - 1}{k'_{eff}} = \frac{k_{eff} - 1}{k_{eff}} \quad (1)$$

Where k'_{eff} indicates the core with the poison included and k_{eff} refers to the same core without the poison. Since the poison changes only the thermal utilization factor, the two multiplication factors are related to each other by $k'_{eff}=k_{eff}\ f'/f$. If we assume the unpoisoned core is critical $k_{eff} = 1$, then poison reactivity is given by,

$$\rho_p \simeq -0.6\sigma_a^p \frac{N_p}{\sum f} = -\sigma_a^p \frac{N_p}{\sum f}\frac{\eta}{\nu} f \quad (2)$$

In Fig 1 reactivity with mean life time due to poisoning is shown.

Equilibrium Xenon

A very small nuclear denseness of Xenon nuclide can have a right smart reactivity consequence. Of all isotopes it has the largest thermal neutron absorption cross section. For Counterbalancing Xenon Poisoning, a reactor operating at a constant flux density _0, the equilibrium concentrations of 135I and 135Xe are found from decay/buildup equations by setting the time derivative to zero. The result is

$$I_0 = \gamma_I \left(\frac{\sum f}{\lambda_I}\right)\phi_0 \quad (3)$$

$$X_0 = [\phi_0\gamma_I + \phi_0\gamma_X]\frac{\sum f}{\lambda_X + \sigma_a^X \phi^0} \quad (4)$$

From equations it is understood that, while the ^{135}Xe concentration is independent of $Ø_0$ at high flux density levels, the ^{135}I concentration continues to increase linearly with $Ø_0$. Now, the macroscopic absorption cross section of Xenon is

$$\sum_{aX} = \frac{\gamma_I + \gamma_X \sum f \phi_T}{\phi_X + \phi_T} \quad (5)$$

Now, the reactivity equivalent of equilibrium xenon is

$$\rho = -\frac{\gamma_I + \gamma_X}{\nu p \epsilon} \quad (6)$$

In this case,

$$p = \epsilon = 1 = -2.73\% \quad (7)$$

This is the maximum reactivity due to equilibrium xenon in a fueled uranium reactor.

The ^{135}I would decay away, and the 135Xe concentration would finally begin to decrease as it decays.

In Figure 2 Poison Reactivity has shown. Following, the shutdown from various flux levels.

If during the shutdown transient, reducing the xenon reactivity temporarily to below its equilibrium values, the reactor were started up again, the large absorption cross section for 135Xe would cause this nuclide to be burned up very rapidly.

Once the reactor has poisoned out, it is requisite to postponement until the negative 135Xe reactivity has peaked and descended back to a level that can be offset by all controllable positive reactivaties. In many power or propulsion reactors, the time-to-poison is usually only a few tens of minutes, and the speculator may experience significant drive to develop the reactor restarted ahead it poisons out for annulling a prolonged flow of lost output. The interval throughout which the reactor cannot be resumed is called the poison shutdown time and is typically of 15-25 hours continuance. In Figure 3 Poison Reactivity for negative to positive region has shown. If the xenon and iodine have reached equilibrium prior to shutdown, then the reactivity becomes,

$$\rho = -1/\nu p\epsilon[\frac{(\gamma_I + \gamma_X)\phi_T}{\phi_T + \phi_X}e^{-\lambda_X t} + \frac{e^{-\lambda_X t} - e^{-\lambda_I t}}{\phi_I - \phi_X}\gamma_I \phi_T] \quad (8)$$

It is unimaginable to restart the reactor, and the reactor is stated to have poisoned out.

In Fig 4 Equilibrium Xe(135) concentrations is shown.

Equilibrium Samarium

The second fission product poison which must be accounted for explicitly in power reactors is ^{149}Sm. This stable nuclide is a daughter of the fission products ^{135}Sm and ^{135}Sm. The generation rate of ^{149}Sm is the decay rate of ^{149}Pm. There is negligible production of ^{149}Sm as a direct fission product. Since ^{149}Smis stable, the only way it can vanish is for it to absorb a neutron which it does at a volumetric rate of $\sigma_a^s \phi(t) S(t)$ where S(t) is the average ^{149}Sm concentration. Thus the decay/buildup equations for ^{149}Pm and ^{149}Sm are

$$\frac{\Delta P(t)}{\Delta t} = -\lambda_P P(t) + \lambda_P \sum f\phi(t) \quad (9)$$

$$\frac{\Delta S(t)}{\Delta t} = \lambda_P P(t) - \sigma_a^S \phi(t) S(t) \quad (10)$$

Because of the long half-lives of ^{149}Pm and 149Sm, the buildup of ^{149}Sm to its equilibrium level takes many tens of hours, especially for reactors operating at low average flux densities ϕ_0. It is seen the equilibrium ^{135}Sm is, a level that is independent of the flux density. Thus at equilibrium, all reactors have the same amount of ^{149}Sm poisoning.

$$S_0 = \frac{(\gamma_P \sum f)}{\sigma_a^s}) \quad (11)$$

In Fig. 5 shows the buildup of Sm(149)to equilibrium has shown. When the time derivatives are zero, the reactivity is,

$$\rho = -\gamma_\rho / \nu p\epsilon \quad (12)$$

As,

$$\rho = \epsilon = 1 = 69.25\% \quad (13)$$

For Samarium after shutdown, concentration after t time is,

$$S(t) = S0 + P_0(1 - exp(-\lambda P t)) \quad (14)$$

and its reactivity for shutdown is

$$\rho = \frac{\gamma_P}{\nu p\epsilon}[1 + \phi_T/\phi_S(1 - e^{-\lambda p t})] \quad (15)$$

Finally maximum value is,

$$\rho = -[1 + \phi_T/\phi_S]\frac{\gamma_P}{\nu p\epsilon} \quad (16)$$

CONCLUSION

In this paper theoretical results were analyzed and discussed. The fission products that accumulate in a reactor core act as long-term heat sources through their radioactive decays and parasitic neutron absorbers or poisons that, over time, decrease the thermal utilization factor and introduce negative reactivity into a core. The nuclear reactor power earlier closedown, the position where the reactor starts up in iodine pit, and the start power, so on, all have consequence on the responsiveness deserving of xenon and samarium poisoning, and the different conditions can lead to totally different physics characteristics. In addition, the time when the reactor starts up in iodine pit is a very important factor for nuclear reactors safety. The terminations are very significant to the maneuverability and procedure protective reactors.

FIGURES

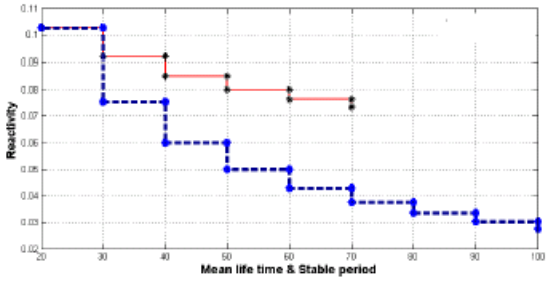

Fig. 1. Reactivity with mean life time because of poisoning

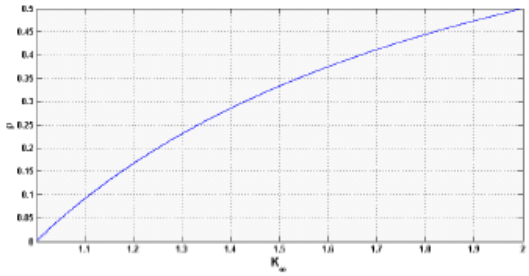

Fig. 2. Poison Reactivity

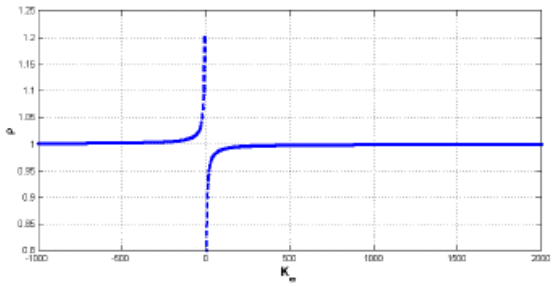

Fig. 3. Poison Reactivity for negative to positive region

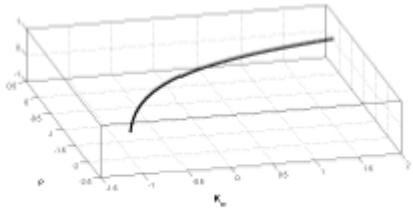

Fig. 4. Equilibrium Xe(135) concentrations

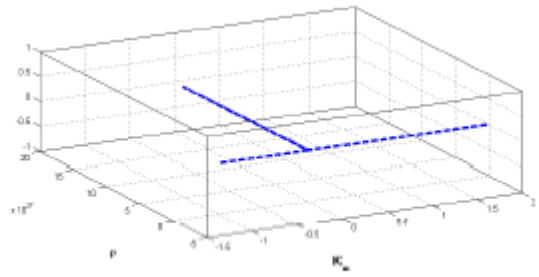

Fig. 5. The buildup of Sm(149)to equilibrium

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Nil

CONFLICT OF INTEREST

Nil