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(54) **Title:** NUCLEAR FUEL, A FUEL PELLET CONTAINING THIS NUCLEAR FUEL, AND A FUEL ROD CONTAINING THESE FUEL PELLETS

(57) **Abstract:** Nuclear fuel, where it contains uranium telluride UTe2 and uranium germanide UGe2, where the uranium has a uranium 235U isotope enrichment of not more than 4.99% by weight, with uranium telluride UTe2 having a maximum enrichment of less than 5% and is proportional to powdered uranium germanide UGe2 in a ratio of 1 :9.

Nuclear fuel, a fuel pellet containing this nuclear fuel, and a fuel rod containing these fuel pellets

Background of the Invention

[001] The invention concerns a nuclear fuel, a fuel pellet containing this nuclear fuel, and a fuel rod containing these fuel pellets.

State of the art

[002] Nuclear fuel for pressurized water and boiling water nuclear reactors (with minor modifications also for other types - light water cooled graphite moderated; graphite moderated CO2 cooled; heavy water cooled and moderated; and fast reactors) is manufactured from uranium dioxide UO2, which is sintered in the form of ceramic pellets. In these pellets, a fission chain reaction takes place during the operation of the reactor, heat is released and fission and activation products are produced. The result of these processes is the fact that in a pellet with a diameter of less than a centimeter, the temperature gradient between the center and the edge is about 800°C, in the case of abnormal or accidental processes even more. The pellets are stacked and placed in a cladding made of zirconium alloys (or steel in the case of graphite moderated CO2 cooled or fast reactors). The resulting rod is filled with an inert helium atmosphere and sealed at the top and bottom. The fuel rods are then assembled into nuclear fuel assemblies and inserted to the core.

[003] Sintered ceramic uranium dioxide has a very low thermal conductivity, which causes a high radial temperature gradient in the nuclear fuel pellets of light water nuclear reactors. The present state-of-the-art is such that a high gradient is considered acceptable. However, due to this gradient, the pellet cracks, swells, crumbles and is less resistant to radiation damage. In case of damage to the fuel cladding, releasing radionuclides into the primary circuit is likely. In case of accidental situations and a sudden increase in temperatures in the fuel, the central part of the fuel can reach the melting point of UO2, even if the periphery or fuel pellet is at a safely low temperature. Another problem is the accumulated heat, which is proportional to the integral of the temperature field function in the fuel pellet. In the event of a loss of cooling accident, it is necessary to remove this heat from the fuel in the first moments, because it worsens the balance of the abnormal situation.

[004] The aim of the present invention is to present a device, which removes above mentioned disadvantages of the state of the art.

Feature of the Invention

[005] The above mentioned disadvantages are considerably eliminated by nuclear fuel, which contains uranium telluride UTe2 and uranium germanide UGe2, where the uranium has a uranium 235U isotope enrichment of not more than 4.99% by weight, with uranium telluride UTe2 having a maximum enrichment of less than 5% and is proportional to powdered uranium germanide UGe2 in a ratio of 1:9.

[006] The above mentioned disadvantages are considerably eliminated also by fuel pellet, which contains the nuclear fuel according to the claim.

[007] In an advantageous embodiment it is provided with a connector and a conductor enabling the electrical quantities of the nuclear fuel to be monitored during nuclear reactor operation.

[008] In another advantageous embodiment it has a maximum diameter of 1.5 cm and a maximum height of 2.5 cm.

[009] In another advantageous embodiment the upper and lower edges of the pellet are grinded outwards to form a lens-like shape of a height of 1 mm.

[0010] The above mentioned disadvantages are considerably eliminated also by fuel rod, which contains fuel pellets according to any of the claims.

[0011] In an advantageous embodiment an electrically attached conductor is arranged on the first fuel pellet from the top and the first fuel pellet from the bottom, which conducts through the cladding and allows the measurement of electrical quantities in the fuel material during nuclear reactor operation.

Preferred Embodiments of the Invention

[0012] The nuclear fuel according to the invention contains uranium telluride UTe2 and / or uranium germanide UGe2 in any weight ratio, the uranium used having a uranium 235U isotope enrichment at most 4.99% by weight.

[0013] In an exemplary embodiment, the powdered standard uranium telluride UTe2 has a maximum enrichment of less than 5% of 235U by weight and is mixed with the powdered uranium germanide UGe2 in weight ratios of 1:9.

[0014] The invention also relates to a fuel pellet formed by sintering; further grinding, and providing by a connector and a conductor, see below.

[0015] The fuel pellet can be a maximum diameter of 1.5 cm and a maximum height of 2.5 cm. The upper and lower edges of the pellet are grinded to form lens-like shape outwards to a height of 1 mm in the center of the pellet in order not to bind the pellets during operation, but to ensure their electrical and thermal contact. A wire is attached to the pellet to monitor the electrical quantities of the fuel material during operation.

[0016] The essence of the innovative solution is therefore based on the fact that instead of the ceramic material used at the moment, the above compounds and their combinations are used, as they have unique thermomechanical properties, and their neutron-physical properties are suitable for use as a nuclear fuel. The electrical and thermal conductivity of these materials is high, which makes it possible to reduce the temperature gradient in nuclear fuel by hundreds of degrees. Germanium-bound reactivity is slightly higher than tellurium-bound reactivity, calculations show that similar fuel campaigns as with ceramic oxide fuel can be achieved with proposed fuel with the same enrichment of the fuel with the isotope uranium 235U.

[0017] The new fuel is a good thermal and electrical conductor. In order to avoid bowing (bending of the fuel to the bow-like shape), the nuclear fuel pellets are preferably lens-like grinded outwards to touch by the centers of the pellets. Calculations show that a relatively intensive axial heat transfer between the individual pellets can be achieved in this way. At the same time, good electrical contact between the pellets is ensured.

[0018] These pellets are placed on top of each other and enclosed in a conventional zirconium alloy cladding (or other standard cladding), thus forming a fuel rod, which is also the subject of the invention. In a suggested version the fuel rods are arranged so that an electrically attached conductor is placed on the first pellet from the top and the first pellet from the bottom. Conductor passes through the cladding and allows measuring electrical quantities in the fuel material during operation of the nuclear reactor depending on reactor power, local nuclear fuel burn-up, local reactor neutron flux densities, neutronics perturbations, etc. This unique method of nuclear fuel monitoring is made possible by the specific properties of the new UTe2 and UGe2 materials and specific suggested solutions.

Claims

1. Nuclear fuel, **characterized in, that** it contains uranium telluride UTe2 and uranium germanide UGe2, where the uranium has a uranium 235U isotope enrichment of not more than 4.99% by weight, with uranium telluride UTe2 having a maximum enrichment of less than 5% and is proportional to powdered uranium germanide UGe2 in a ratio of 1:9.

2. Fuel pellet, **characterized in, that** it contains the nuclear fuel according to the claim 1.

3. Fuel pellet according to the claim 2, **characterized in, that** it is provided with a connector and a conductor enabling the electrical quantities of the nuclear fuel to be monitored during nuclear reactor operation.

4. Fuel pellet according to one of the claims 2 or 3, **characterized in, that** it has a maximum diameter of 1.5 cm and a maximum height of 2.5 cm.

5. Fuel pellet according to one of the claims 2 to 4, **characterized in, that** the upper and lower edges of the pellet are grinded outwards to form a lens-like shape of a height of 1 mm.

6. Fuel rod, **characterized in, that** it contains fuel pellets according to any of the claims 2 to 5.

7. Fuel rod according to the claim 6, **characterized in, that** an electrically attached conductor is arranged on the first fuel pellet from the top and the first fuel pellet from the bottom, which conducts through the cladding and allows the measurement of electrical quantities in the fuel material during nuclear reactor operation.