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### Method and facility for converting uranium hexafluoride into uranium dioxide

#### Abstract

A conversion process for converting uranium hexafluoride into uranium dioxide includes the steps of hydrolysis of UF<sub>6</sub> to uranium oxyfluoride (UO<sub>2</sub>F<sub>2</sub>) in a hydrolysis reactor (4) by reaction between gaseous UF<sub>6</sub> and dry water vapour injected into the reactor (4), pyrohydrolysis of UO<sub>2</sub>F<sub>2</sub> to UO<sub>2</sub> in a pyrohydrolysis furnace (6) by reacting UO<sub>2</sub>F<sub>2</sub> with dry steam and gaseous hydrogen (H<sub>2</sub>) injected into the furnace (6), extracting excess gas in the reactor (4) via a collecting device (50) comprising several filters (52), periodically cleaning the filters (52) by injecting a neutral gas into the filters (52) from the outside to the inside of the reactor (4) to remove powder stuck on the filters (52), and measuring the relative pressure in the reactor (4). The conversion method further includes carrying out point cleaning of the filters (52) when the relative pressure in the reactor (4) exceeds a predetermined point cleaning threshold.

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## Background/Summary

(1) The present disclosure relates to the field of the production of uranium dioxide (UO.sub.2) powder, intended in particular for the manufacture of UO.sub.2 pellets for nuclear fuel rods.

### BACKGROUND

(2) It is possible to enrich uranium in the form of uranium hexafluoride (UF.sub.6). However, it is then necessary to convert UF.sub.6 into UO.sub.2 to make UO.sub.2 pellets.

(3) To do this, it is possible to convert gaseous UF.sub.6 into uranium oxyfluoride (UO.sub.2F.sub.2) by hydrolysis in a reactor, by injecting UF.sub.6 gas and dry water vapor into the reactor to obtain UO.sub.2F.sub.2 powder, then converting the UO.sub.2F.sub.2 powder into UO.sub.2 powder by pyrohydrolysis in a furnace, circulating the UO.sub.2F.sub.2 powder in the furnace and injecting dry water vapor and hydrogen (H.sub.2) gas in the furnace.

(4) To obtain a UO.sub.2 powder of homogeneous quality, the furnace may be fitted with means allowing vigorous stirring of the UO.sub.2F.sub.2 powder and promoting contact of the UO.sub.2F.sub.2 powder with the hydrogen and water vapor.

(5) A co-product resulting from the successive UF.sub.6.fwdarw.UO.sub.2F.sub.2.fwdarw.UO.sub.2 conversions is hydrogen fluoride (HF) gas which is very toxic and corrosive.

(6) The hydrolysis reaction is carried out under an atmosphere of neutral gas (or inert gas), preferably under a nitrogen atmosphere. To do this, neutral gas is injected into the reactor, forming a gas flow sweeping the reactor.

(7) In the production phase, to avoid overpressure in the conversion installation, the neutral gas, the excess reactive gases and the hydrogen fluoride resulting from the conversion may be evacuated through filters intended to retain the particles in suspension, especially UO.sub.2F.sub.2 and UO.sub.2 particles.

(8) The filters become gradually clogged and may be unclogged regularly by countercurrent injection of neutral gas.

(9) To prevent the formation of powder agglomerates on the internal wall of the pyrohydrolysis furnace, the conversion installation may be provided with percussion members which strike against the external wall of the furnace.

(10) U.S. Pat. No. 6,136,285 discloses such an installation for converting UF.sub.6 to UO.sub.2 for the implementation of such a conversion method.

(11) In such a conversion method, UO.sub.2 is generated in the form of a sinterable powder to form UO.sub.2 pellets by sintering.

(12) It is difficult to obtain, constantly over time, a quality UO.sub.2 powder, i.e. having satisfactory characteristics, in particular in terms of apparent density, specific surface area, particle size, and chemical composition.

(13) To meet the requirements for use in the nuclear industry, a UO.sub.2 powder intended to form UO.sub.2 pellets must be homogeneous. It must have the lowest possible level of impurities

(mainly fluorine) and preferably less than 50 ppm (50 µg/g UO<sub>2</sub>), a specific surface area of between 1 m<sup>2</sup>/g and 4 m<sup>2</sup>/g, a ratio oxygen/uranium between 1.80 and 2.50% and relative humidity less than 1%. It must have good mixing capacity and an aptitude for spontaneous flow (flowability) thus making it possible to withstand high rates of pellet production. Preferably, it also has a homogeneous particle size distribution (normal law) and a reactivity to natural sintering (or sinterability) making it possible to obtain on the sintered ceramic pellet a density greater than 96.5% of the theoretical density of the UO<sub>2</sub> and a hardness greater than 15 daN/m.

(14) In order to obtain a homogeneous UO<sub>2</sub> powder of constant quality, it is preferable that the conversion installation operates continuously and without jerking. The accumulation of powders on the filtration members causes progressive clogging of the filters and the resulting increased pressure drop leads to an increase in the internal pressure of the conversion installation. This pressure variation may lead to the shutdown of the conversion installation to clean or change the filters before reaching the safety of the conversion installation by exceeding a pressure threshold.

(15) U.S. Pat. No. 7,422,626 teaches a method for achieving efficient and homogeneous unclogging of the filters of the filtration members without interrupting the evacuation of gases and thus increasing the efficiency of the installation.

(16) However, the method described is not optimized and may lead to variations in the operating parameters of the conversion installation and to variations in the characteristics of the UO<sub>2</sub> powder produced.

## SUMMARY

(17) One of the aims of the present disclosure is to provide a method for converting UF<sub>6</sub> to UO<sub>2</sub> which makes it possible to increase the yield of the conversion method while producing a homogeneous UO<sub>2</sub> powder of constant quality.

(18) To this end, the present disclosure provides a method for converting uranium hexafluoride (UF<sub>6</sub>) to uranium dioxide (UO<sub>2</sub>) comprising the steps of hydrolysis of UF<sub>6</sub> to uranium oxyfluoride (UO<sub>2</sub>F<sub>2</sub>) in a hydrolysis reactor by reaction between gaseous UF<sub>6</sub> and dry water vapor injected into the reactor, pyrohydrolysis of UO<sub>2</sub>F<sub>2</sub> to UO<sub>2</sub> in a pyrohydrolysis furnace by reaction of UO<sub>2</sub>F<sub>2</sub> with dry water vapor and hydrogen (H<sub>2</sub>) gas injected into the furnace, extraction of excess gas in the reactor via a capture device comprising several filters, periodic cleaning of the filters by injection of a neutral gas into the filters from the outside towards the interior of the reactor to take off the powder stuck on the filters, and for measuring the relative pressure in the reactor, the conversion method further comprising the implementation of a punctual unclogging of the filters when the relative pressure in the reactor exceeds predetermined punctual unclogging threshold.

(19) According to particular modes of implementation, the conversion method comprises one or more of the following optional characteristics, taken in isolation or in any technically feasible combination: it comprises the injection of a neutral scavenging gas into the reactor so that the conversion of UF<sub>6</sub> to UO<sub>2</sub>F<sub>2</sub> takes place under a nitrogen atmosphere; the dry water vapor and H<sub>2</sub> are injected into the furnace (6) so as to circulate in the furnace (6) against the current of the UO<sub>2</sub>F<sub>2</sub>, towards the reactor; it comprises shutting down the conversion installation if the relative pressure in the reactor exceeds a predetermined safety threshold; the safety threshold lies between 100 and 500 mbar, preferably between 200 and 450 mbar; the punctual unclogging threshold is for example set in a range of 100 mbar below the safety threshold, and is for example 50 mbar and preferably 30 mbar below the safety threshold; it comprises the setting in vibration and/or the percussion of a wall of the reactor, preferably regularly or continuously during the conversion; the vibration is performed by means of a flow device comprising at least one flow member configured to vibrate and/or impact a wall of the reactor, directly or via an intermediate part, for example a removable intermediate part; it comprises the step of striking a percussion surface of the furnace during the conversion of UO<sub>2</sub>F<sub>2</sub> to UO<sub>2</sub> in order to loosen the UO<sub>2</sub>F<sub>2</sub> or UO<sub>2</sub> powder sticking to an internal

surface of the furnace; the furnace comprises a rotating drum receiving the UO.sub.2F.sub.2 and into which are injected dry water vapor and H.sub.2, the percussion surface being an external surface of the drum; the percussion step is carried out using at least one percussion device comprising a striker that is movable relative to the percussion surface and an intermediate part arranged between the striker and the percussion surface so that the striker strikes the percussion surface through the intermediate part, the intermediate part being movable between a position spaced apart from the percussion surface and a percussion position in contact with the percussion surface.

(20) The present disclosure also provides a conversion installation designed for the implementation of a conversion method as defined above.

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## Description

### BRIEF SUMMARY OF THE DRAWINGS

(1) The present disclosure and its advantages will be better understood upon reading the following description, given solely by way of example, and made with reference to the accompanying drawings, in which:

(2) FIG. 1 is a schematic view of a conversion installation for the conversion of UF.sub.6 to UO.sub.2;

(3) FIG. 2 is a schematic view of a percussion device for impacting the pyrohydrolysis furnace; and

(4) FIG. 3 is a schematic view of a device for emitting UF.sub.6 gas for the continuous supply of the hydrolysis reactor.

### DETAILED DESCRIPTION

(5) The conversion installation 2 illustrated in FIG. 1 comprises a hydrolysis reactor 4 for the conversion of UF.sub.6 into UO.sub.2F.sub.2 powder, by reaction between gaseous UF.sub.6 and dry water vapor injected into the reactor 4.

(6) The conversion installation 2 comprises a pyrohydrolysis furnace 6 for converting the UO.sub.2F.sub.2 powder supplied by the reactor 4 into UO.sub.2 powder, by reacting the UO.sub.2F.sub.2 powder with dry water vapor and H.sub.2 gas injected into the furnace 6.

(7) The conversion installation 2 comprises a supply device 8 designed to inject the reactive gases (UF.sub.6 gas, dry water vapor and H.sub.2 gas) into the reactor 4 and into the furnace 6.

(8) The supply device 8 is supplied from sources of reactive gases, comprising at least one source of gaseous UF.sub.6, at least one source of dry water vapor and at least one source of gaseous H.sub.2.

(9) The supply device 8 comprises reagent injection ducts 10 for injecting the reactive gases into the reactor 4 and into the furnace 6. The reagent injection ducts 10 comprise an injection duct for UF.sub.6 supplying the reactor 4, a first dry water vapor injection duct supplying the reactor 4, a second dry water vapor injection duct supplying the furnace 6 and an H.sub.2 injection duct supplying the furnace 6.

(10) The supply device 8 is further designed for the injection of a neutral gas into the reactor 4, in particular in the production phase of the conversion installation 2, so that the conversion of UF.sub.6 into UO.sub.2F.sub.2 takes place under a neutral gas atmosphere. In this case, preferably, the supply device 8 is designed to allow the injection of neutral gas into the reactor 4 without injecting the neutral gas into the furnace 6.

(11) The neutral gas injected into reactor 4 in the production phase for carrying out the conversion of UF.sub.6 into UO.sub.2F.sub.2 is hereinafter referred to as "neutral scavenging gas".

(12) The supply device 8 is preferably designed for the injection of the neutral scavenging gas together with the dry water vapor (H.sub.2O) and the UF.sub.6.

(13) To do this, as in the example illustrated, the supply device 8 comprises for example a

concentric injector **11** making it possible to inject the dry water vapor (H.sub.2O), the UF.sub.6 and the neutral scavenging gas in a concentric manner, i.e. by forming three concentric injection jets.

(14) Preferably, the supply device **8** is further designed for the injection of neutral gas into the reactor **4** and into the furnace **6**, so as to be able to maintain a neutral gas atmosphere in the reactor **4** and in the furnace **6** when the conversion installation **2** is not in production.

(15) Thus, in the production phase, the supply device **8** injects neutral scavenging gas into the reactor **4** in order to convert UF.sub.6 into UO.sub.2F.sub.2 under a neutral gas atmosphere, without injecting neutral gas into the furnace **6**, and, in the shut-down and start-up phase, the supply device **8** injects neutral gas into the reactor **4** and into the furnace **6** so as to maintain a neutral gas atmosphere.

(16) The supply device **8** comprises one or more neutral gas injection ducts **12** for the injection of neutral gas into the reactor **4** and/or into the furnace **6**. Each neutral gas injection duct **12** is supplied from a source of neutral gas. The neutral gas is preferably nitrogen (N.sub.2).

(17) In the example illustrated, the concentric injector **11** is supplied by the reagent injection pipe **10** supplying the reactor **4** with water vapor (H.sub.2O), by the reagent injection duct **10** supplying the reactor **4** with UF.sub.6, and by a neutral gas injection duct **12**, for the injection of the neutral scavenging gas into the reactor **4**. As an option, the supply device **8** may be designed for supplying the reactant injection duct **10** supplying the reactor **4** with water vapor (H.sub.2O) and/or the reagent injection duct **10** supplying the reactor **4** with UF.sub.6 with neutral gas upon shut-down or start-up of the conversion installation **2**.

(18) The supply device **8** comprises a respective supply actuator **14** disposed at the inlet of each reactant **10** or neutral gas **12** injection duct, the supply actuator **14** making it possible to control the flow of gas in the injection duct.

(19) Preferably, the supply actuators **14** are provided in the form of flow regulators, suitable for maintaining the flow of gas passing through them at a set value.

(20) Preferably and in order to avoid any risk of UF.sub.6 leakage, the supply actuators **14** of the supply device **8** are resistant to seismic stresses.

(21) The conversion installation **2** comprises an electronic control system **16** for controlling the conversion installation **2** and in particular the supply device **8**, in particular the supply actuators **14**.

(22) As illustrated in FIG. **1**, the reactor **4** delimits a reaction chamber **18** into which the reagent injection ducts **10** open, supplying the reactor **4** with gaseous UF.sub.6 and with dry water vapor, and in which the conversion of UF.sub.6 to UO.sub.2F.sub.2 by hydrolysis takes place. The UO.sub.2F.sub.2 thus obtained is in the form of a powder falling to the bottom of the reaction chamber **18**.

(23) Reactor **4** has an outlet tubing **20** extending from reaction chamber **18** and connected to furnace **6** so as to transfer UO.sub.2F.sub.2 powder from the bottom of reaction chamber **18** to furnace **6**.

(24) The conversion installation **2** comprises a thermal chamber **22** surrounding the reactor **4** and a heater **24** for heating the internal volume of the thermal chamber **22** and therefore the reactor **4**.

(25) The furnace **6** has an inlet **26** connected to the outlet duct **20** of the reactor **4** to receive the UO.sub.2F.sub.2 powder and an outlet **28** to supply the UO.sub.2 powder.

(26) The conversion installation **2** comprises a transfer device **30** for transferring the UO.sub.2F.sub.2 powder from the reaction chamber **18** to the furnace **6**. The transfer device **30** here comprises a motorized endless screw driven by a motor to push the UO.sub.2F.sub.2 powder from reaction chamber **18** to inlet **26** of furnace **6**.

(27) The furnace **6** comprises a drum **32** having a central axis C, an axial end of which forms the inlet **26** while the opposite axial end forms the outlet **28** of the furnace **6**.

(28) The drum **32** is provided for the circulation of the UO.sub.2F.sub.2 powder from the inlet **26** to the outlet **28** with circulation of dry water vapor and H.sub.2 in the furnace **6** against the current of the UO.sub.2F.sub.2 powder.

(29) The drum 32 is rotatably mounted about its central axis C inclined relative to the horizontal so that the inlet 26 is higher than the outlet 28, the rotation of the drum 32 causes the powder to advance from the inlet 26 towards the outlet 28.

(30) The furnace 6 comprises a motorized rotational drive device 33 designed for driving the drum 32 in rotation about its central axis C. The rotational drive device 33 comprises for example a motor and a transmission device, for example a chain or belt, coupling the motor to the drum 32.

(31) As an option, the furnace 6 may be advantageously provided with a crank handle which allows the drum 32 to be turned manually in the event of failure of the rotational drive device 33.

(32) The drum 32 is preferably provided with baffles 35 disposed inside the drum 32 to control the flow of reactive gases and the passage time of the powder in the furnace 6.

(33) Optionally, the drum 32 is provided with lifting members 37 protruding from the inner surface of the drum 32 and designed to lift and let fall the powder present in the drum 32 due to the rotation of the drum 32 about the central axis C, so as to improve the mixing of the powder and promote homogeneous contact of the powder particles with the reactive gases circulating in the drum 32. The lifting members 37 are for example in the form of lifting vanes or lifting angles distributed over the internal surface of the drum 32.

(34) In an advantageous embodiment, the drum 32 of the furnace 6 and the transfer device 30 of the reaction chamber 18 are designed to operate independently of each other, in particular to allow the shut-down of either of them while maintaining the functioning of the other.

(35) In the example illustrated, the drum 32 of the furnace 6 and the transfer device 30 of the reaction chamber 18 are designed for independent rotation of the screw of the transfer device 30, on the one hand, and of the drum 32 on the other hand, and in particular for stopping the rotation of either the screw or the drum 32 while maintaining the rotation of the other.

(36) This arrangement makes it possible, in the phases of shutting down the conversion installation 2, to finish removing the UO.sub.2 powder from the furnace 6 while the reactor 4, and in particular the transfer device 30, are already stopped.

(37) In the example illustrated, the second water vapor injection duct and the H.sub.2 injection duct supply the drum 32 through the outlet 28 for the circulation of the dry water vapor from the pyrohydrolysis and the H.sub.2 from the outlet 28 to inlet 26 of furnace 6.

(38) In the example illustrated, a neutral gas injection duct 12 is connected to the reagent injection duct 10 for the injection of H.sub.2 into the furnace 6 and/or to the reagent injection duct 10 for the injection of H.sub.2O into furnace 6, so as to inject neutral gas into furnace 6 via the reagent injection duct(s) 10 when shutting down or starting up the conversion installation 2, the injected neutral gas then circulating from the outlet 28 of the furnace 6 to the inlet 26 of the furnace 6. As an option or as a variant, the supply device 8 comprises a neutral gas injection duct 12 for the injection of neutral gas into the furnace 6 which opens directly into the furnace 6 without passing through a reagent injection duct 10.

(39) The supply of a reactant injection duct 10 with neutral gas when shutting down the conversion installation 2 makes it possible to purge this reagent injection duct 10 when shutting down, while injecting the neutral gas. The supply of a reagent injection duct 10 with neutral gas during a start-up allows the temperature rise of the conversion installation 2 and the supply of the conversion installation 2 with reagents when the reaction parameters are achieved in reactor 4, respectively furnace 6.

(40) The furnace 6 comprises a heater 34 for heating the drum 32. The heater 34 comprises heating elements 36 surrounding the drum 32 and distributed along the drum 32. The furnace 6 comprises a thermal chamber 38 surrounding the drum 32 and the heating elements 36.

(41) The conversion installation 2 comprises a collection device 40 for collecting the powder at the outlet of the furnace 6. The collection device 40 comprises an inlet duct 42 connected to the outlet 28 of the furnace 6 and opening into a collection container 44. The collection device 40 comprises a thermal chamber 46 surrounding the collection container 44. The second vapor injection duct and

the H.sub.2 injection duct preferably open into the collection container **44**.

(42) The conversion installation **2** comprises a capture device **50** for capturing and removing the gases going back to the reactor **4**, comprising the excess reactive gases, hydrogen fluoride (HF) resulting from the conversion and the neutral gas.

(43) The capture device **50** is disposed in the reactor **4**, preferably in an upper region of the reaction chamber **18**.

(44) The capture device **50** comprises a plurality of filters **52** for retaining the solids that may be entrained by the gases going back into the reactor **4**, in particular particles of UO.sub.2F.sub.2, or even UO.sub.2.

(45) Filters **52** are for example made of a porous material allowing the passage of excess reactive gases, neutral gas and HF resulting from the reaction of conversion of UF.sub.6 to UO.sub.2F.sub.2 then to UO.sub.2 while retaining a capacity for retention of UO.sub.2F.sub.2 or UO.sub.2 particles. In a preferred embodiment, the filters **52** are made of ceramic or a nickel-based superalloy.

(46) UO.sub.2F.sub.2 and UO.sub.2 powders are volatile and easily carried away by gas streams. In addition, they tend to adhere to the surfaces with which they are in contact.

(47) In operation, powder agglomerates are created, more or less heterogeneous in terms of composition and more or less compact, on the filters **52** and on the walls of the reactor **4** and of the furnace **6**. These powder agglomerates containing fissile material may in particular be concentrated in retention zones which may exist at various points of the conversion installation **2** such as for example at the junction between the reactor **4** and the furnace **6**.

(48) Powder agglomerates may break off under their own weight and mix with UO.sub.2F.sub.2 powder and UO.sub.2 powder in the powdery state. The presence of compact clusters in the powder creates heterogeneity in the treatment of the powder in furnace **6** and may lead to the presence of residual UO.sub.2F.sub.2 particles in the UO.sub.2 powder obtained at the end of the conversion, thus degrading its quality.

(49) In addition, the accumulation of powder on the filters **52** causes a progressive clogging of the filters **52** and causes an increase in the internal pressure of the reactor **4**. The pressure variations have a significant impact on maintaining a constant quality of the O.sub.2 powder obtained at the end of the conversion and an excessively high internal pressure of the reactor **4** may lead to a safety alert of the conversion installation **2**.

(50) When the filters **52** are clogged with the UO.sub.2F.sub.2 and/or UO.sub.2 powders, it is necessary to stop the conversion installation **2** and to clean or change the filters **52**, which is tedious and expensive.

(51) Clogging may also occur at the level of the device for injecting the reactants into the reactor **4**, here the concentric injector **11**. In fact, if the injection pressure and temperature the gas are not sufficient, the UF.sub.6 may crystallize at the outlet of the concentric injector **11** and thus block the supply of reactants to the reactor **4**. It is therefore important to maintain a constant supply pressure, in particular when the source of UF.sub.6 changes.

(52) The conversion installation **2** advantageously comprises an unclogging device **53** designed for unclogging the filters **52**, for example by pulse injection of neutral gas through the filters **52** against the current, i.e. towards the interior of the reaction chamber **18** of reactor **4**. The neutral gas is, for example, nitrogen (N.sub.2).

(53) The injection of neutral gas against the current is liable to disturb the pressure balance inside the reactor **4**. It is desirable to carry out the unclogging in a controlled manner, according to determined parameters so as to limit disturbances in the operation of the reactor **4**, and in particular the pressure inside the reactor **4**.

(54) Advantageously, the unclogging device **53** is designed to perform the unclogging of the filters **52** in an automated manner, by carrying out the unclogging sequentially through separate groups of filters **52**.

(55) The unclogging device **53** is then designed to inject the neutral gas against the current



sequentially into the different groups of filters 52. Each group of filters 52 comprises a single filter 52 or several filters 52.

(56) In a preferred embodiment, the filters 52 are grouped into two groups each containing a respective half of the filters 52 and the unclogging is carried out alternately in the two groups with an injection of neutral gas carried out periodically, for example every 30 seconds. It is also possible to carry out the unclogging cycle, for example by thirds or by fourths, and/or to adapt the injection frequency.

(57) The neutral gas injection pressure against the current in each filter 52 is chosen to limit the disturbances in the reactor 4. A relative pressure applied to each filter 52, preferably between 2 and 5 bars, in particular between 3 and 4.5 bars, makes it possible to obtain satisfactory unclogging of the filter 52. Unless otherwise stated in the text, the expression "relative pressure" refers to the pressure difference with respect to atmospheric pressure.

(58) In order to guarantee a constant injection pressure of the neutral gas, the unclogging device 53 is for example supplied from a reservoir 55 containing the neutral gas and maintained at a constant pressure.

(59) The duration of injection of neutral gas against the current in each filter 52 is chosen to limit the disturbances in the reactor 4 while allowing satisfactory cleaning, in particular over the entire surface of the filter 52 during the injection period. The duration of injection of neutral gas against the current in each filter 52 is for example less than 1 s.

(60) Preferably, during the injection of neutral gas against the current into each filter 52, the capture device 50 is designed to cut off the suction through this filter 52 before the injection of neutral gas against the current to prevent the neutral gas used for unclogging escaping directly via the capture device 50.

(61) Preferably, the unclogging device 53 is designed to perform the unclogging cyclically, in particular with a period chosen to avoid the accumulation of powders on the filters 52 while limiting the impact of this injection on the operation of the conversion installation 2. Preferably, the period is between 30 seconds and 1 minute.

(62) Thus, according to a preferred embodiment, the unclogging device is designed to repeat the unclogging sequence automatically and cyclically (or periodically). Automatic, sequential and periodic unclogging of the filters 52 makes it possible to ensure operation of the conversion installation 2, for example at a relative pressure of between 10 mbar and 500 mbar in the reactor 4, preferably between 50 and 400 mbar and more preferably between 100 and 350 mbar, which makes it possible to obtain a UO.sub.2 powder having satisfactory characteristics, in particular a reasonable fluorine content which is substantially constant over time.

(63) The unclogging of the filters 52 causes the falling of the powder clusters formed on the filters 52 and prevents an excessive rise in pressure in the reaction chamber 18.

(64) The sequential and periodic unclogging makes it possible to limit the size and the compactness of the agglomerates of solids formed on the filters 52 and to avoid their detachment under their own weight and their fall by gravity in too great a quantity at the bottom of the reaction chamber 18 in the transfer device 30. The mixture of compact agglomerates with the powder of UO.sub.2F.sub.2 in the pulverulent state may in fact induce heterogeneities in the physical and chemical characteristics of the UO.sub.2 powder which is obtained therefrom and in particular on its fluorine content.

(65) The unclogging carried out in groups of several filters 52 prevents the powder expelled from a filter 52 from sticking to another filter 52 as could be the case with an individual unclogging of the filters 52. The unclogging carried out by groups of several filters 52 makes it possible to generate a powder mist and to limit the formation of clumps.

(66) As an optional addition to the sequential and periodic unclogging, the unclogging device 53 may include a control, manual or automatic, to allow punctual unclogging of the filters 52, in particular when they reach the end of their life and the sequential and periodic unclogging becomes

insufficient. This punctual unclogging may be unclogging by one of the filters **52** or by unclogging of a group of filters **52** of reduced size.

(67) As illustrated in FIG. **1**, preferably, the conversion installation **2** further comprises at least one flow device **56** designed to prevent the accumulation of powder on the walls of the reaction chamber **18** and sticking on the walls of the reaction chamber **18** of the powder clusters evacuated from the filters **52** during the unclogging operation.

(68) The flow device **56** makes it possible to promote a continuous flow of the powder and stable conditions for supplying the furnace **6** with UO.sub.2F.sub.2 powder both in terms of quantity and in terms of quality, and in particular with a stable fluorine content over time.

(69) The flow device is designed to vibrate and/or impact at least one wall of the reactor **4**, preferably regularly or continuously.

(70) The flow device **56** comprises for example one or more percussion members, each percussion member being designed to impact a wall of the reactor **4** so as to generate a shock wave in the walls of the reactor **4**, and/or one or more vibrating members, for example vibrating pots, each vibrating member being arranged on a wall of the reactor **4** and designed to generate a vibratory signal (or vibration) and transmit this vibration to the walls of the reactor **4**. In a preferred embodiment, the flow device **56** comprises one or more members which generate shocks to lift the powder from the wall as well as vibrations to help it flow.

(71) In the following, the percussion organs, the vibrating organs and the organs delivering the two functions are called "flow members".

(72) Thus, in general, the flow device comprises at least one flow member designed to vibrate and/or strike a wall of the reactor **4**.

(73) The flow members allow regular or even continuous vibration of the walls of the reactor **4**.

(74) The flow device **56** here comprises four flow members **58**, for example of the electro-striker type, arranged two by two in two diametrically opposed positions of the outer surface of the wall of the reactor **4**.

(75) Advantageously, when the flow device **56** comprises several flow members **58** and when the reactor **4** is in operation, the flow members **58** are controlled to act sequentially.

(76) The number, position and operating sequence of the flow members **58** may be designed as a function of the geometry of the reactor **4**, the quality of the powder and the operating parameters of the unclogging device **53**.

(77) Each flow member **58** may be fixed directly to the wall of the reactor **4** or, for example, via an intermediate part. In this case, the intermediate part may be for example removable to facilitate its maintenance.

(78) The combination of the unclogging device **53** and a flow device **56** makes it possible to limit the size and the compactness of the powder clusters which are deposited on the filters **52** and on the walls of the reactor **4**, to control the falling of the clusters to the bottom of reactor **4** and thus ensure the homogeneity of the UO.sub.2 powder, in particular a fluorine content which is substantially constant over time.

(79) The conversion installation **2** comprises sealing devices **54** to ensure sealing between the transfer device **30** and the reaction chamber **18**, between the reactor **4** and the furnace **6** and between the furnace **6** and the collection device **40**. The sealing devices **54** are arranged at the junction between the transfer device **30** and the reaction chamber **18**, at the junction between the outlet duct **20** of the reactor **4** and the inlet **26** of the furnace **6**, and at the junction between the outlet **28** of the furnace **6** and the inlet duct **42** of the collection device **40**. The sealing devices **54** ensure the sealing by allowing the rotation of the transfer device **30** relative to the reactor **4** and the rotation of the drum **32** of the furnace **6** relative to the reactor **4** and to the collection device **40**.

(80) The sealing devices **54** are pressurized with an inert gas, and preferably with nitrogen.

(81) To this end, as illustrated in FIG. **1**, the conversion installation **2** comprises, for example, pressurization supplies **57** arranged to supply the sealing devices **54** with an inert pressurization

gas.

(82) The pressure of the neutral gas supplying the sealing devices **54** is greater than that present in the conversion installation **2** to prevent any dispersion of powder outside the conversion installation **2**. In practice, the neutral gas for pressurizing the sealing devices **54** may pass into the reactor **4** and/or into the furnace **6**, and the operating parameters of the reactor **4** and of the furnace **6** are designed to take into account this supply of neutral gas.

(83) The conversion installation **2** comprises at least one percussion device **60** for striking a percussion surface **62** of the furnace **6** so as to detach the UO.sub.2F.sub.2 or UO.sub.2 powder from the internal surface of the drum **32**.

(84) The conversion installation **2** here comprises a percussion device **60** disposed at each axial end of the drum **32** to strike a percussion surface **62** formed by the outer surface of the axial end of the drum **32** axially exiting the thermal chamber **38** of the furnace **6**. As a variant, the percussion surface **62** may be defined by any other surface of the furnace **6** making it possible to transmit vibrations to the peripheral wall of the drum **32** when this percussion surface **62** of the furnace **6** is struck.

(85) The conversion installation **2** may advantageously comprise several percussion devices **60** disposed at the same end of the drum **32**, being distributed angularly around the drum **32**.

(86) In a preferred embodiment, the conversion installation **2** comprises two groups of percussion devices **60**, each group being disposed at a respective end of the two ends of the drum **32**, and the percussion devices **60** of each group being distributed angularly around the drum **32**.

(87) The percussion devices **60** are similar. Only one percussion device **60** is illustrated in more detail in FIG. 2.

(88) As illustrated in FIG. 2, each percussion device **60** comprises a striker **64** movable relative to the percussion surface **62** in a percussion direction P and an intermediate part **66** disposed between the striker **64** and the percussion surface **62** so that the striker **64** strikes the percussion surface **62** via the intermediate part **66**, the intermediate part **66** being movable in the direction of percussion P between a position spaced apart from the percussion surface **62** and a position of contact with the percussion surface **62** of the furnace **6**.

(89) The percussion direction P is here perpendicular to the plane tangent to the percussion surface **62** at the point of contact of the intermediate part **66** with the percussion surface **62**. The percussion direction P is here substantially radial with respect to the central axis C of the drum **32**.

(90) The striker **64** is carried by a percussion actuator **68** suitable for moving the striker **64** in reciprocating translation in the direction of percussion P. The percussion actuator **68** is here a double-acting hydraulic or pneumatic cylinder.

(91) The percussion device **60** has a support **70** carrying the actuator **68** and the intermediate part **66**, so that the intermediate part **66** is located between the striker **64** and the percussion surface **62**. The intermediate part **66** is slidably mounted on the support **70** following the percussion direction P.

(92) The intermediate part **66** has a rear surface **66A** designed to be struck by the striker **64**, and a front surface **66B** designed to come into contact with the impact surface **62**. In the contact position, the front surface **66B** is in contact with the percussion surface **62**, while in the spaced apart position, the front surface **66B** is spaced apart from the percussion surface **62**.

(93) The percussion device **60** comprises an elastic return member **72** arranged to return the intermediate part **66** to the spaced apart position. The intermediate part **66** is received in a housing **74** of the support **70**, the elastic member **72** being interposed between an internal shoulder **74A** of the housing **74** and an external shoulder **66C** of the intermediate part **66**.

(94) The elastic member **72** is here a helical spring surrounding the intermediate part **66** and compressed when the intermediate part **66** moves from the spaced apart position to the contact position.

(95) The percussion device **60** comprises a position sensor **76** making it possible to know the

position of the striker **64**. The position sensor **76** is for example an inductive sensor disposed near the intermediate part **66**, and making it possible to determine whether the striker **64** is in the contact position or not with the intermediate part **66**. The percussion actuator **68** is controlled as a function of the position signal supplied by the position sensor **76**.

(96) In operation, the percussion actuator **68** moves the striker **64** in reciprocating translation so as to move the striker **64** away from the intermediate part **66** and then move the striker **64** against the intermediate part **66**, so as to strike the percussion surface **62** by the intermediate part **66**. The striker **64** moves intermediate part **66** from the spaced apart position to the contact position against the elastic member **72**.

(97) The repeated impacts of the striker **64** could damage the striker **64** itself and the outer surface of the drum **32**. The provision of an intermediate part **66** separate from the striker **64** and which is not permanently linked to the furnace **6**, allows the intermediate part **66** to be used as a disposable part or a wearing part. In the example illustrated, the intermediate part **66** is mounted to move relative to the furnace **6**.

(98) Obtaining a UO.sub.2 powder exhibiting satisfactory characteristics, in particular an impurity content, essentially fluorine, of less than 50 ppm, a homogeneous particle size distribution situated for example in the range from 20 to 100  $\mu\text{m}$ , and a specific surface area less than 4 m.sup.2/g, depends on the operating conditions of hydrolysis and pyrohydrolysis, in particular of the supply rates of the reactants and of the temperature.

(99) The supply device **8** is designed to supply the reactants and the neutral gas, in particular the neutral scavenging gas, at determined flow rates.

(100) The heater **24** of the reactor **4** is designed to maintain the reactor chamber **4** in an adequate temperature range to obtain UO.sub.2F.sub.2 and then UO.sub.2 powders with the desired characteristics.

(101) Advantageously, during a stabilized production phase, the hourly mass flow rate of the supply to reactor **4** with gaseous UF.sub.6 is between 75 and 130 kg/h, the hourly mass flow rate of supply to the reactor **4** with dry water vapor lies between 15 and 30 kg/h, and the temperature in the reactor **4** lies between 150 and 250° C.

(102) These ranges of values make it possible to obtain UO.sub.2F.sub.2 powder, ultimately making it possible to obtain UO.sub.2 powder with the desired characteristics. In particular, these ranges of values make it possible to obtain UO.sub.2 powder having a specific particle surface area of between 1 m.sup.2/g and 4 m.sup.2/g, and preferably between 1.9 m.sup.2/g and 2.9 m.sup.2/g. In addition, these ranges of values make it possible to obtain UO.sub.2 powder with a residual fluorine (F) content of less than 50 ppm, preferably less than 35 ppm and more preferably less than 20 ppm.

(103) In an advantageous embodiment, the hourly mass flow rate of supply to reactor **4** with gaseous UF.sub.6 is between 90 and 120 kg/h and the hourly mass flow rate of supply to reactor **4** with dry hydrolysis water vapor is between 20 and 25 kg/h.

(104) To prevent crystallization of UF.sub.6 during its injection into reactor **4**, reactor **4** is supplied with UF.sub.6 at a supply temperature of between 75° C. and 130° C., preferably between 90° C. and 120° C.

(105) In a particular embodiment, the conversion installation **2** comprises an emission device making it possible to emit the UF.sub.6 continuously to the reactor **4** with a regulated flow rate and a temperature of UF.sub.6.

(106) The UF.sub.6 is transported in tanks which are for example cylindrical. At room temperature, UF.sub.6 is in the solid state. The change from the solid state to the gaseous state is carried out by heating the tanks, for example in a heating chamber, in particular in a furnace (not waterproof) or in an autoclave (waterproof).

(107) As illustrated in FIG. **3**, the conversion installation **2** has an emission device **82** for supplying the reactor **4** with UF.sub.6 gas from tanks **84** containing UF.sub.6. Each reservoir **84** is closed by a

sealing valve **85**.

(108) The emission device **82** comprises at least two heating chambers **86**, each heating chamber **86** being designed to receive a reservoir **84** of UF.sub.6 in the solid state and to heat it to generate UF.sub.6 in the gaseous state, the emission device **82** being designed to supply the reactor **4** sequentially from the heating chambers **86**, passing from a current heating chamber **86** to a following heating chamber **86** when the reservoir **84** is received in said current heating chamber **86** is no longer sufficiently full, preferably without interrupting the flow of UF.sub.6 gas supplying the reactor **4**. Preferably, each heating chamber **86** is able to heat and maintain the respective reservoir **84** at a temperature above the triple point temperature of UF.sub.6, for example at a temperature above 75° C. and preferably at a nominal temperature of 95° C., for example 95° C.±10° C.

(109) The emission device **82** thus comprises a supply circuit **87** designed for the emission of UF.sub.6 to the reactor **4** selectively from one of the heating chambers **86**, while the other heating chamber **86** heats a reservoir **84** in waiting for the emission of UF.sub.6 from this reservoir **84** or is recharged with a reservoir **84** filled with UF.sub.6.

(110) Each heating chamber **86** is for example connected to the reactor **4** by means of a valve **88** for regulating the respective flow rate, the closure of which makes it possible to isolate the heating chamber **86** from the reactor **4** while its opening makes it possible to fluidly connect the heating chamber **86** to the reactor **4**. The opening of the valve **85** of the reservoir **84** then of the valve **88** allows the flow of UF.sub.6 from the heating chamber **86** to the reactor **4** due to a pressure difference between the reservoir **84** and reactor **4**. Heating chamber **86** is then in a passive emission mode.

(111) As an option, each reservoir **84** is connected to the reactor **4** by means of a respective pump **90** associated with each heating chamber **86** and disposed in parallel with the valve **88** associated with this heating chamber **86**. The pump **90** is preferably a positive displacement pump and more preferably a positive displacement pump with bellows.

(112) Activation of the pump **90** makes it possible to force the circulation of the gaseous UF.sub.6 from the heating chamber **86** to the reactor **4** when the pressure in the reservoir **84** contained in the heating chamber **86** is insufficient to ensure this circulation. The heating chamber **86** is then in an active emission mode. When valve **88** is open, pump **90** is bypassed.

(113) The emission device **82** comprises for example a device for opening the valve of the respective reservoir **84** from the outside of each heating chamber **86** and an electronic control unit **92** designed to control the valve **88** and, if necessary, the pump **90** associated with each heating chamber **86** and ensure the power supply sequentially from the heating chambers **86**, and, where appropriate, the passage from passive mode to active mode for each heating chamber **86**.

(114) The emission device **82** is for example designed to control the passage from one heating chamber **86** to the next, and where appropriate the passage from passive mode to active mode in a manner dependent on the pressure in each reservoir **84**.

(115) To do this, the emission device **82** comprises for example a pressure sensor **94** associated with each reservoir **84**, the electronic control unit **92** being designed to control the valve **88** and, if necessary, the pump **90** associated with each heating chamber **86** according to the measurements provided by the pressure sensors **94**.

(116) At the start of a production cycle, a reservoir **84** is heated in a first heating chamber **86**, preferably under a neutral gas atmosphere to improve the heat exchanges between the atmosphere of the heating chamber **86** and the reservoir **84**. The neutral gas is, for example, nitrogen. When the required temperature is reached, i.e. when the solid UF.sub.6 has been liquefied and the UF.sub.6 in the reservoir **84** is in a phase of liquid/gas equilibrium, and after opening the sealing valve **85** of the reservoir **84**, the valve **88** disposed between the outlet of this first heating chamber **86** and the injection duct **10** of the UF.sub.6 in the reactor **4** opens and the emission of UF.sub.6 begins in passive emission mode from this first heating chamber **86**. In parallel, the heating of another reservoir **84** in a second heating chamber **86** begins.

(117) As the emission of UF.sub.6 progresses, the pressure in the reservoir **84** of the first heating chamber **86** drops to a value close to that which may cause a drop in the flow rate of UF.sub.6 and the reversal of the flows between the reactor **4** and the reservoir **84** received in this first heating chamber **86**. There are then still several kilograms of UF.sub.6 in the reservoir **84**. Before reaching this stage, the first heating chamber **86** switches from passive emission mode to active emission mode with the closing of the valve **88** and the starting of the corresponding pump **90**. The emission of UF.sub.6 may thus continue until emission of almost all of the UF.sub.6 contained in the reservoir **84** of the first heating chamber **86**, for example with a pressure at the end of emission of 100 mbar absolute in the reservoir **84**. At this moment, the reservoir **84** received in the second heating chamber **86** has reached the temperature required for the emission of UF.sub.6 and the sealing valve **85** of the reservoir **84** is open. The valve **88** associated with the first heating chamber **86** closes and the valve **88** associated with the second heating chamber **86** opens and the emission of UF.sub.6 continues from the reservoir **84** of the second heating chamber **86** without interruption and without significant modification of the flow rate, of the temperature and of the pressure of the UF.sub.6 during the switching from the first heating chamber **86** to the second heating chamber **86**. In parallel, the valve **85** of the reservoir **84** received in the first heating chamber **86** is closed and, after cooling, the first heating chamber **86** is vented to atmosphere, unlocked and the reservoir **84** is evacuated and replaced by a new reservoir **84** filled with UF.sub.6.

(118) As a variant and to further reduce the variations in supplying the reactor **4** with UF.sub.6, the valve **88** associated with the second heating chamber **86** may open before the valve **88** associated with the first heating chamber **86** closes and the UF.sub.6 emission continues from the two reservoirs **84**, the first heating chamber **86** operating in active emission mode and the second heating chamber **86** operating in passive emission mode. The opening of the valve **88** associated with the second heating chamber **86** may take place, for example, when the valve **88** is closed and when the pump **90** of the first heating chamber **86** is started up or at any other time before stopping the emission of UF.sub.6 by the reservoir **84** of the first heating chamber **86**.

(119) Preferably and in order to be able to cut off the UF.sub.6 supply as close as possible to the emission source under all circumstances, the valves **88** are resistant to seismic stresses.

(120) The emission device **82** allows continuous production of the conversion installation **2**, using almost all of the UF.sub.6 contained in the reservoirs **84** with an emission of UF.sub.6 at the required pressure and temperature and with the required flow.

(121) Preferably, the reactor **4** is supplied with dry hydrolysis water vapor at a supply temperature of between 175° C. and 300° C., in particular between 200° C. and 270° C.

(122) Preferably, the furnace **6** is supplied with dry water vapor from pyrohydrolysis water with an hourly mass supply rate of between 25 and 40 kg/h, in particular between 30 and 35 kg/h.

(123) Also preferably, the furnace **6** is supplied with dry water vapor from pyrohydrolysis water at a supply temperature of between 250° C. and 450° C., preferably between 300° C. and 400° C.

(124) Preferably, the volume flow rate for supplying the furnace **6** with H.sub.2 is between 10 and 25 Nm.sup.3/h, in particular between 15 and 20 Nm.sup.3/h ("Nm.sup.3/h" means normal cubic meters per hour and is a unit of measurement of the quantity of gas which corresponds to the content of a volume of one cubic meter, for a gas found in normal conditions of temperature and pressure (20° C. and 1 atm)). The H.sub.2 is usually injected at room temperature.

(125) The injection parameters of the neutral scavenging gas supplied to reactor **4** influence the reactions occurring in reactor **4**.

(126) Preferably, the supply rate of the neutral scavenging gas of the reactor **4** is between 1.5 and 5 Nm.sup.3/h, the injection temperature of the neutral scavenging gas is between 80° C. and 130° C., and the relative supply pressure of this neutral scavenging gas is greater than the relative pressure inside the reactor **4** and is preferably less than 1 bar.

(127) In a particular embodiment, the supply rate of the neutral scavenging gas is between 2 and 3 Nm.sup.3/h and the injection temperature of the neutral scavenging gas is between 90 and 105° C.

(128) Furthermore, the heating elements **36** of the furnace **6** are controlled to establish in the furnace **6** a gradually increasing and then decreasing temperature from the inlet **26** of the furnace **6** to the outlet **28** of the furnace **6**.

(129) Furnace **6** comprises for example several successive sections defined along furnace **6**, in this case six successive sections **S1** to **S6** from inlet **26** to outlet **28** of furnace **6**, each section **S1** to **S6** being heated by heating elements **36** dedicated to this section **S1** to **S6**.

(130) The furnace **6** comprises a respective temperature sensor **80** associated with each section **S1** to **S6**. The temperature of each section of the furnace **6** is considered to be that measured by the temperature sensor **80** associated with this section. Each temperature sensor **80** is for example a thermocouple adjacent to the heating elements **36** associated with the section.

(131) The heating elements **36** dedicated to each section **S1** to **S6** are controlled independently of those dedicated to the other sections so that the temperature measured by the temperature sensor **80** located in this section is located at a determined set value.

(132) In an advantageous embodiment, each section **S1** to **S6** is provided with several temperature sensors **80** and the temperature of each section **S1** to **S6** of the furnace **6** is considered to be the average of the temperatures measured by the temperature sensors **80** in associated with this section **S1** to **S6**.

(133) In an advantageous embodiment, the heating elements **36** of the furnace **6** are controlled to establish a following temperature profile: first section **S1**: between 660 and 700° C. second section **S2**: between 700 and 730° C. third section **S3**: between 720 and 745° C. fourth section **S4**: between 730 and 745° C. fifth section **S5**: between 660 and 700° C. sixth section **S6**: between 635 and 660° C.

(134) This temperature profile makes it possible to control the evolution of the pyrohydrolysis of the UO.sub.2F.sub.2 powder, which is a complex reaction made up of several elementary reactions which depend in particular on the temperature.

(135) In the production phase, the unclogging device **53** performs periodic unclogging, automatically and regularly. In addition, preferably, the flow device **56** vibrates and/or strikes the reactor **4**, automatically, regularly or continuously, and/or the percussion device **60** strikes the furnace **6**, automatically and regularly, to drop the powder stuck to the internal walls before it forms large and/or compact clumps.

(136) The filters **52** may nevertheless become excessively clogged during the operation of the conversion installation **2** and as they age.

(137) The increase in the relative pressure inside the reactor **4** is generally representative of the fact that the unclogging of the filters **52** becomes insufficient.

(138) Monitoring the pressure inside reactor **4** makes it possible to monitor the efficiency of cleaning.

(139) Preferably, in the stabilized production phase, it is desirable that the relative pressure inside the reactor **4** remains between 10 mbar and 500 mbar, preferably between 50 and 400 mbar and more preferably between 100 and 350 mbar.

(140) Conversion installation **2** comprises a pressure sensor **P1** to measure the pressure inside reactor **4**.

(141) Preferably, if the relative pressure inside the reactor **4** exceeds a predetermined safety threshold, the control system **16** is designed to order a shutdown of the conversion installation **2**.

(142) The safety threshold is for example between 100 and 500 mbar, preferably between 200 and 450 mbar and even more preferably between 200 and 400 mbar, in particular around 350 mbar.

(143) Advantageously, if the relative pressure inside the reactor **4** exceeds a predetermined unclogging threshold, the unclogging device **53** is controlled to carry out unclogging of the filters **52**. This punctual unclogging may be carried out with an unclogging injection pressure in the upper part of the injection pressure range of neutral gas for sequential unclogging or even at an injection pressure greater than said range. The punctual unclogging may moreover be carried out specifically

on one or more filters 52, for example individually on one or more particular filters 52 which would be blocked individually or together on a limited number of filters 52.

(144) The punctual unclogging threshold is for example set in a range of 100 mbar below the safety pressure of the installation and is for example 50 mbar and preferably 30 mbar lower than the safety threshold of the installation.

(145) As a matter of fact, in the event of significant clogging of the filters 52, the pressure increases rapidly in the reactor 4 and it becomes difficult, if not impossible, to unclog the filters 52 without stopping the installation in order to carry out manual cleaning or their replacement or without creating heterogeneities of the UO.sub.2F.sub.2 powder at the outlet due to the addition to the UO.sub.2F.sub.2 powder of uncontrolled quantities of agglomerates falling from the filters 52 into the transfer device 30 during the unclogging operation.

(146) During unclogging, the injection of neutral gas inside each filter 52 makes it possible to expel the UO.sub.2F.sub.2 powder particles trapped on the outer surface of the filter 52, while limiting the disturbances of the reactor 4 operating at a pressure relative between 10 mbar and 500 mbar.

(147) The setting in vibration and/or the percussion of one or more walls of the reactor 4, here by the flow device 56 equipping the reactor 4, also makes it possible to detach the particles of UO.sub.2F.sub.2 powder which may be deposited on the inner wall of the reactor 4.

(148) The striking of a percussion surface 62 of the furnace 6, here by the percussion device 60, makes it possible to prevent the formation of powder clusters in the furnace 6, which could also affect the quality of the UO.sub.2 powder produced. by the conversion installation 2.

(149) Controlling the flow rates of reactive gases and neutral scavenging gas and the temperature in the reactor 4 and in the furnace 6 also allow the establishment of hydrolysis and pyrohydrolysis reactions under conditions for obtaining satisfactory UO.sub.2 powder.

(150) In general, in operation, all of the gases injected into reactor 4 or into furnace 6 are injected at a pressure greater than that existing in reactor 4 or furnace 6, for example at a pressure of at least 20 mbar at above the pressure inside the reactor 4 or the furnace 6, and preferably at least 50 mbar above.

(151) The provision of a percussion device on the furnace 6 is advantageous regardless of the control of the conversion method and of the conversion parameters.

(152) Thus, in general, the present disclosure relates to an installation for converting uranium hexafluoride (UF.sub.6) into uranium dioxide (UO.sub.2), the conversion installation comprising: a hydrolysis reactor for the conversion of UF.sub.6 into uranium oxyfluoride powder

(UO.sub.2F.sub.2) by reaction between gaseous UF.sub.6 and dry water vapor; a pyrohydrolysis furnace for the conversion of the UO.sub.2F.sub.2 powder supplied by the reactor into UO.sub.2 powder by reaction between UO.sub.2F.sub.2, dry water vapor and hydrogen (H.sub.2) gas, the furnace having a surface percussion; and at least one percussion device for striking the percussion surface, the percussion device comprising a striker movable relative to the percussion surface and an intermediate part arranged between the striker and the percussion surface so that the striker strikes the percussion surface through the intermediate part, the intermediate part being movable between a position spaced apart from the surface of the furnace and a percussion position of the furnace.

(153) The conversion installation may further comprise one or more of the following optional features, taken individually or in any technically feasible combination: the percussion device comprises an elastic return member to return the intermediate part to the spaced apart position; the percussion device comprises a pneumatic or hydraulic actuator for moving the striker; the furnace comprises a rotating drum receiving the UO.sub.2F.sub.2 and into which are injected dry water vapor and H.sub.2, the percussion impact surface of the furnace being an external surface of the drum; at least one flow device designed to vibrate and/or strike at least one wall of the reactor, and preferably comprising at least one flow member arranged on a wall of the reactor to set in vibration and/or impact the wall, directly or via an intermediate part, for example a removable intermediate



part; at least one capture device designed to capture gases present in the reactor, and comprising filters; at least one unclogging device designed for unclogging the filters, preferably by separate filter groups, each filter group comprising one or more filters, in particular sequentially by filter group and/or cyclically; an emission device for supplying the reactor with UF.sub.6, the emission device comprising at least one heating chamber, the or each chamber being designed to receive a reservoir of UF.sub.6 in the solid state and heat it to generate UF.sub.6 in the gaseous state, and a supply circuit designed to supply the reactor from the or each heating chamber; the supply circuit comprises a pump associated with the or each heating chamber to force the circulation of UF.sub.6 from the reservoir received in the heating chamber to the reactor, the or each pump preferably being a positive displacement pump and more preferably a positive displacement bellows pump. the supply circuit comprises a flow control valve associated with the or each heating chamber and placed bypassing the pump associated with the heating chamber.

## Claims

1. A method for converting uranium hexafluoride (UF.sub.6) to uranium dioxide (UO.sub.2) in a conversion installation, the method comprising: hydrolysis of UF.sub.6 to uranium oxyfluoride (UO.sub.2F.sub.2) in a hydrolysis reactor by reaction between gaseous UF.sub.6 and dry water vapor injected into the hydrolysis reactor; pyrohydrolysis of UO.sub.2F.sub.2 to UO.sub.2 in a pyrohydrolysis furnace by reaction of UO.sub.2F.sub.2 with dry water vapor and hydrogen gas (H.sub.2) injected into the pyrohydrolysis furnace; extracting excess gas in the hydrolysis reactor via a capture device comprising several filters; periodically unclogging of the filters by injecting a neutral gas into the filters from an outside to an inside of the hydrolysis reactor to remove powder stuck on the filters; measuring the relative pressure in the hydrolysis reactor; implementing a punctual unclogging of the filters when a relative pressure in the hydrolysis reactor exceeds a predetermined punctual unclogging threshold; and shutting down the conversion installation if the relative pressure in the hydrolysis reactor exceeds a predetermined safety threshold, wherein the punctual unclogging threshold is set in a range of 100 mbar below the safety threshold.
2. The method according to claim 1, further comprising injecting a neutral scavenging gas into the hydrolysis reactor so that the conversion of UF.sub.6 to UO.sub.2F.sub.2 takes place under a nitrogen atmosphere.
3. The method according to claim 1, wherein the dry water vapor and the H.sub.2 are injected into the pyrohydrolysis furnace so as to circulate in the pyrohydrolysis furnace against a current of the UO.sub.2F.sub.2, to the hydrolysis reactor.
4. The method according to claim 1, wherein the safety threshold is between 100 and 500 mbar.
5. The method according to claim 1, further comprising vibrating and/or striking a wall of the hydrolysis reactor.
6. The method according to claim 5, wherein the vibration is performed by a flow device comprising at least one flow member configured to vibrate and/or strike a wall of the hydrolysis reactor, directly or via an intermediate part.
7. The method according to claim 1, further comprising impacting a percussion surface of the pyrohydrolysis furnace during the conversion of UO.sub.2F.sub.2 to UO.sub.2 in order to take off powder of UO.sub.2F.sub.2 or UO.sub.2 sticking to an internal surface of the pyrohydrolysis furnace.
8. The method according to claim 7, wherein the pyrohydrolysis furnace comprises a rotary drum receiving the UO.sub.2F.sub.2 and into which are injected dry water vapor and H.sub.2, the percussion surface being an outer surface of the drum.
9. The method according to claim 7, wherein the impacting of the percussion surface is performed using at least one percussion device comprising a striker movable relative to the percussion surface and an intermediate part disposed between the striker and the percussion surface such that the

striker strikes the percussion surface via the intermediate part, the intermediate part being movable between a position spaced from the percussion surface and a percussion position in contact with the percussion surface.

10. A conversion installation for converting uranium hexafluoride (UF<sub>6</sub>) to uranium dioxide (UO<sub>2</sub>), the conversion installation comprising: a hydrolysis reactor for the conversion of UF<sub>6</sub> to uranium oxyfluoride (UO<sub>2</sub>F<sub>2</sub>) by reaction between gaseous UF<sub>6</sub> and dry water vapor injected into the reactor; a pyrohydrolysis furnace for the conversion of UO<sub>2</sub>F<sub>2</sub> to UO<sub>2</sub> by reaction of UO<sub>2</sub>F<sub>2</sub> with dry water vapor and hydrogen gas (H<sub>2</sub>) injected into the furnace; a capture device for capturing and extracting of excess gas in the reactor, the capture device comprising several filters; an unclogging device configured for unclogging of the filters by injecting a neutral gas into the filters from the outside to the inside of the reactor to remove a powder stuck on the filters; a pressure sensor configured for measuring a pressure inside the hydrolysis reactor; and a control system configured to shut down the conversion installation if the relative pressure in the hydrolysis reactor exceeds a predetermined safety threshold, the unclogging device configured to: periodically unclog the filters by injecting a neutral gas into the filters from an outside to an inside of the hydrolysis reactor to remove the powder stuck on the filters; and implement a punctual unclogging of the filters when a relative pressure in the hydrolysis reactor exceeds a predetermined punctual unclogging threshold, wherein the punctual unclogging threshold is set in a range of 100 mbar below the safety threshold.

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