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(54) PROCESS FOR PRODUCING RADIOACTIVE MOLYBDENUM

PROZESS ZUM HERSTELLEN VON RADIOAKTIVEM MOLYBDÄN

PROCÉDÉ DE PRODUCTION DE MOLYBDÈNE RADIOACTIF

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Description

[Technical Field]

[0001] The present invention relates to an efficient manufacturing method of radioactive molybdenum ^{99}Mo which is parent nuclide of radioactive technetium (^{99m}Tc) used as the radioactive diagnosis medicine.

[Background Art]

[0002] The life time (Half period) of radioactive technetium (^{99m}Tc) used in large quantities around the world to diagnose cancer or disease of internal organs, or to inspect the function of internal organs is 6.0 hours, and it is short. Therefore, radioactive technetium ^{99m}Tc obtained by manufacturing radioactive molybdenum ^{99}Mo which is the parent nuclide, and extracting from ^{99}Mo (Half period is 66 hours) manufactured is usually used for the medical diagnosis etc. For mention of irradiation of ^{98}Mo to produce ^{99}Mo, see US-A-4 990 787.

[0003] ^{99}Mo is obtained so far by irradiating neutrons to highly enriched uranium obtained by concentrating ^{235}U to about 95% in a nuclear reactor to cause the nuclear fission reaction, and extracting ^{99}Mo from the fission products. There is especially a problem in the viewpoint of the nuclear non-proliferation with regard to the method of using the enriched uranium. Therefore, International Atomic Energy Agency (IAEA) appeals every country in the world to use low enriched uranium (^{235}U) of 20% or less, and the technological development therefor is advanced in the world now. However, if the low enriched uranium in which the uranium enrichment is adjusted to 20% or less is used as a raw material for ^{99}Mo manufacturing, a large amount of radioactive waste generated along with the fission reaction is produced. In particular, the problem that the formation of plutonium increases approximately twenty-fivefold is newly presented. For that reason, the nuclear fission method which uses the uranium as a raw material to manufacture ^{99}Mo is reviewed.

[0004] The above-mentioned problem is raised in the method of using uranium as a raw materias for ^{99}Mo manufacturing. However, as a method of not using uranium as a raw material for ^{99}Mo manufacturing, ^{99}Mo manufacturing by a (n, r) method has been put to practical use, in which neutron beams are irradiated to a solid material which is Mo compound of concentrated ^{98}Mo or natural Mo compound in a nuclear reactor. Here, in a nuclear reactor, neutrons are irradiated to powdered or pelletized molybdenum oxide (MoO_3) of a solid state, which is Mo compound of a natural isotope to cause the nuclear reaction of $^{98}Mo(n, \gamma)^{99}Mo$ (Hereinafter, this nuclear reaction is called the (n, γ) reaction or (n, γ) method). In this method, only ^{99}Mo whose specific radioactivity is very low in comparison with the nuclear fission method in which uranium is used as a raw material is produced. This method is examined so far as a method of having an advantage not to generate the radioactive waste according to nuclear fission like a uranium method and to manufacture at a low cost, and it has been put to practical use as a gel method ^{99m}Tc generator now. However, the gel method ^{99m}Tc generator of a (n, γ) method has not come to spread widely because of problems on the reproducibility in the manufacturing and on the quality side especially.

[0005] Because the specific radioactivity of ^{99}Mo manufactured by the (n, γ) method is low, the technology which collects ^{99m}Tc by a conventional, small column type one is not able to be put to practical use. However, as is described in JP 8-309182 A1 and JP 10-30027 A1 as development of an efficient Mo adsorbent, it has recently come to be able to collect ^{99m}Tc from ^{99}Mo by the (n, r) method in which the specific activity is low. Therefore, the practical use of a method of manufacturing ^{99}Mo by the (n, γ) method in which Mo compound is used as a raw material is expected.

[Disclosure of Invention]

[0006] In a current (n, γ) method, ^{99}Mo is generally produced by using powdered or pelletized molybdenum oxide (MoO_3) of a solid state as a raw material, enclosing the raw material with a closed container, inserting it into a nuclear reactor by using material irradiation equipment of the nuclear reactor, picking up the material irradiation equipment after irradiating neutrons for a fixed period of time (In general, 5-7 days), opening the closed container picked up, and making its contents (^{99}Mo is generated in MoO_3, and they exist together) react, for instance, with caustic soda or aqueous ammonium, and dissolving them. However, there are problems that the adjustment and the QC (quality control) of molybdenum oxide as the raw materials are complex, and the manufacturing ability of ^{99}Mo is low because it is necessary continuously to irradiate the same irradiation body while irradiating for a fixed period of time and therefore the irradiation body containing the raw material cannot be replaced.

[0007] Because the conventional equipment which irradiates the solid MoO_3 raw material is very expensive, the manufacturing ability is low, and a new container is required every time the (metallic) irradiation container where a MoO_3 raw material is enclosed is irradiated, in addition, because the container itself is made radiation after using (irradiating) and becomes radioactive contamination waste, there is the problem that the radioactive contamination waste increases further according to the increase in an amount of manufacturing of ^{99}Mo. In the present invention, the above-mentioned problem is solved by manufacturing ^{99}Mo by changing the state of Mo compound to which neutrons are irradiated in a nuclear reactor from a solid state into a solution state.

[0008] According to the present invention, there is provided a method of manufacturing radioactive molybdenum as set out in claim 1.

[0009] More concretely, ^{99}Mo is obtained by collecting

the Mo solution in continuous or batch processing, for instance, by circulating or feeding Mo solution, and generating ^{99}Mo in the Mo solution by the radioactivation of ^{98}Mo.

[0010] The Mo compound containing ^{98}Mo of the natural isotopic ratio or Mo compound in which ^{98}Mo is concentrated more than the natural isotopic ratio is dissolved in water, and may be ammonium molybdate.

[0011] Preferably the method further comprises the steps of extracting continuously or periodically hydrogen and oxygen gases generated by the radiolysis of water when neutrons are irradiated to the Mo solution in the nuclear reactor, and purging the hydrogen and oxygen with inert gas to dispose of them.

[0012] Moreover, the method may comprise the steps of collecting after reuniting the hydrogen and oxygen with catalyst to return to water, and collecting to remove hydrogen and oxygen obtained by decomposing in radiation the water.

[0013] The method may employ a fluid pass-through type irradiation capsule installed in a reactor core, and a means for generating and collecting ^{99}Mo in continuous or batch processing by circulating the Mo solution in the capsule.

[0014] This method may be carried out in apparatus, which comprises: injection equipment which injects a fixed amount of Mo solution in continuous or batch processing; collecting equipment which collects ^{99}Mo generated in continuous or batch processing; equipment which extracts and removes hydrogen and oxygen of the gas generated by radiolysis reaction of the water generated in the irradiation capsule; a storage facility in which catalyst which has function to return the hydrogen and oxygen of the extracted gas to water by recombination reaction is filled, circulation equipment of the Mo solution to which a heat exchanger to do cooling in the irradiation capsule is attached; equipment which picks up and collects ^{99}Mo generated in continuous or batch processing, measuring equipment by which amounts of the generation and the collection of ^{99}Mo are measured, and a shielding facility to shield the radiation such as gamma rays generated from ^{99}Mo generated and collected and ^{99m}Tc of the coexisting daughter nuclide.

[0015] The present invention thus may use an irradiation capsule which is far low-cost compared with the conventional high-cost irradiation equipment. According to the present invention, it is possible to increase the manufacturing ability of ^{99}Mo and manufacture it in continuous or batch processing.

[0016] Because in the present invention, the desired ^{99}Mo can be manufactured only by installing a fluid pass-through type capsule which can inject and collect solution from the outside and by injecting the solution into it in continuous or batch processing, the radioactive contamination waste generated when manufacturing ^{99}Mo by using the conventional irradiation equipment is not generated. Moreover, because the Mo solution which contains ^{99}Mo generated can be shipped only by dispensing and collecting it in a special container like a vial container made of glass without processing after collecting it, the entire process from the stock of raw material to the collection of ^{99}Mo which is specified substance can be simplified compared with the prior art.

[0017] As mentioned above, because the facility cost is cheap, the radioactive contamination waste is not generated according to manufacturing, and the entire manufacturing process is easier, the present invention has feature that ^{99}Mo manufacturing cost is cheaper.

[0018] Although powdered or pelletized molybdenum oxide (MoO_3) is used in a conventional solid irradiation method, It is preferable that the solution dissolving operation after the irradiation is carried out in palletized forms, because a large amount of ^{99}Mo is generated after the neutron irradiation. The reason is that there is a fear that the powder disperses, and spills at the stage of the operation by which it is dissolved in case of the powder which contains a large amount of radioactive ^{99}Mo, and the work area might be polluted with radioactive substance (^{99}Mo).

[0019] The complex operations are accompanied when the raw material is palletized. And The difficulty is attended to the management and the maintenance of the quality, because impurities are apt to be mixed at the pelletizing operation. On the other hand, as for the Mo solution which is the raw material used in the present invention, it is possible to adjust just by dissolving Mo compound to high purity water by maintaining the high purity Mo compound (ammonium molybdate) used. Because impurities can be absorbed and removed just by causing to flow into an aluminum column, et al. even when they are in the Mo solution, it is easy for the Mo solution irradiation method to maintain high quality because the adjustment of the irradiation body raw material is easy, compared with the solid MoO_3 irradiation method.

[0020] With regard to a solid irradiation, if the MoO_3 irradiation body is in a powder form, it is necessary to seal up first the irradiation body in a quartz tube, and then enclose in a metallic irradiation container (In general, aluminum family metal). If the MoO_3 irradiation body is in a pelletized form, the sealing up and the enclosing is performed directly in the metallic irradiation container. These irradiation containers become radioactive contamination waste because they are radioactivated by neutron irradiation. On the other hand, a Mo solution irradiation method of the present invention includes only an operation that a constant amount of Mo solution is injected with the pump through piping to an irradiation capsule in continuous or batch processing. An irradiation container is unnecessary. Therefore, the radioactive contamination waste is not generated along with ^{99}Mo manufacturing.

[0021] The ^{99}Mo manufacturing ability by the solid irradiation method in material testing reactor JMTR of Japan Atomic Energy Agency is 220Ci(^{99}Mo)/week, for instance, even when existing facility is remodeled. In addition, it is total 570Ci (^{99}Mo)/week even when expanded.

Moreover, about 700 million yen to 1.5 billion yen is necessary according to the calculation as those remodeling cost and installation cost. According to the solution irradiation capsule of the present invention, the manufacturing ability of 569Ci(^{99}Mo)/week in one system, which is almost equal to the solid irradiation method, that is, substantially the same manufacturing ability as the above-mentioned expanded facility in the solid irradiation method can be obtained only by circulating 28% solution of ammonium molybdate to the capsule with the zone of 55 mm in inside diameter ϕ and 700 mm in height to which neutrons are irradiated (effective content volume 1.66L) at the rate of 277mL/day. Moreover, the provisional calculation of the installation cost is about 200 million yen a system. Accordingly, the present invention is superior to the conventional method also in ^{99}Mo manufacturing ability and the installation cost.

[0022] Next, ^{99}Mo manufacturing processes will be compared. In the conventional solid irradiation method, it is manufactured by inserting an irradiation container into a nuclear reactor with material irradiation equipment, picking up after irradiating neutrons for a fixed period of time (generally, for 5 to 7 days), opening the closed container picked up, and making its contents (^{99}Mo is generated in MoO_3, and they exist together) react, for instance, with alkaline solution such as caustic soda, aqueous ammonium and dissolving them. Therefore, the process to bring into the state which can be shipped as ^{99}Mo is complex because it is impossible to replace the irradiation body on its way, and it is necessary to open the MoO_3 irradiation body which contains ^{99}Mo in another facility and dissolve. On the other hand, the Mo solution which contains ^{99}Mo can be collected only by activating the pump of ^{99}Mo collection equipment in the Mo solution irradiation method according to the present invention. In addition, because the Mo solution which contains ^{99}Mo generated can be shipped only by dispensing and collecting it in a container as it is, the entire process from the stock of raw material to the collection of ^{99}Mo product can be simplified.

[0023] Further, the efficient manufacturing method of radioactive substance according to the present invention, which is socially useful can be used to manufacture other radioactive substance. For example, because the life time of radioactive rhenium (^{88}Re) which can be used to treat cancers is short (The half period of ^{188}Re is 17.5 hours), radioactive tungsten ^{188}W which is parent nuclide of ^{188}Re is manufactured, ^{188}Re extracted from the ^{188}W can be used for cancer care. In this case, efficiently manufacturing the aimed ^{188}W becomes possible by irradiating neutrons in a nuclear reactor to W solution in which W compound containing ^{186}W of the natural isotopic ratio is dissolved in water, or W solution in which ^{186}W is concentrated more than the natural isotopic ratio is dissolved in water, carrying out two step reaction of ^{186}W(n, γ)^{187}W $\rightarrow$ ^{187}W(n, γ) ^{188}W to produce ^{188}W in the W solution, and by collecting the W solution in continuous or batch processing. Or it becomes possible by circulating or feeding W solution, radioactivating ^{186}W to generate ^{188}W in the W solution, and by collecting the W solution in continuous or batch processing.

[Brief Description of Drawings]

[0024] FIG. 1 is a drawing showing ^{99}Mo manufacturing apparatus of Mo solution circulating type.

[Best Mode for Implementing the Invention]

[0025] An apparatus for carrying out this invention is shown in FIG. 1. Capsule4 for solution irradiation is set up in the core 2 of a nuclear reactor (3). This capsule is connected with external Mo solution injection equipment (6, 7, 8) and generation ^{99}Mo collection container 11 via pipe 9 through which the Mo solution is introduced and pipe 10 through which the Mo solution is collected. Ammonium molybdate solution is adjusted, and stored in a container of Mo solution supplying system 6 beforehand.

[0026] The Mo solution is injected into the irradiation capsule via pipe 9 by pump 7. The irradiation time of the Mo solution in the capsule by neutrons can be adjusted by injecting the Mo solution in continuous or batch processing. Though time for irradiating neutrons to the Mo solution is needed for 5-7 days, the gas generated by the radiolysis of water and the heat generated by the irradiation of the capsule in the core can be removed by circulating the Mo solution in the capsule by the operation of an external valve and circulating pump 8 into the system to remove hydrogen gas and oxygen gas generated by the radiolysis of water in heat exchanger 13 and extraction gas processing system 14.

[0027] A constant amount of the Mo solution irradiated by a predetermined amount of neutrons can be collected into ^{99}Mo collection container 11 to obtain ^{99}Mo. Because ^{99}Mo with a high radioactivity is collected into this container 11, it is necessary to cover the radiation such as gamma rays discharged from there with lead etc. and reduce the radiation exposure of workers. It is also possible to automate ^{99}Mo collection operation because ^{99}Mo can be collected only by the operation of pumps 8 and 15. The hydrogen gas and the oxygen gas generated by the radiolysis of water of the Mo solution in the capsule whose content volume is 1.66L are respectively 0.18NL and 0.09NL per day, which are few. However, because these gases are in danger of returning to the system, they are removed by extracting in extraction gas processing system 14 when the Mo solution is circulated or collected.

[0028] These hydrogen and oxygen gases can be discharged outside of the system by purging with inert gas such as nitrogen gas or helium gas for instance, or returned to the Mo solution after returning to the state of water by reuniting the hydrogen and the oxygen by using the catalyst, The Mo solution collected to ^{99}Mo collection container 11 is transported to ^{99}Mo dispensation unit 117, and is dispensed in ^{99}Mo shipping container like a

vial. The ^{99}Mo shipping container is put in the transport container with radiation shield as it is, and shipped as ^{99}Mo product after packed.

[0029] In the Mo solution irradiation method, all processes from the collection of ^{99}Mo to the shipment of ^{99}Mo product can be carried out in a short period of time. Therefore, suppressing the depletion by natural decay of ^{99}Mo (The half period is 66 hours) that the life time is short to the minimum becomes possible.

[Industrial Applicability]

[0030] According to the present invention, it becomes possible to manufacture efficiently parent nuclide ^{99}Mo of ^{99m}Tc daily used in large quantities for the medical treatment diagnosis in the world including Japan becomes possible according to the present invention. As for ^{99}Mo, the most is manufactured by a method of making highly enriched uranium a raw material now. However, the (n, γ) method which does not use the uranium as a raw material is going to be used because the conventional nuclear fission method, in which uranium is used as a raw material, has the problem described above. When a large amount of ^{99}Mo is manufactured by using the (n, γ) method according to the present invention, enormous social contribution becomes possible.

Claims

1. A method of manufacturing radioactive molybdenum by irradiation of ^{98}Mo, **characterised by** the steps of:

   irradiating neutrons in a nuclear reactor to Mo solution in which Mo compound containing ^{98}Mo of the natural isotopic ratio is dissolved in water, or Mo solution in which ^{98}Mo is concentrated more than the natural isotopic ratio is dissolved in water, to produce ^{99}Mo in the Mo solution by the radioactivation of ^{98}Mo; and
   collecting the Mo solution to obtain ^{99}Mo.

2. The method of manufacturing radioactive molybdenum according to claim 1 wherein said Mo solution is collected in continuous or batch processing to obtain ^{99}Mo.

3. The method of manufacturing ^{99}Mo according to claim 1 or 2, which further comprises the steps of:

   extracting continuously or periodically hydrogen and oxygen gases generated by the radiolysis of water when neutrons are irradiated to said Mo solution in the nuclear reactor; and
   purging the hydrogen and oxygen with inert gas to dispose of them.

4. The method of manufacturing ^{99}Mo according to claim 1 or 2, which further comprises the steps of:

   extracting continuously or periodically hydrogen and oxygen gases generated by the radiolysis of water when neutrons are irradiated to said Mo solution in the nuclear reactor;
   collecting after reuniting the hydrogen and oxygen with catalyst to return to water; and
   collecting to remove hydrogen and oxygen obtained by decomposing in radiation the water in which the Mo compound is dissolved.

5. A method according to any one of claims 1 to 4, wherein the Mo solution is irradiated with neutrons in a fluid pass-through type irradiation capsule (4) installed in a reactor core (2), and means are provided for generating and collecting ^{99}Mo in continuous or batch processing by causing the Mo solution to flow into the capsule.

6. A method according to claim 5, performed in apparatus which comprises:

   injection equipment (6, 7, 8) which injects a fixed amount of Mo solution in continuous or batch processing;
   collecting equipment (10, 11) which collects ^{99}Mo generated in continuous or batch processing;
   removing equipment (14) which extracts and removes hydrogen and oxygen of the gas generated by radiolysis reaction of the water generated in the irradiation capsule;
   a storage facility in which catalyst which has function to return the hydrogen and oxygen of the extracted gas to water by recombination reaction is filled;
   circulation equipment of the Mo solution to which a heat exchanger (13) to do cooling in the irradiation capsule is attached;
   measuring equipment by which amounts of the generation and the collection of ^{99}Mo are measured; and
   a shielding facility to shield the radiation such as gamma rays generated from ^{99}Mo generated and collected and ^{99m}Tc of the coexisting daughter nuclide.

Patentansprüche

1. Verfahren zur Herstellung von radioaktivem Molybdän durch Bestrahlung von ^{98}Mo, durch folgende Schritte **gekennzeichnet**:

   Bestrahlen einer Mo-Lösung, in der eine Mo-Verbindung mit ^{98}Mo mit dem natürlichen Isoto-

penverhältnis in Wasser gelöst ist, oder einer Mo-Lösung, in der ^{98}Mo mit einer Konzentration über dem natürlichen Isotopenverhältnis in Wasser gelöst ist, in einem Kernreaktor mit Neutronen, um in der Mo-Lösung ^{99}Mo durch radioaktive Aktivierung herzustellen; und
Entnehmen der Mo-Lösung, um ^{99}Mo zu erhalten.

2. Verfahren zur Herstellung von radioaktivem Molybdän nach Anspruch 1, wobei die Mo-Lösung in einem kontinuierlichem Verfahren oder Chargenverfahren gewonnen wird, um ^{99}Mo zu erhalten.

3. Verfahren zur Herstellung von ^{99}Mo nach Anspruch 1 oder 2, das weiters folgende Schritte umfasst:

kontinuierliches oder periodisches Extrahieren von Wasserstoff- und Sauerstoffgas, die durch die Radiolyse von Wasser gebildet werden, wenn die Mo-Lösung im Kernreaktor mit Neutronen bestrahlt wird; und
Spülen des Wasserstoffs und Sauerstoffs mit Inertgas, um sie zu beseitigen.

4. Verfahren zur Herstellung von ^{99}Mo nach Anspruch 1 oder 2, das weiters folgende Schritte umfasst:

kontinuierliches oder periodisches Extrahieren von Wasserstoff- und Sauerstoffgas, die durch die Radiolyse von Wasser gebildet werden, wenn die Mo-Lösung im Kernreaktor mit Neutronen bestrahlt wird;
Entnehmen nach der Rekombination des Wasserstoffs und Sauerstoffs mit einem Katalysator, um diese zu Wasser zurückzuführen; und
Entnehmen, um Wasserstoff und Sauerstoff zu entfernen, die durch Zersetzung mittels Bestrahlung des Wassers, in dem die Mo-Verbindung gelöst ist, erhalten wurden.

5. Verfahren nach einem der Ansprüche 1 bis 4, wobei die Mo-Lösung in einer Fluid-Durchlauf-Bestrahlungskapsel (4), die in einem Reaktorkern (2) eingebaut ist, mit Neutronen bestrahlt wird und Mittel zur Erzeugung und Entnahme von ^{99}Mo in einem kontinuierlichem Verfahren oder Chargenverfahren bereitgestellt sind, indem die Mo-Lösung in die Kapsel geleitet wird.

6. Verfahren nach Anspruch 5, das in einer Vorrichtung durchgeführt wird, die Folgendes umfasst:

eine Injektionseinrichtung (6, 7, 8), die eine festgelegte Menge Mo-Lösung in einem kontinuierlichem Verfahren oder Chargenverfahren injiziert;
eine Entnahmevorrichtung (10, 11), die in dem kontinuierlichem Verfahren oder Chargenverfahren gebildetes ^{99}Mo entnimmt;
eine Entfernungsvorrichtung (14), die Wasserstoff und Sauerstoff aus dem Gas, das durch die Radiolysereaktion des in der Bestrahlungskapsel gebildeten Wassers gebildet wird, extrahiert und entfernt;
eine Speichervorrichtung, in der ein Katalysator enthalten ist, der dazu dient, den Wasserstoff und Sauerstoff des extrahierten Gases durch eine Rekombinationsreaktion wieder zu Wasser zurückzuführen;
eine Zirkulationseinrichtung für die Mo-Lösung, an die ein Wärmetauscher (13) angeschlossen ist, um die Bestrahlungskapsel zu kühlen;
eine Messeinrichtung zur Messung der gebildeten und entnommenen Menge an ^{99}Mo; und
eine Abschirmungsvorrichtung zur Abschirmung von Strahlung wie Gammastrahlung, die durch gebildetes und entnommenes ^{99}Mo sowie ^{99m}Tc des gleichzeitig bestehenden Tochternuklids gebildet wird.

Revendications

1. Procédé de production de molybdène radioactif par irradiation de ^{98}Mo, **caractérisé par** les étapes de:

irradier des neutrons dans un réacteur nucléaire à une solution Mo dans laquelle le composé Mo contenant ^{98}Mo du rapport isotopique naturel est dissous dans de l'eau, ou une solution Mo dans laquelle ^{98}Mo est concentrée plus que le rapport isotopique naturel est dissous dans de l'eau, pour produire ^{99}Mo dans la solution Mo par la radioactivation de ^{98}Mo; et
recueillir la solution Mo pour obtenir ^{99}Mo.

2. Procédé de production de molybdène radioactif selon la revendication 1, dans lequel ladite solution Mo est recueillie dans un traitement continu ou par lots pour obtenir ^{99}Mo.

3. Procédé de fabrication de ^{99}Mo selon la revendication 1 ou 2, qui comprend en outre les étapes de:

extraire continuellement ou périodiquement les gaz d'hydrogène et d'oxygène produits par la radiolyse de l'eau lorsque les neutrons sont irradiés à ladite solution Mo dans le réacteur nucléaire; et
purger l'hydrogène et l'oxygène avec un gaz inerte pour les mettre au rebut.

4. Procédé de fabrication de ^{99}Mo selon la revendication 1 ou 2, qui comprend en outre les étapes de:

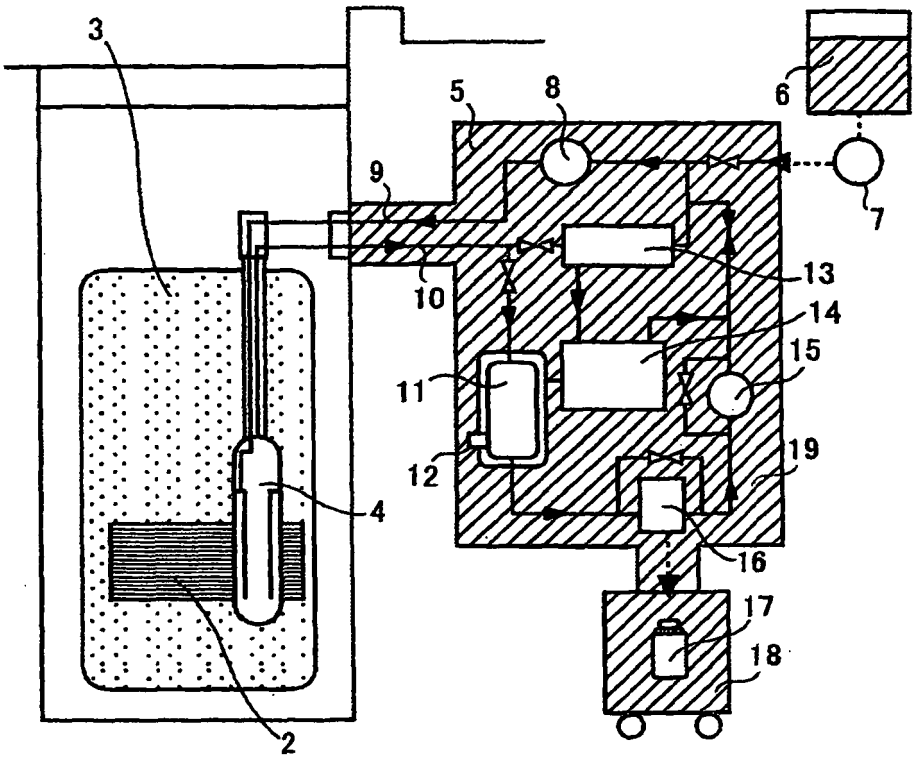
extraire continuellement ou périodiquement les gaz d'hydrogène et d'oxygène produits par la radiolyse de l'eau lorsque les neutrons sont irradiés à ladite solution Mo dans le réacteur nucléaire;
recueillir après la réunion de l'hydrogène et de l'oxygène avec le catalyseur pour le retour à l'eau; et
recueillir pour retirer l'hydrogène et l'oxygène obtenus par décomposition dans la radiation de l'eau dans laquelle le composé Mo est dissous.

5. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel la solution Mo est irradiée avec des neutrons dans une capsule d'irradiation du type à fluide traversant (4) installé dans le coeur (2) du réacteur, et des moyens sont prévus pour produire et recueillir ^{99}Mo par un traitement continu ou par lots en amenant la solution Mo à s'écouler dans la capsule.

6. Procédé selon la revendication 5, exécuté dans l'appareil qui comprend:

un équipement d'injection (6, 7, 8) qui injecte une quantité fixe de solution Mo lors d'un traitement continu ou par lots;
recueillir l'équipement (10, 11) qui recueille ^{99}Mo produit lors d'un traitement continu ou par lots;
retirer l'équipement (14) qui extrait et retire l'hydrogène et l'oxygène du gaz produit par réaction de radiolyse de l'eau produite dans la capsule d'irradiation;
une installation de stockage dans laquelle le catalyseur, qui a pour fonction de ramener l'hydrogène et l'oxygène du gaz extrait à l'eau par une réaction de recombinaison, est introduit;
un équipement de circulation de la solution Mo auquel un échangeur de chaleur (13) destiné à provoquer un refroidissement dans la capsule d'irradiation0 est fixé; et
un équipement de mesure par lequel des quantités de génération et de collecte de ^{99}Mo sont mesurées; et
une installation de protection pour protéger le rayonnement, comme des rayons gamma produits par ^{99}Mo produits et recueillis et ^{99m}Tc du nucléide engendré coexistant.

FIG. 1



REFERENCES CITED IN THE DESCRIPTION

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