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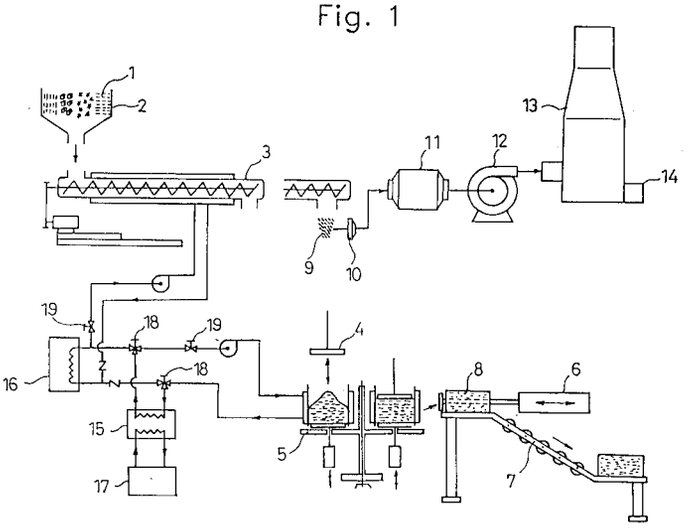
A request for correction of the drawing has been filed pursuant to Rule 88 EPC. A decision on the request will be taken during the proceedings before the Examining Division (Guidelines for Examination in the EPO, A-V, 3.).

## (54) Heating-extruding and solidifying apparatus of combustible low-level radioactive wastes

(57) An apparatus for heating-extruding and solidifying combustible low-level radioactive wastes comprises a hopper 2 for temporarily storing combustible radioactive wastes and a heating-extruding axis 3 having an extruding screw, said heating-extruding axis being provided with a heating element at its cylinder. A rotary press 4 is located at the outlet of said heating-extruding axis 3 for heating and pressing heated and extruded wastes. Systems 15 and 19 are located around said rotary press 4 for performing simultaneous heating and cooling operation. Said rotary press 4 is provided with a lift type rotary pusher 5 for demolding pressed and solidified wastes. Accumulator 7 is disposed at the wastes carrying-out side of said rotary press 4. A forward and backward remover is disposed at the front of said accumulator 7 for pulling said molded wastes 8 on the lift pusher 5 and carrying said molded wastes 8 toward accumulator 7. An inhalation duct 10 is disposed at a location where gas generated from the outlet of said heating-extruding axis 3 and the inlet of said rotary press 4 is inhaled, i.e., at the top of said rotary press, said inhalation duct 10 being connected to a HEPA filter 11 through a duct. The outlet of said filter is connected to an inhalation fan 12, the outlet of said inhalation fan 12 being connected to a scrubber 13. Said scrubber 13 having a circulation water tank 14.

Fig. 1

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## Description

### Field of the Invention

**[0001]** This invention relates to an apparatus for treating combustible solid radioactive wastes which are classified into low-level radioactive wastes produced from nuclear power plants(NPPs). More particularly, this invention relates to an apparatus for heating-extruding and solidifying low level radioactive wastes, such as vinyl, clothing and scraps. The apparatus of this invention minimizes the amount of the offgas produced by the low temperature operation and the rebound effect which is again inflated after pressing combustible wastes. Also, the apparatus of this invention filters and neutralizes the offgas, and prevents the radionuclides from being discharged into air.

**[0002]** The low level wastes refer to tools, gloves, overshoes, decontamination paper, mopper, protection clothes, PVC Sheets, spent resin such as ion-exchange resin, and sludge which are used for operating and maintaining nuclear reactors. Polyethylene sheets, polyvinylchloride sheets, nylon sheets and polyester-cotton are pressed and should be kept safely for preventing radionuclide from being leaked.

**[0003]** Recently, the amount of low and intermediate level radioactive wastes produced from domestic NPPs are reported as six hundred drums(standard : 200L). Of such large amount of the radioactive wastes, combustible radioactive wastes are kept, after being pressed for decreasing the volume and eliminating the accumulation thereof.

**[0004]** However, such a simple pressing method has disadvantage that the radioactive wastes are again inflated after being pressed which results in large volume. Further, the wastes are not solidified and drums are in a repulsive pressed state, whereby the wastes are not kept safely.

### SUMMARY OF THE INVENTION

**[0005]** An object of the present invention is to provide an apparatus for heating-extruding and solidifying low level radioactive wastes, such as vinyl, protection clothes and scraps, wherein the amount of the offgas produced by low temperature operation and rebound effect is minimized, the inflation being produced after pressing combustible wastes, the offgas being filtered and neutralized

**[0006]** In this invention, low level radioactive wastes are inserted into an hopper. In the hopper, the wastes are heated and extruded. The heated and extruded wastes are heated and pressed by a rotary press which is capable of producing several solidified wastes. And then, the rotary press cools and solidifies the wastes, whereby the rebound effect caused by a press process is restrained to the highest degree. The heat-pressed wastes are separated by a rotary pusher and then transferred into a disposal drum by use of a conveyor. Then, the packed drum are kept in interim storage. Poisonous gas produced during the heating-extruding and heating-pressing process is inhaled into an inhalation duct by the use of an inhalation fan, filtered by a HEPA filter, and neutralized in a scrubber, thereby solving the air pollution problems.

**[0007]** The amount of offgas produced during the heating-extruding process and the rotary press process is a little. However, of the offgas more than 99% is hydrogen chloride(HCl) gas. The HCl gas is produced when PVC is decomposed into. Therefore, the amount of HCl gas can be extremely decreased by an operation below 150°C at which PVC starts to be decomposed into HCl gas,

### Brief Description of the Drawings

**[0008]** Fig. 1 shows a whole process flow diagram for heat-pressing and solidifying combustible low level radioactive wastes of this invention.

### Detailed Description of the Invention

**[0009]** In Fig. 1, an apparatus of this invention for heating-extruding and solidifying combustible low level radioactive wastes includes hopper 2 and a heating-extruding axis 3. The heating-extruding axis 3 includes an extruding screw. A heat-medium, i.e. oil supplied from a heat-medium heater 16 is controlled by a temperature controller 19 to have an adequate temperature of 60 to 150°C. The controlled oil temperature is supplied to a cylinder of the heating-extruding axis 3. The outlet of the heating -extruding axis 3 is provided with a rotary press 4 for heat-pressing the heated and extruded wastes. The rotary press 4 is provided with more than three presses for continuously treating the wastes, thus increasing work efficiency.

**[0010]** The side wall of the rotary press 4 is provided with a system for performing cooling and heating operation simultaneously. When heating the wastes supplied from the heating-extruding axis 3, the heat-medium heated from the heat-medium heater 16 is sent through a direction control valve 18 and a temperature controller 19 to the side wall of press. The heat-medium is maintained and circulated at below 150°C, and then is used for heating when the rotary press 4 presses the wastes. After the process mentioned above, in case of cooling the heat-pressed wastes, cooling water is supplied from a cooling feeder 17 to a heat-medium(oil) cooler 15. The cooling water cools the heat-medium by heat-exchange method. The cooled heat-medium can continuously cool the heat-pressed wastes through the direction control valve 18 and the temperature controller 19. By the process mentioned above, the heat-pressed wastes are rapidly solidified. In the heating-extruding axis, softened or melted vinyl and other wastes are mixed and extruded at comparatively low temperature, i.e. 60 to 150°C. To

simplify the process flow, it's possible to use a electrical heater of band type in heating-extruding and heating-pressing the wastes.

**[0011]** The rotary press 4 is provided with a lift pusher 5 for demolding the pressed and solidified wastes. The outlet part of the rotary press 4 is provided with a accumulator 7. The head of the accumulator is provided with a remover 6 for pulling the solidified wastes and carrying the wastes on the accumulator 7. The rotary pusher 5 and remover 6 include a base or removing member attached to the head of the arm of the oil pressure or the air pressure cylinder. The accumulator 7 includes a plurality of rollers disposed uniformly on a sliding roll member.

**[0012]** An inhalation duct 10 is disposed on the top of the rotary press, at which location offgas discharged from the inlet of the rotary press 4 and the outlet part of the heating-extruding axis 3 can be inhaled. The inhalation duct 10 is connected to the HEPA filter 11. The outlet of the HEPA filter is connected to the inhalation fan 12 and the outlet of the inhalation fan is connected to a scrubber 13 through leads, respectively. The scrubber 13 includes a circulation water tank 14.

**[0013]** With the construction of the present invention, the combustible wastes 1 such as PE sheets, PVC sheets, nylon sheets, polyester-cotton are fed through the hopper 2 to the heating-extruding axis 3. The wastes are heated and extruded by the heat-medium heated by the heat-medium heater 16 which is controlled by the temperature controller 19 at the temperature lower than the PVC melting-start temperature of 150°C. Particularly, the heating and extruding temperature is in the range of 60 to 150°C. The extruded wastes 1 are pressed by the rotary press 4 and heated by the heat-medium which is heated by the heat-medium heater 16 and controlled by the direction control valve 18 and the temperature controller 19. The heat-medium in the heat-medium cooler 15 is heat-exchanged and cooled with the cooling water from the cooling water supplier 17, and the cooled heat-medium, of which temperature is controlled by the temperature controller 19, circulates continuously the heating loop of the side wall, cools and solidify the heat-pressed the wastes very quickly.

**[0014]** The molded wastes 8 which are pressed and solidified are pushed by the rotary pusher 5 and carried on the accumulator 7. The molded wastes 8 slide down to the outlet position by the accumulator 7. The wastes, then, are carried to and kept in a storage.

**[0015]** The toxic gas 9 produced during the heating-extruding process of the heating-extruding axis and heating process of the rotary press 4 is forcedly drawn into the inhalation duct 10 by the use of inhalation fan 12. The toxic gases 9 is drawn into the HEPA filter 11 and filtered. When the toxic gases pass through the scrubber, NaOH solution in the circulation water tank 14 is sprayed into the scrubber 13, thus neutralizing the toxic gases 9.

**[0016]** Every process comprising feeding, extruding, pressing, cooling, carrying, and storing is automated. The wastes are exactly weighed in amount when feeded. Trouble is prevented by successive control of each process. Contactless PLC method is used in the apparatus of this invention. Sensors are used in each process. Switches are used to control right position. Control members are used for stopping the operation of the heating-extruding axis in the middle of extruding operation. OR circuits of timer and sensors are used for preventing malfunction and for saving time. Automatic/manual option circuits are used for convenience of working and maintenance, and for the control of the input amount of wastes. Switches are provided for emergent stop operation. Due to the above-mentioned members, the combustible radioactive wastes are solidified more safely and effectively.

* Treatment Example of combustible radioactive wastes

I. Kinds of combustible radioactive wastes
PE sheets, PVC sheets, vinyl sheets, polyester-cotton
II. Test

i) Thermogravimetric Analysis(TGA)

1) Analysis of weight loss according to a temperature increase
2) Measurement of temperature at which thermal behavior shows up

ii) Differential scanning calorimeter(DSC)

1) Melting point measurement
2) Softening point measurement

iii) Pyrolysis gas chromatography(GC)
Analysis of gas produced during pyrolysis (heat decomposition)
iv) Offgas treatment
Confirmation of offgas and establishment of safe treatment

III) Test Results

i) DSC analysis result

1) PE : Melting point 118.89°C
2) Polyester : Melting point 260°C
3) Nylon : Melting point 259.5°C

ii) TGA result

1) PE : Decomposition temperature
2) Polyester : Decomposition temperature 409°C
3) Nylon : Decomposition temperature

419°C
4) PVC : Decomposition temperature 272°C

iii) Pyrolysis GC result

1) PE : $C_1$(Methane $CH_4$), $C_2$(Ethane $C_2H_6$), $C_3$(Propane $C_3H_8$), ·····, $C_{10}$
2) Polyester : $CH_3CHO$, $C_2H_{3\varepsilon}CHO$
3) Nylon : ε-carprolactam
4) PVC : HCl is capable of being decomposed from the temperature of 150°C.

Gases more than 99% produced when benzene and naphthalene are decomposed from additive at the temperature above 230°C is HCl gas.

* Slight amount of CO and $CO_2$ is produced during carbonization

iv) Heating-extruding test result

1) Sample of about 4.5kg (PE 40%, nylon 30%, polyester-cotton 30%) is prepared, heated and pressed.
2) Measuring inflation height after pressing with 20tons of press
3) Density when heat-pressed : 1.0 to 1.1 g/cm$^3$
Density when inflated : 0.6 to 0.7 g/cm$^3$
4) BOUN % = [(height of inflated sample - height when pressed)/height of inflated sample] × 100 ≒ 50%

IV) Treatment of toxic gas

1) Plastic melter is not subject to regulation of offgas (e.g. extruder, catapult)
2) A slight amount of various gases are produced at the temperature above 300°C. However, at 200°C and below, only HCl gas is produced.
3) The produced amount depends on PVC content or is 10 to 50 ppm.
4) When applying the scrubber, about more than 90% can be eliminated and collected.
5) $H_2O$ is contained in the toxic gases depending on the dried state of the wastes.

V. Conclusion

1) The volume of the combustible wastes can be reduced by the heating- pressing method.
2) 30 to 50% of the volume can be reduced, when compared with non-heating press method.
3) More than 99% of offgas is HCl gas. The produced amount depends upon the content of PVC, but the amount is about 10 to 50 ppm.
4) When applying the scrubber, about 90% can be removed.

**[0017]** As described above, with this invention, the inflation is minimized during rotary press process because combustible low-level radioactive wastes go through heating-extruding, heating-pressing and cooling process. Further, low temperature minimizes the toxic gases produced during the heating-extruding and heating-pressing process. The toxic gas is discharged into air after being filtered and neutralized, thus minimizing air pollution.

## Claims

**1.** An apparatus for heating-extruding and solidifying combustible low-level radioactive wastes comprising :

a hopper 2 for temporarily storing combustible radioactive wastes ;
a heating-extruding axis 3 having an extruding screw, heating-extruding axis being provided with a heating element at its cylinder ;
a rotary press 4 located at the outlet of said heating-extruding axis 3 for heating and pressing heated and extruded wastes ;
systems 15 and 19 located around said rotary press 4 for performing simultaneous heating and cooling operation ;
said rotary press 4 being provided with a lift type rotary pusher 5 for demolding pressed and solidified wastes ;
a accumulator 7 conveyed the molded wastes 8 carrying-out side of said rotary press 4 ;
a forward and backward remover 6 carried at the front of said the accumulator 7 for pulling said molded wastes 8 on the lift pusher 5 and carrying said molded 8 toward accumulator 7 ;
an inhalation duct 10 disposed at a location where gas generated from the outlet of said heating-extruding axis 3 and the inlet of said rotary press 4 is inhaled, i.e., at the top of said rotary press, said inhalation duct 10 being connected to a HEPA filter 11 through a duct ;
the outlet of said filter being connected to an inhalation fan 12, the outlet of said inhalation fan 12 being connected to a scrubber 13 ; and
said scrubber 13 having a circulation water tank 14.

**2.** An apparatus for heating-extruding and solidifying combustible low-level radioactive wastes according to Claim 1, wherein said heating-extruding axis 3

heats and extrudes the radioactive wastes at 60 to 150°C.

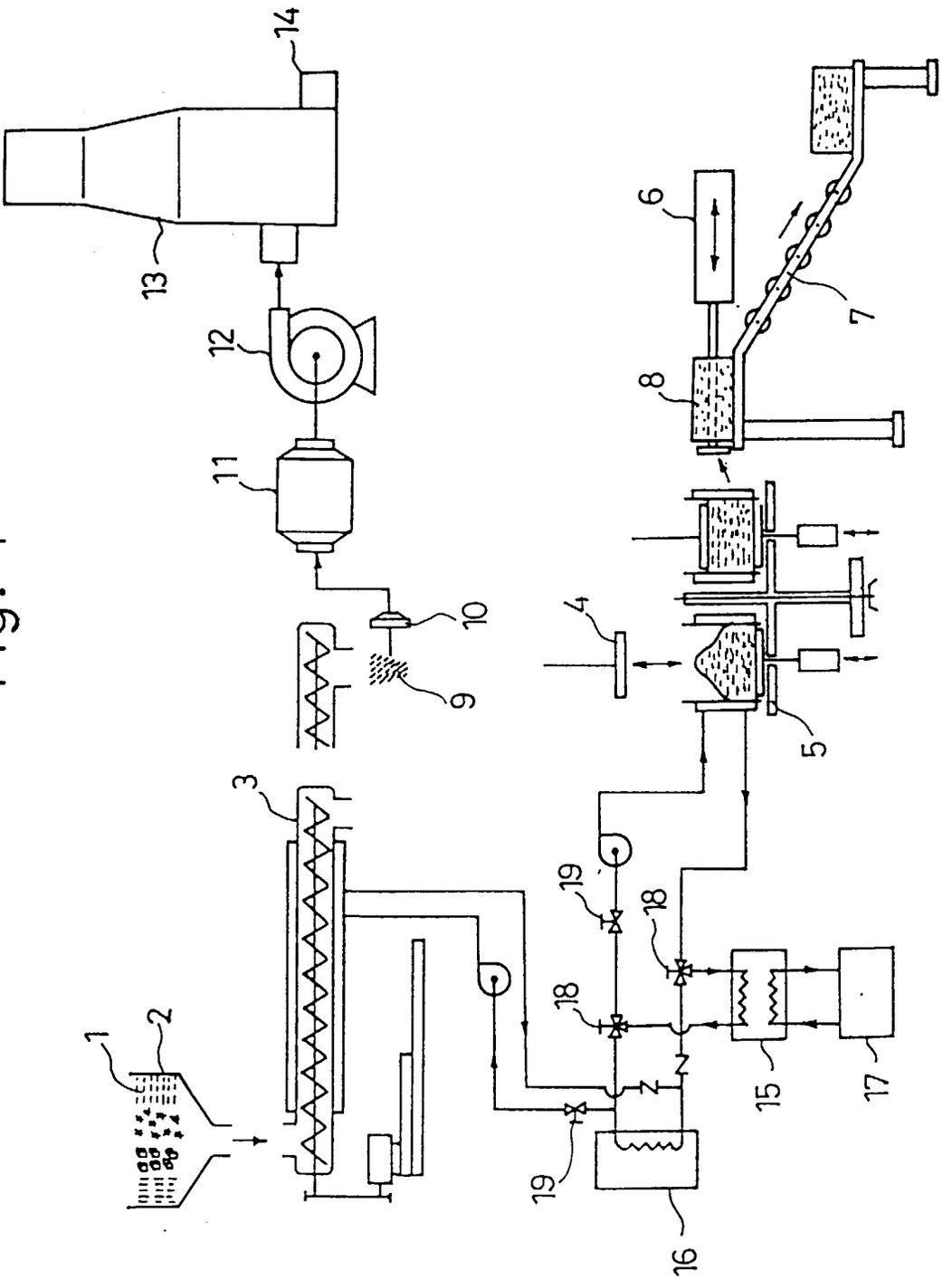
3. An apparatus for heating-extruding and solidifying combustible low-level radioactive wastes according to Claim 1, wherein said rotary press 4 heats and presses the wastes at 15 0°C and below.

4. An apparatus for heating-extruding and solidifying combustible low-level radioactive wastes according to Claim 1, wherein said heating and cooling systems 15 and 19 heat, cool and rapidly solidify the radioactive wastes in rotary press 4 which are heated and extruded by said heating-extruding axis 3.

5. An apparatus for heating-extruding and solidifying combustible low-level radioactive wastes according to Claim 1, wherein said rotary press 4 and said rotary pusher 5 supply successively radioactive wastes and heat, press, solidify and demolding more than four molded wastes.

6. An apparatus for heating-extruding and solidifying combustible low-level radioactive wastes according to Claim 1, wherein a electrical heater of a band type instead of said heat-medium in heating-extruding and heating-pressing can be used.

Fig. 1



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# EUROPEAN SEARCH REPORT

Application Number
EP 98 11 2545

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
|---|---|---|---|
| A | GB 2 122 803 A (GRAVATOM PROJECTS LIMITED) 18 January 1984 * the whole document * --- | 1 | G21F9/30 |
| A | DE 15 89 839 B (GESELLSCHAFT FÜR KERNFORSCHUNG MBH) 13 May 1971 * the whole document * --- | 1 | |
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| A | US 5 164 123 A (GOUDY JR PAUL R) 17 November 1992 * the whole document * ----- | 1 | |
| | | | TECHNICAL FIELDS SEARCHED (Int.Cl.6) |
| | | | G21F |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 8 February 1999 | Brothier, J-A |

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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 11 2545

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08-02-1999

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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