PATENT REQUEST: STANDARD PATENT/PATENT OF ADDITION

I/We, being the person(s) identified below as the Applicant, request the grant of a patent to the person identified below as the Nominated Person, for an invention described in the accompanying standard complete specification.

Full application details follow.

[71] Applicant: METALLGESELLSCHAFT AKTIENGESELLSCHAFT
Address: Reuterweg 14, D-6000 Frankfurt am Main, Federal Republic of Germany.

[70] Nominated Person: METALLGESELLSCHAFT AKTIENGESELLSCHAFT
Address: Reuterweg 14, D-6000 Frankfurt am Main, Federal Republic of Germany.

[54] Invention Title: PROCESS OF COOLING HOT PROCESS GASES

[72] Name(s) of actual inventor(s):
MARTIN HIRSCH, WOLFGANG FRANK and MANFRED HEIL

[74] Address for service in Australia: c/o WATERMARK PATENT & TRADEMARK ATTORNEYS, of The Atrium, 290 Burwood Road, Hawthorn, Victoria 3122, Australia
Attorney Code: WM

BASIC CONVENTION APPLICATION(S) DETAILS
P 40 23 060.0 Federal Republic DE
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Drawing number recommended to accompany the abstract: 1

REPRINT OF RECEIPT

By my/our Patent Attorneys,
WATERMARK PATENT & TRADEMARK ATTORNEYS

STEFAN K. PLYMIN
Registered Patent Attorney

18th July, 1990 (Date)
COMMONWEALTH OF AUSTRALIA
Patents Act 1952-1969

DECLARATION IN SUPPORT OF A CONVENTION APPLICATION FOR A PATENT OR PATENT OF ADDITION

In support of the Convention Application made by

METALLGESellschaft AKTIENGESellschaft

(hereinafter referred to as the applicant) for a Patent for an invention entitled: PROCESS OF COOLING HOT

PROCESS BASES

METALLGESellschaft AKTIENGESellschaft

of Reuterweg 14, D-6000 Frankfurt am Main, FRG by Anneliese Gasteyer and Wolfgang Schneider do solemnly and sincerely declare as follows:

1. I am authorised by the applicant for the patent to make this declaration on its behalf.

2. The basic application as defined by Section 141 of the Act was made in Federal Republic of Germany on the 20th day of July, 1990, by METALLGESellschaft AKTIENGESellschaft

METALLGESellschaft AKTIENGESellschaft

3. I. Martin Hirsch, Dipl.-Ing., Römer-Strasse 7, D-6382 Friedrichsdorf, FRG
2. Wolfgang Frank, Dipl.-Ing., Egerlandstr. 6, D-6236 Eschborn 2
3. Manfred Heil, Dipl.-Ing., Friedrichstr. 4, D-6382 Oberörlen

We are the actual inventor of the invention and the facts upon which the applicant is entitled to make the application are as follows:

The applicant is the assignee of the said actual inventors

4. The basic application referred to in paragraph 2 of this Declaration was the first application made in a Convention country in respect of the invention the subject of the application.

DECLARED at Frankfurt am Main this 20th day of June 1991.

Metallgesellschaft
AKTIENGESellschaft

To: THE COMMISSIONER OF PATENTS

Edw. Waters & Sons, Melbourne.

(Anneliese Gasteyer) (Wolfgang Schneider)
1. A process of cooling hot process gases, in which the process gases are fed through a stationary fluidized bed, which contains cooling elements, part of the solids suspended in the gas stream are separated in the dust-containing space over the fluidized bed and are recycled to the fluidized bed, and solids are separated from the exhaust gas in a deduster and are recycled to the fluidized bed, characterized in that a stationary fluidized bed is provided, which contains cooling elements and is contained in an annular trough, fluidizing gas is fed to the fluidized bed through the gas-permeable bottom of the trough, the inflowing process gas is passed through the central opening of the fluidized bed, cooled solids flow into the process gas stream over the inner rim of the trough and are entrained by said process gas stream into the dust-containing space over the top surface of the fluidized bed, the solids removed in the dust-containing space fall back into the annular fluidized bed, the cooled gas which contains the
remaining solids is fed to a gas cooler, which comprises cooling surfaces, the gas leaving the upper portion of the gas cooler is fed to a deduster, and the solids which have been removed are recycled to the stationary fluidized bed.
The following statement is a full description of this invention, including the best method of performing it known to:
Description

This invention relates to a process of cooling hot process gases, in which the process gases are fed through a stationary fluidized bed, which contains cooling elements, part of the solids suspended in the gas stream are separated in the dust-containing space over the fluidized bed and are recycled to the fluidized bed, and solids are separated from the exhaust gas in a deduster and are recycled to the fluidized bed.

In some processes, hot process gases are formed, which can be cooled only with considerable difficulty. For instance, process gases may contain condensible components or entrained liquid droplets, e.g., of metal or slag, and said condensible components or entrained liquid droplets may form crusts on cooling surfaces in response to a cooling. The process gases may contain poorly flowing fine dusts, which may form crusts even at the temperature of the process gas or when cooled. The process gases may also contain SO₂, or SO₃ may be formed in response to a cooling, or an undesired sulfatizing may occur.
German Patent Specification 34 39 600 discloses that process gases formed by the gasification of carbonaceous solids can be cooled by a process in which the hot process gas is supplied to and cooled in a stationary fluidized bed of sulfur-binding solids. The fluidized bed contains cooling elements, which are flown through by a cooling fluid. The fluidizing gas consists of a recycled partial stream of the process gas which has left the fluidized bed. The process gas is introduced into the fluidized bed from the side or from above. The cooled process gas which has left the fluidized bed is dedusted in a cyclone, cooled further in a heat exchanger, and supplied to a gas purifier. The solids removed in the cyclone and in the gas purifier are recycled to the fluidized bed. A contact between the process gas and cooling surfaces is not avoided so that crusts may be formed. An optimum mixing of the process gas and solids is not achieved.

U.S. Patent 3,977,846 discloses that a process gas which contains hydrocarbons can be cooled in a stationary fluidized bed, which in its lower portion contains cooling surfaces, which are flown through by a cooling fluid. The fluidizing gas consists of an extraneous gas, which is free of hydrocarbons. The process gas is introduced above the cooling surfaces through nozzles, which are disposed in the fluidized bed. The nozzles are heat-insulated to prevent a formation of deposits. The cooled process gas leaving the fluidized bed is
supplied to a deduster. Solids laden with condensed hydrocarbons are withdrawn from the fluidized bed and fresh solids are charged into the fluidized bed. A high wear of the nozzles by corrosive components and solids contained in the process gas must be expected and the nozzles may be clogged.

U.S. Patent 4,120,668 discloses that a process gas which contains molten salt particles and volatile components can be cooled in a stationary fluidized bed, into which the process gas is introduced as a fluidizing gas. The fluidized bed contains cooling surfaces above the level on which the process gas is introduced. The cooled gas is dedusted in a cyclone, and the solids which have been removed are recycled to the fluidized bed. Part of the solids are downwardly removed from the fluidized bed, and fresh solids are charged into the fluidized bed. In that case the above-mentioned disadvantages will also be encountered.

From WO 88/08741 it is known that process gases can be cooled in a circulating fluidized bed in a process in which the process gas is cooled in a mixing chamber with cooled process gas which is recirculated and with cooled solids which are recirculated. The bottom of the mixing chamber is conical and has an opening for receiving the process gas and the recirculated gas. The suspension leaving the mixing chamber can be cooled further on cooling surfaces in the upper portion of the bed vessel and the solids may subsequently be removed in cyclones and be recycled to the bed vessel. A partial stream
of the gas may be recirculated to the bed vessel. Alternatively, the suspension may be discharged without a further cooling and the solids may be removed in cyclones and be recycled to the bed vessel, whereafter the gas may be cooled and may partly be recirculated to the bed vessel. The density of the suspension in the circulating fluidized bed is maintained at 1 to 5 kg/m$^3$ or lower values in that solids are recycled at a rate of 0.92 to 11.5 kg/sm$^3$ (sm$^3$ = standard cubic meter). The large volume of the exhaust gases is due to the recycling of gas at a high rate and requires an expensive gas purifier. A relatively large heat exchange surface area is required owing to the low density of the suspension.

It is an object of the invention to cool hot process gases with a high economy and in such a manner that a formation of crusts and sulfates will be avoided.

That object is accomplished in accordance with the invention in that a stationary fluidized bed is provided, which contains cooling elements and is contained in an annular trough, fluidizing gas is fed to the fluidized bed through the gas-permeable bottom of the trough, the inflowing process gas is passed through the central opening of the fluidized bed, cooled solids flow into the process gas stream over the inner rim of the trough and are entrained by said process gas stream into the dust-containing space over the top surface of the fluidized bed, the solids removed in the dust-containing space fall back into the annular fluidized bed, the cooled gas which
contains the remaining solids is fed to a gas cooler, which comprises cooling surfaces, the gas leaving the upper portion of the gas cooler is fed to a deduster, and the solids which have been removed are recycled to the stationary fluidized bed. The stationary fluidized bed exhibits a distinct density step between the dense phase and the overlying dust-containing space. The annular stationary fluidized bed may be circular or rectangular or polygonal. The cooling surfaces contained in the fluidized bed are suitably replaceably mounted. The cooling surfaces may be connected to constitute evaporators and/or superheaters. The cooling surfaces are generally constituted by tube banks. The walls of the trough are provided with cooling pipes. The inner wall of the trough defines the central opening in the fluidized bed. The cooled solids flow from the stationary fluidized bed across the rim of the inner wall of the trough into the central opening and are admixed to the process gas stream and entrained thereby as a dense suspension in a central jet into the dust-containing space above the fluidized bed so that the process gas will rapidly be cooled to a large extent. Owing to the increase of the volume in the dust-containing space, a major part of the solids will be removed from the central jet in the dust-containing space and will fall back into the stationary fluidized bed and will be recooled therein. The cooling of the process gas to the temperature which is desired in the dust-containing space is effected in that the solids are suitably cooled in the stationary fluidized bed and in that
solids at a suitable rate are caused to enter the central opening. The wall defining the dust-containing space is cooled by cooling pipes. The mixed gases which consist of process gas and fluidizing gas and which contain the remaining solids are fed to a gas cooler and are further cooled therein. The gas cooler is preferably disposed over the dust-containing space. The gas cooler has cooled walls and may also be provided with suspended cooling surfaces. Part of the solids which are still suspended in the gas will be removed in the gas cooler and will fall into the dust-containing space and further into the stationary fluidized bed. The cooling fluid generally consists of water and the gas cooler is connected to constitute an evaporator. The cooled gas has only a low content of remaining solids and is fed to a deduster consisting, e.g., of a cyclone, filter, or gas-purifying electrostatic precipitator and is substantially dedusted therein and is then discharged as an exhaust gas or fed to a further gas purifier. All or part of the solids which have been removed in the deduster are recycled to the stationary fluidized bed. In dependence on the composition of the process gas, part of the solids are removed from the process and are replaced by fresh solids. This will prevent an excessive enriching of the separated substances in the solids. The fluidizing gas may consist of any gas which will not be disturbing in the cooling or in succeeding processes. If air is required for the further processing of the exhaust gas, e.g., in the processing of gases having a high $SO_2$ content, or if air is not disturbing in such
further processing, air may be used as a fluidizing gas. Otherwise a part of the exhaust gas may be recirculated, provided that the recirculated exhaust gas is previously purified to remove substances which would damage the permeable bottom.

To minimize the rate of fluidizing gas, the particle size of the solids in the fluidized bed is suitably less than 1 mm with a median value \(d_{50}\) below 0.5 mm.

According to a preferred feature the suspension in the stationary fluidized bed has a density of 300 to 1500 kg per m\(^3\) of the space of the bed vessel, preferably of 500 to 1000 kg/m\(^3\). Particularly good operating conditions will be achieved in said ranges because the film coefficients of heat transfer will be high.

According to a preferred feature, solids at a rate of 1 to 10 kg/sm\(^3\), preferably 2.5 to 6 kg/sm\(^3\), are supplied from the stationary fluidized bed to the process gas stream. Within said ranges the process gas will rapidly be cooled as desired without a need for very large cooling surfaces.

According to a preferred feature the gas leaving the upper portion of the gas cooler is laden with solids at a rate of 0.1 to 1 kg, preferably 0.2 to 0.6 kg, per sm\(^3\). In that case the pressure drop in the gas cooler will be relatively low and the gas will effectively be cooled.

According to a preferred feature the standard volume rate of the fluidizing gas which enters the stationary fluidized bed through the permeable bottom is 10 to 30\%, preferably 15 to 20\%, of the standard volume rate of the process
gas. As a result, the energy requirement for the fluidizing gas will be relatively low and if the exhaust gas is recycled the costs of the required gas purifier will be reduced.

According to a preferred feature the solids removed in the deduster are recycled at a controlled rate to the stationary fluidized bed. The solids are not removed in the deduster at a constant rate. In case of a direct, uncontrolled recycling the varying rate may be a cause of poor results, which will be avoided by a controlled recycling at a uniform rate. A vessel is interconnected between the deduster and the recycling line in the fluidized bed and serves as a buffer, from which the solids are withdrawn at a controlled rate. The solids are suitably slightly fluidized in the interconnected vessel.

According to a preferred feature the central opening in the stationary fluidized bed is insulated by a refractory lining. The central opening is defined by a sheet metal shell, which is provided on the outside with cooling surfaces. A refractory lining is mounted on the inside surface of the sheet metal shell so that a formation of crusts consisting of solidified components of the process gas will be avoided. Any molten components which are contained in the process gas and deposited on the lining will flow back into the fluidized bed.

According to a preferred feature the solids used to form the fluidized bed are suitable for being processed further together with any materials which have been removed from the exhaust gas.
The invention will be explained further with reference to the figure of the drawing and an example.

The schematic drawing is a longitudinal sectional view showing a cooling system for carrying out the process.

Fluidizing air is blown by the fan 2 through the permeable bottom into the annular trough 1, which contains cooling elements 3. The inner wall of the trough 1 constitutes a central duct 4 for the inflowing process gas. The trough 1 contains a stationary fluidized bed 5, from which solids flow across the inner rim of the trough 1 into the process gas stream 6 in the duct 4 and are admixed to said stream to form a dense suspension, and the process gas is rapidly cooled to a large extent at the same time. That suspension is blown as a central jet into the dust-containing space 21, in which due to the increased cross section and the resulting decrease of gas velocity a major part of the solids are separated and fall back into the fluidized bed 5. The gas, which contains remaining solids, flows into the gas cooler 7, which is provided with schematically shown continuous wall-cooling means 8 and suspended cooling surfaces 9. The gas which has been cooled further flows through the outlet 10 into the cyclone 11. The solids which have been separated fall into the interconnected vessel 12, which serves as a buffer. Solids at a controlled rate are recycled to the fluidized bed 5 by the discharge means 13 through the line 14. The dedusted gas is discharged through line 15. Part of the solids are withdrawn from the fluidized bed through line 16. Fresh solids from
the bin 17 may be fed to the fluidized bed to start the process and to maintain a predetermined height of the bed. The gas may be cooled further in the cooler 18, which may be used, e.g., for feed water heating. The cooling elements for cooling the outer wall of the trough 1 and the wall which defines the dust-containing space 21 are only schematically indicated by the upper tubes 19 and the lower tubes 20.

EXAMPLE

The exhaust gas to be cooled has been formed by the smelting of lead ore in a QSL reactor. The exhaust gas becomes available at a temperature of 1010 to 1050°C and at a rate of 21,800 sm³/h and contains 215 g dust per sm³. The composition is

10.80% SO₂
15.67% CO₂
22.90% H₂O
7.83% O₂
39.80% N₂

The exhaust gas is blown through the duct 4, which is 100 cm in diameter. Air at a temperature of 60°C and under a pressure of 250 mbars is blown at a rate of 5000 sm³/h through the permeable bottom of the trough 1 into the stationary fluidized bed, which contains cooling tube banks 3 having a surface area of 42 m². Cooled solids at a temperature of about 480°C flow from the trough 1 into the duct 4 at such a rate that the exhaust gas contains about 5 kg solids per sm³. 5.27 MW heat
are supplied by the exhaust gas, and about 3.78MW of said heat are transferred to the cooling tube banks in the fluidized bed. At a temperature of 600°C the cooled exhaust gas enters at a velocity of 5.5 m/s the gas cooler 7, which has a cooling surface area of 250 m². The further cooled exhaust gas leaving the gas cooler 7 through the outlet 10 at a velocity of 4 m/s is at a temperature of 350°C and contains 0.5 kg dust per sm³. The gas which is withdrawn through line 15 from the cyclone 11 contains 5 to 10 g dust per sm³. Solids at a temperature of 350°C are recycled from the interconnected container 12 to the fluidized bed 5 at a rate of 13,400 kg/h. Solids are withdrawn from the fluidized bed 5 through line 16 at a rate of 4,500 kg/h. Steam at 40 bars and 250°C is generated at a rate of 12,100 kg/h. Solids consisting of sand having a particle size below 1 mm are fed to the trough 1 in order to start up the process.

Advantages afforded by the invention reside in that the process gases are cooled by means of relatively small heat exchanger surfaces and with the use of additional gas at a low rate and a formation of crusts and a sulfatizing will be avoided. If the preceding unit is shut down so that the supply of process gas is interrupted, a falling of solids from the fluidized bed into the preceding units can be prevented in that the flow rate of the fluidizing gas is reduced or shut down.
THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

CLAIMS

1. A process of cooling hot process gases, in which the process gases are fed through a stationary fluidized bed, which contains cooling elements, part of the solids suspended in the gas stream are separated in the dust-containing space over the fluidized bed and are recycled to the fluidized bed, and solids are separated from the exhaust gas in a deduster and are recycled to the fluidized bed, characterized in that a stationary fluidized bed is provided, which contains cooling elements and is contained in an annular trough, fluidizing gas is fed to the fluidized bed through the gas-permeable bottom of the trough, the inflowing process gas is passed through the central opening of the fluidized bed, cooled solids flow into the process gas stream over the inner rim of the trough and are entrained by said process gas stream into the dust-containing space over the top surface of the fluidized bed, the solids removed in the dust-containing space fall back into the annular fluidized bed, the cooled gas which contains the remaining solids is fed to a gas cooler, which comprises cooling surfaces, the gas leaving the upper portion of the gas cooler is fed to a deduster, and the solids which have been removed are recycled to the stationary fluidized bed.

2. A process according to claim 1, characterized in that the suspension in the stationary fluidized bed has a density of 300 to 1500 kg per m³ of the space of the bed vessel, preferably of 500 to 1000 kg/m³.
3. A process according to claim 1 or 2, characterized in that solids at a rate of 1 to 10 kg/sm³, preferably 2.5 to 6 kg/sm³, are supplied from the stationary fluidized bed to the process gas stream.

4. A process according to any of claims 1 to 3, characterized in that the gas leaving the upper portion of the gas cooler is laden with solids at a rate of 0.1 to 1 kg, preferably 0.2 to 0.6 kg, per sm³.

5. A process according to any of claims 1 to 4, characterized in that the standard volume rate of the fluidizing gas which enters the stationary fluidized bed through the permeable bottom is 10 to 30%, preferably 15 to 20%, of the standard volume rate of the process gas.

6. A process according to any of claims 1 to 5, characterized in that the solids removed in the deduster are recycled at a controlled rate to the stationary fluidized bed.

7. A process according to any of claims 1 to 6, characterized in that the central opening in the stationary fluidized bed is insulated by a refractory lining.

8. A process according to any of claims 1 to 7, characterized in that the solids used to form the fluidized bed are suitable for being processed further together with any materials which have been removed from the exhaust gas.

DATED THIS 18th day of July, 1991

METALLGESELLSCHAFT AKTIENGESELLSCHAFT

WATERMARK PATENT & TRADEMARK ATTORNEYS,
2nd Floor, The Atrium, 290 Burwood Road,
HAWTHORN. VICTORIA 3132.