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SOLIDS DRYING PROCESS
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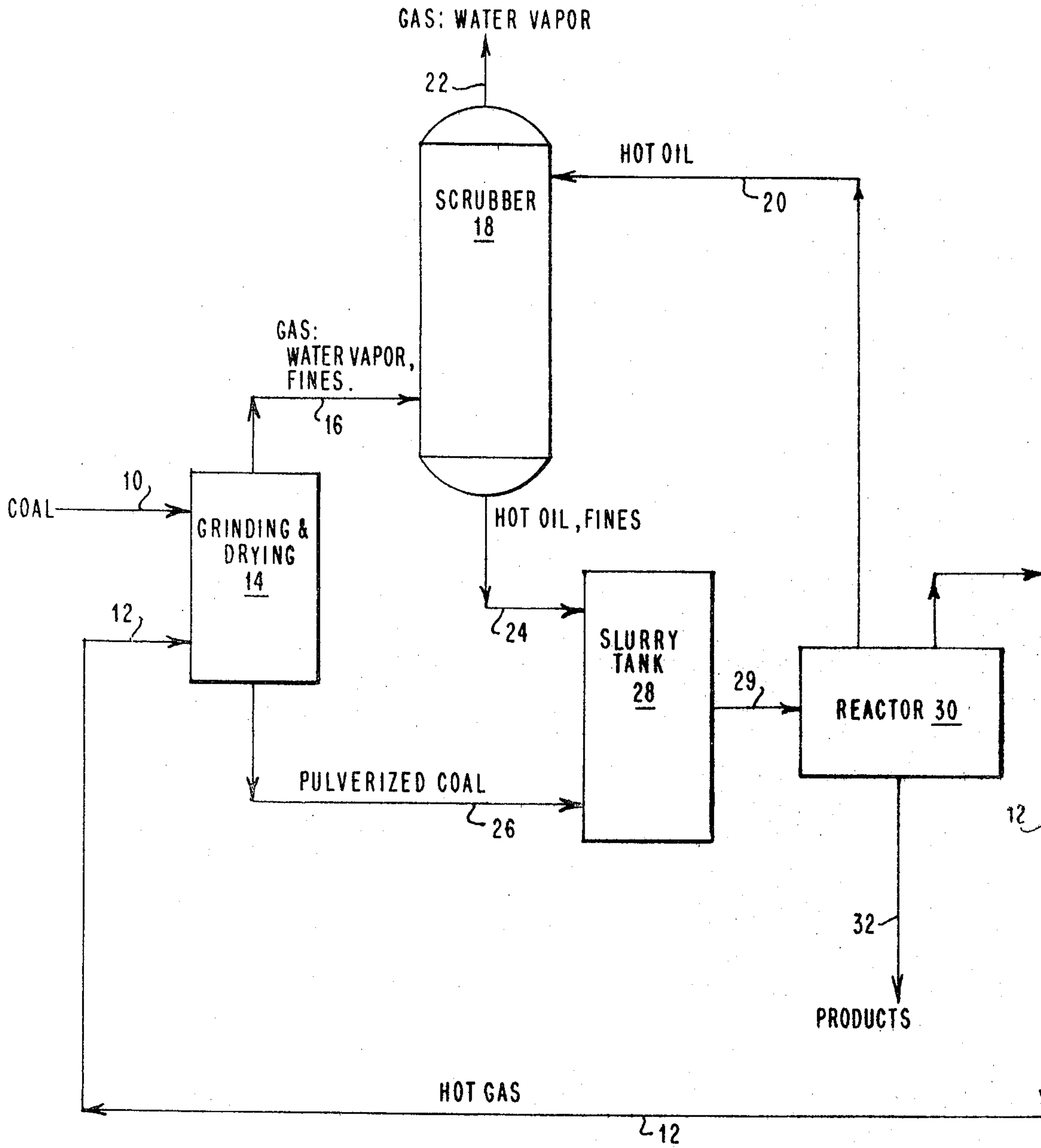


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# SOLIDS DRYING PROCESS

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## ABSTRACT OF THE DISCLOSURE

A process for drying a particulate carbonaceous solid material by passing a hot, relatively moisture-free gas through the material and scrubbing the gas with a liquid which is at a higher temperature than the gas, whereby the liquid retains the fines and the moisture from the solids material is carried away in the gas.

## BACKGROUND OF THE INVENTION

This invention pertains to the drying of solid particulate material and subsequent removing of the fines contained therein from the drying gas. More particularly, it pertains to the drying of a solid carbonaceous material, such as bituminous and subbituminous coals, lignite and peat, which has been pulverized prior to its introduction to a hydrogenation and/or hydrocracking process for the purpose of converting said material to liquid hydrocarbons.

In such systems, it is necessary that the water be removed from the material prior to processing in order to prevent foaming and lowering of hydrogen partial pressures within the reaction zone. The moisture content of the material is reduced by grinding or pulverization along with either concurrent or subsequent drying. The most efficient way to dry such materials is to pass a hot gas which is inert to the material, such as a hot flue or vent gas, through the pulverizing equipment so as to dry the material concurrently with the pulverizing operation. However, it is not necessary that such drying procedure take place concurrently with the pulverizing operation as the particulate material may be separately dried in a fluidized bed type system.

A major disadvantage of the above procedure, however, is the excessive carryover of fine particles with the drying gas. It is necessary that these particles be recovered in order to make the process commercially feasible, since the loss of the fines is extremely expensive. In addition, the problems of air pollution which have recently come to the fore now require that such fines not be discharged into the atmosphere. Today, in most areas, there is statutory prohibition of such discharge. A number of methods for removal of such particles has been developed, but have been shown to be quite expensive. An example in the use of bag filters or other dry recovery methods for separating the fine particles from the gas.

## SUMMARY OF THE INVENTION

I have invented a method which provides for removal of moisture from a particulate solid material and subsequent recovery of the fines contained in the removal gas, while allowing the moisture contained in the drying gas to be carried away. More particularly, with respect to a coal hydrogenation process, my invention involves the removal of the fines-containing drying gas from the particulate coal and passing the hot gas through a hydrocarbon liquid which is at a temperature higher than that of the gas. The fines are retained in the liquid, however, the moisture passes through the liquid and out with the gas. Numerous mechanical scrubbing methods for contacting the liquid and gas are well known in the art.

With respect to a coal hydrogenation process, the dried



pulverized coal is usually slurried in a hydrocarbon slurry oil, obtained either independently or from the hydrogenation process itself, and the slurry is then introduced into a catalytic hydrogenation zone. By use of my invention, it is possible to directly introduce the fines-containing hydrocarbon liquid into the reaction zone, so that an intermediate separation step of the fines from the carrying material is unnecessary. A further modification of my invention is the use of the slurry oil in the hydrogenation process as the scrubbing liquid for the fines-containing gas. In this manner, the hot gas, after having been passed through the solids material, is passed in contact with the slurry oil. The coal fines are then retained in the oil and passed into the coal hydrogenation zone, while the moisture contained in the drying gas is retained in said gas and passes out of the scrubbing zone in the form of a vapor. Since the liquid is at a higher temperature than the gas, the moisture will not be retained in the hydrocarbon liquid.

## DESCRIPTION OF THE DRAWING

The drawing is a schematic flow diagram of a particulate solids drying process.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

While my invention is applicable to any particulate solids drying process where it is required to remove the water vapor from the solids, and to recover the fines, it is particularly useful in coal hydrogenation processes wherein the liquid used to remove the fines from the drying gas can be introduced directly to the coal hydrogenation reactor. Specifically, in processes of the type disclosed in the Johanson U.S. Pat., Re.: 25,770 and the Schuman et al. U.S. Pat. 3,321,393, my invention is especially useful, since in those processes, a hot oil is removed from the reactor effluent and is used to slurry the pulverized coal for introduction into the reactor. Such processes use the so-called "ebullated bed" type of contacting systems, wherein the coal in an oil slurry, is passed upwardly with hydrogen through a catalytic contact zone at high temperatures and pressures. The solid coal passes through the expanded catalytic bed and is converted to liquid hydrocarbons therein. Gaseous and liquid effluents are removed from the reaction zone along with ash and unconverted coal. A selected portion of the effluent is recycled to a slurry tank where a slurry mixture of the hot oil and pulverized coal is made, said slurry being then passed into the reaction zone. A particular embodiment of my invention with reference to the coal conversion process described above, is shown in the drawing and is outlined as follows:

Particulate coal, at a nominal size of about 1¼" diameter at **10** is introduced to the drying and grinding zone **14** along with a hot gas at **12**. The only requirements for this gas is that it be inert to carbonaceous materials under the grinding and drying conditions and also that it be relatively moisture free. Gases, such as nitrogen, carbon dioxide, carbon monoxide and combinations thereof in addition to flue gases obtained from the combustion of fuel, etc., may be used. It would usually be more economical if gas which is readily available at the site, such as a vent gas from the hydrogenation process, is used as the drying gas. The temperature of the gas at the drying process inlet is substantially higher than that of the outlet, it being usual to introduce gas at about 500–700° F. and remove it at about 100–300° F. The contacting system used within the drying zone **14** may be of the fluidized bed type or other systems well known to the art.

After the contacting in zone **14**, the hot gas which contains water vapor and fines is removed through line **16** to scrubber **18**. Here the gas is contacted with a hot hydrocarbon oil from line **20**. The temperatures of the hydrocarbon liquid must necessarily be above that of the fines containing gas. It is normal in these processes for the oil to be at temperatures above 300° F. The scrubbed gas containing only the water vapor is removed overhead at line **22** while the hot oil containing the coal fines is removed through line **24**.

The dry pulverized coal removed from the grinding zone **14** through line **26** and the hot oil containing the fines in line **24** are introduced to a slurry tank **29**. The slurry is then introduced through line **28** to the coal hydrogenation reactor **30**.

As has been discussed above, the reactor system in zone **30** may be any of the numerous catalytic contacting systems known to the art such as the ebullated bed, slurry systems, etc. The gaseous and liquid products from the coal conversion step are removed through line **32**, hot vent gases are removed in line **12** and may be used as the drying gas by recycling back to the grinding and drying zone **14**. Alternatively, an independent inert gas source may be used. A hot hydrocarbon oil is removed from the reactor effluent in line **20** and is returned to the scrubber **18** for use as the scrubbing oil. Alternatively, an independent oil source external of the system may be used as the scrubber. The only requirements of said oil is that it be compatible with introduction to a coal hydrogenation reactor if recycle is desired and, also, that its temperature be higher than that of the gas containing the water vapor and fines. A temperature differential between the drying gas and the scrubbing liquid of at least about 20° F. is needed in order to assure minimum transfer of moisture from the gas to the oil.

In a process as described above for the treatment of 43 tons of coal per hour, the preferred conditions are as follows:

Feed:

Type—coal
Size (after grinding)—minus 40 U.S. mesh
Moisture:
  Initial—12 wt. percent
  Final—2 wt. percent

Drying gas:

Type—flue gas
Drying gas temperature:
  Inlet—650° F.
  Outlet—170° F.
Gas rate—43,000 $ft.^3$/min. measured at 170° F. (30 $ft.^3$/lb. coal feed)

Scrubber conditions:

Oil temperature—300° F.
Oil rate—230 bbl./hour

Obviously, many modifications and variations of the invention as hereinabove set forth may be made without departing from the spirit and scope thereof and, therefore, only such limitations should be imposed as are indicated in the appended claims.

What is claimed is:

**1**. In a process for the hydroconversion of solid carbonaceous materials selected from the group consisting of coal, lignite, peat and mixtures thereof wherein ground, dry carbonaceous solids are fed in a slurry to a reaction zone for conversion in the presence of hydrogen to hydrogenated products wherein the improvement comprises:

(a) drying the ground solid carbonaceous material in a drying zone in direct contact with a heated inert gas selected from the group consisting of nitrogen, carbon dioxide, carbon monoxide, flue gas and mixtures thereof;
(b) removing from said step (a) a gaseous effluent comprising inert gas, moisture and entrained solid carbonaceous material;
(c) scrubbing said gaseous effluent with a liquid hydrocarbon oil having a temperature of at least 300° F. and higher than the temperature of said gaseous effluent to remove said entrained solid carbonaceous material thereby forming a slurry;
(d) removing from step (c) an entrained solid carbonaceous material-free, moisture containing vent gas;
(e) passing said slurry to said reaction zone for hydroconversion.

**2**. The process of claim **1** wherein the temperature of the inert gas enters the drying zone between about 500 and about 700° F. while the temperature of the inert gas leaving the drying zone is between about 100 and about 300° F.

**3**. The process of claim **1** wherein, in the scrubbing step, a portion of the liquid hydrogenated products boiling above about 300° F., and formed in the hydroconversion of said solid carbonaceous materials, are used as the liquid hydrocarbon oil to form said slurry.

**4**. The process as claimed in claim **2** wherein the carbonaceous material is coal having a moisture content of about 12 weight percent, the coal being ground to about minus 40 U.S. mesh and wherein the inert gas is flue gas, the temperature of which prior to the contacting step is about 650° F. and after the contacting step is about 170° F., the rate of the gas through the contacting step being about 30 cubic feet per pound of coal feed, said rate being measured at 170° F. whereby the moisture content of the coal is reduced to about 2 weight percent and wherein the gas, after the contacting step, is scrubbed with slurry oil having a temperature of about 300° F. the oil feed rate to the scrubbing step being about 5.35 barrels per ton of coal feed.

**5**. The process as claimed in claim **3** wherein, in the scrubbing step, the vent gas temperature is less than about 300° F. and the slurry oil temperature is greater than about 300° F. and wherein the temperature differential between the gas and the oil is at least about 20° F.

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