

[54] **METHOD OF COMMINUTING OF MATERIALS AT LOW TEMPERATURES**

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 3,633,830 1/1972 Oberpriller 241/18
 3,818,976 6/1974 Ledergerber 241/17 X

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[57] **ABSTRACT**

Materials which became frangible at low temperatures e.g. synthetic-resin foil scraps, are comminuted by entraining the materials in a carrier gas and treating them with a low-temperature gas, e.g. nitrogen, to render them brittle. The brittle materials are then subjected to milling. The materials are entrained through the mill in the carrier gas while a subatmospheric pressure is maintained for both gas streams in the system.

[30] **Foreign Application Priority Data**

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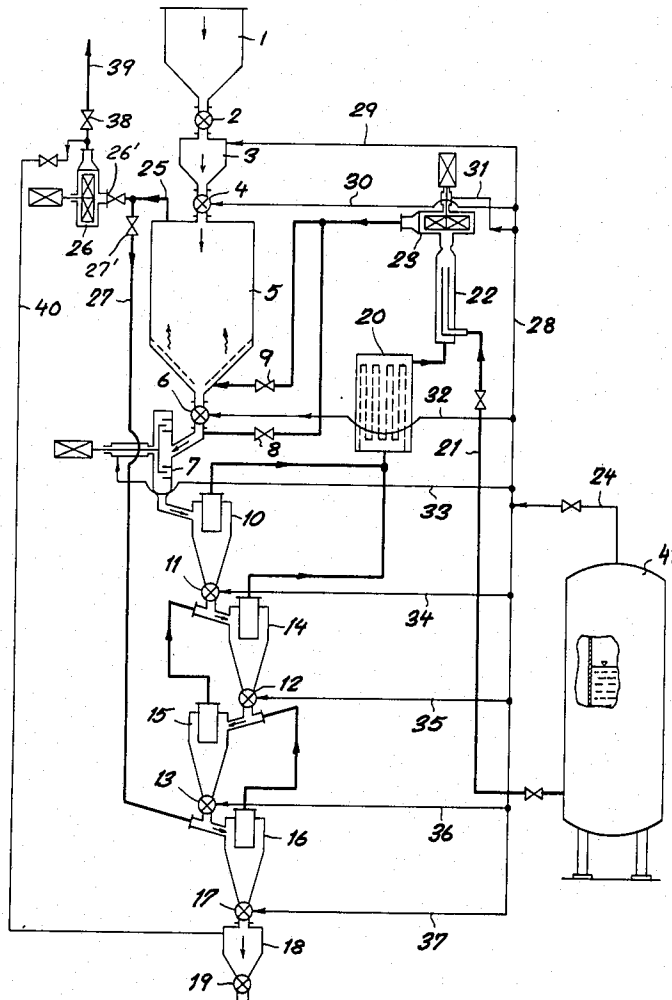
[58] Field of Search 241/17, 18, 23, 65, DIG. 37

[56] **References Cited**

UNITED STATES PATENTS

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5 Claims, 1 Drawing Figure



METHOD OF COMMINUTING OF MATERIALS AT LOW TEMPERATURES

FIELD OF THE INVENTION

The present invention relates to a method of comminuting materials frangible at low temperatures and, more particularly, to a system for the comminution of synthetic-resin foil scraps and the like which are embrittled at cryogenic temperatures and are milled at such temperatures.

BACKGROUND OF THE INVENTION

In the commonly assigned U.S. Pat. No. 3,633,830 there is described a system in which synthetic-resin foil scraps and like materials, frangible at low temperatures, are entrained in a carrier gas and are subjected to cooling by heat exchange with a cryogenic fluid, e.g. nitrogen, to embrittle the materials before they are introduced into a mill. The problem of comminuting materials which are soft, elastic or flexible has long been a subject of interest in the art and it has, in the aforementioned patent and elsewhere, been proposed to use low temperatures to bring about rigidification of the materials prior to or concurrently with comminution so that the materials can be subdivided, as stiff, hard or brittle materials, without the difficulties engendered by flexibility, stretchability or the like.

The technique has been used most effectively in the preparation of regrind, i.e. comminuted synthetic resins which are transformed from foil or sheet scrap into a powder for reuse in extrusion or other forming processes.

In general, the cooling-gas stream is brought into contact with the material to be milled while a carrier gas entrains the material into the mill and is conducted therefrom. The nitrogen is thus branched into a cooling-gas stream and a carrier-gas stream with the cooling-gas stream traversing the material to be milled in a cooling column while the carrier-gas stream subsequently entrains the material into the mill. A portion of the cooling gas after heating in the cooling column can be passed with a portion of the carrier gas separated from the product to a blower which generates the kinetic energy of the gas streams required to displace them and entrain the material to be comminuted, while liquefied gas is expanded into the gas to cool the latter. The injection of expanding liquid into the gas stream prior to its subdivision into the cooling gas portion and the carrier gas portion serves to abstract heat which has been picked up from the product to be chilled prior to and during milling.

From the point of view of energy economy, the process has a disadvantage. For the comminution of thermoplastic synthetic-resin foils, it is generally necessary to provide extremely low temperatures and hence relatively large volumes of cooling gas and thus to utilize large amounts of energy to generate the correspondingly large amounts of cooling gas which are necessary.

OBJECTS OF THE INVENTION

It is the principal object of the present invention to provide a low-temperature milling process or method which has a significantly lower gas consumption or greater gas utilization with cooling closer to the optimum levels than has been attainable heretofore.

Another object of this invention is to provide an improved method for the low-temperature milling of materials such as thermoplastic synthetic-resin foil straps.

SUMMARY OF THE INVENTION

These objects and others which will become apparent hereinafter are attained, in accordance with the present invention, with a system for the low-temperature milling of thermoplastic synthetic-resin foil scraps and like materials which become embrittled at low temperature, in which the material is subjected to chilling with a cool-gas stream and is conveyed to and through the mill in a carrier-gas stream and wherein, according to the key feature of the invention, both gas streams are maintained at a subatmospheric pressure within the system.

The present improvement is based upon by discovery that the use of a subatmospheric pressure at critical points in the system can provide a significant reduction in the energy consumption and gas throughput of a system for the low-temperature milling of materials of the type described.

With low-temperature milling, the "cold" of the cooling medium, e.g. gaseous nitrogen, is consumed to the greatest extent by gas friction. It is possible to evaluate the heat contributions to the system and hence the utilization of the "cold" injected into the system, in the following table (empirically derived):

TABLE

Consumption of Cold Introduced into System	
Gas Friction	80%
Cooling of Materials	10%
Convective and Conductive Losses	5%
Other Losses (leakage, withdrawn gas)	4%
Abstraction of Comminution Heat (milling)	1%

With turbulent flow in the mill at constant temperature and constant gas velocity, the energy consumed in friction is proportional to gas density and the latter is proportional to absolute pressure. The energy dissipated in friction is thus proportional to absolute pressure.

It will be immediately apparent that a reduction in the absolute pressure to which the gas in the system is exposed will lead to a corresponding reduction in the energy lost in friction in the system. Thus less cold and consequently less gas is required at reduced pressure and, in addition, there is a saving in electrical energy used for gas-displacement purposes.

The pressure reduction has the further advantage that it permits the increase of gas density with lowering temperature, which has hitherto caused significant difficulties in earlier systems, to be substantially completely eliminated. The problems arising from such increasing gas density in the region of the active tools of the mill are thereby eliminated and a more effective comminution is obtained since the kinetic energy of the material to be comminuted is less readily absorbed by the surrounding gas. The improvement is most pronounced, of course, in impact, pin and attrition mills.

The subatmospheric pressure is preferably generated by ejecting a portion of the gases into the atmosphere through a compressor so that the system sustains a subatmospheric pressure at the compressor or suction pump of 0.1 to 0.4 bar, preferably 0.2 bar. When the system of the present invention is compared with ear-

lier systems operating at a pressure of about 1 bar, a saving is empirically found in the proportionality between energy loss by friction and pressure, taking into consideration the cold losses of friction (see the foregoing table) of 80% (cold loss by friction) of 16% (proportionality factor between energy and pressure) of 1/5 (ratio of absolute pressure —0.2 bar— of present method to absolute pressure —1 bar— of conventional system).

According to another feature of the invention, the milled product is passed in counterflow to the cold gas stream traversing the system so that a portion of the "cold" carried by the milled product is taken up by the cooling gas and is eventually utilized in the system. This reduces losses of cold from the system and increases the thermal efficiency thereof.

In the present description it should be understood that a loss of "cold" is equivalent to absorption of heat and vice versa. Similarly, a gain of cold is equivalent to an abstraction of heat and vice versa, and it is only for convenience that gain and loss of cold are used in place of the loss and gain of heat, respectively.

It should be noted that the transfer of cold from the milled product and the warming thereof in heat exchange with the cooling gas to be used elsewhere in the system has the additional advantage that condensation upon the milled product because of moisture in the atmosphere when the milled product is at a temperature below the dewpoint of the atmosphere is avoided.

The heat transfer from the milled product is best carried out according to the invention by passing the milled product through a cascade of cyclones and recovering from the cyclones, gas which is cooled by injection of liquefied gas and mixed with the cooling and/or the carrier gas streams.

To prevent the entry of air and its moisture into the system it has been found to be advantageous to provide those portions of the apparatus which are not completely sealed against the atmosphere with a blocking gas preventing intrusion of moisture laden atmospheric air into the systems. The blocking gas can be provided at the inlet for the material to be milled and at the outlet for the milled product. The cold blocking gas can be drawn from the gas phase or space of a storage vessel for liquefied gas.

Of course, it is generally advantageous to provide all of the parts of the apparatus which are traversed with gas at a temperature below ambient with thermal insulation to limit the input of heat and therefore the loss of cold.

Apparatus for carrying out the process of the present invention comprises a mill at the discharge end of a cooling column or tower which is provided with an injector mixer via a filter as well as with a duct system having at least two compressors.

To generate the subatmospheric pressure in the milling installation and to displace the cooling and carrier gas streams through the two circulating paths, it has been found to be advantageous to provide two compressors such that one compressor is disposed in a duct leading to the mill while the other compressor is disposed in a duct opening into the atmosphere.

To rewarm the milled product and to cool the gases of the cooling column by mutual heat exchange, it has been found that cascaded cyclones provide the most effective results as heat transfer system. In general, gas-solid and similar heat exchange processes use other types of heat exchangers and it is indeed surprising that

a cascade arrangement of cyclonic gas-solid separators can provide the high level of heat transfer efficiency which has been obtained.

BRIEF DESCRIPTION OF THE DRAWING

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the sole FIGURE of the drawing which is a flow diagram of a system embodying the present invention.

SPECIFIC DESCRIPTION

The apparatus of the present invention comprises a hopper **1** whose funnel shaped bottom is provided with a cell-wheel gate **2** opening into an intermediate receptacle **3** having a funnel shaped bottom communicating by a similar cell-wheel or rotary-vane metering device **4** with a cooling column **5**.

The cooling gas is introduced to the perforated frustoconical bottom of this column **5** through a valve **9** and the cold solids pass through another rotary-cell metering device **6** into an impact pin or attrition mill **7**. The pin mill **7** has an axial inlet and a peripheral outlet as described and illustrated at pages 8 - 38 to 8 - 40 of PERRY'S CHEMICAL ENGINEERS' HANDBOOK, McGraw-Hill Book Company, 1963.

The product outlet of the mill, which is driven by an electric motor, communicates with the first cyclone of a cascade **10, 14, 15** and **16** of cyclones, each of which is separated from the next cyclone by a rotary gate **11, 12, 13** for metering solids while preventing backflow of gases. The last cyclone **16** communicates via a gate **17** with an intermediate vessel **18** whose rotary cell gate **19** dispenses the warmed granular product. A storage vessel for liquefied gas is represented at **41** and the liquefied gas may be injected via line **21** and a venturi-type mixer **22** into the system at the inlet of a compressor **23**. The other compressor of the system is shown at **26** and various ducts are provided at **29-37** to supply cold gas from a line **24** and the gas phase above the storage vessel **41** to the various valves, bearings and seals which are not hermetic, to serve as a blocking gas for release into the atmosphere or to prevent induction of moisture-laden air from the atmosphere.

In operation, the product to be milled, e.g. thermo-plastic scrap foil as described in the aforementioned patent, is fed from the hopper or storage receptacle **1** through the solids-metering gate **2** into an intermediate hopper or vessel **3** and is continuously metered via the gate **4** into the cooling column **5**.

In the cooling column **5**, the material to be milled falls in counterflow to the cooling gas introduced via valve **9**, the later flowing upwardly. The cooling gas, partly warmed by heat exchange with the product to be milled in the column **5** flows via lines **25** to the compressor **26** which opens into the atmosphere and discharges a portion of this gas via lines **39** and a valve **38**. The compressor **26** thus maintains a subatmospheric pressure of said **0.2** bar in the system.

The remainder (in a proportion determined by valves **26', 27'**) of the partly warmed cooling gas is recirculated via line **27** to the lowest cyclone **16** of the cascade **10, 14, 15, 16** wherein it is passed in direct heat exchange with the comminuted or milled product. The gas passes upwardly from cyclone to cyclone until from cyclone **10** and cyclone **14**, it is passed through a filler **20** and returned through the venturi mixer **22** to the

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inlet of the compressor 23. By admixture with expanding liquefied gas supplied at line 21, the gas is recooled and delivered at 9 to the cooling tower.

A portion of the gas stream displaced by the compressor 23 is branched via valve 8 to serve as a carrier gas entraining the cold material to be milled from the gate 6 through the mill 7. The carrier gas transverses the mill 7 with the cold material which is subdivided in the mill to a powder. The carrier gas and the powder enter the uppermost cyclone 10 of the cascade and the solid material passes from cyclone 10 through gate 11 to cyclone 14. The carrier gas is returned to the filter 20 at the cyclone 10. In cyclones 14, 15 and 16, the comminuted product is subjected to treatment with the previously warmed cooling gas stream as already described. The gates 2, 4, 6, 11, 12, 13, 17 and 19 may be of the rotary air-lock type illustrated and described at p. 7-33 of PERRY'S CHEMICAL ENGINEERS' HANDBOOK, op. cit.

Compressor 26 is so dimensioned that it draws off exactly the same volume of gas which is supplied by the tank 41. Thus, the subatmospheric pressure in the entire system remains constant, once established.

Compressor 23 and valves 8 and 9 are so set that the gas quantity per unit time fed by compressor 23 into the column 5 is greater than that removed from column 5 by compressor 26. Thus, the difference is passed by line 27 to the cyclone 16 and is circulated. The circulation of gases through the system is thus effected by compressor 23.

Thus compressor 23 passes a first portion of a carrier gas stream via valve 8 through the mill 7 along a closed path through the heat exchanger 20 and unit 22 back to the compressor 23.

A first portion of the cold gas stream is circulated along a closed path through the valve 9 to the cooling

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column 5 via line 27 to the cyclones 16, 15 and 14 in succession before being returned to the heat exchanger 20, unit 22 and the compressor 23.

A second portion of the latter gas stream is discharged via line 25 into the atmosphere through the compressor 26 and the first portion of the two gas streams are fed into one another just ahead of the heat exchanger 20.

In the unit 22 the cold gas stream emerging from the cascaded cyclones 16, 15, 14 is further cooled by the injections of liquefied gas at 22.

I claim:

1. in a process for the comminution of material at low temperature wherein the material is cooled by a cold gas stream and is entrained through a mill by a carrier gas stream, the improvement which comprises maintaining said cold gas stream and said carrier gas stream under subatmospheric pressure and by passing first portions of both said streams along respective closed paths, discharging a second portion of one of said gas streams into the atmosphere through a compressor, and feeding said first portion of the other of said gas streams into said first portion of said one of said gas streams.

2. The improvement defined in claim 1 wherein said subatmospheric pressure is substantially 0.1 to 0.4 bar.

3. The improvement defined in claim 2 wherein said subatmospheric pressure is substantially 0.2 bar.

4. The improvement define in claim 1 wherein the milled product and first portion of said cold gas stream are passed in counterflow through a plurality of cascaded cyclones.

5. The improvement defined in claim 4 wherein said gas stream emerging from said cascaded cyclones is further cooled by injecting liquefied gas therein.

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