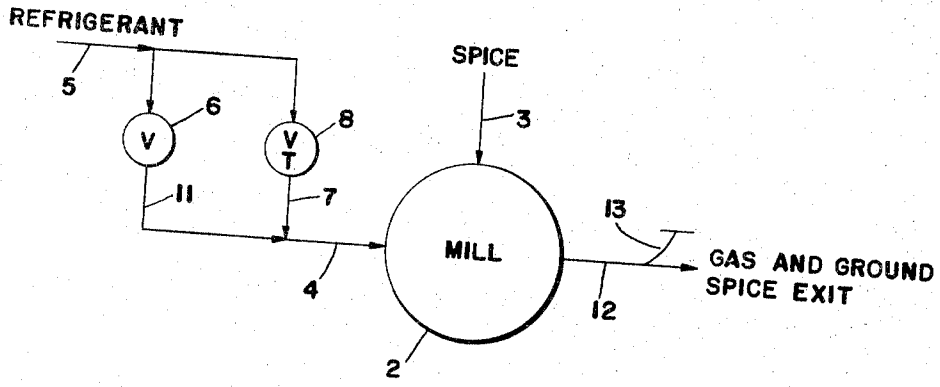
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A. M. COHODAS

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METHOD OF TEMPERATURE REGULATION IN A SPICE GRINDING PROCESS

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METHOD OF TEMPERATURE REGULATION IN A SPICE GRINDING PROCESS

Alvin M. Cohodas, Allentown, Pa., assignor to The Glidden Company, Cleveland, Ohio, a corporation of Ohio

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This invention relates to an improvement in process for grinding solid spices in the presence of normally gaseous refrigerant. Such grinding helps to retain the essential oil content of the spice while dissipating deleterious heat.

Related processes have been proposed featuring extremely cold grinding temperatures, regulation of solids spice flow from the grinder in response to desired grinding temperature, and pre-cooling of the spice in suspension of gasiform refrigerant, which suspension is subsequently fed to the mill. Problems encountered in such operations include undesirable condensation of atmospheric moisture vapor on resulting ground spice discharged to conventional classifying, packaging, and storage operations.

I found that grinding of the spice at a rate adapted to give a mill discharge temperature in a comparatively narrow range, i.e., above the atmospheric dew point, and below the spice deterioration temperature (in any case not in excess of 95° F.), provided a ground spice product of excellent quality suitable for year-around production. This product exhibited good retention of essential oils and was in desirable dry pulverulent condition as opposed to a pasty or semi-liquid condition. However, variation of the flow of solid spices to the mill in response to maintaining discharge temperature in this comparatively narrow temperature range is difficult and costly, particularly when atmospheric humidity is high, and it is generally impractical to maintain such control concurrently with optimum grinding loads for a particular machine. Using a fixed flow of solids and making the discharge temperature control responsive to the total volume of fluid refrigerant flow to the grinder appeared to be mechanically more efficient and simpler. However, when this expedient was tested, it proved to be impractical because the temperature varied wildly in spite of delicate flow adjustments.

The production problem was solved by the improvement in process which comprises: establishing and maintaining a fixed main fluid refrigerant flow to the milling zone and a smaller variable auxiliary fluid refrigerant flow to the milling zone, then maintaining temperature of resulting output refrigerant vapor substantially constant at a predetermined value above the ambient dew point and below the spice deterioration temperature by varying the rate of the auxiliary flow in response to temperature change in said resulting output vapor.

The attached drawing is a flow diagram showing a simple way of practicing the invention. Solid spice, **3**, flows at substantially constant rate into conventional swing hammer mill, **2**, driven by means not shown. Normally gaseous refrigerant, **5**, flows at constant rate through main valve **6**, lines **11** and **4**, and into mill **2**. A stream of ground spice and resulting vapor discharges from the mill through output conduit **12**, and the output gas temperature is measured by thermometer **13** in the conduit. Valve **6** is set manually relative to the spice feed to give initially an output vapor temperature 3–4° F. above the predetermined temperature between ambient dew point and the deterioration temperature of the particular spice being ground, said predetermined temperature being generally about room temperature (77° F.). Then a side-stream of refrigerant is admitted into the mill through auxiliary valve **8**, line **7**, and line **4** in amount sufficient to lower output vapor temperature approximately to its predetermined value. Thereafter, in response to temperature rise indicated on thermometer **13**, valve **8** is opened

wider; conversely, in response to temperature drop on thermometer **13**, valve **8** is throttled. The operation is readily adapted to automatic control with valve **8** being an automatic valve responsive to a conventional temperature-sensing element such as a thermocouple in place of thermometer **13**, the reference point for throttling of such automatic valve being the predetermined outlet vapor temperature.

Because of the high volume of output vapor relative to solid spice and their intimate mixing in the mill, the temperature of the output ground spice and output vapor are, for practical purposes, the same. Hence, sensing of the output vapor temperature substantially free of spice is satisfactory for controlling that of the spice and minimizing deposition of insulating solids on the temperature-sensing element, which would make control otherwise sluggish.

By the term "solid spice" or simply "spice" herein I mean to comprehend any of the various aromatic vegetable productions in the solid form, e.g., leafy materials, beans and seed products. Spices which I can and have ground are marjoram, thyme, sage, cardamon seed, black, cayenne and white pepper, clove, nutmeg, cassia, leek, cinnamon, gentian root, celery, anise, savory, cumin, coriander, mustard, tarragon, rue, parsley, angostura, ginger, onion, garlic, paprika, turmeric, rosemary and the like as well as mixtures of same.

The deterioration temperature of a spice is reached when an undesirable change occurs in the product being ground such as substantial deteriorative oxidation from air occluded in the spice feed, a physical transformation from a solid to liquid or pasty condition, or undesirable color change. The deterioration temperature for many spices is about 96° F. e.g., marjoram, thyme, cardamon, and mustard seed. However, some popular spices, e.g., oregano and sage, will exhibit deteriorative color change from green to unattractive brown at about 85° F., and nutmeg and mace become pasty at 90–95° F. Accordingly, I operate with an output vapor temperature not substantially in excess of about 85–95° F. depending on the sensitivity of the particular spice being ground.

To obtain the steadiest and most economical refrigerant feed rate consistent with maximum ground spice output rate from particular grinding apparatus, the temperature response range of the auxiliary refrigerant flow advantageously is less than about 10° F. and preferably about 5° F. or less.

Normally gaseous refrigerant for my purposes are those which are fluid in this use, that is, liquid, gas, or mixture of liquid and gas, and are gaseous at 72° F. and 760 mm. Hg total pressure. Suitable normally gaseous refrigerants include nitrogen, carbon dioxide, and innocuous halohydrocarbons. Because it needs no recovery system, leaves no undesirable odor or flavor with the spice, and avoids the solid phase problem which can arise with carbon dioxide, I prefer to use nitrogen as my normally gaseous refrigerant.

The fluid state of the nitrogen refrigerant for getting the most production from a particular mill will be dependent upon the spice being ground. Where an all gaseous nitrogen feed (—200° F.) can be used while getting maximum ground spice output, as for example in the case of grinding mustard seed, I use such nitrogen feed for simplicity. For some spices the maximum mill output of ground spice is obtained with a mixture of gaseous and liquid nitrogen, for example, the half liquid and half gas (by weight) feed which I use for the popular spices marjoram, oregano, thyme, and sage. With still other spices including decorticated cardamon, maximum mill output is achieved with an all-liquid nitrogen feed (—320° F.). Hence, I prefer to manifold both gaseous and liquid nitrogen to make a particular mill versatile with

respect to the variety of spices it can grind at maximum output.

I can use any milling apparatus useful for comminuting spices, which apparatus will contain the spice being ground in contact with the normally gaseous refrigerant. Such devices include hammer mills, attrition mills, pounder mills, pebble mills and the like. For efficiency and economy, I prefer to use a swing hammer mill.

Suitable temperature-sensing elements include those for placement in the output refrigerant stream, such as the pressure-filled expansion thermometers of the liquid-pressure, gas-pressure and vapor-pressure types. Alternative thermometer elements such as those formed of bimetallic materials can be located within wall portions of the ground spice conduit downstream of the mill discharge. With a thermometer designed for placement in the output refrigerant vapor, I advantageously position it away from the immediate grinding area, e.g., 10–20 feet downstream from the mill discharge. This minimizes sensing aberrations caused by deposition and build-up of ground spice on the element. For spices normally classified (sifted) right after grinding the sensing element is positioned as close as 1–5 feet from the mill discharge and only a few feet upstream of the classification apparatus. In such case, the temperature-sensing device can be connected to vibrating means, or placed for occasional tapping, if spice accumulations are experienced.

The following examples show ways in which my invention has been practiced, but should not be construed as limiting the invention. In the examples the mill used was a Fitzpatrick swing hammer mill, Model No. D–6, equipped with a 10 horsepower motor which drove the hammers at 7200 revolutions per minute, and it was connected for flow operation substantially as illustrated in the drawing.

Example I

Sage leaves were fed into the mill by auger at the rate of 300 pounds per hour. A mixture of equal parts, by weight, of liquid nitrogen (having temperature of —320° F.) and gaseous nitrogen (having temperature of —200° F.) was injected into the mill through the main valve in an amount sufficient to obtain initial output vapor temperature of 77° F. Then the main valve was pinched back to raise the output vapor temperature 3–4° F., and a bypass valve auxiliary to the main valve, connected to operate automatically in response to deviation in outlet vapor temperature from 77° F., was actuated. Outlet vapor temperature maintained itself thereafter within a few degrees of 77° F. The nitrogen feed rate averaged 25 pounds per hour of gas plus 25 pounds per hour of liquid. In the sustained automatic operation it was estimated that about 90% of the refrigerant entered the mill via the main refrigerant valve and the balance through the automatic auxiliary valve. One hundred per cent of the ground product passed through a 40 mesh U.S.S. screen. No browning (oil oxidation) or charring (vegetable fiber burning) of the ground sage was observed, and the ground sage was considered to have excellent odor and flavor.

Example II

Nutmeg was ground in the manner of Example I, at a rate of 400 pounds per hour, and with a nitrogen feed rate averaging 50 pounds per hour gas and 50 pounds per hour liquid. The ground product was dry and pulverulent, did not become pasty and displayed excellent odor and flavor. Fineness was 95% through a 24 mesh U.S.S. screen.

Example III

Decorticated cardamon was ground in the manner of Example I, except the nitrogen feed was all liquid. Feed rate of liquid nitrogen averaged 100 pounds per hour and cardamon feed rate was 200 pounds per hour. The ground product exhibited excellent flavor and odor and fineness was 95% through a 40 mesh U.S.S. screen.

Example IV

Mustard seed was ground in the manner of Example I, except that the nitrogen feed to the mill was all vapor (—200° F.); the nitrogen feed rate averaged 40 pounds per hour and the spice feed rate was 400 pounds per hour. The particulate product was considered to have excellent strong flavor and odor and 95% passed through a U.S.S. screen of 30 mesh fineness.

I claim:

1. In a process for the grinding of solid spice in a milling zone in the presence of normally gaseous refrigerant wherein spice to be ground and a flow of said refrigerant are fed to said milling zone and a suspension of ground spice in resulting vapor is discharged from said milling zone, the improvement which comprises: establishing and maintaining a fixed rate main refrigerant flow to said milling zone a smaller variable rate auxiliary fluid refrigerant flow to said milling zone; and maintaining temperature of resulting output refrigerant vapor substantially constant at a predetermined value above the ambient dew point and below the spice deterioration temperature by varying the rate of said auxiliary flow in response to temperature change in said resulting output vapor.

2. The process of claim **1** wherein said temperature of the resulting output vapor is maintained not substantially in excess of about 85–95° F.

3. The process of claim **1** wherein the temperature response range of said auxiliary flow is less than about 10° F.

4. The process of claim **1** wherein the refrigerant is nitrogen.

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A. LOUIS MONACELL, *Primary Examiner.*

H. H. KLARE, *Assistant Examiner.*