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PROCESS FOR THE COMMINUTION OF SILICEOUS IRON ORES

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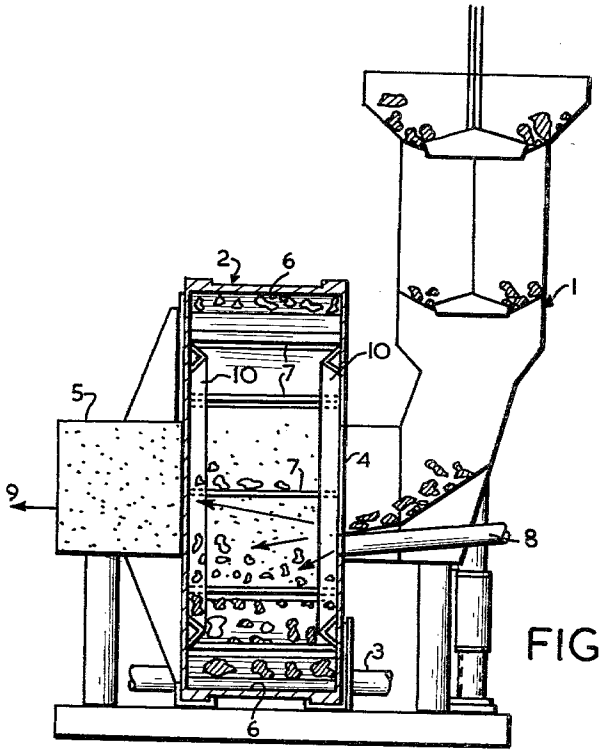


FIG. 1

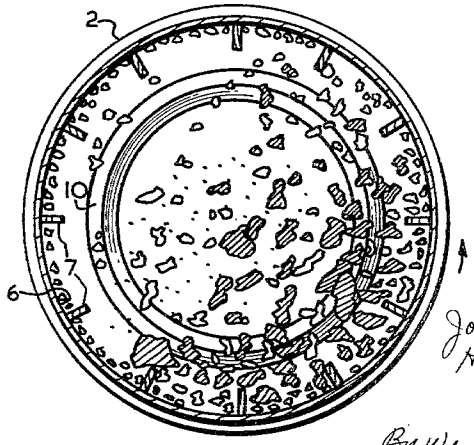


FIG. 2

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PROCESS FOR THE COMMINUTION OF SILICEOUS IRON ORES

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The present invention involves appreciation of the fact that mineral ores when exposed to high temperatures within the range 200 to 1300° C. in a chemically active atmosphere undergo intergranular cracking. The cracks are generated by volume charges in the ore particles caused by either chemical action or by thermal effects or both. For example, intergranular cracking in the quartz matrix of hematite-quartzite ore is caused by volume changes occurring during the reduction of hematite to magnetite. The propagation of cracks is assisted, especially at temperatures in the range 500° C. to 700° C. by stresses induced by the differences in the thermal expansions of quartz and hematite and by the anisotropic crystallographic inversion of quartz.

Intergranular cracking is also achieved in, for example, siliceous sulphide ores by subjecting them to high temperatures within the range 200 to 1300° C. in an oxidising atmosphere.

The primary object of the invention is to provide a process for the autogenous grinding or comminution of lump ores in which the ore is tumbled in a rotating grinding drum while being subjected to high temperatures in the presence of a chemically active atmosphere.

A further object of the invention is to provide a process for the autogenous grinding of siliceous iron ores at high temperatures in the presence of a reducing atmosphere.

Another object of the invention is to provide an apparatus for carrying out the process of the invention in which the ore particles furnish a self replacing lining affording thermal insulation and minimising wear of the grinding unit surface.

The process in accordance with the invention is a high temperature process for the autogenous grinding of ores characterised in that a lump ore is tumbled in a rotating grinding drum while being subjected to the influence of a chemically active atmosphere, the temperature within the drum being between 200° C. and 1300° C.

The invention also includes a process for the high temperature autogenous grinding of ores in the presence of a chemically active atmosphere, comprising the steps of feeding lump ore into a grinding drum fitted with lifters and rotated at speeds within 30% above or below the critical speed of the drum whereby a sufficient layer of ore is maintained on the inner circumference of the drum affording protection of the drum surface against wear and chemical action and providing thermal insulation.

Throughout the present specification the term "autogenous grinding" means that the ore material itself furnishes the principal grinding medium but includes also the use of minor amounts of an auxiliary grinding medium for example hard metallic balls, such minor

amounts not occupying more than 10% of the mill volume.

The term "critical speed" as used throughout the specifications refers broadly to a speed of rotation of any given size of rotatable grinding drum such that ore particles are maintained by centrifugal face against the internal surface of the drum. In conjunction with the use of lifters the speed of rotation so defined may include speeds varying within 30% above or below the precise critical speed. In this connection it will be appreciated that the ore material being treated in accordance with the invention is of irregular size and the critical speed refers to the speed at which the finer ore particles are retained on the internal drum surface. In a preferred embodiment of the apparatus the retention of ore particles on the drum surface is augmented by providing a series of lifters which continually collect ore material and promote sufficient coverage of the drum surface.

The process of invention is now more fully described with reference to the specific treatment of a hematite-quartzite iron or utilising the apparatus illustrated in the accompanying drawings.

In the drawings:

FIGURE 1 is a sectional elevation illustrating a preferred form of the apparatus and

FIGURE 2 is a transverse section of the grinding drum indicating the distribution of lump ore material in the course of autogenous grinding at or near the critical speed of rotation of the drum.

Cold or preheated lumps of hematite-quartzite are fed from a sealed hopper 1 into a hot rotating grinding drum or mill 2 which may or may not contain an auxiliary grinding medium for example metallic balls. A cylindrical form of grinding drum or mill fitted with end plate deflectors 10 is preferred. Alternatively a rotating cylindrical drum with conical ends may be employed. The grinding drum may be carried on rollers 3 or otherwise suitably supported. Appropriate gas tight seals are provided at both the inlet 4 and the exit 5 of the drum.

In operating the grinding drum it is advantageous but not essential to employ a rotational speed at or slightly below the critical speed so that an adherent protective layer of ore lumps is maintained on the inner circumferential periphery of the drum which may be provided with lifters 7.

It will be appreciated that the peripheral layer of ore material provides both a thermal insulation and protection against mechanical abrasion of the drum lining 6.

The grinding drum which operates at temperatures in the range 200° C. to 1300° C. but preferably between 400° C. and 700° C. at constant temperature in this range or at temperatures varying cyclically about a temperature of 600° C., may be heated in any way desired but for preference is heated internally through the partial combustion in a burner 8 of sufficient quantities of reducing gases constituting the chemically active atmosphere which may be preheated by heat exchange with the outgoing ore and gases or by combustion of bleed gases from the system.

The reducing gases are fed into the ore stream at or adjacent to its point of entry into the drum but may alternatively be fed countercurrent to the ore stream.

The ore in the drum is spalled through thermal shock, fissured by reduction, shattered by impact and ground

to fine powder through the tumbling action in the drum and is transported from the drum either in suspension in the outgoing reducing gases 9 or as a separate stream of material.

It is essential that the sizing of ore employed should be sufficiently large that the ore is autogenously ground and that full use is made of the effect of thermal shock in the communication of the lumps.

The particle size of the ore material is irregular and is not necessarily classified. Ore in lumps as mined or after primary or secondary crushing is suitable for use in accordance with the invention. However, where insufficiently large lumps of ore are encountered, then the employment of the previously defined minor amounts of auxiliary grinding medium is conveniently used to achieve the final comminution of the ore material.

The outgoing gases and solids may be classified in an elutriating column or other sizing equipment external to the mill, the oversize returning to the mill, the undersize or "product" passing either separately or with the stream of gases to a suitable plant where in cyclones or other separators the product is segregated from the main gas stream for despatch to a magnetic or other concentration plant. A proportion of the gas is bled from the main stream and the volume lost is replaced with make-up rich gas in such a manner that the average composition of the gas beyond the point of addition of the make-up gas is maintained constant. The make-up gas can consist principally of carbon monoxide or hydrogen or other gaseous reducing agent, produced in a separate gas making plant, from coke and coal, residual oils, or natural gas or other solid or liquid or gaseous material containing carbon and/or hydrogen. After the make-up gas has been added the mixed gases are then reheated and pass to the grinding unit where they maintain the temperature in this unit. Conveniently, but not necessarily, the reheating can be carried out using the gases bled from the main stream in order to adjust gas composition or by heat exchange with the gases and ore leaving the grinding mill.

The present invention is now described in more detail with reference to the treatment of hematite-quartzite ore as described in the following examples:

EXAMPLE 1

Hematite quartzite lumps analysing 24% Fe of size distribution:

	Percent
−2″+1½″	11.9
−1½″+1″	47.7
−1″+½″	29.9
−½″+¼″	10.5
−¼″	Nil

and liberating below 200 mesh BSS were continuously fed to an externally heated grinding drum fitted with lifters, and maintained at 580 to 600° C.

Reducing gases, 10% hydrogen in nitrogen, were humidified by the injection of 3% steam in order to suppress reduction to oxides of iron lower than magnetite, and were preheated before entering the mill. The gases left the mill at a linear velocity of 20 ft./sec. and elutriated a −10 mesh product, passing to a cyclone separator. To ensure that re-oxidation to hematite could not occur the separated ground product was kept in a reducing atmosphere until the temperature fell below 100° C.

Typical results and the details of a blank test in nitrogen A are given below:

Table I

Test	Ratio of wt. of grinding medium to wt. of ore in mill	Production rate tons/hr. per ton ore in mill		Davis tube magnetic separation test results			
				−10+200 mesh		−200 mesh	
		−10 mesh	−200 mesh	Percent Rec.	Grade Fe, percent	Percent Rec.	Grade Fe, percent
(A) Grinding, no reduction	0.8/1	0.09	0.03				
(B) Grinding and reduction:							
(a) Light ball charge	0.8/1	0.44	0.27	94.3	55.1	93.6	60.7
(b) Heavy ball charge	20/1	1.60	1.03	89.8	41.5	90.0	62.3

It should be noted that the weight of ore in the grinding drum in test B*a* was five times greater than in test B*b*.

EXAMPLE 2

Hematite quartzite ore, analysing 24.3% Fe, of size distribution.

	Percent
−4″+3″	6
−3″+2″	34
−2″+1″	35
−1″+½″	13
−½″+¼″	7
−¼″	5

and liberating below 200 mesh BSS, was autogenously ground at 85% of the critical speed in a 4 ft. diameter cylindrical grinding mill of the type illustrated. The mill was maintained at an average temperature of approximately 580° C. by the partial combustion of coke ovens gas in twin burners 8 of internal diameter 3″. The ore underwent rapid thermal cycling about this temperature the surface approaching the flame temperature of approximately 1200° C. and the drum wall temperature of approximately 500° C. at different points inside the drum. No auxiliary grinding medium was employed.

The mass of ore in the drum was maintained constant at 350±20 lb. by feeding cold ore through the double bell hopper 1. The ground product was elutriated from the mill at a rate of 3.9 lb. per minute or 0.65 tons/hour/ton in mill.

The size distribution of the product being:

−10 mesh+100 mesh	14.8
−100 mesh+200 mesh	20.9
−200 mesh+300 mesh	9.9
−300 mesh	54.4

Magnetic separation of the ground product yielded a concentrate analysing 60.7% Fe with an iron recovery of 91.0%.

EXAMPLE 3

To illustrate the invention further the following Table II gives results of test procedures in which hematite-quartzite lumps, −1″+¾″ in size, were batch milled at 600° C. in an externally heated smooth walled grinding drum.

The particles analysed 41.0% Fe and the liberation point of the hematite was estimated to be below 200 mesh.

The results of two blank tests A and B and typical grind reduction C are set out below:

Table II

Test	Ratio of weight of grinding medium to weight of ore in mill	Time, mins.	Size of product		Percent hematite reduced to magnetite
			Percent, ⅛"	Percent, 200 mesh, BSS	
(A) Grinding, no reduction	14/1	10	4.8	(1)	0
		20	6.2	3.8	0
(B) Reduction, no grinding.	0/1	10	1.2	Negligible [1]	29
		20	4.9	Negligible [1]	59
(C) Grinding and reduction.	14/1	10	65.7	59.0	78
		20	93.0	87.1	96

[1] Not determined.

In test A no reducing gases were admitted to the grinding drum; in tests B and C a reducing atmosphere of coal gas was maintained. In test B breakage by spalling occurred but grinding was suppressed by packing the ore in a perforated cylinder which rolled inside the mill. The percentage reduction of hematite to magnetite was determined by chemical and X-ray analyses. The −100 mesh product from test C after 20 minutes, on Davis tube magnetic testing yielding 94% recovery of iron in a grade analysing 61% Fe.

What we claim is:

1. Process for the high temperature autogenous grinding of ores, which comprises tumbling and autogenously grinding lump iron ore in a grinding drum fitted with lifters and rotated at speeds within about 30% of the critical speed of the drum while maintaining a sufficient layer of ore on the inner circumference of the drum to afford protection of the drum surface against wear and chemical action and provide a heat insulating medium, concomitantly providing the ore in the grinding drum with a chemically active atmosphere, and maintaining the temperature within the drum between 200° C. and 1300° C.

2. Process according to claim **1** in which the iron ore is hematite-quartzite ore and in which the temperature within the drum is about 500 to 700° C., whereby the hematite is reduced to magnetite.

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