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PELLETIZATION OF PHOSPHATE SHALE

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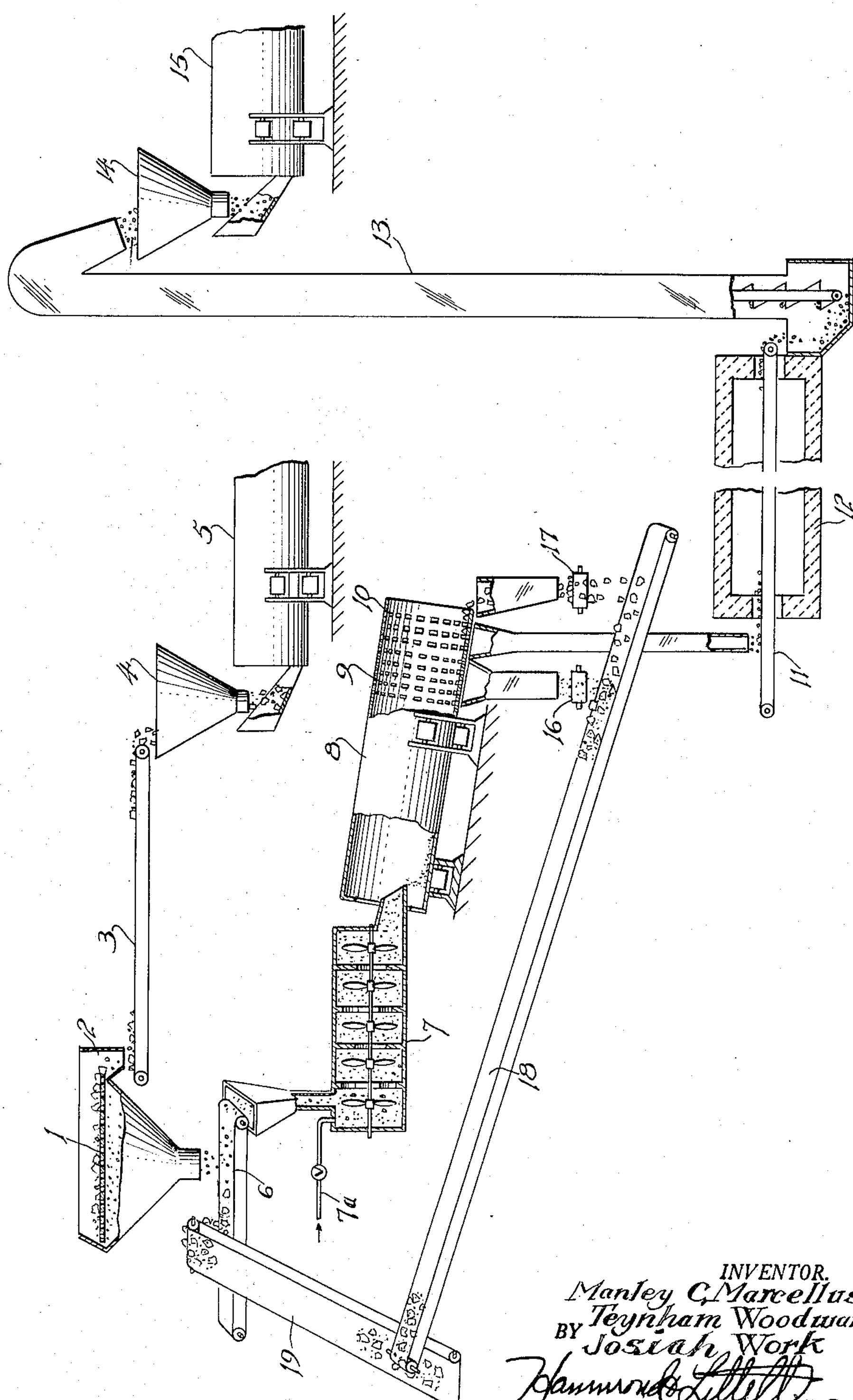

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PELLETIZATION OF PHOSPHATE SHALE

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This invention relates to the pelletization of phosphate shale to produce feed for electric phosphate smelting furnaces for the production of elemental phosphorus or phopshate compounds.

Electric phosphate smelting furnaces require a feed of phosphatic ore which has been calcined to decompose hydrated and carbonaceous material and which is of relatively coarse particle size, in the range of plus 6 mesh to 3 inches, to allow the escape of gases, generated or introduced during the smelting operation, through the furnace burden with a minimum of resistance. When the proportion of small material in the charge is too large, resistance to gas flow through the charge is high and there is a tendency of the fine material to fuse and arch above the slag pool. Gas pressure then increases until it is sufficient to break through the obstruction and thus causes puffs or blows in the furnace. Material passing a 3 inch screen and retained on a 6 mesh screen is satisfactory for use in an electric phosphate smelting furnace, but the proportion of smaller size material must not be large.

Considerable difficulty has been encountered in the economical production of suitable calcined feed for electric phosphate smelting furnaces from phosphate shales such as occur in the western portion of the United States, as tyified by those found in the vicinity of Pocatello, Idaho. The shale-like character of the phosphate deposits found in the western part of the United States and particularly in the States of Utah, Wyoming, Idaho and Montana is distinctly different than the sand-like phosphate deposits found in the southeastern part of the United States.

The shale as it is received from the mines, after crushing to minus 3 inch size, normally contains on the order of 60% minus ¼ inch particles and on the order of 40% of compacted rocks of a size of ¼ inch to 2 inches or more. If this material is fed to a calcining kiln operated at a hot zone temperature sufficient to effect heat nodulization of the shale, the amount of fine particle size material in the shale is so large that it cannot all be formed into satisfactory nodules or pellets by building on the coarse particles, and the result is that the dust forms a layer on the walls of the kiln which rapidly reaches incipient fusion, further lump shale becomes embedded in the fused layer or sticky mass and an adherent scale builds up rapidly in the hot zone of the kiln which requires reaming, shooting or boring of the kiln every two or three hours in order to prevent eventual plugging of the kiln.

This reaming or boring operation interferes with regular production, produces non-uniform product discharge, and also results in the discharge from the kiln of large slugs of fused calcined scale which must be cooled, broken and re-screened before feeding to the electric furnaces.

Alternatively, when the entire "mine run" product, crushed and ground to pass through a ¼ inch or ½ inch mesh screen, is fed to the calcining kilns and then calcined at a temperature which produces sintered nodules of the size required for electric furnace smelting, the fine

material sifts through the coarser pieces to the walls of the kiln, and the lower melting constituents of the fine and coarse fractions are heated to the fusion point. This causes stickiness and adherence of both fine and coarse particles to the walls of the kiln, so that a scale or ring builds up rapidly on the walls of the hot zone of the kilns, requiring frequent rodding, boring or shooting for the removal of the scale to keep the kiln open.

The delay occasioned by the removal of the scale or rings interferes with the regularity of the kiln operation and leads to non-uniform kiln discharge products. The large nodules of fused material, which may range from one foot to several feet in diameter, discharged as a result of the rodding or boring operations, are difficult to cool and break to suitable size for furnace feed, and the handling of these large nodules of hot material is extremely hard on the kiln and conveying equipment. Large balls are also formed by agglomeration of the fused material in the bed and these too are difficult to handle and put undue strain on the kilns and handling equipment.

When the whole phosphate shale is crushed to minus ¼ inch, moistened, passed through a pug mill and formed into pellets of ½ inch to 1½ inch size and the pellets dried and calcined in calcining kilns, much of it does not contain sufficient clayey material to act as a binder and the pellets are hence structurally too weak to withstand mechanical handling and conveying, kiln calcination and the necessary handling and compression pressures encountered in feeding them to the furnaces.

Washing the western phosphate shales, as is the practice in producing phosphorus and phosphate products from the phosphate sands in the Tennessee Valley phosphate deposits, as described for example in Chemical Engineering Report No. 4 of the Tennessee Valley Authority published in 1950, is impractical and does not produce a product which can be converted into a suitable furnace feed.

It is, therefore, an object of this invention to provide a method and process by which the entire phosphate ore used for electric smelting furnace feed, including both the coarse and fine fractions, from western phosphate shales may be calcined to produce suitable electric furnace feed and phosphorus or phosphate products.

Another object of this invention is to provide a method of calcining phosphate shales of the type found in the State of Idaho and other western states which will provide satisfactory and economical operation of the calcining kiln without the necessity for frequent boring and reaming of the kilns and without the production of excessively large lumps of calcined shale which need to be broken after removal from the calcining kiln and before feeding to the electric furnace.

Another object of this invention is to provide a method of concentrating the clayey or binder content of Idaho phosphate shales in the fine particle size fraction of these shales so as to provide sufficient binder to bind the fine particle size fraction into pellets of sufficient strength after calcining to withstand handling and pressures to which they are subjected in feeding to the electric furnaces.

Another object of this invention is to provide a method of preparing and calcining western phosphate shales for electric furnace feed which will permit operation of the calcining kilns at lower temperatures than possible in the heat nodulization of the whole shale and at the same time provide a more satisfactory product and better kiln operating conditions.

Various other objects and advantages of this invention will appear as this description proceeds.

We have discovered a method whereby the whole of the raw phosphate as received from the western phosphate deposits, such as found for example in southern

Idaho, may be economically processed to produce a suitable feed of sufficiently uniform size for electric phosphate smelting furnaces.

As indicated above, efforts to pelletize the crushed and ground entire mine run product gave results ranging from largely unsatisfactory up to totally unsuccessful, depending upon the particular source and character of the ore. Likewise, efforts to crush and grind only the coarse fraction of the mine output and then pelletize this material were also unsuccessful.

Surprisingly enough, however, when the fines fraction from the screening of the crushed mine run shale was pelletized it was found that this material pelletized satisfactorily and formed calcined pellets of sufficient strength to withstand subsequent furnacing operations.

This discovery has made possible the practical utilization of the large proportion of fines encountered in the typical processing of western shales, and has eliminated to a great extent the difficulties described above which were associated with prior art efforts to process the mine run product.

The utilization of our discovery has even made unnecessary the use of additional binder material or deflocculating agents, expedients which have occasionally been used in an effort to overcome the difficulties of the prior art. However, deflocculants such as sodium carbonate, sodium hydroxide and sodium polyphosphates, or the like, may be added for better deflocculation and dispersion of the clayey or binder content of the mineral, and additional binders may, of course, be used if desired.

In the practice of our invention, we, therefore, take the whole of the western phosphate shale as it comes from the mine and, after crushing to minus 3 inch size, separate it into two fractions consisting of approximately 40% of a coarse fraction which may range from a minimum of ¼ to ½ inch to a maximum of 2 to 3 inch size particles, and approximately 60% of a fine particle size fraction under minus ¼ to minus ½ inch size particles. The large size particles are fed to calcining kilns for calcination at suitable temperature conditions to decompose the hydrated and carbonaceous material and to sinter the material into pellets of sizes satisfactory for electric furnace feed. The fine particle size fraction is mixed with sufficient water (of the order of 12 to 15%) to produce satisfactory wet pellets of the order of ½ inch to 1½ inches in diameter, pelletized and dried in a quiescent bed to a moisture content of less than 6% and preferably less than 4%, and these pellets calcined to decompose the hydrated and carbonaceous material therein and form a satisfactory electric furnace feed. The pelletized fine fraction contains sufficient clayey binder (measured as particles of minus 200 mesh size) to form pellets of sufficient strength to withstand normal calcining, handling and furnace operations and produce calcined pellets of sizes suitable for feeding to electric furnaces, and the removal of the fines and dust from the coarse fractions produces a product which can be uniformly calcined to likewise produce a satisfactory feed for the electric smelting furnaces without excessive scale or ring formation on the walls of the kilns.

In the passage of both the coarse fraction and the pelletized fraction through the calcining kilns, certain breakage and dusting inevitably occurs. The amount of this breaking and dusting is relatively small and the broken and dusted particles will agglomerate and adhere to the larger particles to the extent that the build-up of a fused scale on the walls of the kiln in the hot zone of the kilns is very materially reduced.

Whereas, when operating on whole shale, build-up was so great as to require reaming or boring of the hot zone of the kiln every two or three hours, when operating with separate calcining of the coarse particle size fraction and the pelletized fine particle size fraction, it is not necessary to ream or bore the hot zone of the kiln more than once a day and no shooting of the scale or ring formation is necessary. This reduced scale build-up permits steadier operation of the kilns and reduces the formation of large fused nodules, which are dislodged in the boring operation, and, therefore, reduces the strain on the kilns and conveying equipment caused by these large fused nodules. The steady operation of the kilns results in higher production of calcined pebbles per operating hour and higher operating time giving a greatly increased capacity for the same equipment.

In addition to more satisfactory operation of the calcining kilns, it is possible to operate the calcining kilns at 150° to 300° C. lower bed temperature than when operating on whole raw shale. In order to produce satisfactory furnace feed charge when operating on whole raw shale, it was necessary to operate the calcining kiln at a bed or hot zone temperature of approximately 1300° to 1350° C., which also increased the tendency toward incipient fusion of the dust layer and lower melting constituents and scale or ring formation, whereas when operating on coarse and fine fractions of raw shale in which the fine fraction has been separated and wet pelletized, satisfactory calcining conditions may be obtained with a bed or hot zone temperature of approximately 1050° to 1200° C. This reduced temperature not only provides fuel economy, but permits a greater amount of shale to be heated to the required temperature and passed through the kilns in a given period and, therefore, increases the kiln capacity.

Where the whole shale contains of the order of 18% of claybearing or minus 200 mesh material, the minus ¼ inch fraction will contain about 30% of claybearing or minus 200 mesh material and the coarse fraction will contain about 8% of claybearing or minus 200 mesh material. While the minus 200 mesh material is not a direct measure of the available clay binder in the shale, it is proportional thereto and provides a convenient measurement of the binding properties of the fine particle size fraction.

By thus concentrating the clayey or minus 200 mesh material in the fine fraction sufficient binder is provided in this fraction to satisfactorily bind the entire fine or minus ¼ to minus ½ inch fraction so that it can be formed into wet pellets of suitable size for the electric furnace feed, and which, when dried and calcined, will be of sufficient strength to withstand handling and furnacing operations.

Where the whole shale contains more than 18% of clayey (minus 200 mesh) material, when separated into two fractions containing plus ¼ inch or plus ½ inch material and minus ¼ or minus ½ inch material, the fine fraction, which normally runs about 60% of the whole crushed shale, will have a larger percentage of minus 200 mesh or clayey material and the coarse fraction will have a smaller percentage of clayey material or binder. In either case, by separating the fine fraction from the coarse fraction of the shale, sufficient binder material will be concentrated in the fine fraction to permit satisfactory production of pellets by wet pelletization and calcining, and the coarse fraction is of sufficient strength and sufficiently free of dust to permit calcination without undue scaling of the calcining kilns or other complications.

Referring now to the drawings which illustrate one method of operating our process, the figure is a schematic layout of a plant design embodying the use of our process.

In the layout indicated, the raw shale as it comes from the mines or stockpiles passes over a vibrating or shaking screen 1 in which dust is removed from the coarse fraction, which may be plus ¼ inch or plus ½ inch size particles, and the larger size particles move along the screen and into a box 2 from which they are discharged onto a belt or other type of conveyor 3 which conveys them to the bin 4 from which the plus ¼ inch or plus ½ inch shale particles may be conveyed to the rotary inclined kiln

5 by any suitable feeding means. The fine particle size fraction consisting of minus ¼ inch or minus ½ inch material, including the dust from the coarser particles passing through the screen 1, is deposited on a belt or other conveyor 6 and passes into a pug mill or other mixing device 7 where water from the line 7*a* equal to about 12% to 15% of the fine particle shale is added and the material mixed. From the pug mill the particles pass into a rotating inclined pelletizer 8 which has suitable inclination and is rotated at a suitable speed to roll the particles of mixed shale into balls or pellets preferably from ½ to 1½ inches in diameter. The pelletizer 8 may be heated if desired to prevent the moist pellets from sticking to it and to give a dry skin coating to the pellets.

At the lower end of the pelletizer 8, a screen or perforations 9 permits material of minus ½ inch diameter to drop through the screen. The perforations or screen 10 at the lower end of the pelletizer 8 permits pellets of ½ to 1½ inches in diameter to pass through and the oversized material is discharged at the end of the pelletizer. The over-sized and under-sized material may be conveyed by any suitable means, such as belt conveyors 16, 17, 18 and 19, back to the belt 6 and passed again through the pug mill 7. The pellets of ½ inch to 1½ inches in diameter drop onto the belt 11 and are conveyed through a tunnel or other form of quiescent drying kiln 12 in which the moisture is reduced to below 6% and preferably to below 4%. From the end of the kiln 12 the pellets are elevated by means of a bucket elevator or the like 13 and are deposited in a bin 14 from which they may be conveyed into a rotary kiln 15. Tray, chain grate or pallet dryers are preferably used to dry the pellets in quiescent, thin layers until they have become hardened sufficient to withstand the subsequent handling which they must undergo in the calcining and furnacing operations.

In passage through the kilns 5 and 15, the phosphate shale is heated to a temperature preferably of above 1050° C. which is sufficient to decompose the hydrated and carbonaceous material therein and produce sintered nodules suitable for electric furnace smelting. As the dust has been removed from the coarse particle size fraction and the fine particle size fraction, including the dust, has been moistened, mixed and pelletized, there is much less dusting of the shale particles in their passage through the kilns and much less build-up of scale on the walls of the kilns in the hot zones thereof than in the calcining of the whole raw shale. The absence of a fused layer adjacent the walls of the kiln permits more ready transfer of heat from the flame to the tumbling bed of lump material and the fact that the lumps of shale in the absence of a fused scale layer can be satisfactorily calcined at about 150° C. to 300° C. lower hot zone temperature results in more satisfactory operation of the kilns and greater output.

While the plant has been illustrated as a schematic layout, it will be understood that the various elevators, conveyors, mixers and other devices are diagrammatically indicated and that other devices than those indicated may be used. In addition to pug mill 7, other mixing devices such as mullers and the like may be used to produce more thorough blending and mixing of the fine particle shale and water. Instead of feeding the coarse shale particles into kiln 5 and the pelletized shale particles into kiln 15, each kiln may be fed with a mixed feed of coarse particles and pelletized particles.

While we have described our invention and the advantages thereof with particular reference to rotary calcining kilns, many of the advantages of our invention are also obtained where shaft or other forms of calcining kilns are used, and various other modifications and changes may be made from the procedure and plant layout here described without departing from the spirit of our invention or the scope of the appended claims.

We claim:

1. The method of preparing an electric phosphate furnace feed from whole phosphate shale as mined and crushed to minus 3 inch size by increasing the clayey content of the fine fraction to permit pelletizing thereof, which comprises screening said shale to produce a fine particle size fraction containing the larger amount of the clayey material and a coarse particle size fraction substantially free from dust and containing a smaller amount of clayey material, calcining the coarse fraction to produce electric smelting furnace feed therefrom, moistening, pelletizing and drying the fine particle size fraction and passing the said pellets through a rotary kiln operated at a temperature above approximately 1050° C. to produce a pelletized electric smelting furnace feed therefrom.

2. The method of preparing an electric phosphate furnace feed from whole phosphate shale as mined and crushed to minus 3 inch size and containing about 18% of minus 200 mesh clayey binder material which comprises separating the whole crushed shale into a plus ½ inch and a minus ½ inch fraction and thereby producing a minus ½ inch fraction containing more than 25% of minus 200 mesh clayey binder material and a plus ½ inch fraction substantially free of dust, calcining the plus ½ inch fraction, moistening, pelletizing, drying and calcining the minus ½ inch fraction and using both fractions as a feed for electric phosphate furnaces.

3. The method of preparing an electric phosphate furnace feed from whole phosphate shale as mined and crushed to minus 3 inch size and containing about 18% of minus 200 mesh clayey binder material which comprises separating the whole shale into a plus ¼ inch and a minus ¼ inch fraction and thereby producing a minus ¼ inch fraction containing more than 25% of minus 200 mesh clayey binder material and a plus ¼ inch fraction substantially free of dust, calcining the plus ¼ inch fraction, moistening, pelletizing, drying and calcining the minus ¼ inch fraction and using both fractions as a feed for electric phosphate furnaces.

4. The method of preparing western phosphate shale for feed to electric smelting furnaces for the production of phosphorus and phosphatic products, which comprises crushing the mined shale into minus 3 inch particles separating the crushed mined shale into a coarse size fraction of about ¼ to 3 inch particles and separating dust from said coarse size fraction, and a fine size fraction of about minus ¼ inch particles containing a larger percentage of minus 200 mesh clayey binder material than the percentage of said minus 200 mesh clayey binder material contained in the whole mined shale, moistening, pelletizing and drying the fine particle size fraction, passing the coarse size fraction substantially free of dust through a calcining kiln operated at hot zone temperatures of approximately 1050° to 1200° C., and passing the pelletized fine particle size fraction through a calcining kiln operated at a hot zone temperature of approximately 1050° to 1200° C. thereby producing from the whole of the mined shale a final product all of which may be used for feed to electric smelting furnaces.

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