July 16, 1957 J. C. BARNETT ET AL 2,799,573

METHOD OF SINTERING ORES

Filed April 7, 1953 4 Sheets-Sheet 1

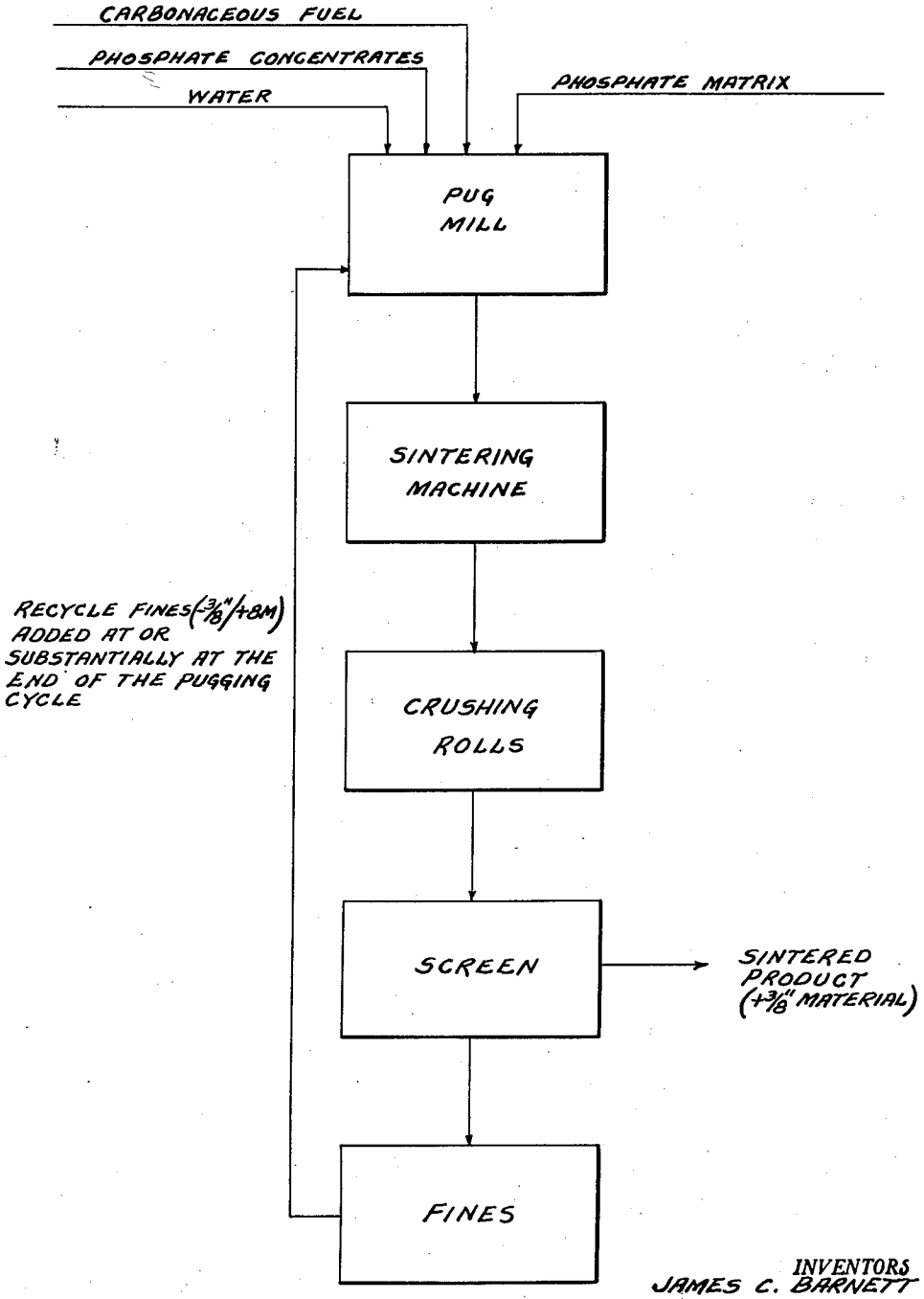
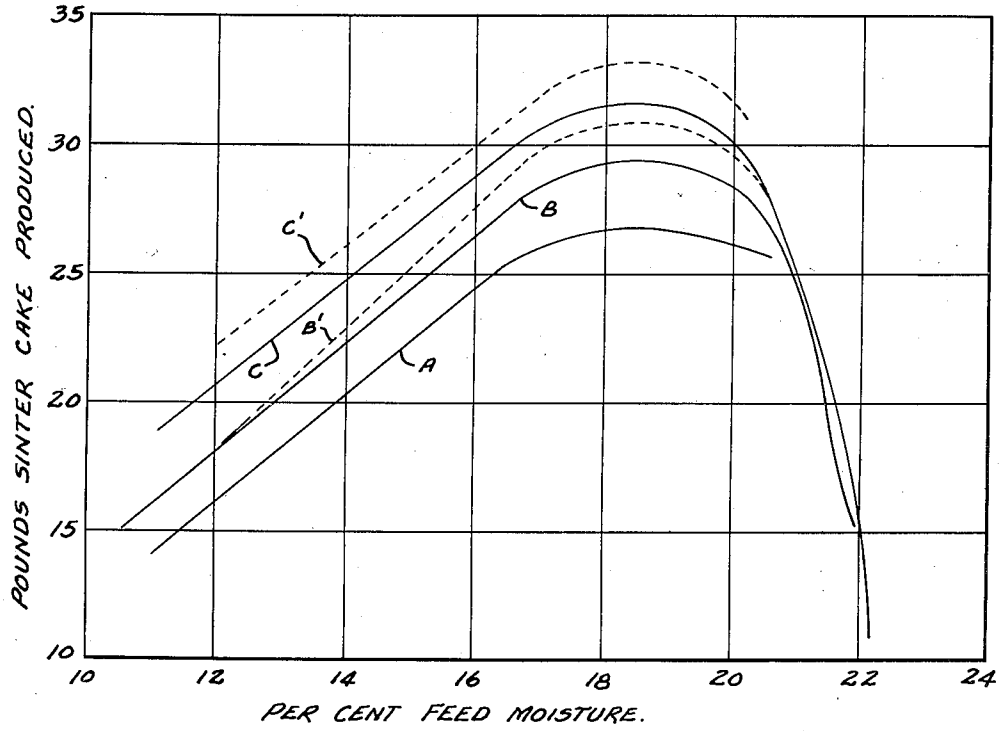


Fig. 1

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PHOSPHATE SINTER PRODUCTION AS A FUNCTION OF FEED MOISTURE WHEN VARIED AMOUNTS OF RECYCLE FINES WERE ADMIXED WITH THE SINTER FEED BOTH BEFORE AND AFTER PUGGING



LEGEND
A: 0% FINES
B: 10% FINES
C: 20% FINES
—— FINES PUGGED IN FEED.
---- FINES ADDED AFTER PUGGING.
ALL 30-70 RATIO MATRIX TO CONCENTRATES.

Fig. 2

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METHOD OF SINTERING ORES

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PHOSPHATE SINTER PRODUCTION AS A FUNCTION OF FEED MOISTURE WHEN 20 PER CENT FINES WERE ADMIXED WITH DIFFERENT TYPES OF SINTER FEEDS BOTH BEFORE AND AFTER PUGGING.

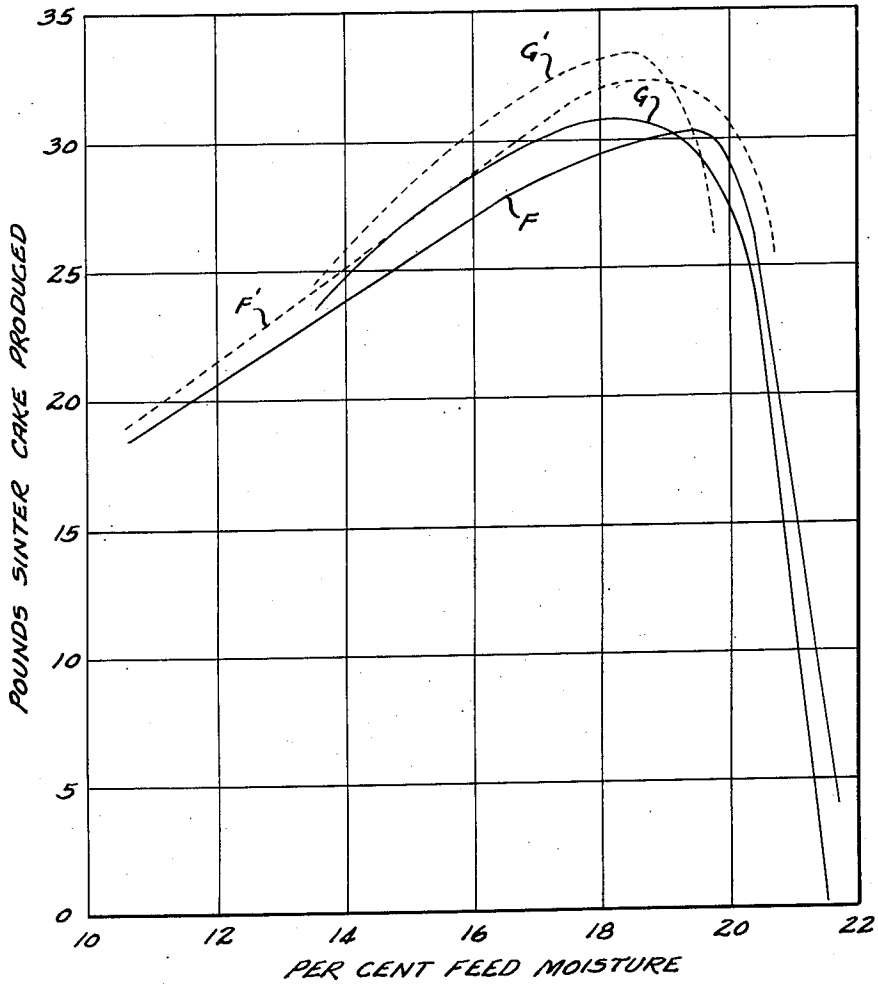


Fig. 3

LEGEND

F: 0-100 RATIO MATRIX TO CONCENTRATES
G: 50-50 RATIO MATRIX TO CONCENTRATES
—— FINES PUGGED IN FEED
---- FINES ADDED AFTER PUGGING
ALL 20% FINES

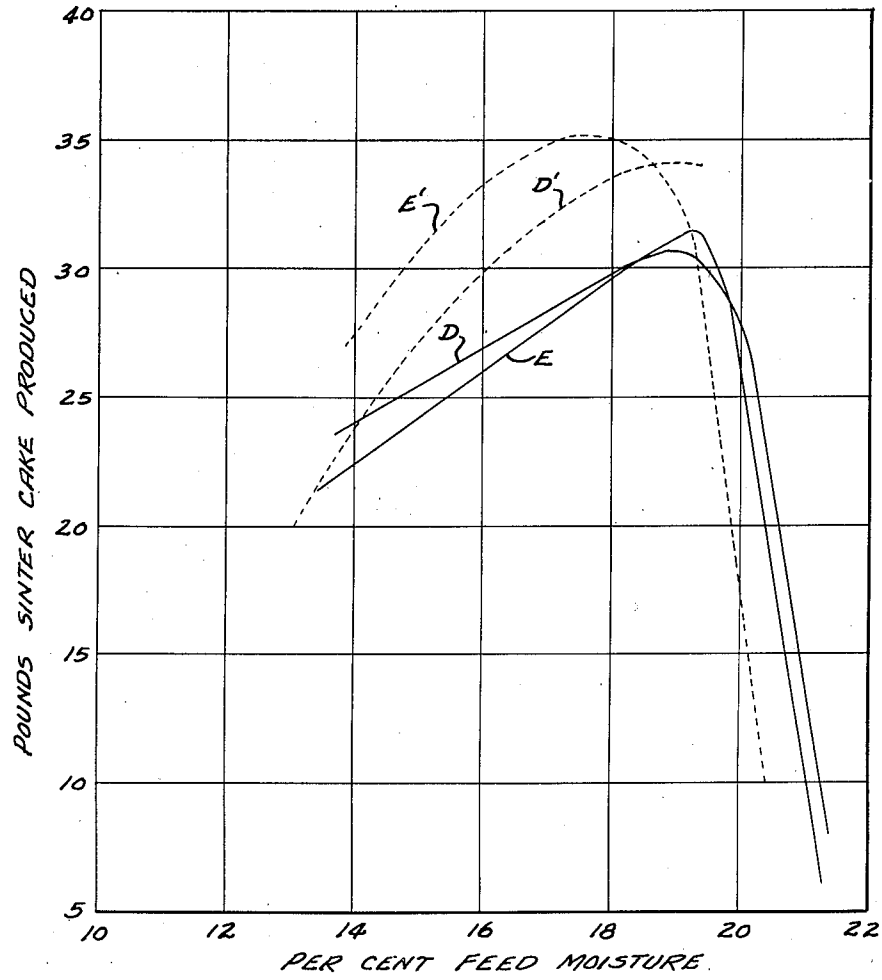
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METHOD OF SINTERING ORES

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PHOSPHATE SINTER PRODUCTION AS A FUNCTION OF FEED MOISTURE AND BED DEPTH WHEN THE RECYCLE FINES WERE ADMIXED WITH A TYPICAL SINTER FEED BOTH BEFORE AND AFTER PUGGING.



LEGEND

D: 8-INCH BED DEPTH
E: 10-INCH BED DEPTH
—— FINES PUGGED IN FEED
---- FINES ADDED AFTER PUGGING

ALL 30-70 RATIO MATRIX TO CONCENTRATES 20% FINES

Fig. 4

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METHOD OF SINTERING ORES

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Application April 7, 1953, Serial No. 347,372

6 Claims. (Cl. 75—5)

The instant invention is directed to the sintering of metal-bearing material, such as ores, concentrates and the like, to effect agglomeration of the particles. It is particularly concerned with the sintering of finely divided phosphate ores by blast roasting on a Dwight and Lloyd sintering machine.

An object of the invention is to provide an improved method of sintering which results in a substantial increase in sinter production and a substantial improvement in sinter quality as compared to prior art methods of sintering.

Another object of the invention is to provide an improved sintering method in which higher sinter yields are obtained when using the optimum amount of water in the sinter feed than has been heretofore possible by the methods of the prior art.

An additional object of the invention is to provide an improved sintering method in which the maximum production previously obtainable by prior art methods is now obtainable by using a sinter feed having a much wider range of water content.

An additional object of the invention is to provide an improped sintering method which permits burning of substantially deeper sinter beds and thereby increases the productive capacity of the sinter machine.

A further object of the invention is to provide an improved method of sintering involving the use of a sinter feed which permits higher gas flow through the bed and thus an increased flame propagation rate with a correspondingly higher production rate and without an increase in windbox suction.

A still further object of the invention is to provide an improved method of sintering which involves the use of a sinter feed having improved heat transfer characteristics during sintering and which results in decreased wear on the mixer during the mixing operation.

Other objects and advantages will become apparent to those skilled in the art as the description of the invention proceeds.

In the sintering of ores on a Dwight and Lloyd or equivalent sintering machine, a mixture of ore, carbonaceous fuel, water and recycle material from the prior operation of the machine is charged onto a moving grate and ignited by a flame while air is drawn downwardly through the grate into wind boxes which are connected to a source of reduced pressure. This serves to force the air downwardly through the material on the grate and thus combustion is propagated down through this material. Once the bed is ignited, the ignition flame is removed and the fuel content of the bed continues to burn as additional air is forced through the bed. The heat from such combustion causes the fine ore to sinter together and form a porous aggregate.

In the sintering of ores on a machine of this type, it has been the practice to use a sinter feed prepared by mixing together finely divided ore, coke or other carbonaceous fuel, a relatively small proportion of recycle fines and water. These materials, including the recycle

fines, have heretofore been mixed simultaneously, resulting in a sinter feed which possesses a rather low burning rate, thus limiting the production obtainable from the machine. In addition, this procedure has suffered from excessively high maintenance on the mixing device since the recycle material is very abrasive.

We have made the surprising discovery that the limitations encountered in the aforesaid method of sintering ores, and particularly phosphate ores, are overcome by the novel procedure hereinafter described. In accordance with this procedure, finely divided ore, a carbonaceous fuel and water are first intimately and uniformly mixed together in a pug mill or another suitable mixing device. Then at, or substantially at, the end of the mixing or pugging operation, recycle fines from a prior sintering operation are thoroughly blended with the mixture of ore, fuel and water. After completing this operation, the resulting feed is charged to the sintering machine and subjected to sintering in the usual manner. The sintered product is then crushed between rolls, on a metal bar grizzly screen or another suitable crushing device and screened to separate the fines from the oversize material which is the desired product. The fines thus obtained are recycled and used in the manner previously described in the production of further quantities of sintered product.

For a more complete understanding of the instant invention, reference is made to the accompanying drawings and the illustrative example hereinafter presented.

Figure 1 illustrates a flow sheet of the improved method of sintering of the instant invention.

As a modification of the method illustrated in Figure 1, the sintered product from the crushing rolls is passed through a two-inch grizzly screen to separate a +2" material as sintered product and a —2" undersized material. This undersized material is treated on a vibrating screen and separated into three fractions, namely, a —2"/+⅜" sintered product which is mixed with the +2" material, a —⅜"/+8-mesh material (recycle fines) and a —8-mesh product (dust) which is incorporated with the finely divided ore, carbonaceous fuel and water and charged to the pug mill or another suitable mixing device. The recycle fines are returned to the process in the manner shown in the flow sheet.

Figure 2 graphically illustrates phosphate sinter production as a function of feed moisture when varied amounts of recycle fines were admixed with the sinter feed before and after pugging.

As indicated in Figure 2, curves A, B and C demonstrate the effect of feed moisture on phosphate sinter production when 0%, 10% and 20% by weight of recycle fines were pugged in feed, whereas curves B' and C' show the effect of feed moisture when 10% and 20% by weight of recycle fines were added after pugging the feed.

Figure 3 graphically illustrates in curves F, F' and G, G' phosphate sinter production as a function of feed moisture when 20% fines were admixed with different types of sinter feeds before and after pugging.

Figure 4 graphically illustrates in curves D, D' and E, E' phosphate sinter production as a function of feed moisture and bed depth when the recycle fines were admixed with a typical sinter feed before and after pugging.

The description of a typical method and apparatus used in practicing the instant invention will now be given.

The apparatus used in practicing this invention consisted essentially of a laboratory pug mill and a sinter pot pilot plant.

The pug mill had a 24-inch diameter shell which was 32 inches long and rotated at 9.1 R. P. M. Inside this shell there was an eccentrically mounted shaft containing four rows of 5-inch cutter blades (12 blades per

row) which rotated at a speed of 177 R. P. M. and in an opposite direction from the shell.

The sinter pot pilot plant consisted of an 18-inch x 18-inch pot, which was 11 inches in depth and whose sides tapered downward to a 14½-inch x 14½-inch grate. Underneath the grate there was provided a 12-inch wind box with a 4-inch exhaust main about which the pot was pivoted so that it could be inverted to dump the charge. A blower fan was employed to draw air through the wind box at a rate which was measured by an orifice and controlled by an externally located control valve. Above the sinter pot there was a retractable ignition hood which was fired by a propane-air mixture.

The sinter feeds were prepared from stocks of sinter grade phosphate matrix, phosphate concentrates, recycle fines, recycle dust and anthracite dust. They were all prepared in the same manner except in those instances where the fines were withheld from the pug mill and mixed with the feed after the pugging operation. In these cases, the fines were mixed with the pugged feed by pouring the two through a 1-inch sample splitter, simultaneously. After the first split the two halves were simultaneously poured into a large pan and then poured back through the splitter and combined again.

The two types of sinter feeds were charged to the sinter pot pilot plant in exactly the same manner, that is, sixty pounds of the wet feed, except in those runs using sinter beds of varying depths, was charged into the sinter pot in such a manner as to provide a bed depth of about 6¾ inches. After a layer of coke fines had been sprinkled over the top of the charge to assure its complete ignition, a reduced pressure of 8 inches of water was produced in the wind box by opening the air flow control valve. The gas flow rate at this standard 8-inch suction was used as a criterion of the beds' initial po-

Table I

Sinter Feed Analysis		Gas Flow (Standard Cu. Ft. Per Min.)		Sinter Cake, lbs.	Percent −8-Mesh After Crushing	lbs. +8M Min.-Ft.² Grate Area	Comments
H_2O, percent	C, percent	8" H_2O	Average After Ignition				
12.6	------	52	42	17.0	25.9	1.55	
14.1	------	78	49	21.0	24.6	1.94	0% Fines Pugged In Feed, 30-70 Ratio.
16.5	------	109	60	25.5	24.2	2.38	
18.5	------	127	70	26.75	23.1	2.53	
20.7	------	157	----------	25.5	22.9	2.42	
10.6	------	37	37	15.25	26.3	1.38	
12.8	------	73	48	20.0	25.0	1.84	
15.2	9.0	103	59	24.5	23.6	2.30	10% Fines Pugged In Feed, 30-70 Ratio.
17.0	8.7	135	69	28.5	23.6	2.69	
18.4	9.0	148	75	29.5	23.0	2.67	
20.3	9.0	179	79	28.0	19.3	2.78	
22.0	------	161	94	15.0	21.2	1.45	
11.1	8.9	40	37	16.0	23.2	1.51	
13.9	------	85	49	21.5	21.7	2.06	
15.5	9.3	111	60	26.5	22.2	2.54	10% Fines Added After Pugging Feed, 30-70 Ratio.
15.5	------	108	64	26.5	19.9	2.61	
17.0	------	145	72	30.0	18.5	3.01	
19.6	------	156	75	30.25	20.9	2.94	
20.2	8.7	174	82	29.0	18.7	2.90	
12.6	8.6	93	48	22.0	21.6	2.12	
13.9	------	123	59	26.5	21.4	2.67	
14.7	------	110	59	26.5	19.2	2.63	
16.4	8.6	153	70	29.5	19.2	2.93	20% Fines Pugged In Feed, 30-70 Ratio.
19.0	8.5	179	77	31.5	16.8	3.22	
20.2	------	200	84	29.0	16.0	3.00	
22.2	------	171	108	11.0	20.9	1.07	
12.9	7.5	80	51	24.5	19.5	2.42	
15.7	------	135	69	29.25	18.9	2.92	20% Fines Added After Pugging Feed, 30-70 Ratio.
17.4	8.4	161	78	32.5	17.8	3.28	
19.3	------	195	87	33.0	15.8	3.42	
19.3	8.1	185	85	33.0	16.6	3.38	
10.6	------	57	35	18.5	22.5	1.76	
14.8	7.8	119	61	24.75	18.9	2.47	
15.8	------	132	64	26.75	18.3	2.58	20% FinesPugged In Feed, 0-100 Ratio.
18.4	------	156	74	29.75	14.8	3.12	
19.8	------	174	82	30.0	17.7	3.04	
21.7	------	172	------	4.0	--------	--------	
10.6	------	55	35	19.0	20.4	1.86	
14.6	------	132	66	25.25	18.9	2.52	
16.4	------	146	72	29.5	17.8	2.98	20% Fines Added After Pugging Feed, 0-100 Ratio.
18.3	8.1	175	82	32.25	16.8	3.30	
19.9	------	175	77	31.0	16.2	3.20	
20.8	------	184	89	25.25	19.3	2.51	
13.5	------	121	51	23.5	20.0	2.31	
15.6	8.5	152	61	28.0	20.0	2.76	
17.1	8.3	186	72	30.0	17.5	3.04	20% Fines Pugged In Feed, 50-50 Ratio.
17.7	8.5	188	73	30.0	16.3	3.09	
19.2	8.7	205	77	30.25	17.0	3.09	
20.5	8.3	------	90	22.5	15.9	2.32	
13.4	8.7	119	59	24.25	19.4	2.40	
15.4	------	165	70	29.0	17.6	2.94	20% Fines Added After Pugging Feed, 50-50 Ratio.
17.1	------	197	79	32.25	17.0	3.30	
17.7	------	220	89	31.0	15.9	3.21	
18.5	------	------	95	33.5	14.9	3.51	
19.82	------	------	100	26.0	15.3	2.76	
13.7	------	99	48	23.5	17.3	2.44	
17.4	7.8	143	67	29.0	16.9	2.98	20% Fines Pugged In Feed, 30-70 Ratio, 72 lbs. Charge, 8-Inch Bed.
19.0	------	174	81	30.75	16.4	3.16	
21.4	------	171	91	8.0	--------	--------	
13.1	------	84	55	25.0	20.0	2.46	20% Fines Added After Pugging, 30-70 Ratio, 72 lbs. Charge, 8-Inch Bed.
17.7	7.2	148	76	33.0	16.8	3.38	
19.4	------	189	86	34.0	14.7	3.56	
13.5	------	87	66	21.5	19.4	2.13	
17.9	7.7	127	76	29.5	16.9	3.01	20% Fines Pugged In Feed, 30-70 Ratio, 92 lbs. Charge, 10-Inch Bed.
19.3	------	147	74	31.5	17.7	3.18	
21.3	------	154	74	6.0	--------	--------	
13.9	------	96	55	27.0	18.1	2.72	
17.4	------	151	80	35.0	16.7	3.59	20% Fines Added After Pugging, 30-70 Ratio, 92 lbs. Charge, 10-Inch Bed.
19.1	------	160	83	32.5	16.2	3.40	
19.2	------	182	116	25.0	14.2	2.65	
20.4	------	177	106	10.0	--------	--------	

rosity. At this point the ignition hood was placed over the sinter pot and the wind box control valve opened further to allow the full application of reduced pressure.

The sinter bed was ignited for 40 seconds using a flame temperature of about 1350° C., whereupon the ignition hood was removed. In exactly 5 minutes after ignition commenced, the blower fan was cut off. During this period, the gas flow rate, the wind box suction and the wind box temperature were measured at one minute intervals. The sinter pot was then inverted and the cake dumped into a heavy metal pan. After the recovered charge had been weighed, the sinter cake was scraped free of all non-sintered material and weighed. When the sinter cake had cooled, it was crushed in a 10-inch roll crusher (⅞ inch roll spacing). The crushed fragments were screened through ⅜-inch and 8-mesh screens, the percentage of −8-mesh material being used as a criterion of sinter quality.

The instant invention is further illustrated by the following specific example which clearly demonstrates the advantages obtained by admixing recycle fines with the sinter feed after pugging. In this example, the sintering operation was carried out in the manner described above, using a sinter feed containing 0%, 10% and 20% by weight (dry basis) of recycle fines.

The properties of the sinter feed and sinter bed, the amount of carbon used and the quantity of sinter produced are given in Table I.

The expression "ratio" as used in this table has reference to the weight ratio of the phosphate sinter grade matrix to phosphate concentrates.

All feeds had same weight of fuel added except those used for deeper bed depths where fuel was proportionately increased. Variations in carbon content shown in the above table are due to experimental and analytical error.

The results recorded in this table are graphically illustrated in Figures 2, 3 and 4 of the accompanying drawings. From these figures, it will be observed that, regardless of the moisture content of the sinter feed, the amount of fines and the feed proportions used, or the bed depth, the sinter production was consistently increased when the recycle fines were added after the pugging operation.

In the practice of the instant invention, the recycle fines, i. e., the −⅜″/+8-mesh materials, are employed in an amount varying from about 5% to about 25% by weight of the sinter bed or, more specifically, from about 10% to about 20% by weight and within these limits about 15% by weight is preferred.

The fuel content of the sinter bed varies with the ore being sintered, but in general it falls within the range of about 2% to about 15% or, more specifically, in the range of about 7% to about 12% by weight of the bed.

More particularly, in the sintering of phosphate ores, the practice is to use a fuel content of about 6% to about 12% or, more specifically, about 7% to about 8% by weight of the bed.

Illustrative examples of fuels which may be used in the practice of the instant invention are coke, coal, peat, charcoal, hydrocarbons and other carbon-containing fuels.

The amount of water used in preparing the sinter feed may vary within the range of about 5% to about 21% by weight or, more specifically, within the range of about 16% to about 20% by weight of the sinter bed. Within the above range, a sinter feed moisture content of about 18.5% by weight is preferred.

The optimum percentages and percentage ranges stated above apply to phosphate sintering and it is to be understood that these variables will vary with the ore being sintered. Suffice it to say that they may be readily determined in each case by those skilled in the art and so no attempt will be made to state them here.

The admixing of the recycle fines with the sinter feed substantially at the end of or after the pugging operation, instead of before or during the principal portion of the pugging operation leads to a number of highly advantageous results.

For example, when using an optimum feed moisture of about 18.5%, the maximum yield of sintered product obtained by the method of the instant invention is invariably higher than that obtainable by the prior art method in which the recycle fines are pugged in the feed. This fact is clearly demonstrated by the accompanying graphs and also by the following typical experimental results.

Type of Sinter Feed (Matrix to Concentrate Ratio)	Optimum Feed Moisture, Percent	Fines Pugged In Sinter Feed, Sintered Product Produced, Lbs.	Fines Added After Pugging Sinter Feed, Sintered Product Produced, Lbs.
0–100 feed ratio	18.5	29.8	32.2
30–70 feed ratio	18.5	31.8	33.3
50–50 feed ratio	18.5	30.8	33.5

Moreover, by the method of the instant invention, the maximum sinter production achieved by the prior art methods at an optimum feed moisture of 18.5% may be obtained by the present invention over a wider range of sinter feed moisture content. As evidence of this fact, reference is made to the following typical experimental data.

Type of Sinter Feed (Matrix to Concentrate Ratio)	Feed Moisture Resulting In Maximum Sinter Production By Prior Art Methods	Feed Moisture Resulting In Equivalent Maximum Sinter Production By Method Of Instant Invention
	Percent	*Percent*
0–100 feed ratio	18.5	16.6–20.2
30–70 feed ratio	18.5	16.8–20.0
50–50 feed ratio	18.5	16.4–19.4

In view of the normal fluctuations which occur in the sinter feed moisture, the widening of the effective feed moisture range has the desirable effect of increasing sinter production and facilitating the control over the sintering operation.

In addition, the method of the instant invention makes passible the use of deeper sinter beds because of the higher sintering rate which may be employed. This burning of deeper beds not only results in increasing the productive capacity of the sinter machine but lowers the percentage of recycle to the machine. The reason for this is that thick sinter cakes have less abrasive surface and therefore yield less dust and fines. Thus, the addition of fines after pugging in accordance with this invention provides increased sinter production and better sinter quality.

Furthermore, the recycle fines retain their jagged edges when they are admixed after pugging; whereas, when they are pugged with the other components of the feed, they are coated with mud and converted into round, wet pellets which have poor heat transfer properties.

Also, the recycle fines are very abrasive and cause excessive wear and tear on the cutter blades of the pug mill when they are pugged in the sinter feed. In contrast thereto, the addition of the recycle fines to the sinter feed at, or substantially at, the end of the pugging operation results in a substantial reduction in the cost of maintaining the cutter blades.

What is claimed is:

1. The method of sintering ores, which comprises intimately mixing together finely divided ore, fuel and water, blending with said mixture recycle fines from a previous sintering operation and then subjecting the

blended product to blast roasting at a temperature sufficient to effect agglomeration of said ore; said fines, said fuel and said water respectively constituting about 5% to about 25%, about 2% to about 15%, and about 5% to about 21%, by weight of said blended product, and said blending step being carried out substantially at the end of said mixing operation.

2. The method of sintering ores, which comprises intimately mixing together finely divided ore, fuel and water, blending with said mixture recycle fines from a previous sintering operation and then subjecting the blended product to blast roasting at a temperature sufficient to effect agglomeration of said ore; said fines, said fuel and said water respectively constituting about 10% to about 20%, about 7% to about 12%, and about 16% to about 20%, by weight of said blended product, and said blending step being carried out at the end of said mixing operation.

3. The method of sintering phosphate ores, which comprises intimately mixing together finely divided phosphate ore, a carbonaceous fuel and water, blending with said mixture recycle fines from a previous phosphate sintering operation and then subjecting the blended product to blast roasting at a temperature sufficient to effect agglomeration of said ore; said fines, said fuel and said water respectively constituting about 10% to about 20%, about 7% to about 12%, and about 16% to about 20%, by weight of said blended product, and said blending step being carried out substantially at the end of said mixing operation.

4. The method of sintering phosphate ores, which comprises intimately mixing together in a pug mill finely divided phosphate ore, carbon and water, blending with said mixture recycle fines from a previous phosphate sintering operation and then subjecting the blended product to blast roasting at a temperature sufficient to effect agglomeration of said ore; said fines, said fuel and said water respectively constituting about 10% to about 20%, about 7% to about 8%, and about 16% to about 20%, by weight of said blended product, and said blending step being carried out at the end of said mixing operation.

5. The method of sintering phosphate ores, which comprises intimately mixing together in a pug mill finely divided phosphate ore, coke and water, blending with said mixture recycle fines from a previous phosphate sintering operation and then subjecting the blended product to blast roasting at a temperature sufficient to effect agglomeration of said ore; said fines, said coke and said water respectively constituting 15%, about 7% to about 8%, and about 18.5%, by weight of said blended product, and said blending step being carried out at the end of said mixing operation.

6. In the method of sintering phosphate ores, which comprises intimately mixing together sinter feed components comprising finely divided phosphate ore, carbonaceous fuel and water, and then subjecting the resulting product to blast roasting at a temperature sufficient to effect agglomeration of said ore, the improvement which comprises blending recycle fines from a previous phosphate sintering operation with said mixture; said fines, said fuel and said water respectively constituting about 10% to about 20%, about 7% to about 12%, and about 16% to about 20%, by weight of said blended product, and said blending step being carried out substantially at the end of said mixing operation.

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