April 16, 1963 T. J. REGAN 3,085,757

METHOD OF COMMINUTING PARTICULATE MATERIAL

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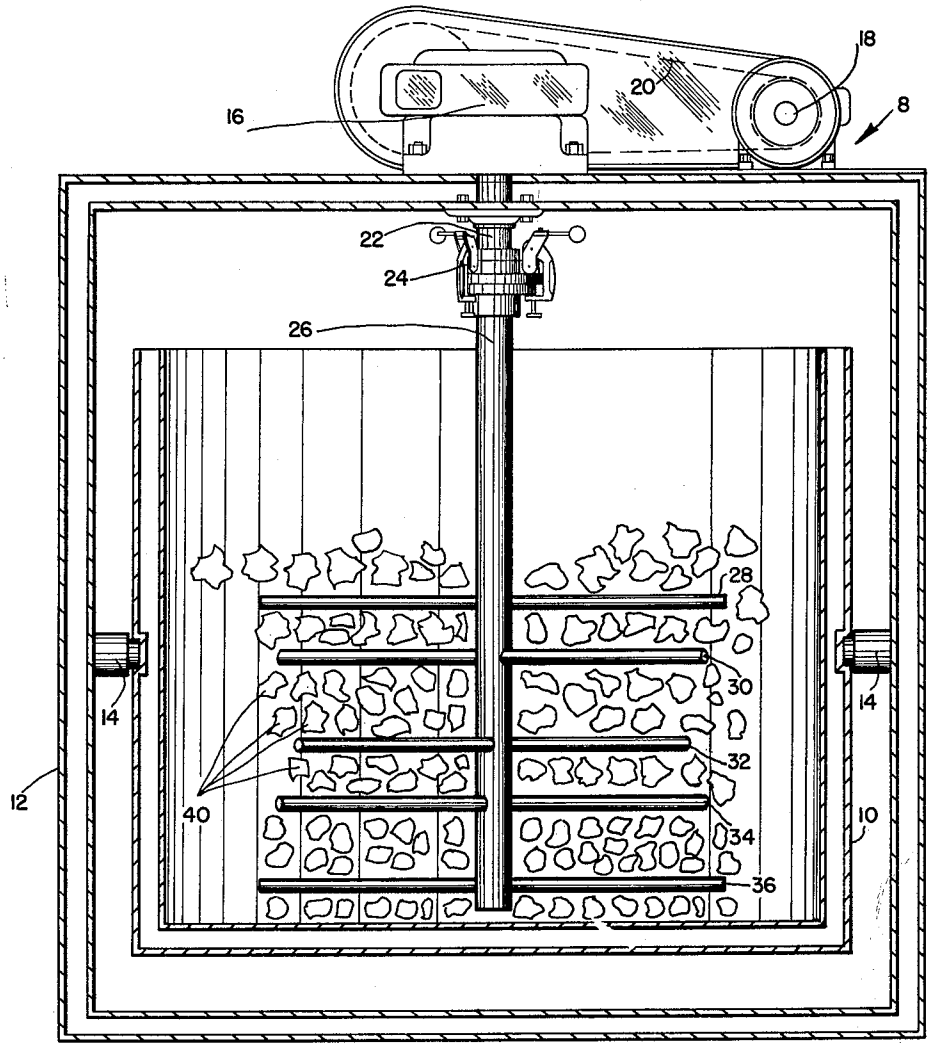


Fig. 1

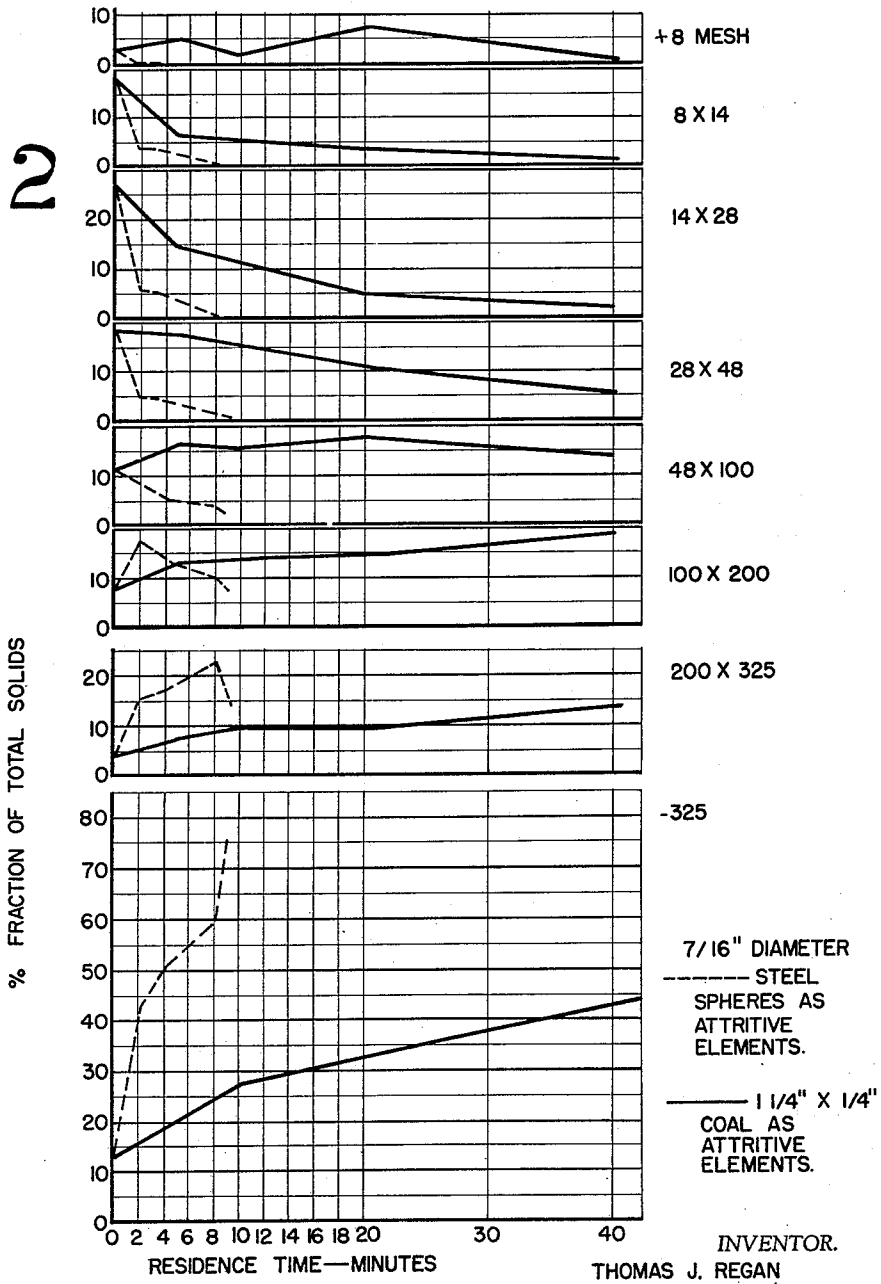
INVENTOR.
THOMAS J. REGAN
BY Stanley J Price Jr
his ATTORNEY

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Fig. 2



INVENTOR.
THOMAS J. REGAN

BY Stanley J Price

his ATTORNEY

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METHOD OF COMMINUTING PARTICULATE MATERIAL

Thomas J. Regan, Pittsburgh, Pa., assignor to Consolidation Coal Company, Pittsburgh, Pa., a corporation of Pennsylvania

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The present invention relates to an improved method of comminuting solid particulate material and more particularly to a method of attriting coal to a predictable particle size distribution.

In recent years, transportation of coal in a water slurry through long distance pipelines has become economically attractive. It has been found that a coal-water slurry containing coal particles having an increased percentage by weight of fine coal particles such as will pass through a 325 mesh Tyler Standard screen and, at the same time, having a significant percentage of relatively coarse coal particles such as will remain on an 8 mesh Tyler Standard screen is a preferred particle size distribution for pipeline transportation. Unfortunately, the proper percentages of fine and coarse particles do not occur in the natural particle size distribution of fine coal. The present invention is concerned broadly with comminuting coal having a naturally occurring particle size distribution to increase the fine fraction, i.e. through 325 mesh Tyler Standard screen particles and, at the same time, retain a significant percentage of the coarse fraction, i.e. on 8 mesh particles.

The present invention contemplates a novel comminuting method in which the coarser particle sizes are continuously replenished as will hereinafter be described. At the same time, the final particle size distribution of the comminuted product material can be predictably varied so that, within limits, a particulate material having a desired particle size distribution can be synthesized.

In U.S. Patent No. 2,764,359, issued September 25, 1956 to Andrew Szegvari, there is described and claimed a method for the "Treatment of Liquid Systems and Apparatus Therefor." That patent teaches the use of a vessel containing a plurality of hardened attritive elements such as steel spheres or the like to grind particulate material into very fine particles. As shown in the Szegvari patent, the hardened attritive elements are agitated within the vessel so that a large number of collisions take place between the attritive elements and the particles to be ground. The energy transfer resulting from the large number of collisions serves to comminute the particulate material.

The present invention broadly contemplates substituting large pieces of the particulate material to be comminuted for the attritive elements shown in the aforesaid Szegvari patent, thereby improving the treatment taught by the Szegvari patent. Further, the present invention contemplates feeding a range of particle sizes to the attritor vessel to permit control of the product particle size within predetermined limits.

It has been found that several advantages accrue from utilizing large pieces of the material to be attrited as the attritive elements within the attritor vessel. A primary advantage is that the top size particles may be continuously replenished from the attritive elements themselves as the attritive elements are worn and broken by use. Thus, when particles of coal are attrited for pipeline transportation, it is possible to increase the percentage of fine particles and, at the same time, preserve a significant percentage of coarse particles for advantageous transportation as hereinbefore discussed.

Another advantage accruing from the use of large pieces of the material to be ground as the attritive elements is

the fact that the degradation of the attritive elements does not contaminate the attrited product. While this consideration is of minor importance in the comminution of coal, it can be of prime importance in fields, such as the production of dyes and pigments, where small amounts of contamination can cause a large discrepancy in the quality of the finished product.

A further advantage of utilizing attritive elements formed from larger pieces of the material to be attrited is the fact that it is often difficult to separate the attried product from other types of attritive elements. For example, when grinding a coal-water slurry by a batch process in a vessel having steel spheres as the attritive elements, it was found that the slurry adhered to the surface of the steel spheres and had to be diluted and washed from the spheres. This problem is not encountered when coal is utilized as the attritive element. Since the present invention is equally adaptable to batch or continuous processes in the attrition of particulate material, this feature is significant.

With the foregoing considerations in mind, it is the primary object of the present invention to provide an improved method of comminuting particulate material.

Another object of this invention is to provide a method of attriting particulate material in a vessel by utilizing larger particles of the material to be attrited as the attritive elements.

Another object of this invention is to provide a method of attriting particulate material by which the particle size distribution of the product may be predictably varied.

Another object of this invention is to provide a method of attriting particulate material in which the product is not contaminated by degradation of the attritive elements.

These and other objectives achieved by the present invention will become apparent as this description proceeds. In the detailed description to follow, the invention will be described as it applies to the comminution of coal in a batch process. It is to be understood that other particulate materials can be comminuted by the process of the present invention and that the process can be adapted for continuous operation without departing from the scope of the invention. Throughout the following description, Tyler Standard screen sizes will be referred to for size designation and, therefore, reference to 8 mesh, or 14 mesh, without additional qualifying language is intended to be read as 8 mesh Tyler Standard screen or 14 mesh Tyler Standard screen as the case may be.

In the drawings:

FIGURE 1 is a schematic representation of the attritor vessel and attritive elements utilized to practice the present invention.

FIGURE 2 is a graphic representation of the change in particle size with increased residence time in the attritor vessel of FIGURE 1.

Referring now to FIGURE 1, there is shown an attritor **8** having a vessel **10** that is generally cylindrical and which is supported by a frame **12**. Vessel **10** is supported in frame **12** by trunnions **14** so that vessel **10** may be pivoted about the axis of trunnions **14** to empty vessel **10**. The supporting frame **12** has an agitator drive **16** mounted thereon above vessel **12**. Agitator drive **16** is drivingly connected to a motor **18** by belts **20**. The agitator drive **16** has a driven shaft **22** depending therefrom through frame **12**. Clamped to shaft **22** by a clamp **24** is an agitator **26** that extends into vessel **10** in coaxial relation therewith.

The agitator **26** has a plurality of radially extending arms **28**, **30**, **32**, **34** and **36** affixed thereto to provide agitation of the material within vessel **10** upon rotation of agitator **26** by drive mechanism **16**. As described thus far, the attritor **8** is similar to that disclosed in detail in the aforesaid Szegvari Patent No. 2,764,359. The at-

tritor is preferably of the type disclosed in that patent except for the attritive elements, although other similar attritor vessels may be utilized without departing from the scope of the invention.

Placed within vessel **10** are a plurality of attritive elements **40** which are large pieces of the particulate material to be ground in the attritor. Throughout this description, the attrition of coal will be discussed and, therefore, elements **40** will be lumps of coal. When other material is ground, relatively large pieces of that material are utilized as the attritive elements.

Table I has been prepared to show the difference in results obtained by using large pieces of coal as attritive elements as opposed to the use of steel spheres for that purpose. FIGURE 2 is a graphical representation, by particle size fraction, of the data tabulated in Table I.

TABLE I

Particle Size Distribution Change With Increased Residence Time in Attritor Vessel

1¼" x ¼" LUMP COAL AS ATTRITIVE ELEMENTS

Screen Size Fraction	Feed, Percent Wt. Fraction	After 5 Minutes, Percent Wt. Fraction	After 10 Minutes, Percent Wt. Fraction	After 20 Minutes, Percent Wt. Fraction	After 40 Minutes, Percent Wt. Fraction
+8 Mesh	3.2	5.6	2.3	8.3	1.5
8 x 14	17.7	6.9	5.1	3.7	1.4
14 x 28	26.6	14.1	11.0	5.0	2.6
28 x 48	18.0	17.4	15.3	10.4	5.5
48 x 100	10.8	15.8	15.5	17.0	13.2
100 x 200	6.8	12.9	13.9	14.1	18.3
200 x 325	4.1	7.2	9.6	9.2	13.5
−325	12.8	20.1	27.3	32.3	44.0

7/16" DIAMETER STEEL SPHERES AS ATTRITIVE ELEMENTS

Screen Size Fraction	Feed, Percent Wt. Fraction	After 2 Minutes, Percent Wt. Fraction	After 4 Minutes, Percent Wt. Fraction	After 8 Minutes, Percent Wt. Fraction	After 9 Minutes, Percent Wt. Fraction
+8 Mesh	3.1	0.2	0.1	0	0
8 x 14	17.7	4.3	3.5	0.4	0.3
14 x 28	26.6	6.6	5.7	1.1	0.6
28 x 48	17.8	5.4	4.6	1.9	0.6
48 x 100	10.6	8.7	5.3	3.7	1.8
100 x 200	7.0	16.6	13.3	10.0	6.1
200 x 325	4.2	15.3	17.0	23.4	14.1
−325	13.0	42.9	50.5	59.5	76.5

To obtain the data tabulated in Table I, a quantity of coal having a normal particle size distribution and which would all pass through a screen having ¼" openings was mixed with water to form a slurry having about 60% by weight solids, such as, for example, between a 50% to 60% by weight slurry and was introduced into the attritor vessel **10**. The attritive elements **40** were lumps of coal which would pass through a screen having an opening of 1¼" and which would remain on a screen having an opening of ¼". For brevity, the particle size of the attritive elements **40** is indicated as 1¼" x ¼" coal. The coal was attrited within vessel **10** by rotating the agitator **26**. The particle size distribution of the coal after varying periods of residence time under attritive action is shown in Table I. The coal was removed from the vessel **10** through a screen (not shown) having openings of ¼". Thus, all the product size fractions noted as +8 mesh on Table I are ¼" x 8 mesh since they pass through a ¼" screen opening and are retained on an 8 mesh Tyler Standard screen. It may be noted at this point that an attempt was made to attrite the slurry containing the 60% by weight of coal having a normal size distribution without attritive elements of any kind in the vessel. When agitated within the vessel without attritive elements, there was no significant particle size change in the slurry particles.

The feed to the attritor vessel was coal slurry of approximately 60% by weight of solids which would pass through a screen having ¼" openings and which had a normal particle size distribution. In a paper published in the "Journal of the Institute of Fuel," volume 7, October 1933—pp. 29–36, titled "The Laws Governing the Fineness of Powdered Coal," Drs. P. Rosin and E. Rammler of Berlin, Germany, set forth the statistically normal particle size distribution of a sample of comminuted coal. When plotted on a log-log scale versus particle size, the cumulative percentage by weight of the normal sample passing through each successively smaller Tyler Standard screen size is a straight line. The plot of size distribution of a log-log-scale has become known as a Rosin-Rammler plot and is discussed in detail in U.S. Bureau of Mines Information Circular No. 7,346 dated February 1946.

The "Feed Percent Wt. Fraction" column on Table I shows the percent by weight of the total normal sample of coal which remains on the particular screen designated to the left. Thus, for example, 26.6% by weight of the total normal sample passes through a 14 mesh screen but remains on a 28 mesh screen (14 x 28 screen size fraction). Moving horizontally across Table I for any particular screen fraction, the percentage by weight of the total sample which is that particular size may be determined for various periods of attrition within vessel **10**. Thus, if the previously discussed 14 x 28 fraction is selected it will be seen that when initially fed to the attritor, 26.6% by weight of the coal is of that size. After 5 minutes of attrition with 1¼" x ¼" coal as the attritive elements **40**, 14.1% by weight of the total is 14 x 28 mesh coal; after 10 minutes, 11.0% is 14 x 28 mesh; after 20 minutes 5.0% is 14 x 28 mesh; and after 40 minutes, 2.6% of the total sample is 14 x 28 mesh.

With a finer fraction, such as the through 325 mesh fraction (−325), 12.8% of the initial feed is −325 mesh, and after 40 minutes of attrition, the percentage of this size has increased to become 44.0% of the total sample.

The lower portion of Table I shows similar data when utilizing 7/16" diameter steel spheres as the attritive elements rather than larger lumps of coal. Here again, the change in particle size distribution with increased residence time can be determined by Table I. In both cases, with either coal or with steel spheres as the attritive elements, the initial feed has a statistically normal or natural particle size distribution.

To facilitate comparison of the attritive action of steel spheres and coal as attritive elements, FIGURE 2 has been plotted from the data of Table I. In FIGURE 2, the percentage by weight of the total sample of each screen fraction has been plotted against residence time in the attritor. From FIGURE 2, several characteristics of each type of attritive elements may be noted. First, attrition takes place much more rapidly with steel spheres as the attritive elements. For example, substantially all of the +8 mesh, 8 x 14, 14 x 28 and 28 x 48 fractions of coal have disappeared after 9 minutes of residence time when steel spheres are utilized as the attritive elements. Also, after a 9 minute period, 76,5% of the sample will pass through a 325 mesh screen. With 1¼" x ¼" coal as the attritive elements substantial portions of each size fraction remain even after 20 minutes of residence in the attritor and only 32.3% of the sample will pass through a 325 mesh screen.

As stated previously, for pipeline transportation it is desirable to maintain significant percentages of the +8 mesh particle size fraction while, at the same time, increasing the percentage of −325 mesh particles in the attrited product. By controlling the residence time within the attritor vessel, a desired size distribution can be obtained for the attrited product. This size distribution is statistically predictable and, therefore, the coal need not be screened for size to insure that the desired particle size distribution is obtained.

From FIGURE 2 it will be noted that with 1¼" x ¼" coal as the attritive elements, that +8 mesh fraction

of coal particle sizes is maintained at a relatively high level throughout the residence period within the attritor. It has been determined that comminution of the 1¼" x ¼" attritive element coal takes place within the attritor and that this coal contributes to the maintenance of a relatively high +8 mesh fraction level.

In the example presented in the upper portion of Table I, and plotted in solid lines in FIGURE 2, it was found that after 5 minutes residence time, the charge of 1¼" x ¼" coal attritive elements had decreased in weight by 8.9%; after attriting for 10 minutes, the charge of 1¼" x ¼" coal had decreased in weight by 14.1%; after 20 minutes it decreased by 43.6% and after 40 minutes it had decreased by 49.2%. The reduced or lost weight of the charge of 1¼" x ¼" coal attritive elements passed out of the vessel with the attrited product through the ¼" opening screen as part of the product. This fact accounts for the relatively high level of +8 mesh particles maintained in the product even though the fine, —325 mesh particles increased with increased residence time. When coal is utilized as the attritive element, there is a greater latitude in residence time for a particular particle size distribution and, therefore, coal attritive elements will more readily give the desired commercial results.

It has been found that attrition will take place within the vessel **10** with either dry particles or a water slurry.

A water slurry of the particles is preferred for most efficient attrition. Good results have been experienced with a water slurry having approximately 60% by weight of solids when fed to the attritor vessel **10**. The data of FIGURE 2 and Table I reflects the results of 60% by weight solids slurries when fed to a vessel containing 1¼" x ¼" coal attritive elements. As stated previously, if only coal particles passing through a ¼" opening screen and having a normal particle size distribution are placed within the vessel **10** without any type of attritive elements **40**, substantially no attrition of the particles occurs when the agitator **26** is rotated. Thus, attritive elements substantially larger than the particulate material to be attrited are required.

In summary it has been found that the attritive action can be more readily controlled by utilizing attritive elements made of the same material as the product to be attrited since the attrition takes place at a reduced rate; and residence time for a particular particle size distribution is not extremely critical. It has also been found that the percentages of fine coal particles can be increased and the percentages of coarser coal particles maintained at a significant level by utilizing coal as the attritive elements. The use of the same material as the product for the attritive elements prevents contamination of the product from degradation of the attritive elements and eases handling of the product since no difficulty in separating the product from the attritive elements is encountered.

According to the provisions of the patent statutes, I have explained the principle, preferred construction, and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiments. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. The method of preparing particulate coal containing a quantity of particles that remain on an 8 mesh Tyler Standard screen and a quantity of particles that pass through a 325 mesh Tyler Standard screen for transportation by pipeline so that the prepared coal product will contain an increased amount of coal particles that pass through a 325 mesh Tyler Standard screen and also contain coal particles that remain on an 8 mesh Tyler Standard screen, said method comprising the steps of:

(1) introducing said particulate coal into a vessel containing an inventory of attritive elements, said vessel having a vertical shaft with a plurality of arms extending radially therefrom, said attritive elements consisting essentially of coal particles that will pass through a screen having 1¼" openings but will be retained on a screen having ¼" openings,

(2) agitating said attritive elements and said particulate coal within said vessel by rotating said shaft,

(3) withdrawing a prepared coal product from said vessel through a screen having ¼" openings, and

(4) thereafter introducing said prepared coal product into a pipeline for transportation therethrough.

2. A method of preparing particulate coal containing a quantity of particles that remain on an 8 mesh Tyler Standard screen and a quantity of particles that pass through a 325 mesh Tyler Standard screen for transportation as a water slurry through a pipeline so that the prepared coal slurry will contain an increased amount of coal particles that pass through a 325 mesh Tyler Standard screen and also contain coal particles that remain on an 8 mesh Tyler Standard screen, said method comprising the steps of:

(1) preparing a slurry of said particulate coal and water, said slurry having a coal concentration of between 50 percent and 60 percent by weight,

(2) introducing said slurry into a vessel containing an inventory of attritive elements, said vessel having a vertical shaft with a plurality of arms extending radially therefrom, said attritive elements consisting essentially of coal particles that will pass through a screen having 1¼" openings, but will be retained on a screen having ¼" openings,

(3) agitating said attritive elements and said slurry within said vessel by rotating said shaft,

(4) withdrawing a prepared coal slurry from said vessel through a screen having ¼" openings, and

(5) thereafter introducing said prepared coal slurry into a pipeline for transportation therethrough.

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