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(54) **Process for producing a high concentration coal-water slurry.**

(57) A process for producing a coal-water slurry having a high coal concentration, a low viscosity and a good stability is provided, which process comprises causing the slurry to have a composition of coal particles so that when the particles are divided into 8 fractions, each having a particle diameter range listed below, then the proportions by weight of the particles contained in the respective fractions, relative to the total weight of the particles contained in the slurry can fall within the following numeral value ranges:

F_1: ($D_L/4$ to D_L) --- 29.0 to 50.0 % by weight
F_2: ($D_L/4^2$ to less than $D_L/4$) --- 20.0 to 25.0 % by weight
F_3: ($D_L/4^3$ to less than $D_L/4^2$) -- 12.0 to 15.0 % by weight
F_4: ($D_L/4^4$ to less than $D_L/4^3$) --- 6.0 to 10.0 % by weight
F_5: ($D_L/4^5$ to less than $D_L/4^4$) --- 3.0 to 12.0 % by weight
F_6: ($D_L/4^6$ to less than $D_L/4^5$) --- 1.5 to 5.2 % by weight
F_7: ($D_L/4^7$ to less than $D_L/4^6$) --- 0.8 to 4.0 % by weight
F_8: ($D_L/4^7$ to 0) --- 0.7 to 9.0 % by weight

wherein D_L represents the maximum particle diameter.

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PROCESS FOR PRODUCING A HIGH CONCENTRATION COAL-WATER SLURRY

This invention relates to a coal-water slurry, and more particularly it relates to a process for producing a coal-water slurry having a good stability, a high coal concentration and a low viscosity with minimal settlings.

Recently coal has come to be actively used in place of petroleum mainly at thermal power stations. However, coal in the form of solid fuel is difficult to handle; hence a large transport cost is required which is a great influence on the cost of coal itself. Thus techniques by which coal is slurried to make it possible to handle coal in the form of fluid have been energetically developed. One of the products thus developed is a mixture of heavy oil with coal (Coal and Oil Mixtures, hereinafter referred to as "COM"). In the case of COM, however, the ratio by weight of heavy oil to coal is about 1 : 1; thus COM cannot be regarded as a oil-free fuel and also its merit in respect of cost is small. Further, methacoal in the form of a mixture of methanol with coal also has a high cost; hence it has not yet been practically used.

On the other hand, CWM in the form of a mixture of coal with water (CWM: abbreviation of Coal-Water Mixtures) is sufficiently practical in respect of cost; hence it has recently been greatly noted. However, a problem raised in the combustion of CWM is water content in CWM. Even as far as its combustion efficiency is concerned, naturally the lower the water content, the better the efficiency, and in the case of direct combustion, a water content of 30 % or less is preferred. However, the lower the water content, the higher the viscosity of CWM; this raises a problem that when it is transported by way of pipeline or the like, the pressure loss increases.

Further, when CWM is practically used, a problem of storage is also raised. When CWM is stored in a usual tank, it is necessary for it to have a superior stability, but since CWM consists of coal particles and water, it is preferred to reduce their particle diameter, in order to inhibit coal particles from settling as much as possible. However, there is a tendency that when the particle diameter is reduced, the viscosity increases.

In order to overcome such drawbacks, it has been attempted to adjust the particle diameter distribution of coal particles to thereby prepare a CWM of the so-called "good stability" having a high coal concentration and a low viscosity with minimal settlings. However, coal particles are not completely spherical, and also the method of measuring the particle diameter of coal particles are various as follows: a method by means of sieves, a settling method represented by the "Andreasen Pipette," a method of analyzing the particle shapes by way of photographs of SEM (Scanning Electron Microscope) to calculate their representative diameter, etc. Thus, the definition of the particle diameter also varies depending on the measurement methods. This causes errors in adjusting the particle diameter distribution, and it becomes difficult to produce a CWM having a high coal concentration, a low viscosity and a good stability.

Now, the present inventors have considered that this problem might be solved by adjusting the particle diameter distribution according to a method of measuring the particle diameter distribution regarded as most adequate, and have made extensive research. As a result, we have succeeded in obtaining the objective CWM having a high coal concentration, a low viscosity and a good stability.

The object of the present invention is to provide a process for producing a coal-water slurry having a high coal concentration, a low viscosity and a good stability.

The present invention relates to a process in which the particle diameter distribution of coal particles is measured relative to all the particle diameter ranges according to a definite method for measurement and then the particle diameter distribution is adjusted so as to reduce the viscosity of a coal-water slurry at high coal concentrations and make particle settling minimum i.e. improve the so-called stability.

Accordingly, the present invention provides a process for producing a coal-water slurry having coal particles dispersed in water, which process comprises causing the slurry to have a composition of coal particles, so that when the coal particles are divided into 8 fractions (F_1, F_2, ------- and F_8), each having a particle diameter range listed below (($\text{from } D_L/4 \text{ to } D_L$), ($\text{from } D_L/4^2 \text{ to less than } D_L/4$), ----- ($\text{from } D_L/4^7 \text{ to } 0$), wherein D_L represents the maximum particle diameter of the coal particles), then the proportions by weight of the coal particles contained in the respective fractions, relative to the total weight of the coal particles contained in the slurry fall within the following numerical value ranges:

F_1: ($D_L/4$ to D_L)	29.0 to 50.0% by weight
F_2: ($D_L/4^2$ to less than $D_L/4$)	20.0 to 25.0% by weight
F_3: ($D_L/4^3$ to less than $D_L/4^2$)	12.0 to 15.0% by weight
F_4: ($D_L/4^4$ to less than $D_L/4^3$)	6.0 to 10.0% by weight
F_5: ($D_L/4^5$ to less than $D_L/4^4$)	3.0 to 12.0% by weight
F6: ($D_L/4^6$ to less than $D_L/4^5$)	1.5 to 5.2% by weight
F_7: ($D_L/4^7$ to less than $D_L/4^6$)	0.8 to 4.0% by weight
F_8: ($D_L/4^7$ to 0)	0.7 to 9.0% by weight

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings, in which:

Fig. 1 shows a chart illustrating the particle sizes of low viscosity slurries and cumulative particles diameter distributions thereof when produced in accordance with the present invention.

Fig. 2 shows a bar chart illustrating particle diameters and proportions by weight of the respective fractions.

Fig. 3 shows a diagram illustrating the relationship between particle diameter distributions and slurry viscosities.

Fig. 4 shows a chart illustrating the relationship between particle diameter distributions and stability.

Fig. 5 shows a chart illustrating the relationship between the amount of dispersant added and viscosity.

Fig. 6 shows a chart illustrating the relationship betweeen pH and viscosity.

Fig. 7 shows a chart illustrating the relationship between the amount of ultrafine particles of 0.05 μm or less added and stability.

Fig. 8 shows a view of piping system illustrating an embodiment of an apparatus for producing CWM.

Figs.9 and 10 each show a chart illustrating the particle diameter of slurry produced by the apparatus of Fig. 8 and cumulative sieve pass proportion by weight.

The present invention will be described referring to the accompanying drawings.

Coal is ground in wet or dry manner by means of a mill and a part of the resulting particles is taken to measure their particle diameter distribution. In measuring the particle diameter distribution, it was considered that the weight proportion of finely divided particles had a great influence upon the viscosity and the stability relative to the setting of the slurry. Thus in an example, the particles were divided into the following 8 fractions (each a constituent part as a group), and the respective fractions were each sieved by a sieve most adequate thereto (e.g. sieve according to JIS standards or millipore filter having the particle diameter well adjusted) to measure the weight of the fraction.

In the following list, D_L represents the maximum particle diameter of particles. F_1 to F_8 represent symbols of the respective fractions.

Particle diameter range

F_1: from $D_L/4$ to D_L
F_2: from $D_L/4^2$ to less than $D_L/4$
F_3: from $D_L/4^3$ to less than $D_L/4^2$
F_4: from $D_L/4^4$ to less than $D_L/4^3$
F_5: from $D_L/4^5$ to less than $D_L/4^4$
F_6: from $D_L/4^6$ to less than $D_L/4^5$
F_7: from $D_L/4^7$ to less than $D_L/4^6$
F_8: from $D_L/4^7$ to 0

In the present invention, particles were divided into 8 fractions for measurement, but the number of fractions is not always limited to 8, but practically it may be from 5 to 15 unless the distribution of the particle sizes changes.

More than one kind of coal or coal slurry were mixed so that the constituent proportions by weight of F_1 to F_8 might have a certain value, respectively, and if necessary, water was added for adjusting the water content, to study their viscosities. In this case, if the maximum particle diameter D_L is too large, the amount of unburned matter at the time of combution increases, while if it is too small, the slurry viscosity increases; hence the maximum particle diameter D_L was made from 44 to 420 μm.

Further, a certain kind of coal was chosen and the proportions of fractions were varied to study the influence upon viscosity. Further, when proportions of fractions exhibiting a relatively low viscosity were converted into cumulative distributions, a tendency was found. Fig. 1 shows a chart illustrating the relationship between the particle diameter and the cumulative sieve pass weight proportion in the case where three kinds of slurries (No.1 to No.3) were prepared from coal A (bituminous coal, ash content 9.5 %). There are shown cumulative particle diameter distributions in the case of a coal concentration of 70 % and 1,000 cP or less. In this case, the particle diameter D is 297 μm and only distributions of particle sizes of 1 μm or larger are shown. Further, the slurry viscosity refers to numerical values obtained when an inner cylinder-rotation type viscometer was rotated at a shear rate of 90 sec^{-1} for 5 minutes. It is seen from Fig. 1 that the proportions in the case of 1 μm or more each constitute a nearly straight line. Further, when the cumulative sieve weight proportion U(D)% is 100 % at $D = D_L$, D_S (minimum particle diameter) at which U(D) = 0 % should be present. Thus, we propose the following equations (1) and (2) as those indicating a particle diameter distribution mode of coal particles contained in a slurry exhibiting a low viscosity at a high coal concentration:

$$U(D) = \left(\frac{D - D_s}{D_L - D_s}\right)^q \times 100\ \% \qquad \text{-----}\ (1)$$

$$U(D) = \frac{D^q - D_s^q}{D_L^q - D_s^q} \times 100\ \% \qquad \text{-----}\ (2)$$

wherein q represents an index.

In both the equation (1) and (2), when $D = D_L$, $U(D) = 100\%$, and when $D = D_s$, $U(D) = 0\ \%$. That is, these equations correspond well to practical particle size distributions.

If $D_s = 0$ in the equation (1) and (2), the equations both give the following equation (3):

$$U(D) = \left(\frac{D}{D_L}\right)^q \times 100\ \% \qquad \text{-----}\ (3)$$

This equation (3) corresponds to Andreasen's equation which has been known as a particle diameter distribution equation giving the closest packing for powder of a continuous particle size system. As to this Andreasen's equation, studies were made in the past, and it was confirmed that when q= from 0.35 to 0.40, the percentage packing attains the maximum. The percentage packing, however, varies depending on particle shapes, and as to the systematic relationship between the q value and the slurry viscosity and stability of coal-water slurry, no study has ever been made. Further, Andreasen's equation is a distribution equation in the case where particles having an infinitesimal particle diameter were presumed, but the equation cannot be, as it is, applied to a practical coal-water slurry. In contrast the present inventors confirmed that the equation (1) and (2) correspond well to practical distributions.

Fig. 2 shows the weight proportions of the respective fractions in the case where D_L = 297 µm, D_s = 0.01 µm and q = 0.3 in the equations (1) and (2). In this case, in order to compare the particle diameters more strictly, particles were divided into the following 15 fractions (dotted lines in Fig. 2 indicate the case of the equation (2) and solid lines therein indicate the case of the equation (1)):

		Particle diameter range
(1) F_1:	from	$D_L/2$ to D
(2) F_2:	from	$D_L/2^2$ to less than $D_L/2$
(3) F_3:	from	$D_L/2^3$ to less than $D_L/2^2$
(4) F_4:	from	$D_L/2^4$ to less than $D_L/2^3$
(5) F_5:	from	$D_L/2^5$ to less than $D_L/2^4$
(6) F_6:	from	$D_L/2^6$ to less than $D_L/2^5$
(7) F_7:	from	$D_L/2^7$ to less than $D_L/2^6$
(8) F_8:	from	$D_L/2^8$ to less than $D_L/2^7$
(9) F_9:	from	$D_L/2^9$ to less than $D_L/2^8$
(10) F_{10}:	from	$D_L/2^{10}$ to less than $D_L/2^9$
(11) F_{11}:	from	$D_L/2^{11}$ to less than $D_L/2^{10}$
(12) F_{12}:	from	$D_L/2^{12}$ to less than $D_L/2^{11}$
(13) F_{13}:	from	$D_L/2^{13}$ to less than $D_L/2^{12}$
(14) F_{14}:	from	$D_L/2^{14}$ to less than $D_L/2^{13}$
(15) F_{15}:	from	$D_L/2^{14}$ to 0

It is seen that the case of the equation (1) is different from that of the equation (2) in that the proportion of finely divided particles is higher and there are minimum points F_{13} and F_{14} where the weight proportion becomes minimum.

Thus, the present inventors varied the values of D_L, D_s and q in the equations (1) and (2) to study their influences upon the viscosity and stability of slurry, whereby many findings could be obtained.

From these findings, coal-water slurry of the present invention is preferably composed so that diameter distribution of coal particles having particle diameters in the range of from 1,000 µm to 0.005 µm substantially satisfies the following equation and the following ranges of numeral values:

$$(1)\quad U(D) = \left(\frac{D - D_s}{D_L - D_s} \right)^q \times 100$$

(2) D_L = from 44 to 1,000 µm

(3) D_s = from 0.005 to 0.1 µm

(4) q = from 0.25 to 0.50

wherein D represents a particle diameter of coal particles; D_L, the maximum particle diameter thereof ; D_s, the minimum particle diameter thereof; and q, an index.

Further, the slurry is preferably composed so that coal particles of 1 µm or less can be present in an amount of from 5 to 46 % by weight and those of 0.05 µm or less can be present in an amount of 0.5 % or more, more preferably 1 % or more.

Further, it is preferable that the coal-water slurry has a coal content of 60 to 80% by weight and a viscosity of 5,000 cP or less, in terms of numerical values obtained when an inner cylinder-rotation type viscometer is rotated at a shear rate of 90 sec^{-1} for 5 minutes.

A coal-water slurry when produced by the process of the present invention may contain at least one kind of anionic dispersant selected from the group consisting of naphthalenesulfonic acid, orthophosphoric acid, polyphosphoric acids represented by $H_{n+2}P_nO_{2n+1}$ ($n \geqq 2$) or $H_nP_nO_{2n}$ ($n \geqq 3$), tartaric acid, oxalic acid, citric acid, ethylenediamine tetraacetate, ligninsulfonic acid, salts or condensates of the foregoing, tannins including guebracho-tannin and metal salts of carboxymethylcellulose, as a dispersant for coal particles in an amount of 3 % by weight, or less, preferably 1.5% or less, based on the weight of the coal.

Further, at least one kind of pH-adjustor selected from the group consisting of sodium hydroxide, potassium hydroxide, barium hydroxide and sodium carbonate may be added to the slurry as a pH-adjustor for rendering the pH value of the slurry 7 or more, in an amount of 3% or less, preferably 1.5% or less, based on the coal weight.

The present invention will be described in more detail by way of Examples.

Example 1

With coal A (bituminous coal, ash content 9.5%), the proportions of the respective fractions were adjusted according to the above-mentioned method to prepare 20 kinds of coal samples having particle diameter distributions coreesponding to D_L = 297 µm and 149 µm, D_s = 0.01 µm and q = 0.15, 0.20. 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55 and 0.60 in the equation (1), followed by preparing a slurry having a coal concentration of 72 % by adjusting the water content of the respective samples, thereafter adding a poly-sodium naphthalenesulfonate as dispersant in an amount of 0.5 % based on the coal weight and sodium hydroxide as pH adjustor in an amount of 0.1 % based thereon and measuring their slurry viscosities. The results are shown in Fig. 3. It was observed that the viscosities became minimum at q = from 0.40 to 0.45 irrespective of D.

The same studies were made as to the equation (2) to similarly give the minimum viscosities at q = from 0.40 to 0.45. Further, it was observed that the viscosity values, too, accorded nearly with the above in the case of the same values of D_L, D_s and q.

Further, the same studies were made on other kinds of coals to give the minimum viscosities at q = from 0.40 to 0.50

Example 2

With the same slurries as in Example 1, their stabilities were studied. Each of the slurries was placed in a 500 ml graduated cylinder up to a depth of 170 mm, followed by allowing a glass stick of 5 mm in diameter and 10 g in weight to penetrate thereinto only by its self weight to observe the change in the penetration time during which the stick reached the bottom of the cylinder. Fig. 4 shows the relationship between the penetration time at the time when 30 days lapsed after preparation of the slurries (the penetration time just after the preparation being made), and the q value. Namely Fig. 4 shows comparison of stabilities as to the slurries having viscosities shown in Fig. 3 and D_L = 297 µm. The penetration time became minimum at q = from 0.25 to 0.35, and it is seen that the penetration time is shorter and the stablility is superior in the case of the equation (1) as compared with those in the case of the equation (2).

Other kinds of coals were studied varying C_L, etc. to obtain similar results.

It was found through Examples 1 and 2 that slurries according to the equation (1) were superior in stability to those according to the equation (2) and they exhibited equal values as to viscosity. Further it was found that in view of viscosity and stability, particle diameter distributions at q = from 0.25 to 0.50 in the equation (1) were preferable.

Example 3

With coal B (bituminous coal, ash content 13.6 %), Example 1 was repeated to prepare a slurry having a particle diameter distribution corresponding to D_L = 297 µm, D_S = 0.01 µm and q = 0.40 in the equation (1) and a coal concentration of 70 %. A condensate of sodium napnthalinesulfonate as dispersant was added to the slurry to observe the relationship between its amounts added and the slurry viscosities. The results are shown in Fig. 5. In this case, the addition amounts are values based on the coal weight, and sodium hydroxide was added as pH adjustor in an amount of 0.1% based on the coal weight.

The viscosities became minimum in an addition amount ot 0.5% of the dispersant, and more amounts resulted in an adverse effect.

Other kinds of coals were similarly studied, and the viscosities became minimum in addition amounts of from 0.2 to 1.2 %. When other anionic dispersants were added, slurries having a minimum viscosity weresimilarly obtained in addition amounts of from 0.1 to 1.5%.

Example 4

With coal B (bituminous coal, ash content 13.6%), the same slurry as in Example 3 was prepared, followed by varying the amount of sodium hydroxide added, in a fixed amount of 0.5 % of a condensate of sodium naphthalenesulfonate being added, to adjust the pH of slurry to thereby study the influence of pH upon slurry viscosity. The results are shown in Fig. 6. Up to pH 8, the higher the pH, the lower the slurry viscosity, and at higher pHs, the viscosity is almost unchanged. Taking into consideration the amount of sodium hydroxide consumed and corrosion of material, a pH of from 7 to 9 is preferred. In the case of coal, although the pH of slurry prepared therefrom varies depending on the kind of coal and the oxidation degree of its surface, the amount of sodium hydroxide added, necessary for adjusting the pH from 7 to 9, is from 0 to 1.0 % based on the weight of coal.

Example 5

Ultrafine paricles having passed through a millipore filter of 0.05 µm were further added to a slurry of coal B having a particle diameter distribution expressed by the equation (1) and corresponding to D_L = 297 µm, D_S = 0.01 µm and q = 0.40, to study the influence of the ultrafine particles upon the stability of the slurry. The results are shown in Fig. 7. In this figure, the penetration time of the oridinate axis refers to a ratio of the penetration time in 30 days after preparation of slurry to that just after the preparation, and the amount of ultrafine particles added refers to a proportion thereof based on the total weight of coal after the addition.

The stability is best in an amount of the ultrafine particles added of 3 %, and it is seen that particles of 0.05 µm or less contributed to the slurry stability. Studies were carried out varying the particle diameter distribution and the kind of coal. As a result it was found that the viscosity was unchanged when the weight of particles of 0.05 µm or less effective for improving the slurry stability fell within the range of from 0.5 to 6. 5 % (preferably from 1.0 to 4.0 %). Further, it was found that this tendency was unchanged even when the kind of coal, its concentration and D_L were varied.

Example 6

With coal A (bituminous coal, ash content 9.5 %), a process for preparing a slurry having a particle diameter distribution coresponding to the equations (1) and (2), by means of a tube ball mill (650 mm in diameter x 250 mm in length) was studied. The apparatus and flow in this case are shown in Fig. 8. Coal stored in ahopper 1 was fed into a mill 3 through a feeder 2, and at the same time, water and additives were fed into the mill through a feed pipe 4. At that time, conditions were established so as to give a coal concentration of 70 % and average retention times of coal in the mill, of 90 minutes and 120 minutes, and when a stationary state was attained, the resulting slurries were taken to observe their particle diameter distributions. The resurlts are shown in Fig. 9. It is seen that the slurries had particle diameter distributions corresponding to D_L = 420 µm, D_s = 0.04 µm and q = 0.40, and D_L = 300 µm, D_s = 0.01 µm and q = 0.40 in the equation (2).

Next, 10 % of the slurry of the average retention time of 120 minutes discharged from the exit of the mill was returned to the inlet of the mill and again ground. When a stationary state was attained, particle diameters were measured to give a particle diameter distribution corresponding to D_L = 300 µm, D_s = 0.01 µm and q = 0.40 in the equation (1). See Fig. 10.

Other kinds of coals were similarly studied. As a result, it was found that in order to prepare a slurry having a particle diameter distribution according to the equation (1) and a good stability, it was impossible to achieve the object merely by adjusting the retention time in the mill, but a process of recycling from 10 to 50 % of the product slurry (i.e.

recycling feed) was effective.

In view of the above-mentioned Examples, it has been found that in order to obtain a CWM having a high coal concentration, a low viscosity and a good stability, if a strict and systematic control of the particle diameter distribution is conducted by means of sieves and the particle diameter distribution is caused to comply with the following equation, then the viscosity and stability of the resulting slurry becomes optimum:

$$U(D) = \left(\frac{D - D_s}{D_L - D_s} \right)^q \times 100$$

wherein q = from 0.25 to 0.50

D_L = from 44 to 420 μm

D_s = from 0.005 to 0. 1 μm

Further it has been found that when finely divided particles of 0.05 μm or less are present in an amount of from 0.5 to 6.5 % (preferably from 1.0 to 4.0 %), the slurry stability becomes optimum.

Furthermore it has been found that the amount of the dispersant added is optimum in a range of from 0.1 to 1.5 % and it is preferred to add a pH adjustor so as to give a pH of from 7 to 9.

When this invention is conducted, there is exhibited an effectiveness of rendering a mixture of water with powdered coal, a water-coal slurry having a high coal concentration, a low viscosity and a good stability with settlings being formed only with difficulty.

CLAIMS:

1. A process for producing a coal-water slurry having coal particles dispersed in water, which process comprises causing the slurry to have a composition of coal particles, so that when the coal particles are divided into 8 fractions (F_1, F_2, ----- and F_8), each having a particle diameter range listed below, ((from $D_L/4$ to D_L), (from $D_L/4^2$ to less than $D_L/4$), ----- (from $D_L/4^7$ to 0), wherein D_L represents the maximum particle diameter of the coal particles), then the proportions by weight of the coal particles contained in the respective fractions, relative to the total weight of the coal particles contained in the slurry fall within the following ranges of numerical values:

F_1: ($D_L/4$ to D_L)	from	29.0 to 50.0% by weight
F_2: ($D_L/4^2$ to less than $D_L/4$)	from	20.0 to 25.0% by weight
F_3: ($D_L/4^3$ to less than $D_L/4^2$)	from	12.0 to 15.0% by weight
F_4: ($D_L/4^4$ to less than $D_L/4^3$)	from	6.0 to 10.0% by weight
F_5: ($D_L/4^5$ to less than $D_L/4^4$)	from	3.0 to 12.0% by weight
F6: ($D_L/4^6$ to less than $D_L/4^5$)	from	1.5 to 5.2% by weight
F_7: ($D_L/4^7$ to less than $D_L/4^6$)	from	0.8 to 4.0% by weight
F_8: ($D_L/4^7$ to 0)	from	0.7 to 9.0% by weight

2. A process according to Claim 1, wherein the particle diameter distribution of coal particles having particle diameters in the range of from 1,000 μm to 0.005 μm substantially satisfies the following equation and the following ranges of numerical values:

$$(1)\quad U(D) = \left(\frac{D - D_S}{D_L - D_S} \right)^q \times 100$$

(2) D_L = from 44 to 1,000 μm

(3) D_S = from 0.005 to 0.1 μm

(4) q = from 0.25 to 0.50

wherein D represents a particle diameter of coal particles; D_L, the maximum particle diameter thereof; D_S, the minimum particle diameter thereof; and q, an index.

3. A process according to Claim 1, or Claim 2, wherein the coal particles in the slurry are composed so that coal particles of 1 μm or less can be present in an amount of from 5 to 46 % by weight and those of 0.05 μm or less can be present in an amount of 0.5 % or more.

4. A process according to any one of Claims 1 to 3, wherein the slurry has a coal content of from 60 to 80 % by weight and a viscosity of 5,000 cP or less, in terms of numerical values obtained when an inner cylinder-rotation type viscometer is rotated at a shear rate of 90 sec^{-1} for 5 minutes.

5. A process according to any foregoing claim wherein at least one kind of anionic dispersant selected from the group consisting of naphthalenesulfonic acid, orthophosphoric acid, polyphosphoric acids represented by $H_{n+2}P_nO_{2n+1}$ ($n \geqq 2$) or $H_nP_nO_{2n}$ ($n \geqq 3$), tartaric acid, oxalic acid, citric acid, ethylenediamine tetraacetate, ligninsulfonic acid, salts and condensates of the foregoing, tannins including quebracho-tannin and metal salts of carboxymethylcellulose, is added to the slurry, as a dispersant for coal particles in an amount of 3% by weight or less based on the coal weight.

6. A process according to any foregoing claim, wherein at least one kind of pH-adjustor selected from the group consisting of sodium hydroxide,potassium hydroxide, barium hydroxide and sodium carbonate is added to the slurry as a pH-adjustor for rendering the pH value of the slurry 7 or more, in an amount of 3% or less based on the coal weight.

7. A coal-water slurry when produced by the process according to any foregoing claim.

8. A coal-water slurry having a composition of coal particles, so that when the coal particles are divided into 8 fractions (F_1, F_2, ----- and F_8), each having a particle diameter range listed below, ((from $D_L/4$ to D_L), (from $D_L/4^2$ to less than $D_L/4$), ----- (from $D_L/4^7$ to 0), wherein D_L represents the maximum particles diameter of the coal particles), then the proportions by weight of the coal particles contained in the respective fractions, relative to the total weight of the coal particles contained in the slurry fall within the following ranges of numerical values:

F_1: ($D_L/4$ to D_L)	from	29.0 to 50.0%	by weight
F_2: ($D_L/4^2$ to less than $D_L/4$)	from	20.0 to 25.0%	by weight
F_3: ($D_L/4^3$ to less than $D_L/4^2$)	from	12.0 to 15.0%	by weight
F_4: ($D_L/4^4$ to less than $D_L/4^3$)	from	6.0 to 10.0%	by weight
F_5: ($D_L/4^5$ to less than $D_L/4^4$)	from	3.0 to 12.0%	by weight
F6: ($D_L/4^6$ to less than $D_L/4^5$)	from	1.5 to 5.2%	by weight
F_7: ($D_L/4^7$ to less than $D_L/4^6$)	from	0.8 to 4.0%	by weight
F_8: ($D_L/4^7$ to 0)	from	0.7 to 9.0%	by weight

FIG. 1

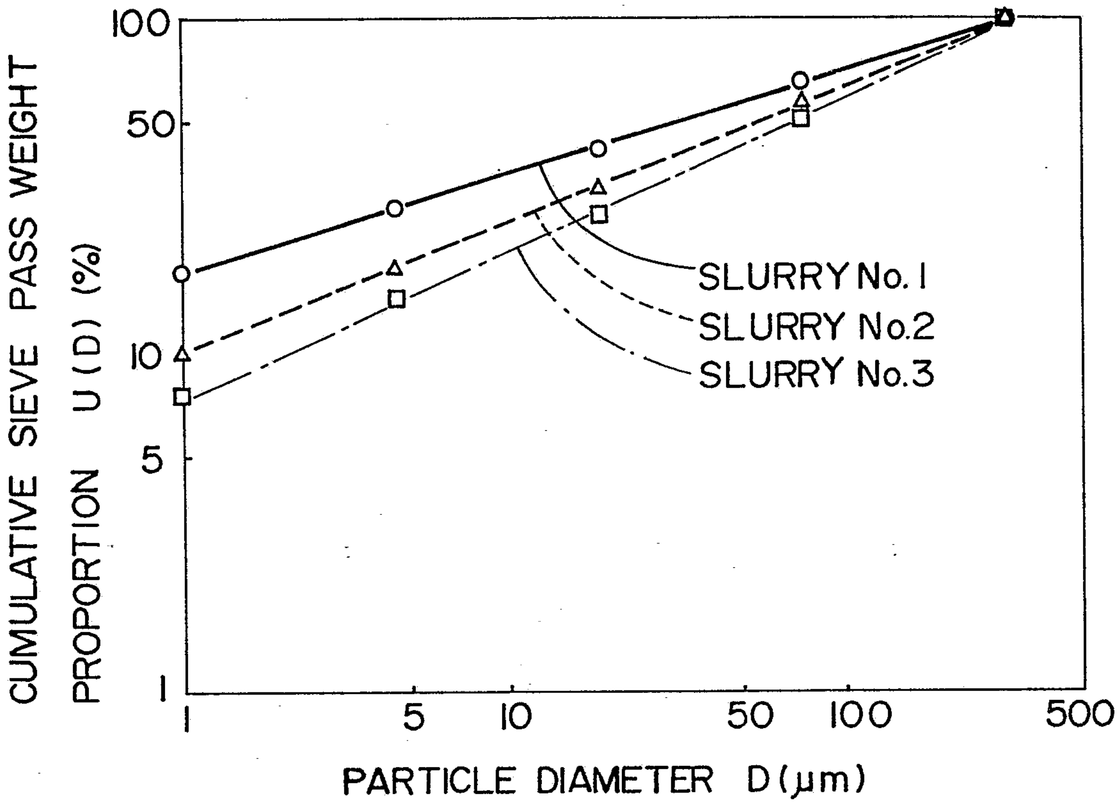

CUMULATIVE SIEVE PASS WEIGHT PROPORTION U(D) (%)
100
50
10
5
1
1
5
10
50
100
500
PARTICLE DIAMETER D(μm)
SLURRY No.1
SLURRY No.2
SLURRY No.3

FIG. 2

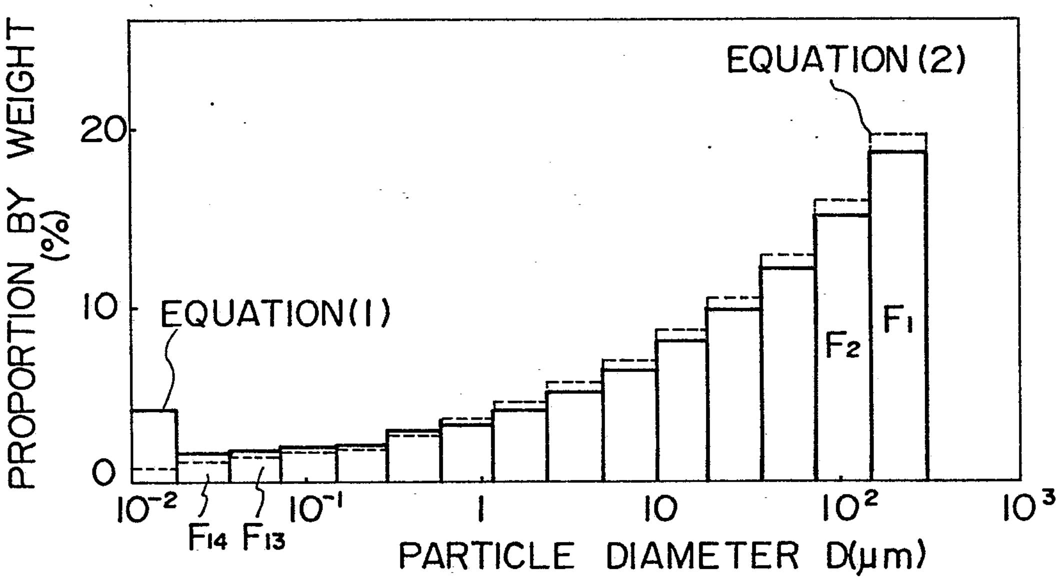
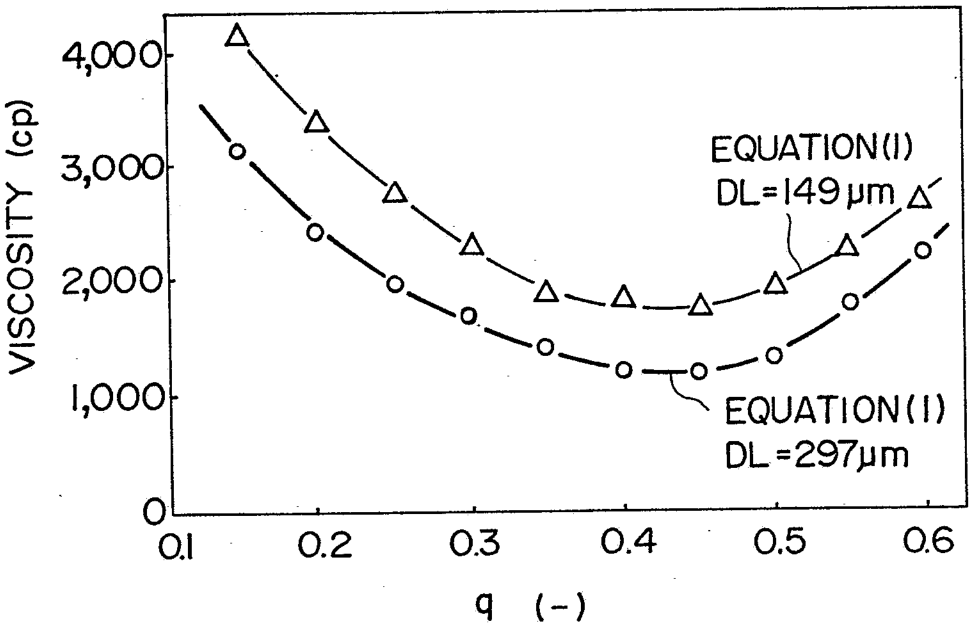
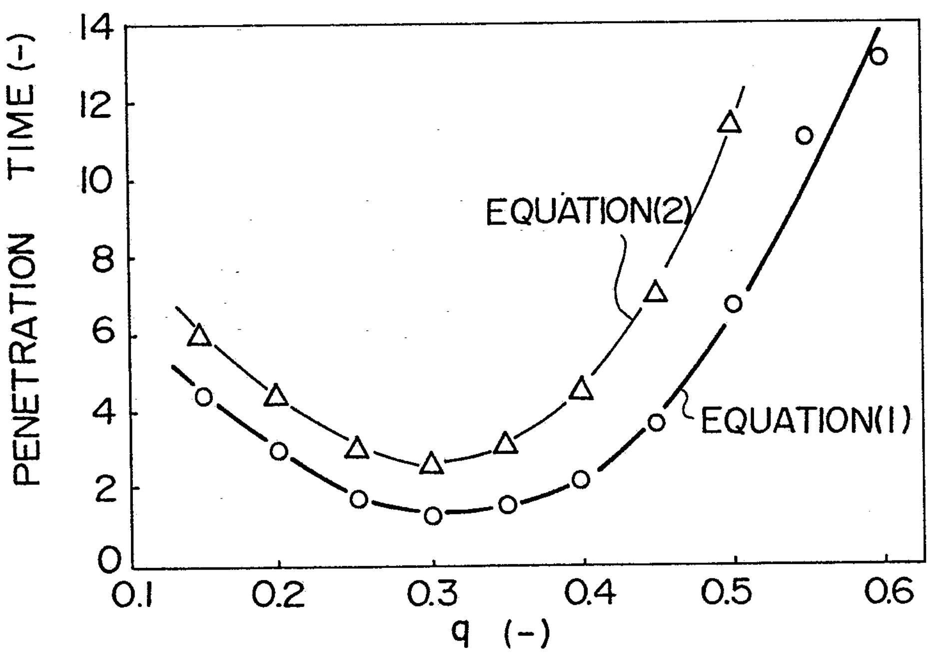

PROPORTION BY WEIGHT (%)
20
10
0
EQUATION (2)
EQUATION(1)
F2
F1
F14
F13
10^-2
10^-1
1
10
10^2
10^3
PARTICLE DIAMETER D(μm)

FIG. 3



VISCOSITY (cp)
4,000
3,000
2,000
1,000
0
0.1
0.2
0.3
0.4
0.5
0.6
q (-)
EQUATION(1)
DL=149 μm
EQUATION(1)
DL=297μm

FIG. 4



PENETRATION TIME (-)
14
12
10
8
6
4
2
0
0.1
0.2
0.3
0.4
0.5
0.6
q (-)
EQUATION(2)
EQUATION(1)

FIG. 5

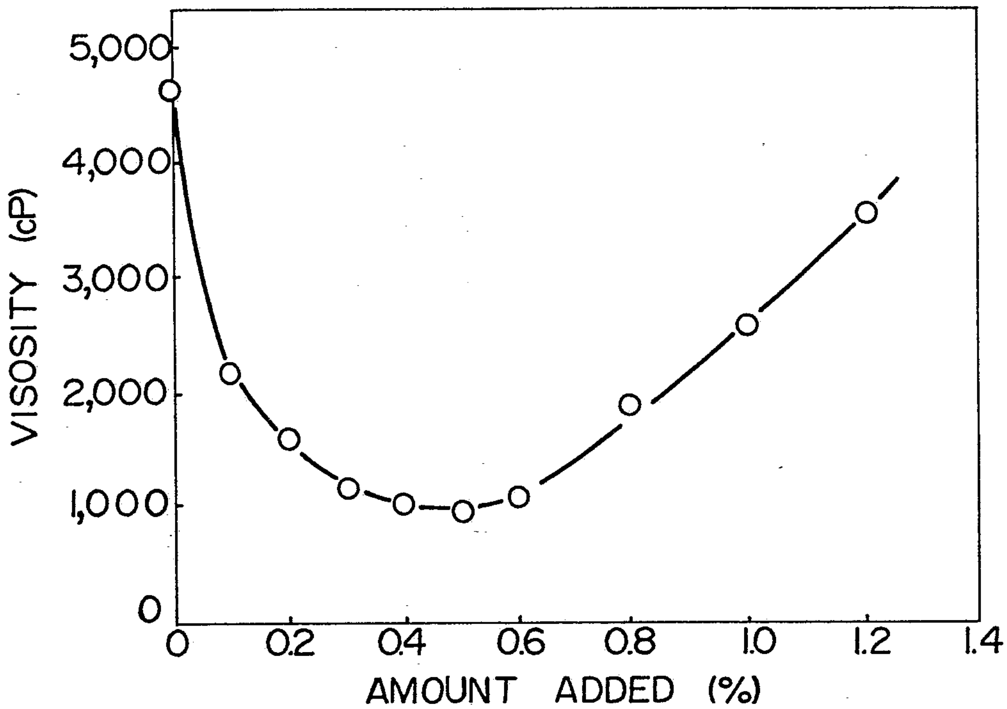

VISOSITY (cP)
5,000
4,000
3,000
2,000
1,000
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
AMOUNT ADDED (%)

FIG. 6

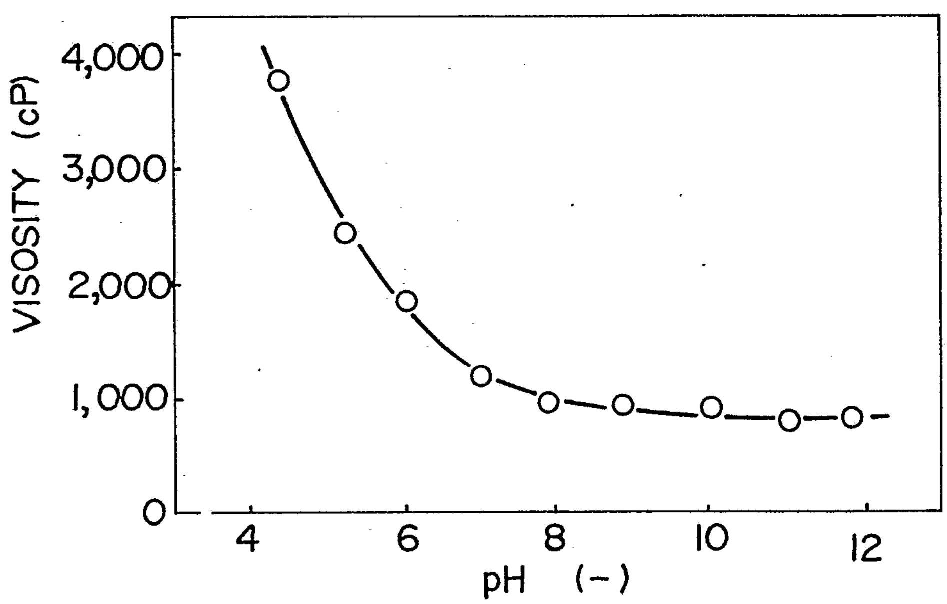

VISOSITY (cP)
4,000
3,000
2,000
1,000
0
4
6
8
10
12
pH (-)

FIG. 7

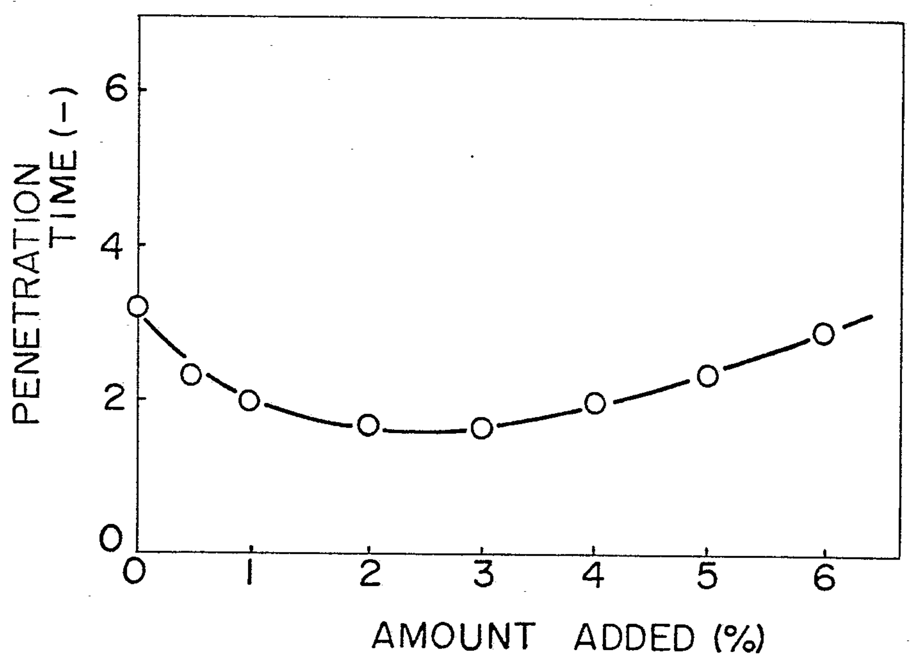


FIG. 8

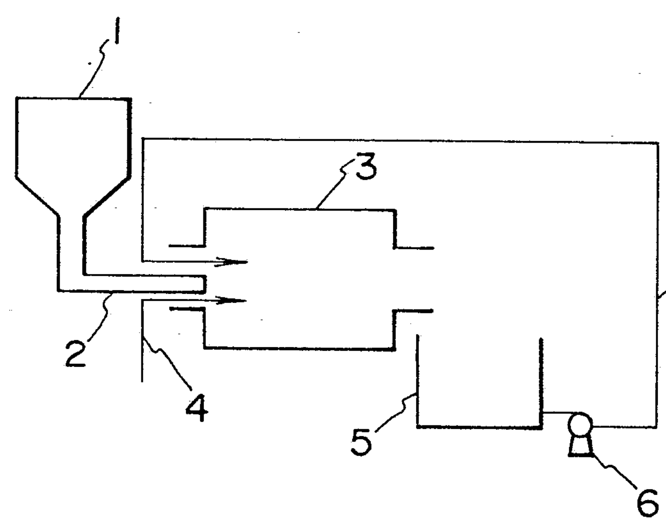


FIG. 9

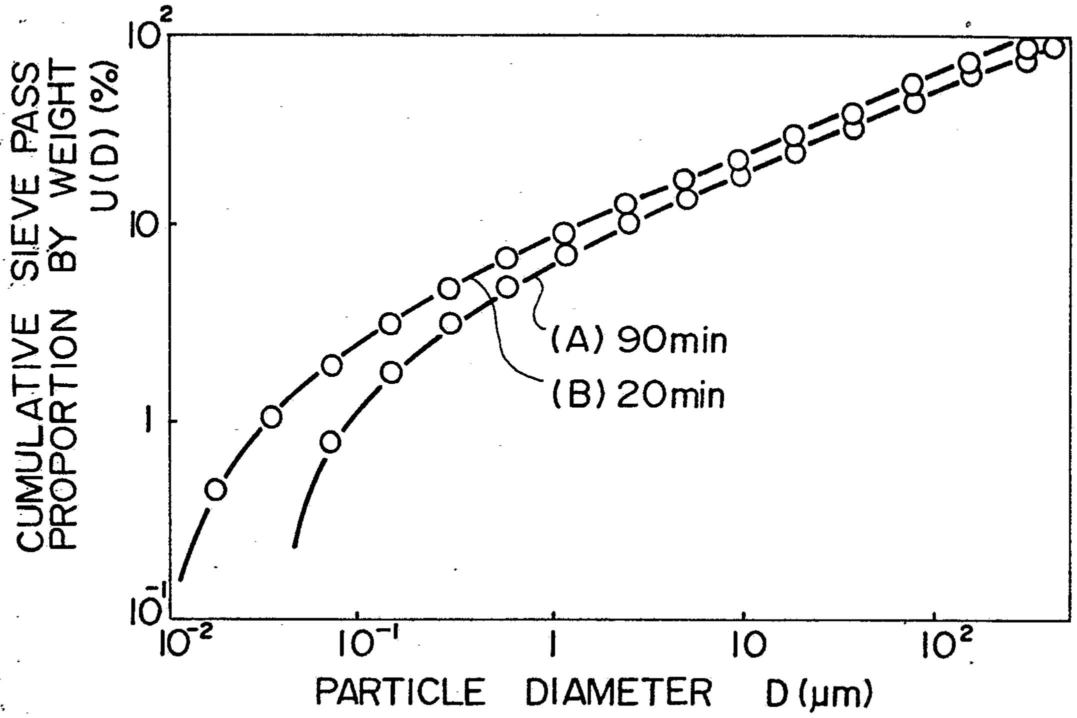
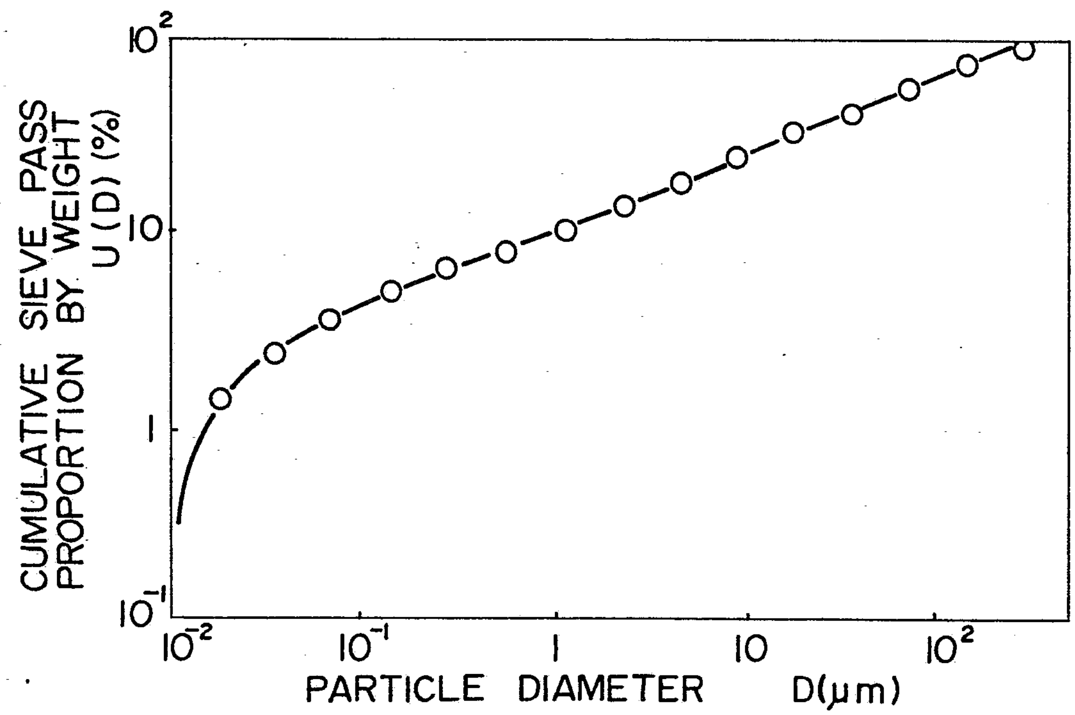

CUMULATIVE SIEVE PASS PROPORTION BY WEIGHT U(D) (%)
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
10^2
(A) 90min
(B) 20min
PARTICLE DIAMETER D (μm)

FIG. 10


CUMULATIVE SIEVE PASS PROPORTION BY WEIGHT U(D) (%)
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
10^2
PARTICLE DIAMETER D(μm)

European Patent Office

EUROPEAN SEARCH REPORT

0165350 Application number

EP 84 30 4234

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	WO-A-8 101 152 (ALFRED UNIVERSITY) * Claims 1,2,6,12-15,17-22; tables 1-4 *	1-8	C 10 L 1/32

A	US-A-3 762 887 (CLANCEY et al.) * Claims 1-4 *	1	

			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
			C 10 L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17-08-1984	DE HERDT O.C.E.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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