United States Patent

Wakazono et al.

[15] 3,664,897

[45] May 23, 1972

[54] **SLURRY EXPLOSIVE COMPRISING AMMONIUM NITRATE AND ALUMINUM POWDER**

[72] Inventors: **Yoshikazu Wakazono,** Zushi-shi; **Terushige Ogawa,** Yokohama-shi; **Yoshiyasu Otsuka,** Niihama-shi, all of Japan

[73] Assignee: **Sumitomo Chemical Co., Ltd.,** Higashi-ki, Osaka

[22] Filed: **Oct. 24, 1969**

[21] Appl. No.: **869,324**

[30] **Foreign Application Priority Data**

Oct. 31, 1968 Japan....................................43/79809

[52] **U.S. Cl.** **149/38,** 149/39, 149/41, 149/43, 149/44, 149/114

[51] **Int. Cl.** **C06b 1/04**

[58] **Field of Search**......................149/38, 39, 41, 43, 44, 114

[56] **References Cited**

UNITED STATES PATENTS

2,589,532	3/1952	Byers	149/38 X
3,307,986	3/1967	Grant	149/41 X
3,367,805	2/1968	Clay et al.	149/114 X
3,432,371	3/1969	Grant	149/43 X

FOREIGN PATENTS OR APPLICATIONS

898,681	6/1962	Great Britain	149/43

Primary Examiner—Leland A. Sebastian

Attorney—Sughrue, Rothwell, Mion, Zinn & MacPeak

[57] **ABSTRACT**

A slurry explosive containing, as the main ingredients, (1) 40 to 80 percent by weight of ammonium nitrate or a mixture of ammonium nitrate and an alkali metal nitrate or a mixture of ammonium nitrate and an alkaline earth metal nitrate or a mixture of ammonium nitrate, an alkali metal nitrate and an alkaline earth metal nitrate, (2) 5 to 20 percent by weight of aluminum powder consisting of aluminum powder (a) which is manufactured by the ball milling method or the stamping method, and the particle size of which is 30 mesh (JIS sieve) or below; and aluminum powder (b) having no leafing property which is manufactured by the atomizing method or the graining method, the particle size of which is 30 mesh (JIS sieve) or below, the mixing ratio by weight of aluminum powder (a) and aluminum powder (b) being 50 to 20: 50 to 80, and (3) 5 to 25 percent by weight of water.

12 Claims, No Drawings

SLURRY EXPLOSIVE COMPRISING AMMONIUM NITRATE AND ALUMINUM POWDER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a slurry explosive containing aluminum powder and having an improved specific gravity and an improved sensitivity.

2. Description of the Prior Art

A slurry explosive containing ammonium nitrate, or ammonium nitrate and a nitrate of an alkali metal and/or an alkaline earth metal, especially a slurry explosive containing ammonium nitrate and 2,4,6-trinitrotoluene (hereinafter referred to as TNT) or aluminum powder or a mixture thereof and water as the main ingredients is known as an effective industrial explosive, and has been satisfactorily used at sites such as hard rock or water springs, where an ammonium nitrate-fuel oil explosive cannot be employed. Such an explosive is absolutely safe in handling, and can easily be charged into a bore hole. Therefore, in recent years, such an explosive has been charged by means of a forcing pump utilizing the slurry characteristic thereof. Such a slurry explosive has a higher explosion velocity and illustrates a better explosive performance in comparison with the well known ammonium nitrate-fuel oil explosive.

Accordingly, such a slurry explosive is effective in boulder blasting, and crushing costs in succeeding steps are considerably reduced. In addition, such a slurry explosive is lower in transportation cost and boring cost, since it is higher in specific gravity than the ammonium nitrate-fuel oil explosive.

Furthermore, such a slurry explosive is not only excellent in explosive performance but is also characterized by being safer because water is contained in the composition.

Among the slurry explosive compositions used today, there are the following system compositions: ammonium nitrate - TNT - water, ammonium nitrate-TNT-aluminum-water, ammonium nitrate-smokeless powder-water, ammonium nitrate-smokeless powder-aluminum-water, ammonium nitrate-aluminum-water and ammonium nitrate-fuel-water. On considering explosive performance and cost, the ammonium nitrate-TNT-water or ammonium nitrate-aluminum-water system is most effectively used.

Aluminum used for the preparation of slurry explosives has been conventionally selected from the classes in a limited range, such as ball milling aluminum powder. Such aluminum powders are occasionally employed by coating the surface thereof with stearic acid, as described in the specification of U.S. Pat. No. 3,367,805. This is due because the aluminum powder must coexist with water in the slurry explosive. Consequently, this causes the cost of manufacturing slurry explosives to be high. In addition, such aluminum powder, for example that manufactured by the ball milling method or the stamping method, has a very small bulk specific gravity, and therefore the specific gravity of a slurry explosive containing such an aluminum powder is often 1.1 to 1.2.

This not only makes the transportation cost thereof high, but also interrupts complete charging into a bore hole filled with water because of incomplete sedimentation.

Aluminum powder manufactured by the ball milling method or the stamping method is of very high sensitivity. For example, it is recognized that when a slurry explosive consisting of 72 percent by weight ammonium nitrate, 7 percent by weight aluminum powder manufactured by the ball milling method, 20 percent by weight water, and 1 percent by weight carboxymethyl cellulose (hereinafter referred to as CMC) is charged in a steel pipe (35 mm. inner diameter and 250 mm. in length) initiation takes place with only one No. 6 electric cap. Such an explosive can never be a safe explosive, and it is very difficult to flow charge such an explosive by means of a pump. However, the high sensitivity of aluminum powder manufactured by the ball milling method or the stamping method is never a defect, because with the TNT system slurry explosive of low sensitivity, it is necessary to use a very high cost, strong booster. For example, in the specification of U.S. Pat. No. 3,097,121, the use of bentonite is recommended for initiating a TNT system slurry explosive. According to research of the present inventors, in experiments to determine the explosive velocity of a TNT system slurry explosive by the Dautriche method using a 35 mm. steel pipe, the following results (shown in Table 1) were obtained.

TABLE 1

Composition of Slurry Explosive	Tetryl, (g)	Filling Density (g/cm^3)	Explosion Velocity m/sec.
TNT 30%, Ammonium	10	1.32	Incomplete explosion
nitrate 49.53%	10	1.42	Incomplete explosion
Water 20%, Guargum 0.27%	15	1.38	4650
CMC 0.2%	15	1.24	4570

It is often found that the kind and amount of booster used has a great influence on explosion velocity.

A TNT-aluminum system slurry explosive solves the above problems of the TNT-slurry explosives. The TNT-aluminum system slurry explosive has the merit of the high sensitivity of aluminum powder manufactured by the ball milling method or the stamping method and the high specific gravity and high explosive power of TNT, and offers an extremely high performance. However, this explosive is high in cost and also is very poor from a safety viewpoint. In addition, this explosive has a problem with production control because two kinds of very different dangerous materials, such as TNT and aluminum powder are required in its manufacture.

SUMMARY OF THE INVENTION

In an ammonium nitrate-aluminum powder-water slurry explosive, an improved explosive is obtained when the aluminum powder consists of aluminum powder (a) which is manufactured by the ball milling method or the stamping method, the particle size of which is 30 mesh (JIS sieve) or below, and aluminum powder (b) having no leafing property which is manufactured by the atomizing method or the graining method, the particle size of which is 30 mesh (JIS sieve) or below, the mixing ratio by weight of the aluminum powder (a) and the aluminum powder (b) being about 50 to 20 : 50 to 80.

Percentages and other materials which can partially replace ammonium nitrate are disclosed in the specification.

One object of the invention is to provide an aluminum-containing slurry explosive having a specific gravity comparable to that of the TNT system slurry explosive.

A further object is to provide a safe explosive with an initiating sensitivity which can be freely controlled.

Another object is to provide an explosive which is highly economical.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The above objects are accomplished by providing a slurry explosive containing as the main ingredients: (1) 40 to 80 percent, by weight, of ammonium nitrate or a mixture of ammonium nitrate and an alkali metal nitrate or a mixture of ammonium nitrate, and an alkaline earth metal nitrate or a mixture of ammonium nitrate, an alkali metal nitrate and alkaline earth metal nitrate; (2) 5 to 20 percent by weight of aluminum powder consisting of aluminum powder (a) which is manufactured by the ball milling method or the stamping method ('-'Aluminum" 445, 22 (1967)), the particle size of which is 30 mesh (JIS sieve) or below, and aluminum powder (b) having no leafing property which is manufactured by the atomizing method or the graining method and the particle size of which is 30 mesh (JIS sieve) or below, the mixing ratio, by weight, of aluminum powder (a) and aluminum powder (b) being 50 to 20 : 50 to 80; and (3) 5 to 25 percent, by weight, of water. The slurry explosive of the present invention may contain one or more materials such as TNT, smokeless powder, carbonaceous fuels including carbon powder and fuel oils, etc., and/or a paste for suspension stability, in addition to the above main ingredients.

There is a great difference between aluminum powder (a) manufactured by the ball milling method or the stamping method and aluminum powder (b) manufactured by the atomizing method or the graining method. The former has a leafing property, while the latter does not. Furthermore, aluminum powder (a) is lower in apparent specific gravity and higher in specific surface area and sensitivity in comparison with aluminum powder (b). Therefore, when blending such aluminum powders in various ratios and incorporating the blended aluminum powders into the slurry explosive, a slurry explosive having the desired specific gravity, sensitivity and explosion velocity is obtained. In particular, the aluminum system slurry explosive containing ammonium nitrate, aluminum powder manufactured by the stamping method, aluminum powder manufactured by the atomizing method and water as its main ingredients is most preferably employed because of the facts that its specific gravity is good, its explosion velocity is high, its preparation is easy, and it is safe to use.

Thus, considering the specific gravity, sensitivity and explosion velocity of the slurry explosive when aluminum powder (a) and aluminum powder (b) are incorporated into the slurry explosive in such a ratio that the former is 50 to 20 percent by weight and the latter is 50 to 80 percent by weight, a preferred result is obtained. It is preferred that the amount of these aluminum powders be larger in the economically acceptable range. However, as in apparent from the description at page 4 of the lecture summaries, 1966 Association, Industrial Powder Association Japan, the increase of explosion velocity with the increase in the aluminum content reaches a saturation at an aluminum content of 10 percent by weight, and aluminum powder (b) is extremely low in sensitivity. Therefore in general 5 to 20 percent by weight of aluminum powder is effectively used. The particle size of the aluminum incorporated into the slurry explosive is related to the viscosity of the slurry explosive. That is, in order to suspend aluminum powder having a large particle size, a large amount of paste is required, and therefore, a slurry explosive containing such aluminum powder suffers from deteriorated flowability and lowered sensitivity.

Accordingly, it is preferred that aluminum powder having a lower particle size, preferably 30 mesh or below, be employed.

The results of Dautriche method measurements on the explosion velocity of slurry explosives of the compositions shown in Table 2 are given in Table 3.

TABLE 3

Composition of slurry explosive (percent by weight)						Inner diameter of iron pipe filled with explosive (mm.)	Filling density (g./cm.³)	Explosion velocity (m./sec.)
Aluminum powder by the atomizing method	Aluminum powder by the stamping method	Ammonium nitrate	Water	Guargum	CMC			
7	0	72.1	20	0.4	0.5	80	1.35	3,180
10	2	67.1	20	0.4	0.5	35	1.38	4,720
7	0	72.1	20	0.4	0.5	35	1.34	(1)
7	1	71.1	20	0.4	0.5	35	1.33	(1)
7	2	70.1	20	0.4	0.5	35	1.31	3,820
7	3	69.1	20	0.4	0.5	35	1.30	4,680
0	5	74.1	20	0.4	0.5	35	1.21	4,100

1 Incomplete explosion.

For example, according to results of experiments by the present inventors, the specific gravities of the explosive ammonium nitrate-aluminum-water system having incorporated therewith aluminum powder manufactured by the stamping method and aluminum powder manufactured by the atomizing method, in various ratios, are as shown in Table 2.

TABLE 2

	Composition of slurry explosive, percent by weight						
Sample	Aluminum powder by atomizing method	Aluminum powder by stamping method	Ammonium nitrate	Water	Guargum	CMC	Filling density, g./cm.³
A	15	0	69.1	15	0.4	0.5	1.43
B	10	0	74.1	15	0.4	0.5	1.42
C	10	2	67.1	20	0.4	0.5	1.38
D	10	3	66.1	20	0.4	0.5	1.37
E	7	0	72.1	20	0.4	0.5	1.34
F	7	1	71.1	20	0.4	0.5	1.33
G	7	2	70.1	20	0.4	0.5	1.31
H	7	3	69.1	20	0.4	0.5	1.30
I	0	7	72.1	20	0.4	0.5	1.16
J	0	15	69.1	15	0.4	0.5	1.05

Since the specific gravity of TNT system slurry explosive is generally 1.30 to 1.35, considering only the specific gravity of the slurry explosive, the content of aluminum powder manufactured by the atomizing method is preferably above 7 percent, by weight. In the case of incorporating above 15 percent, by weight, aluminum powder manufactured by the stamping method, the specific gravity of the slurry explosive lowers to an extreme degree and comes close to the specific gravity of water, and therefore the use of the slurry explosive in a water pit is made difficult.

The measurement was carried out by Dautriche method according to JIS, 10 g. of tertyl was used as a booster, and a No. 6 electric cap was used as the initiator.

As will be understood from these test results, a slurry explosive containing 7 percent by weight of atomizing method aluminum powder exploded incompletely in a 35 mm. inner diameter iron pipe, but exploded completely in 80 mm. thereof. The explosive containing stamping method aluminum powder was recognized to completely explode in 35 mm., even if its aluminum powder content was 5 percent by weight.

Thus, a slurry explosive containing aluminum (a) and aluminum (b) in the weight ratio of 2:7, or the like, may be effectively employed in view of specific gravity, sensitivity, explosion velocity and safety in handling.

The present invention will be illustrated with the following examples, which are, however, not to limit the scope of the present invention.

EXAMPLE 1

The initiating sensitivity and explosion velocity of a slurry explosive containing 7 percent by weight of aluminum powder (average particle size 44μ) manufactured by the atomizing method and 0 to 3 percent by weight of aluminum powder (average particle size 74μ) manufactured by the stamping method and having the compositions shown in Table 4 were measured. The results are shown in Table 5.

TABLE 4

	Composition of slurry explosive (percent, by weight)						
Sample	Aluminum by atomizing method	Aluminum by stamping method	Ammonium nitrate	Water	Guargum	Borax	Antimonyl potassium tartarate
a	7	0	72.5	20	0.3	0.1	0.1
b	7	1	71.5	20	0.3	0.1	0.1
c	7	2	70.5	20	0.3	0.1	0.1
d	7	3	69.5	20	0.3	0.1	0.1

TABLE 5

	Initiation by a blasting cap using tetryl as a booster			Initiation by a blasting cap only	
Sample	Tetryl (g).	Filling density	Explosion velocity (m/sec)	Filling density	Explosion velocity (m./sec.)
a	15	1.34	(1)	----------	----------
b	15	1.32	(1)	----------	----------
c	15	1.30	3,840	1.32	(1)
d	10	1.28	4,670	1.29	4,400

[1] Incomplete explosion.

A No. 6 electric cap was used for initiation. With 30 percent by weight of aluminum powder manufactured by the stamping method as the aluminum content, initiation was possible with one blasting cap, while, with 22 percent by weight of that aluminum, initiation was possible by boosting with 15 g. of tetryl, but was impossible with only a blasting cap. And the sample c, in which the total aluminum content was occupied by aluminum powder formed by the stamping method illustrated a 4,250 m/sec. explosion velocity.

EXAMPLE 2

	% (by weight)
Ammonium nitrate	63.5
Aluminum powder by the ball milling method (average particle size 37μ)	3
Aluminum powder by the atomizing method (average particle size 44μ)	7
Water	20
Hexamethylene tetramine	6
Guargum	0.4
Antimonyl potassium tartarate	0.1

The slurry explosive composition having the above composition had a 1.29 filling density and a 4,700 m/sec. explosion velocity. In this case, initiation by a blasting cap was possible.

EXAMPLE 3

	% (by weight)
Ammonium nitrate	48.0
Sodium nitrate	16.0
Aluminum powder by the ball milling method (average particle size 74μ)	4.0
Aluminum powder by the atomizing method (average particle size 61μ)	7.0
Water	19.0
Carbon powder	5.0
CMC	0.9
Octadecyltrimethyl ammonium chloride	0.1

The explosion velocity of the slurry explosive having the above composition was 5570 m/sec.

EXAMPLE 4

	% (by weight)
Ammonium nitrate	54
Sodium nitrate	10
Aluminum prepared by the ball milling method (average particle size) 37μ)	3
Aluminum prepared by the atomizing method (average particle size)	7
Water	19.6
Hexamethylene tetramine	6
Guargum	0.3
Antimonyl potassium tartarate	0.1

The explosion velocity of the slurry explosive having the above compositions was 5,570 m/sec. at a filling density of 1.24.

EXAMPLE 5

Six bore holes having a 3 inch diameter and a 6 m. depth were made to the bench-cut of andesite at 1.8 m. intervals, and 1.4 m. of line of least resistance burden.

Thirteen kilograms of the slurry explosive having the same composition as in Example 2 was filled into the bore holes. As the initiator, a No. 6 electric cap was employed, and as the booster, 375 g. of dynamite (grade: SHIN KIRI (nitroglycerin gel type dynamite)) was employed.

The position of initiation was at the bottom of the hole for two bore holes, at the center thereof for two other bore holes, and at the upper side thereof for the last two bore holes. After explosion, 288 m^3 (about 1,100 ton) of andesite was quarried.

To further exemplify material which will describe the aluminums used in this invention, all of which are known to the art, reference should be made to the following two citations: "Aluminum" edited by Kent R. Van Harn, American Society for Metals, Park, Ohio (1967), Volume I, pages 337–344, Volume 2, pages 623–630.

What we claim is:

1. A slurry explosive containing as the main ingredients (1) 40 to 80 percent by weight of ammonium nitrate or a mixture of ammonium nitrate and an alkali metal nitrate or a mixture of ammonium nitrate and an alkaline earth metal nitrate or a mixture of ammonium nitrate, an alkali metal nitrate and an alkaline earth metal nitrate, (2) 5 to 20 percent by weight of aluminum powder consisting of aluminum powder (a) which is manufactured by the ball milling method or the stamping method, the particle size of which is 30 mesh (JIS sieve) or below, and aluminum powder (b) having no leafing property which is manufactured by the atomizing method or the graining method, the particle size of which is 30 mesh (JIS sieve) or below, the mixing ratio by weight of the aluminum powder (a) and the aluminum powder (b) being about 50 to 20 : 50 to 80, and (3) 5 to 25 percent by weight of water.

2. A slurry explosive according to claim 1, wherein the slurry explosive further contains a member selected from the group consisting of 2,4,6-trinitrotoluene, smokeless powder, carbonaceous fuels, and mixtures thereof.

3. A slurry explosive according to claim 1 wherein the slurry explosive further contains a paste for suspension stability.

4. A slurry explosive according to claim 1 wherein aluminum (a) is manufactured by the ball milling method.

5. A slurry explosive according to claim 1 wherein aluminum (a) is manufactured by the stamping method.

6. A slurry explosive according to claim 1 wherein aluminum (b) is manufactured by the atomizing method.

7. A slurry explosive according to claim 1 wherein aluminum (b) is manufactured by the graining method.

8. A slurry explosive according to claim 1 wherein aluminum (a) is lower in apparent specific gravity and higher in specific surface area and sensitivity then aluminum (b).

9. A slurry explosive according to claim 1 wherein aluminum (a) is manufactured by the stamping method and aluminum (b) is manufactured by the atomizing method, and the slurry contains above 7 percent by weight of aluminum (b) but not above 15 percent by weight of aluminum (a).

10. A slurry explosive according to claim 1 containing 40 to 80 percent by weight of ammonium nitrate.

11. A slurry explosive according to claim 1 containing 40 to 80 percent by weight of a mixture of ammonium nitrate and an alkali metal nitrate.

12. A slurry explosive according to claim 1 containing 40 to 80 percent by weight of a mixture of ammonium nitrate, an alkali metal nitrate and an alkaline earth metal nitrate.

* * * * *