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Biswas

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[54] **METHOD FOR THE PREPARATION OF THICKENED SLURRY EXPLOSIVES**

[75] Inventor: **Dilip Kumar Biswas**, Bihar, India

[73] Assignee: **Imperial Chemical Industries, Limited**, London, England

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[52] **U.S. Cl.** ..... **149/14,** 89/20 C, 149/44

[51] **Int. Cl.** **C06c 3/10,** C06d 1/08

[58] **Field of Search** ..... 86/20, 20 C; 149/44, 149/38; 102/23

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Primary Examiner—Benjamin A. Borchelt
Assistant Examiner—H. J. Tudor
Attorney—Cushman, Darby & Cushman

[57] **ABSTRACT**

Improved method for the preparation of thickened slurry explosives wherein a cross-linking agent is fed to the surface of a stream of thickened aqueous slurry explosive to cross-link the thickening agent on the outer layer of the stream. The invention also includes a nozzle adapted to feed a liquid cross-linking agent to a stream of slurry explosive as it emerges through the nozzle discharge port.

6 Claims, 2 Drawing Figures

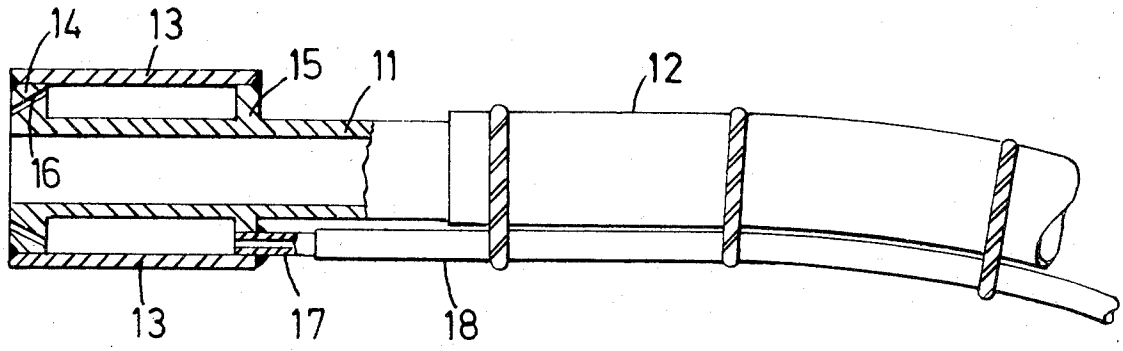


FIG. 1.

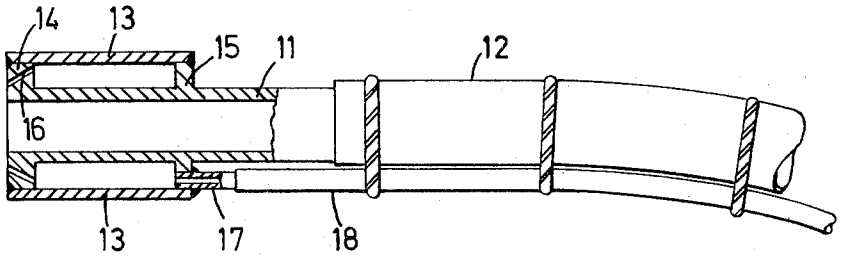
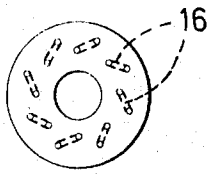


FIG. 2.



Inventor
DILIP KUMAR BISWAS
By
Cushman, Darby & Cushman
Attorneys

METHOD FOR THE PREPARATION OF THICKENED SLURRY EXPLOSIVES

This invention relates to an improvement in the method of preparation of thickened slurry blasting explosives and to an improved method of stiffening the outer layer of a column of a slurry explosive. The invention also includes thickened slurry explosive composition and a nozzle for use in preparing thickened slurry explosive.

Slurry explosives which comprise an oxygen-supplying salt, for example, ammonium nitrate, a sensitiser and, optionally, additional fuel suspended in a saturated solution, commonly an aqueous solution, of the oxygen-supplying salt, are well known and widely used. It is usual in aqueous slurries to thicken the aqueous solution by dissolving therein a thickener to prevent segregation of the solid ingredients. The slurry is often further thickened, to prevent dilution in wet shotholes, by the addition of a material to cross-link the thickener. Thus it is common to use polymeric thickening agents containing cis-hydroxyl groups, for example, guar gum, and to incorporate a cross-linking agent, for example, borax or a soluble chromate or dichromate, to cross-link the thickening agent by reaction with the hydrocyl groups. However, when the thickening agent is fully cross-linked the slurry explosive is difficult to load into a borehole or a container because it is difficult to pump. Consequently the incorporation of the cross-linking agent is often delayed until shortly before the explosive is placed in the desired position in the borehole or container and the cross-linking process is allowed to proceed in situ.

It is an object of this invention to provide an improved method of preparing thickened slurry explosive composition in order to improve the mechanical stability and water resistance of the slurry explosive when it is placed in position in a borehole or a container.

In accordance with this invention a method of preparing a slurry explosive comprises feeding a liquid thickening agent to the surface of a column of slurry explosive composition whereby the thickening agent becomes admixed with the outer layer of the said stream and the outer layer is thickened.

In a preferred method the aqueous slurry explosive composition contains a cross-linkable thickening agent in solution and a cross-linking agent for the said thickening agent is fed to the surface of a column of the slurry explosive so as to mix with the outer layer of slurry composition and cross-link the thickening agent in the outer layer and thereby thicken the outer layer.

A convenient method of preparing slurry explosive by the method of the invention comprises feeding liquid cross-linking agent to the surface of a stream of thickened aqueous slurry explosive composition whereby thickening agent in at least an outer layer of said stream becomes admixed with cross-linking agent and the said outer layer is consequently further thickened.

Advantageously the cross-linking agent is fed as a plurality of jet streams impinging at radially spaced positions on the surface of the stream of slurry. The jets mix with the surface layer of the slurry composition and spread over the entire surface. It is preferred that at least some of the jets should impinge the slurry stream in a non-radial direction. If the non-radial jets are inclined to the radius in the same directional sense, i.e., if they are all arranged to veer clockwise or all counter clockwise, a swirling action is imparted to the surface of the slurry stream which assists mixing and further penetration of cross-linking agent into the slurry stream.

The method of the invention permits slurry explosive to be fed to a borehole or container in a thin, readily pumpable condition, and subsequently to have its outer layer converted quickly to a thickened protective layer. The thickened protective layer can be relatively water-impermeable and mechanically stable and the slurry explosive is consequently prevented from mixing with water which may be in a borehole or from escaping into borehole crevices. Similarly, if the slurry explosive is fed to a porous container, for example, paper or cardboard cartridge cases, the thickened outer layer has a markedly reduced tendency to penetrate the container walls.

In charging a borehole for blasting with a slurry explosive it is generally advantageous to feed the slurry from a feed nozzle initially placed at the bottom of the borehole and retracted from the borehole as a charge is placed in position. For this purpose feeding liquid cross-linking agent around a slurry stream containing cross-linkable thickening agent as it emerges from the feed nozzle is generally satisfactory. However, it is sometimes inconvenient to insert the nozzle to the bottom of the borehole, and, in order to protect the slurry from any water which may be in the borehole, it is preferred, in this case, to feed liquid cross-linking agent to a stream of slurry before the stream is delivered to the borehole to permit the outer layer to become sufficiently thickened to resist water penetration before the slurry stream emerges from the nozzle.

The invention also includes a column of slurry explosive composition having an outer layer thickened to a greater degree than the remainder of the column. Preferably the column contains dissolved, uniformly dispersed cross-linkable thickening agent which is more cross-linked in the outer layer than in the remainder of the column.

The preferred aqueous slurry explosive comprises ammonium nitrate as an oxidising salt, a sensitiser, water, thickening agent and cross-linking agent. The thickening agent preferably comprises guar gum and the preferred cross-linking agent for the guar gum comprises a water-soluble chromate or dichromate, for example, potassium dichromate or a water soluble pentavalent antimony compound, for example, potassium pyroantimonate.

The sensitiser may be a self explosive material, for example, trinitrotoluene (TNT) or pentaerythritol tetranitrate (PETN) or it may be a non-explosive material, for example, aluminium.

The invention further includes a nozzle for mixing slurry explosive and cross-linking agent in accordance with the method of the invention, which nozzle comprises a tubular member adapted at its inlet end to be attached to a supply of slurry explosive and provided at its discharge end with a discharge port through which a stream of slurry explosive fed through the member may be discharged, and liquid feed means through which a liquid cross-linking agent may be fed to the surface of the stream of slurry explosive.

The liquid feed means preferably comprises a jacket surrounding the tubular member, the jacket having one or more inlets through which liquid cross-linking agent

may be fed under pressure and a plurality of outlets radially spaced around and directed towards the axis of the tubular member, through which outlets jets of liquid cross-linking agent may be fed to impinge on a stream of slurry explosive fed through the tubular member.

Preferably at least some of the outlets from the jacket should extend in a non-radial direction and it is further preferred that the non-radial outlets should be inclined to the radius in the same directional sense.

In one convenient form of the nozzle the end wall of the jacket is flanged on the end of the tubular member, the discharge port and at least some of the outlets from the jacket being formed as passages through the end wall. Using this nozzle liquid cross-linking agent may be fed to a stream of slurry explosive after it emerges from the discharge port. In another form of nozzle at least some of the jacket outlets extend from the jacket through the wall of the tubular member so that with this nozzle cross-linking agent may be fed to a stream of slurry explosive and the outer layer of the slurry consequently cross-linked before it emerges from the nozzle.

The invention will now be further illustrated by the following description of the practice of the invention which is described, by way of example, with reference to the accompanying drawings wherein

FIG. 1 shows a nozzle partially in longitudinal section;

FIG. 2 is an end view of the nozzle of FIG. 1.

The nozzle of FIG. 1 comprises a tube 11 having a flexible slurry supply pipe 12 sleeved over one end. A tubular jacket member 13 is sleeved over the end of tube 11 and sealed to the tube 11 by jacket end plates 14 and 15. Eight narrow outlet passages 16 are formed through the end plates 14, the outlets being inclined inwardly in a non-radial direction and being evenly spaced around the axis of the tube 11. An inlet tube 17 extends through an aperture in the end wall 15 and a supply pipe 18 for cross-linking agent is attached to the end of tube 17.

In use, slurry explosive composition with admixed cross-linkable thickening agent is pumped as a stream through pipe 12 and tube 11. Liquid cross-linking agent is pumped through pipe 18, tube 17 into jacket member 13 and is discharged through outlet passages 16 as high velocity jets which impinge on the surface of the emergent stream of slurry explosive as a swirling spray. The surface layer quickly becomes cross-linked to a relatively strong thickened crust which resists water penetration and generally protects the softer inner core. The cross-linking action continues inwardly and, if sufficient cross-linking agent is used, substantially the whole mass of slurry becomes cross-linked.

In a modification of the nozzle of FIG. 1 and 2, the tube 11 is extended beyond the jacket and the jacket outlets 16 are formed as non-radial passages in the tube 11. The extension of tube 11 provides a mixing zone wherein the stream of slurry explosive with admixed cross-linking agent in the surface layer is protected until the surface layer has become cross-linked. This modification is especially suitable for loading slurry explosive into water-filled vertical boreholes from a nozzle located at the top of the borehole.

The method of putting the invention into practice is further illustrated by the following Examples.

EXAMPLE 1

The slurry explosive used in this Example had the following composition:

Ingredient	% by weight
Ammonium nitrate	51.5
Sodium nitrate	15.2
Flake aluminium	4.0
Coal powder	5.1
Guar gum (thickening agent)	0.6
Ethylene glycol	1.5
Water	22.1

The cross-linking agent was an aqueous solution of potassium dichromate containing 2.5 percent by weight of potassium dichromate.

The slurry explosive and cross-linking agent were pumped from separate blow cases through tube 11 and tube 17 respectively of a nozzle as shown in FIG. 1. Tube 11 was ⅜ inch interval diameter, tube 17 was 1/16 inch internal diameter and tubular jacket member 13 was ⅞ inch internal diameter, the wall thicknesses being one-sixteenth inch in each case. The end plate 14 was three-sixteenths inch thick and the outlet passages 16 were 1/64 inch diameter. The slurry was pumped at a blowcase pressure in the range 40 to 60 p.s.i.g. and the cross-linking agent was pumped at a blowcase pressure in the range 3 to 5 p.s.i.g.

The slurry with the cross-linking agent admixed in the surface layer was fed to 1¼ inches bore × 12 feet long polythene and steel pipes by inserting the nozzle fully into the pipe and retracting it as loading proceeded. The loading rate was about 8 Kg/minute. The slurry was found initially to be cross-linked in a surface layer only but after 24 hours it was cross-linked almost to the centre.

When fresh and after 7 days storage the slurry in the pipes detonated at a velocity of 3.5 Km/s and communicated detonation across an air gap of 12 inches.

Example 2

The slurry explosive in this Example had the following composition:

Ingredient	% by weight
Ammonium nitrate	54.5
Sodium nitrate	15.0
Flake aluminium	1.0
PETN	5.0
Guar gum	1.0
Ethylene glycol	1.5
Water	22.0

The cross-linking agent was an aqueous solution of potassium pyroantimonate containing 2.0 percent by weight of potassium pyroantimonate.

The procedure described in Example 1 was followed and an explosive column with a stiff (highly cross-linked) surface layer was produced.

I claim:

1. A method of preparing a slurry explosive which comprises feeding a liquid thickening agent only to the surface of a flowing stream of slurry explosive composition whereby the thickening agent becomes admixed with the outer layer of the said stream and the outer layer is thereby further thickened.

2. A method of preparing a slurry explosive which comprises feeding a cross-linking agent only to the surface of a flowing stream of slurry explosive containing a cross-linkable thickening agent whereby the cross-linking agent becomes admixed with the outer layer of the slurry composition and the thickening agent in the

outer layer is cross-linked and the outer layer is thereby further thickened.

3. A method as claimed in claim 2 wherein the cross-linking agent is fed as a plurality of jet streams impinging at radially spaced positions on the surface of the stream of slurry.

4. A method as claimed in claim 3 wherein at least some of the jets impinge the slurry stream in a non-radial direction, the non-radial jets being inclined to the radius in the same directional sense.

5. A method as claimed in claim 2 wherein the slurry explosive is fed to a borehole and liquid cross-linking agent is fed to the said slurry stream before the stream is delivered to the borehole so as to allow the outer layer of the slurry stream to become sufficiently cross-linked to resist water penetration before it is delivered to the borehole.

6. A column of a slurry explosive varying in composition only in the amount of thickening agent in a diametrical cross section of the column and having a circumferential outer layer of the slurry thickened by an added amount of a thickening agent to a greater degree than the remainder of the column.

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