METHOD AND APPARATUS FOR DELIVERING THICKENED BLASTING AGENTS

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References Cited

UNITED STATES PATENTS
3,566,790 3/1971 Knight, Jr................. 86/20 C X
3,361,023 1/1968 Collins et al............. 86/20.3

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ABSTRACT

Improved methods and apparatus are provided for pumping thickened slurry or liquid blasting agents through confining conduits for blasting geologic formations. Thickened slurry and liquid blasting agents are prepared containing gelling or thickening agents which produce thickened solutions having thixotropic properties. Increased shear is applied to the thickened blasting agents, e.g. they are kneaded, such as for example, in a pumper truck having means for mechanically disturbing the explosive, to temporarily produce a more flowable composition which is pumpable. The explosive is then immediately pumped into position, e.g. boreholes, wells. Upon standing under ambient conditions the blasting agent becomes more viscous thus providing the necessary properties of water resistance and settling stability.

3 Claims, 2 Drawing Figures
METHOD AND APPARATUS FOR DELIVERING THICKENED BLASTING AGENTS

BACKGROUND OF THE INVENTION

Thickened liquid and slurry blasting agents such as those disclosed in U.S. Pat. No. 3,307,986, and the like have received widespread recognition in the mining, oil, and gas industries as high powered safety explosives. It has been the practice to manufacture these blasting agents at a plant, load them into pumper trucks, deliver them to the blast site and pump them to the point of application, e.g., into the borehole. Several difficulties are encountered with this type of delivery. One primary concern is that slurries and liquid blasting agents must be readily pumpable under ordinary pumping pressures and at the same time must be sufficiently viscous and stable so that solid constituents in slurries will not settle and the compositions are sufficiently waterproof so as not to be leached out or washed away by running water in boreholes. In the past it has been necessary to compromise these conflicting requirements in order that blasting agents could be prepared which had a low enough viscosity so as to be pumpable while maintaining sufficient stability and water resistance. For example, see U.S. Pat. No. 3,361,023 for a discussion of this type of compromising.

In many instances, the blasting agents, in order to be pumped, have such a low viscosity that they are hampered by settling instability and low water resistance. One attempt to overcome this difficulty has been to heat thickened blasting agents to temporarily lower the viscosity thereof and pumping the heated compositions into the borehole where they partially set up. However, there are several drawbacks to this proposal. For example, the high temperatures necessary to provide fluidity may be above the melting point of certain ingredients in slurry blasting agents which should remain solid. Secondly, high temperatures may render the blasting agent unduly sensitive to detonation. Thirdly, the use of high temperature causes a thinning of slurries with the result that solid constituents settle out during shipment. Also such heating units require added expense.

Another method which has been proposed is to separately ship the ingredients comprising slurry blasting agents, mix the separate solid and fluid ingredients (including gums and the like) at the blast site and then pump the resultant slurry blasting agents into the borehole before the gums or other thickening agents have a chance to hydrate and crosslink. The blasting agents then set up the borehole. This type of an operation involves several serious drawbacks. First, precise control over manufacturing conditions are difficult to achieve when compositions are mixed in the field. Thus, blasting agents varying in mix, uniformity and strength are sometimes produced. Secondly, the equipment involved must be of a highly technical nature resulting in undue expenses. As an embodiment of this method it has been suggested to employ delayed action crosslinking agents. However, when this system is employed it causes serious operating hazards, for if pumping must be suspended the gelling agent may prematurely crosslink and set up in hoses and pumps.

The present invention concerns an improved method and apparatus for delivering and pumping thickened blasting agents into boreholes, wells and the like.

SUMMARY OF THE INVENTION

In the present invention, slurry and liquid blasting agents, e.g., of the inorganic oxidizing salt, water, sensitizer and/or fuel and thickening agent type, are prepared containing gelling agents which produce solutions having thixotropic characteristics. The thickened blasting agents are subjected to high shear conditions, e.g., kneaded, to increase the flowability thereof and then pumped into position, e.g., borehole. When the blasting agents are under low shear conditions, e.g., when they are at rest in the borehole, they become less flowable and provide stable, waterproof blasting agents.

Thixotropic materials and solutions as employed herein means materials containing a liquid phase or solutions which: (a) have been thickened and/or gelled by incorporating a thickening agent therein; (b) which become more flowable through confining conduits when subjected to high shear conditions and (c) which again become less flowable when the high shear conditions have been removed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically shows one embodiment of the method and improved apparatus of the present invention.

FIG. 2 shows one embodiment of an improved pumping apparatus of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In the practice of the present invention typical thickened blasting agents, e.g., slurries containing particulate and liquid phases and fluid explosives, are thickened with gelling or thickening agents which form thickened solutions having thixotropic properties. The thickened blasting agents are subjected to high shear conditions, e.g., kneaded, agitated, shaken, stirred or the like, to decrease their resistance to flow through confining conduits. The flowable compositions are then pumped into position, e.g., borehole, well and the like, whereupon the thixotropic solution again sets up to decrease the flowability of the blasting agent.

The thickened blasting agents may be subjected to high shear conditions in many different ways. For example, when the agents are delivered in a pump truck, a portion of the agent can be cycled from a supply tank through a pump and back through the tank thus causing a mixing and kneading of the blasting agent prior to being pumped into the borehole. Also, the supply tank of the pump truck can be provided with mechanical mixers, e.g., impellers, paddle wheels, augers, ultrasonic sound producing devices, etc., to subject the blasting agent to high shear conditions. A separate cycling pump can be provided to continuously mix the blasting agents while they are being pumped into the borehole. Special pumps, such as those designed hereinafter, can be employed which subject the blasting agents to high shear conditions.

Broadly speaking the gelling agent must first set up to increase the viscosity of the fluid phase of the blasting agent sufficiently to hold solids in suspension while shipping and during storage and provide water resistance where needed. Secondly, the thickened fluid phases must have thixotropic properties. The gelling or
thickening agent does not necessarily always have to be of the crosslinkable type since the present process allows the use of a greater amount of gelling and thickening agents in blasting agents than heretofore possible, thus naturally providing a thicker, more stable blasting agent. However, crosslinkable gelling agents tend to provide a higher degree of waterproofing, stability in the borehole plus other advantages, and thus are preferred when the blasting agents are to be employed in the presence of very wet or running water conditions.

Thickening and gelling agents which can be employed to provide thickened solutions having thixotropic properties include organic and inorganic natural materials such as, for example, polysaccharides, e.g., guar, karaya, pectins, algins, agar and other natural gums, certain clays, e.g., bentonite, silicates and the like, and synthetic polymers such as polyacrylamides, polyethylene oxides, cellulose materials, e.g., carboxymethyl cellulose, polyvinyl alcohol and other gelling and thickening agents known in the art which provide thickened solutions having thixotropic properties.

Slurry blasting agents to which the present invention pertains are any of those known in the art which contain a fluid phase the viscosity of which is increased by employing thickening and gelling agents. For example, the method can be practiced with the compositions described and claimed in U.S. Pat. Nos. 3,307,986; 3,400,026; 3,397,097; 3,264,151; 3,446,618; 3,242,022; 3,094,443 and 3,091,559, the teachings of which are incorporated herein by reference.

As indicated the present invention also concerns an improvement in pumping apparatus employed to deliver and pump thickened slurry and liquid blasting agents. These pumping apparatuses can comprise a conventional automotive truck having a platform bed located rearward of a conventional cab. Typical of such trucks is that described in U.S. Pat. No. 3,380,333, at column 4, lines 25–42, such disclosure being herein incorporated by reference. A variety of means are provided on such trucks for carrying and pumping slurry explosives. The design described in U.S. Pat. No. 3,380,333, for example, consists of a mixing type set up wherein various constituents making up a slurry explosive are contained in separate storage tanks and mixed at the blast site. The disadvantages associated with this type of mixing system have been previously iterated herein under the section entitled Background of the Invention. In general, when thickened blasting agents are premixed at a manufacturing plant the pumper truck comprises, a supply tank, connecting tubing and hosing for delivery of the thickened blasting agent from the supply tank to the blast site, and pumping means supplying the force necessary for moving the explosive from the tank through the hoses and conduits and into the blast site, e.g., boreholes. A variety of tank designs and sizes are employed. Pumping means comprise many types including pneumatic, electric and other like pumps known in the art. In the present invention a typical pumper truck design is changed so that the thickened blasting agent may be subjected to high shear conditions, e.g., by kneading or otherwise disturbing the explosive prior to being pumped to the blast site.

One embodiment of an apparatus for performing the method of the present invention and for improving pumping apparatus designs is schematically shown in FIG. 1. The apparatus as shown in FIG. 1 can be mounted on a truck frame, skid, trailer or other device which can be made mobile in a manner known in the art.

The apparatus comprises a supply tank 10 containing disturbing means 11 for subjecting the thickened slurry and liquid blasting agents 12 as defined herein to high shear conditions prior to pumping them to the blast site, e.g., borehole. A first conduit 13 connects the supply tank 10 to the inlet of pumping means 14. The outlet to the pump is connected to a high pressure flexible hose 15 or other second conduit means which delivers the thickened blasting agent to the borehole.

The disturbing means 11 can consist of any of a number of devices which mix, stir, tumble, vibrate or otherwise subject the thickened explosive 12 to high shear conditions. Included by way of example are paddle wheels, augers and impellers and the like. Also ultrasonic sound can be employed.

A preferred embodiment of the improved apparatus is shown in FIG. 2. The apparatus comprises a supply tank 10, shown in FIG. 1, and pumping means 14 for cycling the slurry explosive from the supply tank 10 through the first conduit 13, and through a third conduit 16 back to the supply tank 10 prior to being pumped to the blast site through the second conduit 15. Preferably, the third conduit 16 connecting the outlet of the pump 14 to the supply tank 10, is split into a plurality of discharge tubes 17, the open ends of which are located near the upper portion and directed toward the inner walls of the supply tank 10. In this manner the explosive 12, which is discharged from these tubes 17, is forced along the sides of the tank 10 to cause a mixing and turnover of the slurry explosive 12 in the tank 10.

The third conduit 16 is connected to a valve 18 which in turn is connected to the second conduit 15 for delivering the explosive to the blast site. The valve 18 is designed so that the explosive can be diverted to the supply tank 10 to be recycled for a predetermined period of time and then can be directed, either entirely or partially, through the second conduit 15.

The pump 14 can be any of the types employed to pump thickened slurry and/or liquid blasting agents. Preferably a resilient tube type pump is employed. This type of pump allows the explosive to be partially kneaded by the pump itself. One resilient tube pump is illustrated in "Pump Selection and Application", T. G. Hicks, McGraw-Hill Book Co., Inc., First Ed., 1957, pp. 30–31. Another type is partially shown in FIG. 2, No. 14. Other resilient tube type pumps are known in the art.

Several advantages are achieved by employing explosive compositions containing thickened fluid phases having thixotropic properties. Some of these include: more highly thickened explosive compositions can be prepared since the thixotropic nature of the fluid phase allows the explosives to be pumped at normal pumping pressures; higher pumping rates can be employed thus cutting down the operation time in the field; stronger and tougher thickening agents can be employed which allow for higher degrees of water-proofing and settling stability of explosive compositions; and greater quantities of gelling and thickening agent can be employed in the explosives than heretofore taught thus allowing for
longer shelf life along with better resistance to water erosion and settling in the borehole.

Example 1

To illustrate the method of the present invention an explosive composition containing the following constituents as parts by weight was prepared.

<table>
<thead>
<tr>
<th>Component</th>
<th>Parts by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formamide</td>
<td>10.0</td>
</tr>
<tr>
<td>NaNO₃</td>
<td>10.0</td>
</tr>
<tr>
<td>NH₄NO₃</td>
<td>66.7</td>
</tr>
<tr>
<td>H₂O</td>
<td>6.8</td>
</tr>
<tr>
<td>Guar Gum</td>
<td>1.0</td>
</tr>
<tr>
<td>Propylene Glycol</td>
<td>1.2</td>
</tr>
<tr>
<td>Sugar</td>
<td>4.0</td>
</tr>
</tbody>
</table>

This composition is a slurry having particulate inorganic salts suspended in an aqueous solution saturated with respect to the salts and thickened with guar gum. The slurry has a density of about 1.15 gms/cc and viscosity of about 480,000 centipoise as determined with a Brookfield Viscometer Model ABT at 5 r.p.m. with a T-C spindle.

A flexible tube-type pump (Challange Cook Bros. Squeeze Crete), having a 3-inch inside diameter was employed to pump and knead the slurry explosive. This type of pump has a resilient tube which is squeezed by a rotary compression ring which forces the medium being pumped through the pump. The pump employed in this example was capable of developing about 300 psi of pumping pressure.

In the present example an attempt was made to pump the previously defined explosive composition through 125 feet of 2-inch inside diameter hose. The pump could not force the explosive through at a pumping pressure of 300 psi. The hose was then reduced to 75 feet and the slurry was pumped through at the rate of 250 pounds per minute at a pumping pressure of 300 psi. The thickened slurry was then recycled through the pump for about 10 minutes to knead the slurry. After about 10 minutes the slurry was being pumped through the 75-foot length of hose at 900 pounds per minute at 300 psi pumping pressure. This amounted to about a 3.6 times increase in pumping rate. The hose was increased to 100 feet and the pumping rate determined to be 900 pounds per minute at 300 psi pumping pressure. The hose was then increased to its original length of 125 feet and the pumping rate was about 850 pounds per minute at 300 psi pumping pressure. The hose length was then increased to 150 feet and the pumping rate determined to be 800 pounds per minute at 300 psi pumping pressure. All this evidenced the increased pumping rate which was accomplished by kneading the slurry.

The slurry maintained its integrity and resistance to segregation and water erosion.

In a second test a slurry explosive containing about 25 percent by weight particulate aluminum and a partially cross-linked gelling agent was pumped, prior to being kneaded, through 100 feet of 2-inch diameter hose at a rate of about 180 pounds per minute at 300 psi pumping pressure. This slurry was then cycled through the pump for about 10 minutes in the same manner as the first slurry and the pumping rate increased to 600 pounds per minute at 300 psi pumping pressure.

In both of these tests the temperature of the slurries remained about the same and the gelling agents showed no evidence of deterioration.

What is claimed is:

1. In a method for blasting geologic formations which comprises introducing a slurry or liquid blasting agent into the formation and exploding the same, the improvement which comprises:
   a. providing in a container a thickened or gelled blasting agent characterized as being a stable water resistant thickened thixotropic composition which is at least about as stable as the minimum desired stability in the borehole;
   b. subjecting the thickened blasting agent to high shear conditions to render it flowable through a confining conduit; and
   c. introducing the flowable blasting agent from said container into the formation through a conduit wherein ambient conditions of flowability decreases to provide a stable water resistant blasting agent.

2. The method as defined in claim 1 wherein said geologic formation contains free water.

3. In a method for blasting geologic formations which comprises exploding a gelled or thickened blasting agent in the formation, the improvement which comprises:
   a. preparing a gelled or thickened thixotropic blasting agent which is at least about as physically stable as the minimum desired physical stability of the blasting agent when in place in the formation;
   b. transferring the gelled or thickened thixotropic blasting agent to the site of use;
   c. subjecting the gelled or thickened thixotropic blasting agent to high shear conditions to render the blasting agent pumpable; and
   d. pumping the pumpable blasting agent into the formation wherein under ambient conditions it returns to said minimum physical stability.

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