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Development of Emulsion Explosive Using Palm Olein for Blasting Works

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Abstract
Malaysia is one of the biggest producer and of palm olein in this world. There are many applications of palm olein from ice cream to lipsticks. Current progress in the new infrastructure in Malaysia, namely; ECRL, MRT which involve a lot of blasting work that require huge amount of explosive. Therefore, this research explores the potential of using palm olein as a fuel phase in emulsion explosive for blasting work. The objective of this research is to obtain the optimum velocity of detonation (VOD) by varying the microballons and water content. In this experiment, palm olein is used as fuel phase. 15 samples of emulsion explosives were developed with a content 3% of palm olein and ammonium nitrate used fix content of 90%. Three samples were made as control, in which six samples were made variety of water range and follow by another six samples of microballons (1-3%). Detonation velocity testing using fiber optic method was conducted to access the VOD obtain from using 18% water and 3% of microballons, which give a maximum VOD 5800 m/s. The result showed the usage of palm olein with combination of water, microballons can produce higher VOD of emulsion explosive as compared with control sample. Thus, it can be used as an alternative emulsion explosive in blasting industries.

Keywords: *Emulsion explosive, microballons, palmolein, velocity of detonation, water.*

I. Introduction

Explosive for civil use, such as emulsion explosives, slurry explosives and ANFO (Ammonium Nitrate-Fuel Oil) are ammonium (AN) based. Those explosive are well known to show non-ideal detonation behavior due to its slow reaction rate compared to high explosive for military use.

In civil use, explosive is widely used in blasting works for the new infrastructure such as road works and tunneling. Current progress of new infrastructure in Malaysia; such as ECRL, MRT, new stretch of hiwaywhich involve a lot of blasting work that require huge amount of explosive. Explosive, the mixture of oxidizer Phase and fuel phase when react, it will release great amount of potential energy that can produce an explosion if released suddenly, usually accompanied by the production of light, heat, sound, and pressure.

Palm oil is one of the most important economic crops in Malaysia and in 2016, 5.74 million hectares were planted in Malaysia (Kushairi, Singh, &Ong-Abdullah, 2017). 29% of palm olein produced from palm oil is a source of fat and oil to the world, followed by 25% soybean oil and 15% grapeseed oil. For 2016, Malaysia is the world's second largest exporter of palm oil,

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accounting for 30% of the world's total export value (Mielke, 2019).

Palm oil has many uses that can be classified into several categories whether edible or non-edible. For the food industry, palm oil is widely used as cooking oil, vegetable fat, shortening, candy, margarine, ice cream, non-dairy cream, cheese substitute, chocolate and health products. Meanwhile, palm oil also plays a role in the oleochemical industry as surfactants, cosmetics, agrochemicals, lubricants, soaps, personal care products, ink and polymer-based products. As for the biofuel industry, oil palm can be formulated along with petroleum as fuel as well as jet and biogas (Khatun, Reza, Moniruzzaman, &Yaakob, 2017).Therefore, this research explores the potential of using palm olein as a fuel phase in emulsion explosive for blasting work.

Emulsion Explosive

An emulsion explosive is an oil emulsion in oil with water forming a dispersed phase. The aqueous phase, the oil phase and the surfactant or sensitizer are the three basic constituents of Emulsion explosives. The advantage of emulsion explosives over others in the category of ammoniun nitrate fuel (ANFO) is that it is water resistant. For aqueous phase, aqueous solution of ammonium nitrate (AN) will form 85% or more for the formulation. Other oxidizing substances such as sodium and calcium nitrate can also be used as an alternative to AN. The solubility of salt is increased with temperature, where the Salt is dissolved in hot water. However, this solution needs to be mixed with the oil phase which has also been heated as crystallization will occur at around 70^{o}C. (John, 2002)

The stability of the emulsion system is highly dependent on the Oil Phase, which is the fuel of the Ammonium Nitrate oxidiser. The most common types of oils are plants oils, edible oils, refined paraffin or microcrystaline candles. This stability takes into account the oxygen balance between the fuel as well as the oxidation which is the basis for good explosives.

Figure 1.0 : Commercial explosive (Emulex®)

The substances containing air or nitrogen may form an emulsion explosive substance such as oxidizing salts; candles, Al atomized, oils, emulsifiers, gassing agents, organic sensitizer and microballons.

The emulsion blasts with good performance and smoke characteristics are also in accordance with the concept of oxygen equilibrium, that is, the explosive mixture has zero or almost zero oxygen balance function. The oxygen balance calculation has the same design as the water gel. Density, explosive velocity, explosive pressure, sensitivity, energy strength, chemical stability, water resistance, thermal stability and smoke characteristics are important criteria for the production of explosives (Tete, Deshmukh, &Yerpude, 2013).

Table 1.0 Approximate velocities of Detonation For Various Types of Explosive (Yusof, Nor, & Ismail, 2018)

Types Of Explosive	Approximately Velocity Of Detonation (M/S)
ANFO	3600
EMULEX	5100
TNT	7000
PETN	7975
C-4	8092
RDX	8639
TANZ	8846
HMX	9110
ONC	10100

In industries, recycle lubricants oil were used in their production and resulted inconsistence of

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velocity of detonation (VOD) reading. This affected the performance of the product. In this research, palm olein from palm oil will be used as alternative since that palm olein has the potential to substitute the fuel used. Palm olein also known as cooking oil. The new emulsion explosive will be developed using palm olein with additional of sorbiton mono oleate as the fuel phase in the composition of the materials. Water in aqueos phase which dilute the AN and microballons; the sensitizer could also affect the performance of emulsion explosive. Water and microballons will be varied to get the optimum velocity of detonation. The typical compositions emulsion explosive is as Table 2.0.

Table 2.0 : Typical composition of an emulsion explosive (Mahadevan, 2013)

Ingredients	Quantity (%)
Ammonium nitrate	62
Sodium nitrate	6
Sodium perchlorate	5
Calcium nitrate	8
Water	11
Fuel oil	3
Waxes	2
Emulsifier	1.2
Atomized aluminium	0.8
Gassing agents	1.0
Oxygen balance	Close to 0.0

II. Method for preparation of Emulsion Explosive

The preparation of the emulsion explosive was conducted at the Defence Technology Laboratory, National Defence University of Malaysia. The 94% oxidation mixture, 3% fuel phase and 1% sensitizer were used for the preparation of emulsion explosive. After the oxidizer and the fuel became homogeneous, the sensitizer was mixed. For the oxidation phase, distilled water was mixed with ammonium nitrate and heated to dissolve the ammonium nitrate. For Oil Phase; water jackets with temperature around 90^{o}C were used for heating the palm oil, Poluisobutylene Succinic Anhydride Ethanolamine (PIBSA) and sorbitone mono-oleate. When aqueos ammonium nitrate solution was formed, the solution was slowly added to the hot oil phase and mixed with a food mixer until the emulsion formed. Once the emulsion is formed, to ensure the mixture becomes homogeneous, the mixing speed was increased to a maximum level for five minutes.

Figure 2.0: The Emulsion

The sensitizers; microballons were added to the emulsion at room temperature and mixed with maximum speed for five minutes using the food mixer.

Figure 3.0 : The emulsion after adding the microballons

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For the uniform shape, emulsion was inserted into polyvinyl chloride (pvc) pipe. The dimension of the pipe is 58 mm length and 7 mm diameter with the mass 300 gm.

Figure 4.0. The casing for Emulsion Explosive

III. Method of Testing Emulsion Explosive

Dautriche method, photographic method, point to point electric method and also fiber optic cable methodare selections of methods to measured the VOD (Aruna, D.T. et al, 2013). The VOD method used for this research was fiber optic method. This method using optical fiber cables capable for detecting and transmitting a light signal accompanying the detonation wave front.

VOD method was used to test the Performance of the explosive emulsion. From the VOD readings in the unit of ms^{-1} , it can provide good performance indicators for the overall energy or explosive power and especially for brisance or crushing effects.

Methods such as the Dautriche Method, photographic method, directional method and fiber optic cable method are optional methods for measuring VOD (Aruna, D.T. et al., 2013). For this research, optical fiber or VOD method was used. Optical fiber cables can detect and transmit light signals that accompany the detonation wave front. This method is point to point to type wherein the first cable signal the start where the second cable placed at a known fixed distance stops the timing clock. The fixed distance between probes is divided by the total timed recorded gives the VOD value (Cooper, PW).

Figure 6.0: The pipe bomb with fibre optic cable

IV. Result and discussion

Two types of emulsion explosive have been tested. The first type was the new emulsion explosive with constant water. There were eight samples of this type. Another six samples of new emulsion explosive with constant microballons have been tested; the second typeThere were three samples for each of them. Every sample has been calculated the average VOD.The control, Emulex®also been tested. The VOD of Emulex® was 4921 ms^{-1}.

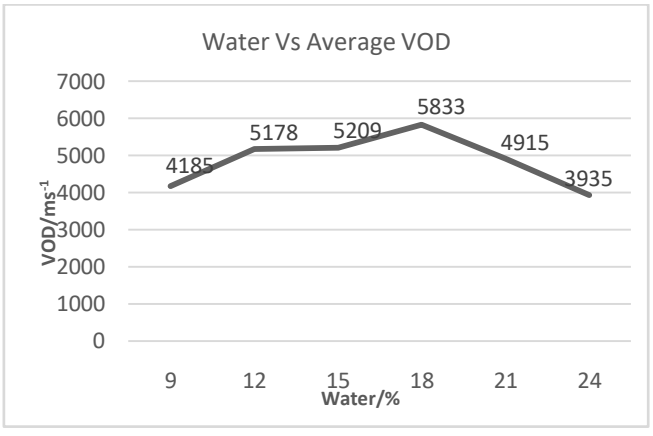

Figure 7.0 : VOD of new emulsion explosive with vary of water and constant percentage of microballons

Figure 7 shows the VOD with changes of water percentage and 3% of microballons. In this graph can see the increasing of VOD with increasing the percentage of water until the optimum contant of

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water, 18%. The percentage of water more than 18% will decrease the VOD. The more content of water will effect the OB equilibrium.

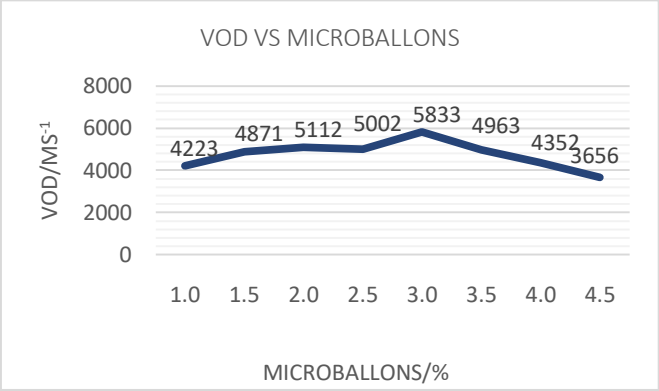

Figure 8: VOD of new emulsion explosive wity vary of microballons percentage and constant percentage of water.

Figure 8 show that the content of microballons should not more than 35. 3% is the optimum result for emulsion explosive to explode with the highest VOD. The microballons basically has the function to lower the density of the emulsion explosive.

V. Conclusion and recommendation

From this study, it can be concluded that the New Emulsion Explosive that has been formulated is has a compatible material with the existing emulsion explosive. New Explosives Emulsion with palm olein content can perform better with high VOD value compared to emulsion explosives in Malaysian market. However, more analysis needs to be done to characterize the morphology of the Emulsion Explosion.

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