# THEORETICAL BASIS OF EXPLOSION EFFECTS USING AL - GRANULES IN BULK EXPLOSIVES

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***ABSTRACT***
*Use of bulk explosives such as AN-FO, heavy AN-FO, SLLURY and various Emulsions significantly improves explosive energy efficiency in the rock massif. Many operating engineers have the opportunity to examine and modify the technical characteristics of explosives and technologists especially, in the production of explosives where the main goal is improvement, the energy capacity by adding various components.*
*The question is when is technically and economically most suitable to use aluminum small particles, in mixtures. This paper presents several comparative parameters aimed to help the mining operating engineers to choose the most economical explosive mixture, including the percentage of added this article.*
***Key words:*** *bulk mixtures, aluminum, blasting parameters, cost*

## INTRODUCTION

The use of bulk explosives mixtures and the realization of the total direct and indirect savings is becoming more common option in the mining industry today. With the addition of aluminum small particles - granules provides an opportunity to increase the power (strength) of the explosives in the future. Feature of aluminum as an additive to improve the overall efficiency seen in all AN-FO explosives mixtures, SLARRI - bulk explosives and all types of emulsion explosives mixtures.

AN-FO explosives are still widely used explosive mixture, and in the beginning of their application is the question which always exists and it is the problem of relatively low strength or power and the unresistance (irregular) to water conditions. With the addition of aluminum granules into these mechanical mixtures, the problem with low strength or power relatively can be overcome, while the capacity of the water resistance requirements for use in mine holes restricting AN-FO mixtures to be used where that water conditions are expressed with high humidity or a large presence of water.

## 1.0 Theoretical settings for using al-granules in bulk explosive mixtures

Bulk SLARRY explosives and heavy emulsions, all types of heavy AN-FO are with improved properties in terms of resistance to water and AN-FO with the addition of aluminum is changed only in terms of increased relative power.
Adding water in these mixtures as a weakening of the explosives and and the result is weight loss, strength and overall energy output.

Aluminum small particles - granules' is added to all bulk mixtures explosive because it is highly energetic fuel. Aluminum increases the total energy capacity, relative strength, temperature explosion and the detonation pressure of the explosive, but does not affect much the speed of detonation.

Relationships and effects by adding aluminum in some types of explosive compounds such as classical AN-FO, are presented in Figure 1.

From Figure 1 it can be seen that the addition and increase the percentage of aluminum in the An-Fo mixtures increases the temperature in the explosion, the density of the mixture, the relative strength of the explosive mixture, while detonating pressure and velocity of detonation or slightly declining slightly. The volume of gaseous products is reduced at the expense of increased temperature in the explosion.

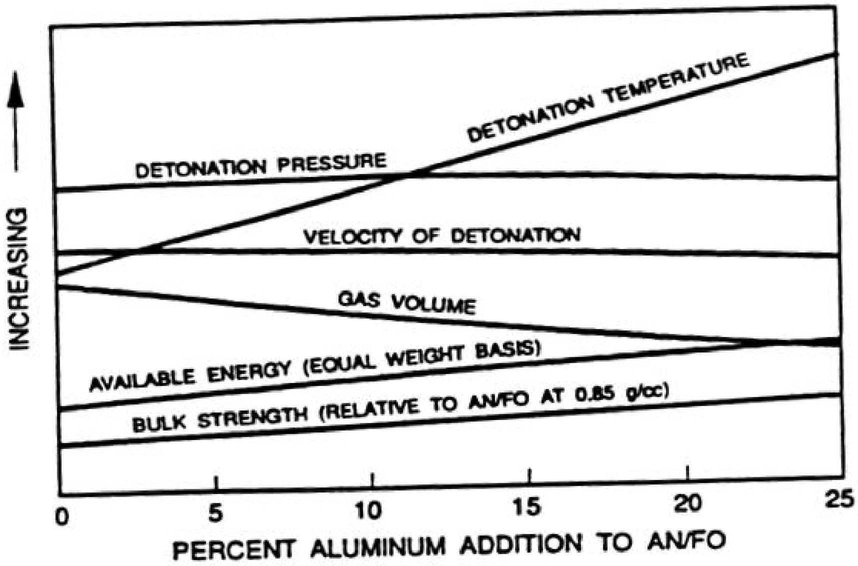


**Fig 1.** ***Effect of increasing aluminium addition to AN/FO***

The reaction of aluminum in an explosive mixture during detonation results in the formation of solid oxides, and when it does not produce gaseous products containing aluminum. The volume and content of the gases created during the explosion are reduced. The heat of formation of aluminum oxides is very high and reaches values over 16,000 kJ / kg and resulted in significant value to heat of explosion, manifested by increased gaseous products temperature.

This higher temperature gas helps to offset a percentage reduction of gaseous products of gas because gasses can perform more work at higher temperature of the explosion.

Because aluminum has a role and act as **fuel** should be reduced other fuels in explosives to keep the oxygen balance of the reaction and therefore the energy capacity. Figure 2 illustrates the percentage of oil fuel necessary to achieve oxygen balance AL / AN / FO with varying degrees of aluminum addition.

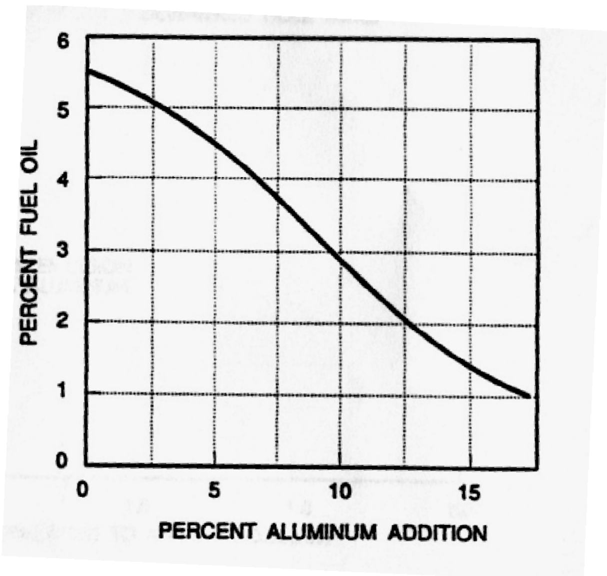


**Fig. 2** ***Percent of fuel oil by weight required to obtain maximum energy output in AL/AN/FO for various levels of aluminum granules adition***

The degree of aluminum as a fuel must conform to certain parameters and specifications to participate fully and effectively in an explosive reaction. Most mportant are the specifications for size, purity, specific gravity, and mechanical and chemical properties of the particles that make these bulk explosive mixtures.

**2.0 Impact of mining method selection and the type of explosives**

For full and efficient use of explosive energy in this case have great influence other blasting, drilling and technical parameters when performing these types of explosives for blasting. Before this, can be mentioned the type of rocks, the method of mining, the method of initiating the design of blasting series i.e. order to initiate etc.

The use of different types of explosives with different strength and water resistance are available on the current level of production of explosives. The presence of water in the mine holes can apply any of the many types SLARRY explosives, Emulsions, heavy AN / FO or aluminized versions of these explosives can be chosen to obtain the required explosive result.

The method of initiating the design of blasting series is of course the one who gives the final results in terms of costs and effects in mining.

For blasting series with a suitable diameter and drilling parameters are chosen explosives with proper strength - power, when the lowest cost (in terms of impact and cost of explosives applied) will be achieved by using explosives who has required strength and lowest cost per unit per obliged charged blast hole.

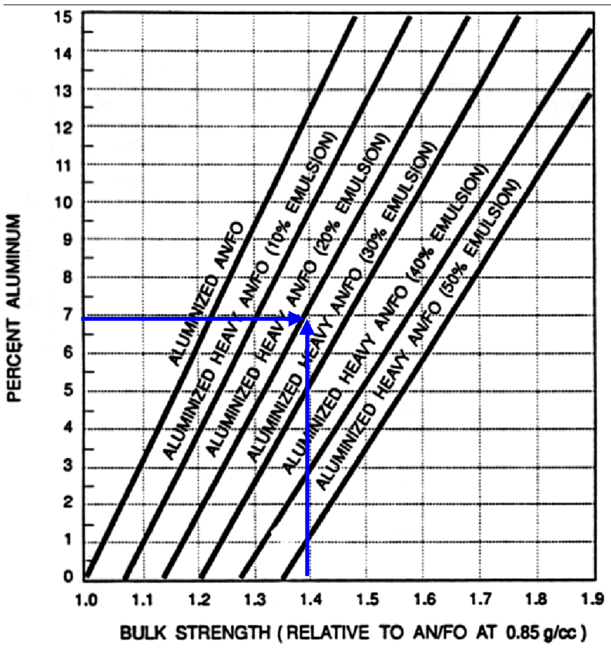


***Fig. 3 Aluminum percent content in varios bulk strengths for selected types of explosives mixtures***

The participation of aluminum in bulk explosive mixtures may vary different and is dependent upon the diameter of the holes and another ingredients of these mixtures. The picture 3 shows different variants of the participation of aluminum in various explosive mixtures with relative strength of mixtures with variation from 1 to 1,9 (compared to the AN-FO 0.85 g/cm$^3$).

If adopted and assumed that the relative strength of these mixtures is 1,4 then is done the best effects and costs are minimal then we can see that in this case the best effects would give the type of explosives **AN-FO - Emulsion (20%)** and **7%** supplement aluminum granules.

One of the first factors to consider when selecting explosives is the water in blast holes. If the holes are pre-wet and full of water and heavy pumping, the first choice would be a liquid explosive mixture (Slurry) with water to suppress outside holes. On the other hand, if the holes are dry or if water can be pumped then you can use the all types AN-FO with a certain percentage of aluminum. Next most important factor is cost, according to a given design blast holes and require certain explosives with adequate power which would be achieved at least (min) cost.

The price of aluminum used in these mixtures has major influence on the cost of explosives, and is one of the products that range that is most the market is volatile. Thus the use of typical explosive mixtures, with force bulk mass (density), strength, and considering the current prices for other ingredients likely to choose the most effective explosives in terms of cost, solely based on the price of aluminum for other ingredients in these types of explosives are standard, consistent and cost for them is relatively known and fixed.

For this purpose, the paper takes the example of prices that are not relevant to the world market prices but the correlation can get some conclusions.

The question is which components can be changed and the effect of explosives to change i.e. cost per ton blasted mass to be similar. If you use an explosive mixture with relatively power of 1,3 and a price of aluminum is $ 0.90/lb, the change in the price of ± 10% of oil or emulsion has little impact on the total cost while changing the price of ammonium nitrate affect the cost charged hole ± 5%.

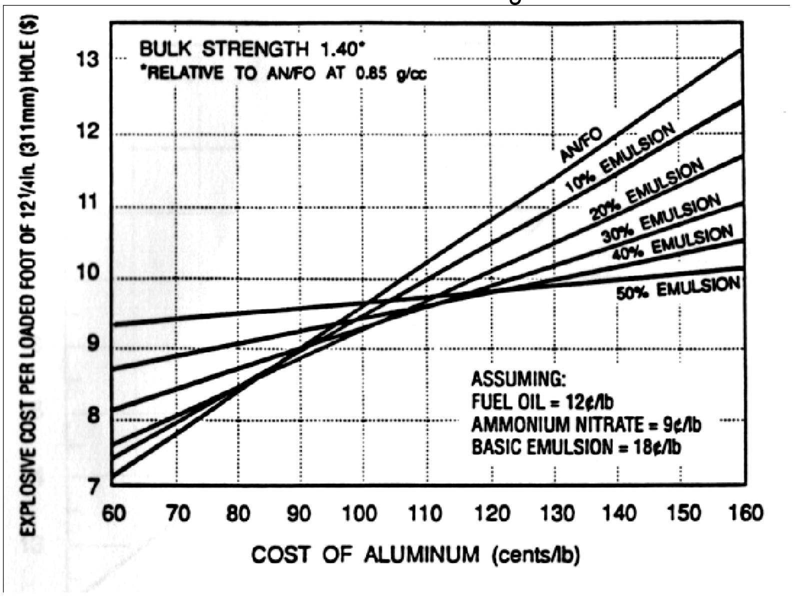


*Fig. 4 Explosive cost per foot of loaded (D 311mm)*

The higher prices of aluminum price of oil fuels continues to have marginal impact (on account of their relatively small percentage participation) while the impact of the cost of ammonium nitrate reduces and cost of emulsion increases.

With the constant change of the components of mixtures, following the effects of mining and achieved cost can be optimal ratio of influential components in these mixtures and certainly the lowest cost per ton blasted mass.

This can be achieved with constant research, make an combinations of multiples variables within the explosive mixtures, application of blasting compounds in different conditions and with different drilling -blasting parameters. With the change of each of this components the cost comparisons, and correlations and comparison of the effects would be received adequate analysis results and overall effectiveness of the explosive charge.

## CONCLUSION

The method of selection of explosives shown in this paper, demonstrates a fairly open way to choose explosives or explosive mixture based on the price of aluminum. This method is not very accurate, the calculation provides firsthand the effect of the change in the price of aluminum on the selection and design of explosives and the blasting effects.

Since this paper can also be concluded that the addition of aluminum to be understood as a means of increasing the relative strength of a particular type of explosives and explosive mixtures primarily for dry and wet blast holes. Good results in blasting we can achieve at high prices of aluminum, especially in areas with high costs of drilling (large diameters>: 200mm) or where the explosives with high relative strength performed in many claims, very hard, deformed and heterogeneous rocks.

**LITERATURE**

1. G.Kamburova, (2007), Vzrivni javlenija i eksplozivi, Book, Edition of „St.Ivan Rilski“, MGU, Sofia, Bulgarija
2. W. A. Crosby, M.E. Pinko, (1997) When to use aluminum in bulk explosives, MRE, Ltd, Kingston, Ontario, Canada
3. R. Dambov, (2001), Methods of blasting, Book, Edition of University "Goce Delcev", Insitute of mining, Stip, R. Macedonia.