Chapter 1

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Amongst the dramatic developments in the explosive technology, emulsion is the recent one, representing the third generation explosives and replacing most of the other commercial explosives. It has completely phased out dynamite, a market leader for over a century. Emulsion explosive is supplementing ANFO in wet ground and where extra strength is required. It accounts for about 50% of the total explosive consumption in India. Being a water-based explosive, it is less sensitive to shock and friction. It is also used in bulk form and meets the requirement of large open cast mines. Earlier, the use of bulk emulsion explosive was restricted to large open cast mines having high explosive consumption. Cut-throat competition among explosive manufacturers and indigenous development of low-cost pump trucks have now made it possible, for small mine operators with small explosive consumption, to use the emulsion explosive.

Bulk emulsion explosive offers the benefit of tailor-made functioning in which explosive characteristics can be varied as per the requirements at the site. In the bulk emulsion system, non-explosive matrix of emulsion is prepared at the explosive plant and is carried to the blasting site on the pump trucks. Bulking agent is then added to the matrix just before charging for sensitization. The matrix attains explosive property in hole. The matrix is sensitized either by the addition of glass micro-balloons or chemicals. However, emulsion explosive manufacturers generally use the later since it is inexpensive.

Performance of an explosive predominantly affects the blast results under a certain set of blast environment conditions. It varies from site to site due to variation in various parameters viz. blast hole diameter, strata temperature, presence of water in the blast hole, sleeping time, confinement etc. It is generally evaluated by measuring its velocity of detonation (VOD). Velocity of detonation is defined as the rate at which the detonation wave travels through the explosive column. It controls the rate of release of explosive energy and also influences the energy partitioning with respect to shock and gas energy. Thus, VOD plays a pivotal role for selection of an explosive for a particular application.
VOI} specified by the explosive manufacturers of their products is generally the VOD determined under the laboratory environment conditions in unconfined space. However, explosive rarely performs with its specified VOD in full-scale blast environment. Detonation behaviour of an explosive in a full-scale blast environment can be predicted by measuring its in-hole VOD under different conditions. The predicted VOD can be helpful in designing a blast more precisely, for selection of an explosive and to change the formulation of the product to suit a particular blast environment.

1.1 Objective of the Study

Emulsion explosive is the most recent addition to commercial explosives. Not much work has been done on the detonation behaviour of emulsion explosives particularly on chemically sensitized bulk emulsion explosives. Vigorously increased use of emulsion explosives in recent years emphasized on the need to study its detonation behaviour under different conditions. The present study aims at elucidating the influence of the following factors on the VOD of bulk emulsion explosives, both in unconfined and rock-confined space:

1. Charge density
2. Charge diameter
3. Water
4. Charge temperature
5. Sleep time
6. Confinement

1.2 Organization of the Thesis

Including this chapter, there are seven chapters in this thesis.

Chapter Two gives an overview of commercial explosives. It incorporates the development story of commercial explosives from black powder to emulsion explosive, a brief description of important characteristics of explosives and a short account of commonly used commercial explosives viz. ANFO, slurry and emulsion. Composition of the emulsion explosives and their bulking methods have been discussed in somewhat detail. The chapter also contains introductory information about the various bulk loading systems.
Chapter Three deals with a brief review of literature related to detonation of explosives. The review of literature has been specially cited on initiation theory, detonation mechanism and VOD measuring techniques. The four stages of detonation viz. initiation, deflagration, deflagration to detonation and detonation have been explained in brief. The chapter also elucidates the hot spot theory of initiation. The detonation mechanism, structure of detonation wave, ideal and non-ideal detonation have also been explicated. Besides this, significance of the VOD and its measurement techniques have also been reviewed.

Chapter Four reviews the work done by the various researchers and research organizations in different parts of the world to investigate the effects of various factors on the VOD of the explosives. The results of the research on impact of some of the factors, which have a strong influence on the VOD, as reported by early researchers, have also been discussed.

Chapter Five deals with the materials and methods used in the work. This chapter presents a brief description of the sites of study, the formulation of the explosive used for the study and its manufacturing process. It also contains the description of the equipments used in the study. The methodology used for preparation of sample cartridges, measurement of VOD in unconfined and rock-confined spaces, cup density, in-hole density and viscosity are also depicted.

Chapter Six gives the description of the experiments. This chapter has been divided into six parts, one for each factor affecting the VOD. Each part is further divided into two sub parts, one for the experiments in unconfined space and the other for the experiments in rock-confined space. The results of the experiments and discussion thereon are also presented in this chapter.

Chapter Seven is on the outcome of the work. The conclusions drawn from the study are put forth and the recommendations for achieving optimum performance of bulk emulsion explosives have been made. Scope for further work is also incorporated in this chapter.