

CHAPTER !

INTRODUCTION

Drilling is the process of creating a hole of predefined parameters i.e. diameter, depth, and direction by mean of impact and /or shearing forces on the rock surface. Principles of rock drilling and the metal drilling process are different because of their specific inherent characteristics. Rock is a non-homogenous, and brittle substance - unlike metals. Drilling forces are applied on the rock surface through a cutting tool, popularly known as a drilling bit. Depending on the type of bit, fine grains and / or small rock pieces are produced during rock drilling, at the bit-rock interface, which is known as drill cuttings. The selection of bits mainly depends upon the rock properties.

Rock drilling is having several roles in various industries including mining, petroleum, gasification, geological, and civil. Drilling has both direct and indirect crucial impacts on the subsequent sequential processes in the completion of the mining cycle. Some of the impact areas are as follows:

1. Powder factor is affected due to the direction and stability of hole,
2. Formation of toes and floor humps due to improper direction of drill holes,
3. Number of oversize boulders and need of secondary blasting,
4. Wearing of equipment due to handling of oversize boulders,
5. Fine generation, handling, and dust control,
6. Grade control design of crusher plant, and cost of crushing, and

7. In the case of stone quarries, obtaining cubical lump products and avoiding formation of micro-cracks are the areas of concern.

By improving the efficiency of the drilling process, the overall profit of industries can be significantly enhanced. Several machine parameters play crucial roles in controlling the rotary drilling process, such as bit parameters, thrust on the bit, bit rotational speed, type of flushing media, etc.

The flushing media plays a vital roles in drilling operation namely, cleaning drill cuttings from the bit-rock interface, and providing fresh cutting surfaces to the bit. In the absence of flushing media, the accumulated cuttings at the hole bottom would go under regrinding causing wastage of drilling energy. The hole cleaning process is classified, as induced cleaning (flushing), and self-cleaning. The extrusion of drill cuttings with any additional source (air or water based drilling fluids), it is known as induced cleaning or flushing. Whereas if the hole cleaning took place with the movement of drill rod (augur drilling), it is known as self-cleaning. The flushing media or drilling fluid can be utilized to solve plenty of drilling problems like low penetration rate, machine vibration bit temperature, wearing of down-the-hole (DTH) assembly, suspension of drill cuttings in drilling fluid, hole wall stability, infiltration, and fluid loss.

To improvise the fluid efficiency as per the specific issue, additives (i.e. alkalis, salts, surfactants, weighting material, polymers, etc.) are mixed with the base drilling fluid like gas, water, and oil. Polymeric compounds as fluid additives possess many important properties like viscosity, thermal stability, gel formation, shear stability, and many more, which render their use as more significant in drilling operations. The solution having polymer additives treated with water as a base fluid is termed as water-based drilling fluid. The use of these fluids can provide improved drillability, safe operation, and longer life to machines.

Performing experimentation on a scale-down setup is often preferred prior to implementation of any new technological improvement. The field experiment on rock drilling with several repetitions may be quite uneconomical, and tedious. It engages a large extent of rock mass, machines, persons, and also interrupts the production. Hence, as a better option, a laboratory miniature drilling setup can be deployed for in-depth study on new technology. Once the desired results are achieved full scaled field experimentation can be conducted to validate the laboratory results.

1.1 Research Gap

- For optimised drilling experimentations, an economic, and user-friendly laboratory setup is required, which should be capable to measure performance parameter with high accuracy.
- For the better understanding on drilling performance, the role of machine and rock parameters is need to be identified with wider range of variations in parameters.
- To study the role of various fluid parameters namely flow speed, type, additives, and concentrations, on rock drilling performance, the efforts needs to be done for its improvement.
- To improve the overall drilling performance, role of innovative drilling fluids additives like grafted and hydrolysed polymers, is also need to be emphasised.

1.2 Objectives and Scope

The objectives of this study are:

- To design and fabricate a laboratory drilling setup that simplifies the experimentation process and provides accurate as well as reliable results on rock drilling in the laboratory.
- To study the effect of various machine and rock parameters on drilling performance.

- To make a comparative study on the behaviour of various drilling performance parameters with different concentrations of aquatic solutions of natural, synthesised, grafted, and hydrolyzed polymeric additives against tap water alone as drilling fluids.
- To identify the role of innovative grafted and hydrolysed polymeric drilling fluids additives on drilling performance. Also suggest an optimum fluid additive.

Also, it is expected to help in the optimization of the machine as well as drilling fluid parameters, to achieve better drilling performance including high efficiency.

1.3 Research Methodology

The objectives of this Ph.D. research project have been achieved by the subsequent implementation of the pre-formulated methodology, as discussed here.

1.3.1 Literature Review

An ample number of technical research papers related to rock drilling, experimental setup fabrication, parameter measurement techniques, flushing media, water-based drilling fluids, and polymers, etc. were reviewed carefully and the related findings were incorporated in the study. This review provides knowledge about rock drilling parameters i.e. controllable (machine-based), non-controllable (rock properties based) and performance parameters, their measurement techniques in field and laboratory, various types of drilling fluid, and different additives (polymeric or conventional) used and experimented by past researchers successfully. The effect of various rock and machine parameters on drilling operation with specified working conditions was also reviewed.

1.3.2 Laboratory Setup Improvement

The existing laboratory drilling setup was capable of providing a good range of variation in machine parameters. It was improved to perform rock drilling operations in the laboratory with greater range and high accuracy. It has also been incorporated with the upgraded facilities like RPM feedback system, vibration measurement setup, bit temperature measurement setup, etc. It also empowered to measure and record the real-time experiment values of parameters like depth of the hole, energy consumption, wattmeter and ampere meter readings, etc. with high accuracy.

1.3.3 Laboratory Work

Rock Sample Preparation:

Cuboid samples of different rocks were prepared in the departmental workshop. The size of samples was set according to the limitation of the laboratory drilling setup.

Polymeric Additive Preparation:

Additives were prepared in a chemistry laboratory under the supervision of experts. Different chemical processes were used to make polymeric additives i.e. polymerization, grafting, and hydrolysis.

Drilling Fluid Preparation:

Drilling fluids of different additive concentrations were prepared for experimentation within the drilling laboratory.

Drilling Experiment:

The experiment was performed initially to understand the role of all machine parameters on drilling performance, followed by implementation of various concentrations of polymer additives as drilling fluids in the range of 10, 30, 50, 70, 90, 110 ppm on sandstone rocks. The effect of varying machine parameters, fluid parameters, and rock parameters on drill performance was identified as the outcome of the experiment. The results of this experiment are presented in

terms of energy consumption, depth covered by bit, time is taken in drilling a hole, bit weight loss, bit temperature, flushing fluid concentration, the flow rate of flushing fluid, and machine vibration. These outcomes were used to calculate the performance parameters of this research work.

1.4 Organization of the Thesis

The thesis is organized into six chapters. Chapter 1 provides an introduction of the research topic and its objective, scope of the work, and research methodology. Chapter 2 presents the summarised literature review related to the project work and also the outcomes of previous studies that have been given in this chapter. Improvement in the fabrication of laboratory drilling setup was covered in Chapter 3, whereas materials and methodology used during experiential work are discussed in Chapter 4 and Chapter 5 covers the results and discussion part of the thesis. Conclusion and Scope of future work are covered in Chapters 6. Finally, the list of references that have been consulted in the preparation for this thesis is given at the last.