Prediction of Temperature Measurement Methods during Rotary Drilling Operations - A Review

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Abstract

The temperature generated during deep hole drilling operations is due to the heat generated between the interface of work piece surface and the tool surface. Several research study have been conducted to predict the temperature involved while drilling process as a predominant functions of many parameters like feed rate, torque, depth of cut etc. Similarly many experimental procedures have been conducted by several researches to measure temperature directly by using thermocouples, infrared measurement, pyrometer, and thermisters etc. There is no precise experimental method is available to measure analytical value of energy, power, heat flux etc, while drilling process. The temperature rigma depends on material compositions and physical properties. This paper presents a review of various experimental and analytical methods for measurement of temperature during drilling operations.

Key words: Temperature, Drilling, Heat flux, Temperature, Thermal response.

1. Introduction

Thermal interaction between the drill hole and the surface of rock is of precise interest in a drilling operation [1]. The drilling process with the carbide tools with MQL is under development in the automobile, mining, petroleum industries etc, due to its high available and its environmental benefits [2]. In general approximately 8 percent of the total energy supplied to the drilling is useful (more than 85 percent) goes into losses due to the frictional heat, as a main consequence of this excessive wearing and fracturing of the drilling bit is observed in the field and laboratory investigations, the main aim for fracturing the rock during drilling operations using drilling tool leads to a excessive temperature development at the interface of the tool and the workpiece [3]. The workpiece thermal deformation is significant in dry or wear-dry machining at low speeds or of high torque and a feed rate, such as the deep hole drilling. The problems developed by work piece thermal expansion are more predominant in MQL drilling of deep holes [4]. Temperature measurement and heat flux estimation are always a difficult task in drilling processes that the heat flux and temperature into the cutting zone during drilling and tapping process are estimated. An analytical methodology based on inverse heat conduction process was applied to find the heat flux. The temperatures were measured in the workpiece using embedded thermocouple

technique, with an MQL condition. Finally, the cutting zone temperature can also be considered as a good initial estimation [5]. [17] developed a model to predict the drilling temperatures of limestone, by using RTD (Resistance temperature detector). [12] developed a mathematical model, for the heating process of diamond drill bit. The difference between experimental and calculated data temperature of the diamond drill bit was more than 12%. [13] conducted drilling experiment under Martian condition; the results found that the drilling efficiency is much greater than under terrestrial pressures and temperature. [19] derived a predicted model for temperature for hard rock and could be applied to rocks which have uniaxial compressive strength in the range of 85-150 MPa. [14] found that the time response of thermocouple to be generally a limiting factor for the transient temperature to assess in solids. The embedded thermocouple method used as a tool, the response time of the thermocouple of the order of 10 microseconds. [15] measured the temperature by using thermocouple method, standard welded thermocouple, and the insulated wires were embedded in the work piece, it would form a hot junction with the drill zone. They found that measured temperatures are reasonable and concluded that the thermal inertia of welded thermocouple is high, with a better time response insulated thin-wire thermal junction measurements to obtain transient can data also considered. [16] used contact measurement techniques such as K-type thermocouple with 1mm diameter. They also used non-contact type measurement of the temperature of the tool and the surface of the hole by using FLIR E60 infrared thermal image camera with different operating parameters such as spindle speed and feed rate conditions. It was concluded that operational parameters increase, the temperature range from 66^0C-135^0C. [18] developed a prediction model by considering the effects of radiation, drill bit configuration, and non-constant heat source. Radiation can be calculated only for a certain distance from the drill head.

2. Temperature measurements

The effect of temperature in underground mines as well as opencast mines is related to the geothermal gradients of rocks overlying the mining excavation. This may exceed the standards of comfort for human beings to work in an underground environment thus causing thermal discomforts and associated risk.[6] The thermal resistivity of a medium material can be determined with the help of the thermal probe and the pyrometer, which is working on the principle of “transient heat method”. The thermal probe, which has been fabricated for determining thermal resistivity of various materials.[7]. ISOMAT 2104, the conductivity and the volumetric heat capacity were measured and the commercial device applies a dynamic measurement method, so that the time of measurement reduces. This method gives a special etalons values of thermal conductivity. This verification of measuring ability had been performed before the actual measurement started. In this methods also probe are used called needle probes [8]. When a borehole is drilled, the temperature in the borehole and in the neighboring rocks gets disturbed, depending on the amplitude and duration of the disturbance, on the distance of the rocks from the hole and on the hydrological conditions. When the drilling operations stop, the source of the thermal disturbance is switched off and, if the thermal transport is purely conductive, the existing disturbance fades away by transient diffusion propagating in space and time. In order to study this thermal restoration process, we

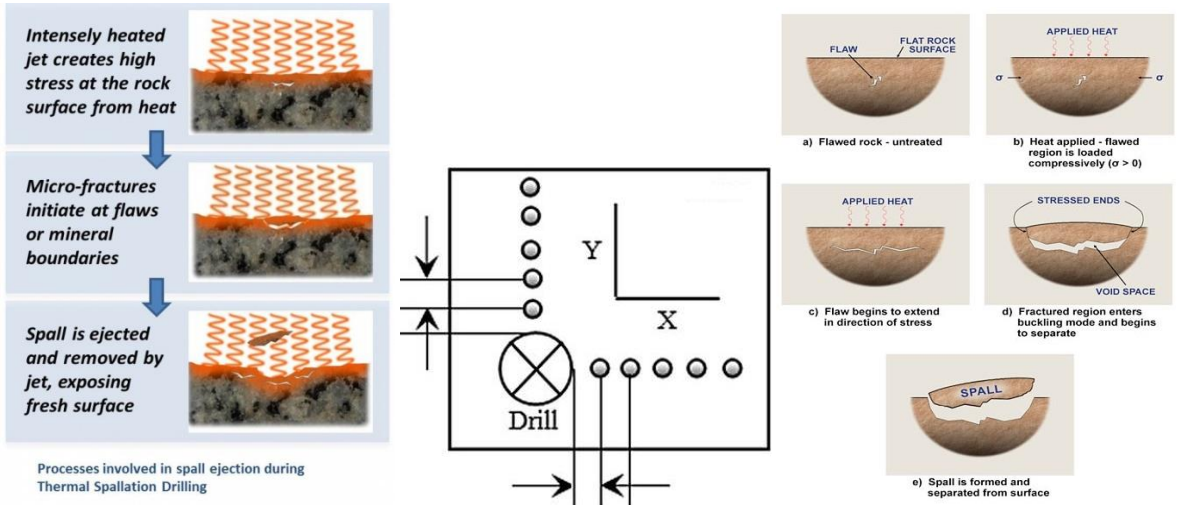
ran several temperature logs directly after shut in of the mud circulation. As the temporal variations of temperature are the largest directly after shut in, the logs should provide the best data on the in situ thermal diffusivity and related rock properties. [9]

3. Effects of temperature

When drilling the deep resources, the surrounding rock readily undergoes the hole opening fracture, borehole collapse, and loss of circulation under high temperature and high pressure. Deep resources such as oil, gas, and solid mineral have drawn more interest. Generally, the deeper drill is characterized by higher pressure and temperature, which make the drilling and borehole stability harder[20]. But in some conditions some physical properties will effects will changes due to increase in temperature during drilling process. The link between temperature and uniaxial compressive strength. It shows that the threshold temperature with external heating, in accordance with the observations, the sample mainly undergoes brittle fracture, specially divided into compacting and linear elastic phases. When it reaches with constant increase in temperature, the sample mainly undergoes the shear and tensile fractures. The damaged under uniaxial pressure in three ways one under room temperature, the sample undergoes the brittle fractures developing along the axial direction. (II) Under intermediate temperature, the sample undergoes the shear fracture. If loaded, the softer part would be damaged without losing its bearing capacity. (III) maximum (saturation temperature), being sheared and tensioned, the sample undergoes the column fractures.[10]

4. Methods of temperature measurement

Many methods are implemented to measure temperature during drilling operations. The thermocouple and the infrared methods are the predominant methods to evaluate the thermal response. Embedded thermocouple methods has been used for materials to measure but for the rock of high strength minerals this methods has not been used because of the high heat generated while drilling operations. Similarly novel technology used to fracturing of the surface and it acts like a drilling tool. Flaws on mineral boundaries, intensely heated jet creates high stress on rock surface form heat. But many researches had implements thermocouple and the thermister to measure the temperature difference while drilling of rock in suit and the laboratory measurements.



Novel technology Embedded thermocouples Spall or flaws methods with external heat

Figure 1. Different methods to measure temperature and novel methods in rock drilling process

Conclusion

During drilling process temperature produced is fairly effects on drilling operation, when it observed in micro scale investigation. For the present study most of the work is predicted while drilling operations is the temperature. The physical properties like porosity, micro structural cracks, and flaws are the predominant effect due to the change in temperature while drilling operations. This paper reviews the effects of temperature, when it comes to surface phenomenon infrared methods were used predominantly, similarly for the hole wall and the hole bottom surface embedded thermocouples methods as predominant role to observe the drilling performance of the rocks. When we have compared with the infrared radiation method with thermocouple method, maximum temperature can be predicted using thermocouple will give a better performance compare with the infrared method, because of the dust distribution during drilling operation will disturb to measure the temperature in case of infrared techniques.

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