Arresting and supplying apparatus for increasing pellet impact drilling speed per run

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Abstract. The paper describes pellet impact drilling which might be used to increase the drilling rate and the penetration rate of hard and tough rock drilling. Pellet impact drilling implies rock destruction by metal pellets having high kinetic energy in the immediate vicinity of the earth formation encountered. The pellets are recirculated in the bottom of the bore hole by a high velocity fluid jet, which is the principle component of the ejector pellet impact drill bit. The arresting and supplying apparatus is supposed to increase speed per run in pellet impact drilling, as it not only replenishes the pellets but also supplies and then picks up the pellets from the bottom hole. The paper presents the design of the pellet-supplying component which ensures a portion of pellets supply to the bottom hole.

1. Introduction

Pellet impact drilling is currently investigated from both practical and theoretical perspectives by the Department of Well Drilling, Tomsk Polytechnic University. This drilling method has a great potential for enhancing the penetration rate of hard and tough rock drilling. Besides, pellet impact drilling can be easily incorporated into the existing mechanical drilling technology without significant reconstruction of the drilling rig.

Pellet impact drilling implies rock destruction by metal pellets having high kinetic energy in the immediate vicinity of the earth formation encountered. The pellets are recirculated in the bottom of the bore hole by a high velocity fluid jet, which is the principle component of the ejector pellet impact drill bit.

We have proved that the most effective way to drill hard and tough rock is t use ejector pellet impact drill bit with the nozzle and the tubular mixing chamber arranged consequently in line [1]. Furthermore, the tubular mixing chamber should end in the diffuser and the pellet arrestor should be installed for the pellets to be sent to the tubular mixing chamber.

2. Designing the arresting and supplying apparatus

Wear pellets is inevitable in pellet impact drilling. In the descriptions of field work results, the initial 63.5 kilo of pellet decrease by 1.13 kilo for 3.5 hours in quartzite drilling [2]. A.B. Uvakov in his work [3] pointed out that average pellet wear for 100 hours is equal to 4-5 mm in diameter.

Pellet impact drilling is provided by several consecutive stages:

1) to supply the pellets to the bottom hole;
2) to pull down ejector pellet impact drill bit;
3) to drill a well;
4) to hoist a drill bit;
5) to pick up the pellets.

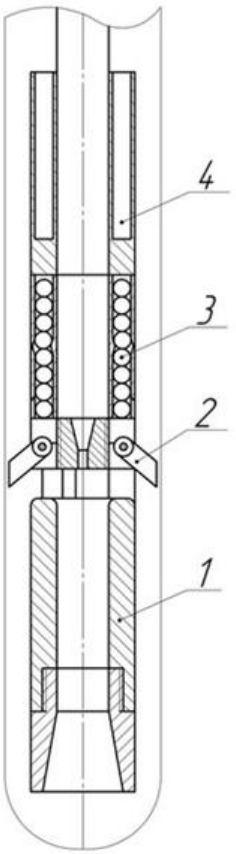

Figure 1. Bottom hole assembly (BHA) with the arresting and supplying apparatus.

1 – drill bit;
2 – arrestor;
3 – pellet supplier;
4 – inlet chamber

According to different investigations [2 – 5] the diameter of used pellets is bigger than the diameter of primary nozzle that prevents pellets to be supplied through a drill string. It is necessary to avoid supplying pellets to the annular space between the drill bit and the wellbore because of its possible pinching or needless space between them and the bottom hole. Two ways for pellets to be supplied to the bottom hole were tested. The first way involved using paper boxes for pellets which after the start of the drilling mud circulation softened and were lifted to the well mouth. The second way used a special container (a core barrel, tapered in upper part and filled with clay). It was pulled down by drill bit, where the pumping fluid under pressure drew pellets. After this, the container was lifted up.

The pellet arrestors of different design were used to pick up pellets after drill bit to be lifted up.

High drilling cost, low reliability and time waste of round-trip operations when is required for the pellet to be replenished are the major factors to design new tool for bit run speed increasing.

In this way, it could be possible to design a new tool to increase the penetration rate, to replenish the pellets, supply and pick them up from the bottom hole. According to its function, it can be called the arresting and supplying apparatus.

Design bottom hole assembly (BHA) with the arresting and supplying apparatus is shown in figure 1. The arresting and supplying apparatus consists of a petal-shaped arrestor (2), pellet supplier (3), inlet chamber (4).

The arresting and supplying apparatus provides the following operations:

1) to pull down BHA with the arrestor in off-position to bottom hole;
2) to influence the pellet suppler in order the pellets to be supplied;
3) to turn the arrestor on;
4) to drill a well while pellets to be worn significantly;
5) to put the arrestor in off-position so that the petals close space between the wellbore and drill bit;
6) to switch a pump on and direct the pellets to the inlet chamber;
7) to act on the pellet supplier so that the pellets to be supplied to the bottom hole;
8) to turn the arrestor on again;
9) to switch a pump on again and continue to drill.

3. Designing the pellet supplier

At the first stage of design the pellet supplier is developed [6], and it is shown in figure 2.

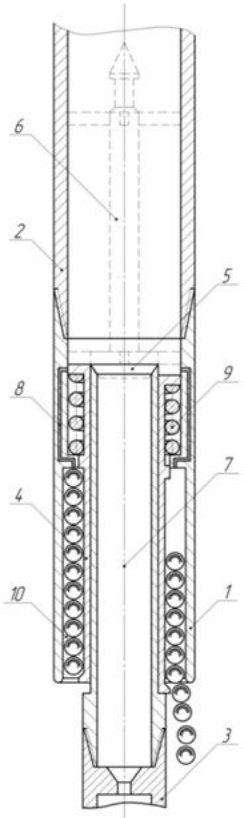

Figure 2. Pellet supplier.

1 – body;
2 – drill string;
3 – ejector pellet impact drill bit;
4 – traveling element;
5 – saddle;
6 – block valve;
7 – central valve;
8 – puff port;
9 – spring;
10 – pellet sector

The pellet supplier includes body (1), connected with a drill string (2) in the upper part and a pellet drill tool in the lower part (3), as well as a traveling element (4) with a saddle (5) to provide a leak-proof fit of the block valve (6). There are two valves in the body (1): a central valve (7) and a puff port (8). The construction is supplied with a spring (9) and a pellet section (10) between the body (1) and the travelling element (4).

The operation principles of the pellet supplier are the following: the pellet section (10) is filled with pellets before the pellet supplier is pulled down to the well. The drilling mud through the central valve (7) is pumped in drilling while the traveling element (4) is kept by the spring (9) in a maximum upward position. To supply drilling mud circulation by pellets the block valve (6) is moved from the well mouth to the drill string (2) which fits the saddle (5) and blocks the central valve (7).

Due to increasing the pressure of drilling mud on the saddle (5), the spring (9) shrinks and drives the traveling element (4) into downwardmost position to open the puff port (8). Being subjected to gravitation and drilling mud pressure, the pellets fall to the annulus space. After this, drilling mud circulation stops putting the traveling element (4) back in the initial position. The block valve (6) is retrieved from the drill string (2) with a help of a back end to be pulled down by a work line. Then the pump is turned on again and drilling continues.

4. Conclusion

Design of the arresting and supplying apparatus is considered to replenish pellets in connection with a drill bit. The design of the pellet supplier which allows pellets to be supplied the bottom hole is suggested.

The possible investigating problems are the following:

- to develop an arrestor and the way of its turning on/off;
- to design a pellet supplier to supply pellets to the bottom hole by portion;
- to develop a low-priced arrestor;
- to find alternative ways influencing the components of the arresting and supplying apparatus.

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