Drilling with Fusion Impregnated Bits

Drilling with a Fusion impregnated diamond bit provides unique challenges due to the equipment utilized and the methods that must be used to produce an optimized and economical run. The objective in the design of the impregnated bit is to produce a product where the matrix erodes exposing diamond. As diamond is exposed it begins to chip creating new cutting surfaces. As the new surfaces are created the diamond wears away and is finally released from the matrix. This allows fresh sharp diamonds to become exposed and come into contact with the rock. If a bit is run incorrectly, process described above can be jeopardized leading to a short run, loss of ROP, and/or a destroyed bit. Operating parameters are a key element of producing a successful Fusion impregnated bit run.

Rotational Speed Relative to Penetration (RPI or RPC)

Optimum bit RPM depends on the formation types being drilled and the inter-relationship between the rig capabilities, peripheral equipment being used, and the individual drilling method.

RPI (revolution per inch) is the most important factor to consider when optimizing the bit life and productivity. RPI is the ratio of the rotational speed (rpm) to the penetration rate. If the RPI is too low, premature diamond tear-out from the matrix is likely. Conversely, if the RPI is too high, it is likely that the diamonds will become polished and the penetration rate will decrease significantly.

RPI = Rotational Speed (rpm) / Penetration Rate (inch/min or cm/min).

For example, 1200 rpm at 6 inch per minute will result in RPI = 1200 / 6 = 200 RPI.

Maintaining a good RPI ensures that the diamonds stay exposed and that the bit wears at an even and controlled rate. Ideally, the RPI should be between 200–250 (80-100 RPC) for impregnated drill bits. Factors such as drill string vibration or rig constraints may prevent operating within the recommended optimal RPI range. In such cases, a lower ratio should be used(150-200 RPI) to optimize the bits performance under adverse drilling conditions. Typically higher RPM leads to increased ROP. Caution should be given to using higher RPM as the matrix wear will decrease, leading to loss of new diamond exposure causing the first layer of diamond to become flat and polished reducing ROP. Lower RPM will cause the matrix to abrade quickly especially under higher WOB loads leading to bit crown failure.

Bit Weight

When drilling with an impregnated bit, the lowest possible WOB should be utilized that produces an acceptable ROP. The WOB has to be sufficient to maintain a rate of penetration relative to the rotational speed and to keep the bit cutting. However, a weight that is too high can cause rapid wear of the matrix due to stripping or even a mechanical failure of the matrix. Too low a weight often results in diamonds being polished and the matrix not being eroded. This leads to the requirement of stripping the matrix on the bit to expose a new layer of diamonds. Ideally, the matrix performs best when it wears at the same rate as that of the diamonds. Refer to the Varel Fusion spec sheet for the WOB operating range and adjust WOB to achieve desired ROP. Then refer to RPI indicator to confirm your operating parameters.

Fluid Velocity

Fluid flow is another critical variable in optimizing drilling efficiency. When a Fusion bit is designed, it will have a fixed TFA built into the bit. The TFA cannot be changed once the bit is manufactured so it is important that you plan ahead with your Varel representative to make sure that the proper TFA has been designed into the bit. Fusion impregnated bits do not have changeable nozzles due to the design constraints of an impregnated bit.

Drilling fluid must effectively cool the bit, remove the cuttings from the bit face, and then transport these cuttings up the annulus of the hole to the surface. Fluid volume should be increased as the penetration rates increase. Too much fluid volume can cause hydraulic lift that seriously affects the actual bit weight and consequently drilling performance. If the fluid flow is too low, the bit can wear prematurely due to the abrasive action of the cuttings. Degradation of the diamond and matrix will occur also due to the excessive heat. In very hard, fine-grained formations, fluid velocity can be intentionally reduced to increase matrix erosion to expose new diamonds.

As the bit wears during use, the waterways will decrease in size. This leads to an increase in standpipe pressure and also reduces the effective WOB due to hydraulic lift or push off. Monitor the pressure at all times to know when this is beginning so a trip can be planned to change bits.

String Stability

It is important to select a combination of RPM and WOB that minimizes drill string vibration and maximizes bit performance. If drill string vibration is an issue, change the operating parameters to try and eliminate it. If changing operating parameters does not stop the vibration, then it is recommended to stop drilling, lift off bottom and restart the bit. Increase operating parameters until a satisfactory ROP is achieved and string stability is returned.

Stripping in the Hole Method

If improper operating parameters have been selected, the bit ROP will slow down and cause the matrix / diamond to polish. It then becomes necessary to strip the matrix surface to expose new diamond. This can usually be accomplished by reducing the RPM by about one third to one half and maintaining a constant penetration rate. WOB will build up then will drop quickly signalling that stripping has occurred and the bit is cutting freely again. Immediately reduce WOB and increase RPM to conform to the correct RPI.