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Review Article

ANALYSIS OF DRILLING TOOL LIFE—A REVIEW

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Drilling is a cutting process that uses a drill bit to cut or enlarge a hole of circular cross-section in solid materials. The drill bit is a rotary cutting tool, often multipoint. The bit is pressed against the work piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work piece, cutting off chips (swarf) from the hole as it is drilled. Here we are analyzing the drilling tool life, which showed us that there are different parameters (Force, feeding Rate, MOQ, Tool Material, Tool Geometry, etc.), which are affecting the Drilling Tool Life.

Keywords: Drill, Drilling tool, Drilling bid

INTRODUCTION

A drill is a tool fitted with a cutting tool attachment or driving tool attachment, usually a drill bit or driver bit, used for boring holes in various materials or fastening various materials together with the use of fasteners. The attachment is gripped by a chuck at one end of the drill and rotated while pressed against the target material. The tip, and sometimes edges, of the cutting tool does the work of cutting into the target material. This may be slicing off thin shavings (twist drills or auger bits), grinding off small particles (oil drilling), crushing and removing pieces of the workpiece (SDS masonry drill), countersinking, counterboring, or other operations.

Drills are commonly used in woodworking, metalworking, construction and do-it-yourself projects. Specially designed drills are also used in medicine, space missions and other applications. Drills are available with a wide variety of performance characteristics, such as power and capacity.

There are many types of drills: some are powered manually, others use electricity (electric drill) or compressed air (pneumatic drill) as the motive power. Drills with a percussive action (hammer drills) are mostly used in hard materials such as masonry (brick, concrete and stone) or rock. Drilling rigs are used to bore holes in the earth to obtain water or oil. Oil wells, water wells, or holes for geothermal heating are created with large

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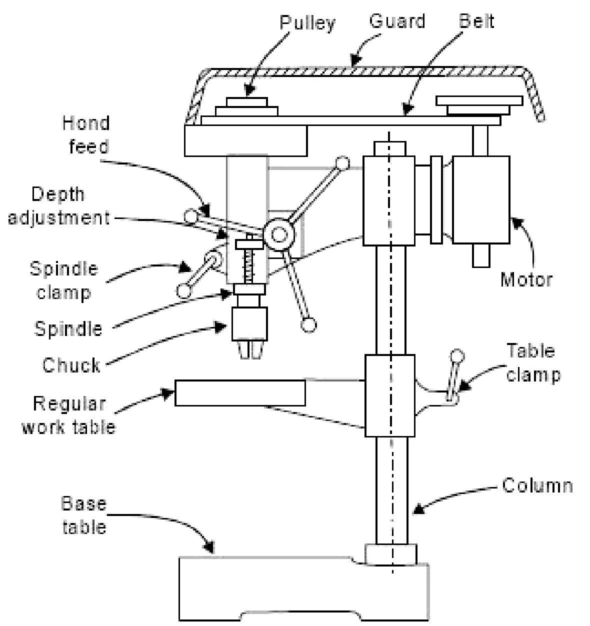
drilling rigs. Some types of hand-held drills are also used to drive screws and other fasteners. Some small appliances that have no motor of their own may be drill-powered, such as small pumps, grinders, etc.

Drilling Machine: A Drilling Machine (also known as a pedestal drill, pillar drill, or bench drill) is a fixed style of drill that may be mounted on a stand or bolted to the floor or workbench. Portable models with a magnetic base grip the steel work pieces they drill. A Drilling Machine consists of a base, column (or pillar), table, spindle (or quill), and drill head, usually driven by an induction motor. The head has a set of handles (usually 3) radiating from a central hub that, when turned, move the spindle and chuck vertically, parallel to the axis of the column. The size of a Drilling Machine is typically measured in terms of swing. Swing is defined as twice the throat distance, which is the distance from the center of the spindle to the closest edge of the pillar. For example, a 16-inch (410 mm) Drilling Machine has an 8-inch (200 mm) throat distance.

Figure 1: Schematic of Drilling Machine



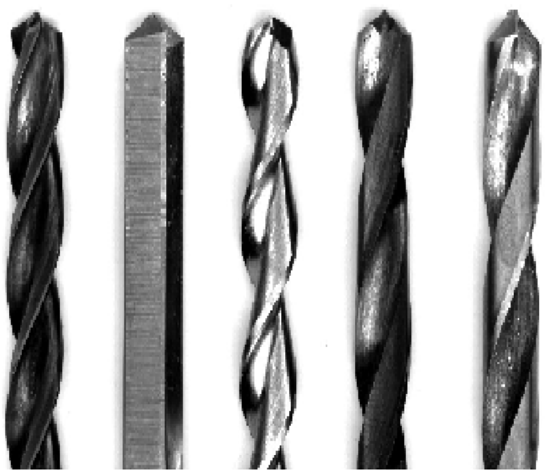
Drilling Capacity: Drilling capacity indicates the maximum diameter a given power drill or Drilling Machine can produce in a certain material. It is essentially a proxy for the continuous torque the machine is capable of producing. Typically a given drill will have its capacity specified for different materials, i.e., 10 mm for steel, 25 mm for wood, etc.

For example, the maximum recommended capacities for the DeWalt DCD790 cordless drill for specific drill bit types and materials are as follows:

Table 1: Capacity of Drilling Bit

Material	Drill Bit Type	Capacity
Wood	Auger	7/8 in (22 mm)
	Paddle	1 1/4 in (32 mm)
	Twist	1/2 in (13 mm)
	Self-feed	1 3/8 in (35 mm)
	Hole saw	2 in (51 mm)
Metal	Twist	1/2 in (13 mm)
	Hole saw	1 3/8 in (35 mm)

Figure 2: Different Types of Drill Bits



Drill Bit: Drill bits are cutting tools used to create cylindrical holes, almost always of circular cross-section. Drill bits come in many sizes and have many uses. Bits are usually connected to a mechanism, often simply referred to as a drill, which rotates them and provides torque and axial force to create the hole.

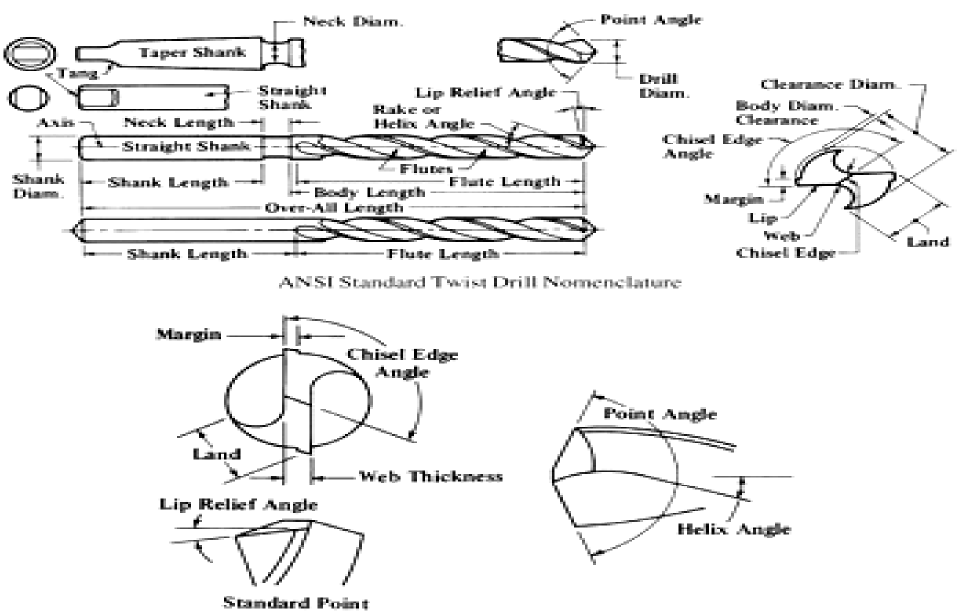
The shank is the part of the drill bit grasped by the chuck of a drill. The cutting edges of the drill bit are at one end, and the shank is at the other.

Drill bits come in standard sizes, described in the drill bit sizes article. A comprehensive drill bit and tap size chart lists metric and imperial sized drill bits alongside the required screw tap sizes.

Tool Geometry

- The spiral (or rate of twist) in the drill bit controls the rate of chip removal. A fast spiral (high twist rate or "compact flute") drill bit is used in high feed rate applications under low spindle speeds, where removal of a large volume of swarf is required. Low spiral (low twist rate or "elongated flute") drill bits are used in cutting applications where high cutting speeds are traditionally used, and where the material has a tendency to gall on the bit or otherwise clog the hole, such as aluminum or copper.
- The point angle, or the angle formed at the tip of the bit, is determined by the material the bit will be operating in. Harder materials require a larger point angle, and softer materials require a sharper angle. The correct point angle for the hardness of the material controls wandering, chatter, hole shape, wear rate, and other characteristics.
- The lip angle determines the amount of support provided to the cutting edge. A greater lip angle will cause the bit to cut more aggressively under the same amount of point pressure as a bit with a smaller lip

Figure 3: Tool Geometry



angle. Both conditions can cause binding, wear, and eventual catastrophic failure of the tool. The proper amount of lip clearance is determined by the point angle. A very acute point angle has more web surface area presented to the work at any one time, requiring an aggressive lip angle, where a flat bit is extremely sensitive to small changes in lip angle due to the small surface area supporting the cutting edges.

- The length of a bit determines how long a hole can be drilled, and also determines the stiffness of the bit and accuracy of the resultant hole. Twist drill bits are available in standard lengths, referred to as Stub-length or Screw-Machine-length (short), the extremely common Jobber-length (medium), and Taper-length or Long-Series (long).

The diameter-to-length ratio of the drill bit is usually between 1:1 and 1:10. Much higher ratios are possible (e.g., "aircraft-length" twist bits, pressured-oil gun drill bits, etc.), but the higher the ratio, the greater the technical challenge of producing good work.

The best geometry to use depends upon the properties of the material being drilled. The following table lists geometries recommended for some commonly drilled materials.

Table 2: Different Angles for Different Materials

Workpiece Material	Tool Geometry		
	Point Angle	Helix Angle	Lip Relief Angle
Aluminum	90 to 135	32 to 48	12 to 26
Brass	90 to 118	0 to 20	12 to 26
Cast iron	90 to 118	24 to 32	7 to 20
Mild steel	118 to 135	24 to 32	7 to 24
Stainless steel	118 to 135	24 to 32	7 to 24
Plastics	60 to 90	0 to 20	12 to 26

Twist Drill Bits: The twist drill bit is the type produced in largest quantity today. It comprises a cutting point at the tip of a cylindrical shaft with helical flutes; the flutes act as an Archimedean screw and lift swarf out of the hole.

The twist drill bit was invented by Steven A. Morse of East Bridgewater, Massachusetts in 1861. The original method of manufacture was to cut two grooves in opposite sides of a round bar, then to twist the bar (giving the tool its name) to produce the helical flutes. Nowadays, the drill bit is usually made by rotating the bar while moving it past a grinding wheel to cut the flutes in the same manner as cutting helical gears.

Twist drill bits range in diameter from 0.002 to 3.5 in (0.051 to 88.900 mm) and can be as long as 25.5 in (650 mm).

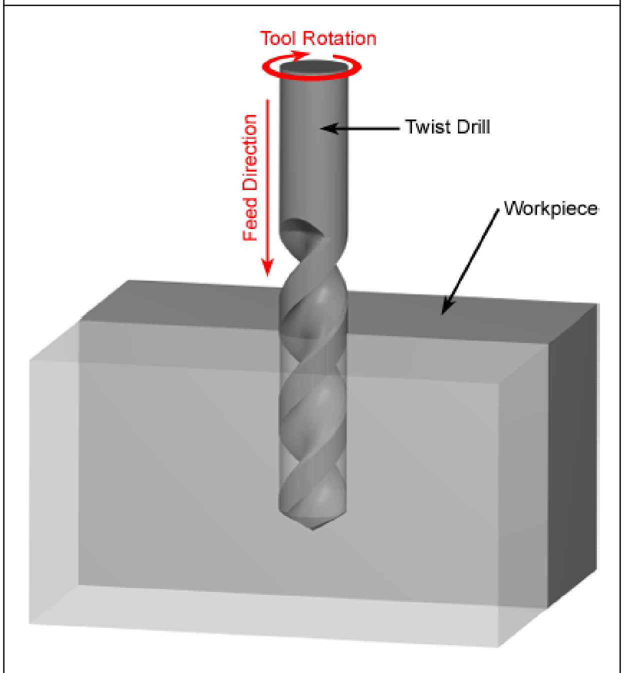
The geometry and sharpening of the cutting edges is crucial to the performance of the bit. Small bits that become blunt are often discarded because sharpening them correctly is difficult and they are cheap to replace. For larger bits, special grinding jigs are available. A special tool grinder is available for sharpening or reshaping cutting surfaces on twist drill bits in order to optimize the bit for a particular material.

The most common twist drill bit has a point angle of 118 degrees, acceptable for use in wood, metal, plastic, and most other materials, although it does not perform as well as using the optimum angle for each material. In most materials it does not tend to wander or dig in.

A more aggressive angle, such as 90 degrees, is suited for very soft plastics and other materials; it would wear rapidly in hard materials. Such a bit is generally self-starting and can cut very quickly. A shallower angle, such as 150 degrees, is suited for drilling steels and other tougher materials. This style of bit requires a starter hole, but does not bind or suffer premature wear so long as a suitable feed rate is used.

Drill bits with no point angle are used in situations where a blind, flat-bottomed hole is required. These bits are very sensitive to changes in lip angle, and even a slight change can result in an inappropriately fast cutting drill bit that will suffer premature wear.

Figure 4: Schematic of Drilling Process

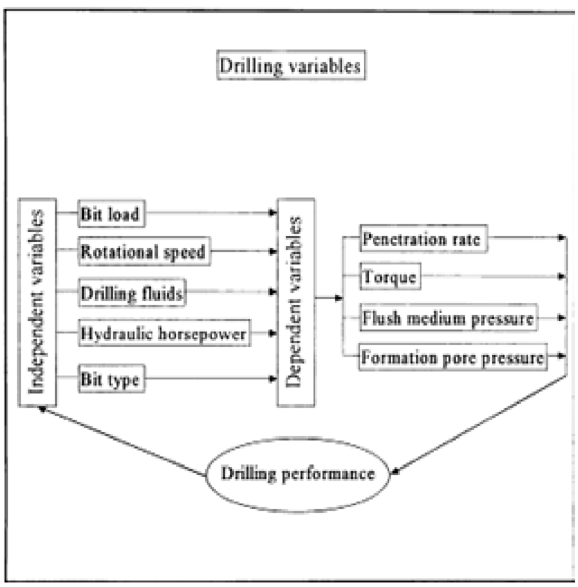


LITERATURE REVIEW

Principles of Drilling: The wide variations in drilling conditions encountered under field conditions make it difficult to develop general rules of operation for maximum drilling efficiency. Field experience usually provides the basis for operations in a particular area, but testing often is too costly and experience too late. Consequently, a method for determining optimum drilling techniques and parameters for any particular drilling condition, with a minimum of engineering effort and drilling experience is greatly needed.

The drilling parameters, or variables, associated with rotary drilling have been analysed and divided in two groups as independent and dependent parameters (Barr and Brown, 1983; Ambrose, 1987; and Shah, 1992). The independent variables are those which can be directly controlled by the drilling rig operator and dependent variables are those which represent the response of the drilling system to the drilling operation. There are, of course, many factors other than those discussed here that effect drilling efficiency and footage cost. These include such factors as formation hardness, abrasiveness of

Figure 5: Drilling Variables Associated with Rotary Drilling



connation and well depth. As these items cannot be conveniently controlled, their influence on costs must simply be accepted.

Dependent Variables

The dependent variables associated with rotary drilling represent the response of the drilling system to the imposed conditions and are the penetration rate of the bit, the torque and the flush medium pressure.

Penetration Rate: The Rate Of Penetration (ROP) of the rotary bit through rock, is expressed in units of distance per unit time. The rate of penetration is considered as one of the primary factors which affect drilling costs and hence it is given a prior consideration when planning for optimised drilling. The subject of drilling rate has been extensively analysed from both the theoretical standpoint and the experimental standpoint with the objective of maximising drilling rate and improving operating efficiencies (Lummus, 1969 and 1970; Eckel, 1967; Huff and Varnado, 1980; Kelsey, 1982; Holester and Kipp, 1984; Ambrose, 1987; Warren and Armagost, 1988; Waller, 1991; and Shah, 1992). Miniature drill bits have been widely used in the laboratory to study combinations of independent drilling variables, as well as to relate drilling rate to measurable rock properties. The determination of the rate of penetration is one of the most important objectives, and is therefore considered and presented in detail in this thesis. Collectively, contributions to the understanding of these factors on the penetration rate have been greatly exploited in an effort to drill faster and more economically.

Torque: Torque is defined as the force required to tum the drill rod, which leads to the bit rotating against the resistance to the cutting and friction forces. In shallow boreholes, the torque is the result of the forces resisting the cutting and shearing action generated at the bit/rock contact by the rotation of the bit. In deep boreholes, additional torque is required to overcome additional forces between the drill rods and the flushing medium. Torque is usually measured in Nm.

The torque required to rotate a bit is of interest for several reasons. First, it may give information about the formation being drilled and/or the condition of the bit. Second, bit torque exerts a significant influence on the "bit walk" experienced in directional wells. Finally, a prediction of bit torque may be useful in matching a bit and mud motor for optimal performance.

Several authors (Paone *et al.*, 1969; Clark, 1979 and 1982; Warren, 1983; Ambrose, 1987; Waller, 1991; and Shah, 1992) have presented theoretical bit torque relationships derived by testing many types of rocks with coring and non-coring bits, and found that the penetration rate increases with torque and a critical value of torque exists below which penetration does not occur. The torque relationship for a given bit is determined largely by the applied weight on bit and the depth of penetration of bit indenters.

Flush Medium Pressure: Drilling fluids in the wellbore can be in either a static or dynamic state. The static system occurs when the fluid stands idle in the well. The dynamic state occurs when the fluid is in motion, resulting from pumping or pipe movement. The static pressure of a column of fluid pressure is known as "hydrostatic pressure" which is an essential feature in maintaining control of well and preventing kicks or blowouts. The hydrostatic pressure of a fluid column is a function of the mud weight or density and the true vertical well depth.

The Rate Of Penetration (ROP) obtained while a well is drilled generally shows a steady decline as well depth increases. The causes of the reduction in ROP with depth can be divided into two categories:

1. A processes that affects the unbroken rock, and
2. Processes that act on the rock once it is broken into chips.

The chip removal process is probably more important in terms of total effect on ROP, but the strengthening of the unbroken rock is not negligible. Although several authors (Garnier, 1959; Feenstra, 1964; and Warren, 1984) have discussed in considerable detail the chip removal process. This reduction of the ROP is often attributed to increasing "differential pressure", increasing hydrostatic head, increasing in-situ stresses, decreasing porosity with depth, and chip hold-down. For the flush medium to flow down the drill string and up the annulus, a pressure difference must exist between the flush descending within the drill rods and that ascending in the annulus outside the drill rods. The pressure required to cause flow has to counteract the difference in the fluid densities, due to suspended rock particles and has to overcome the frictional resistance to flow. Increasing the ROP of the bit increases the weight of suspended rock particles and hence the differential fluid pressure. Pump pressure is used to overcome the frictional resistance and weight imbalance of suspended rock particles. Increasing the fluid flow rate also results in an increase in the differential pressure.

Formation Pore Pressure: The properties of the rock being drilled can, from the definition of drilling variables discussed in the introduction, be considered as an independent variable, the drilling rig operator has no control over it, as they help determine the response to the drilling operation rather than being a response in itself. Formation pore pressure can be major factor affecting drilling operations especially in deep wells. An operator planning a well needs some knowledge of overburden and formation fluid pressure in order to select the necessary hydrostatic or drilling fluid pressure. If this pressure is not properly evaluated, it can cause drilling problems such as lost circulation, blowouts or kicks, stuck pipes, hole instability and excessive costs. The formation pressure is related to pore spaces of the formations which contain fluids such as water, oil or gas. The overburden stress is created by the weight of the overlying rock matrix and the fluid-filled pores. The rock matrix stress is the overburden stress minus the formation pressure.

Independent Variables

The independent variables are the drilling fluids, bit load, the bit rotational speed, bit type and the hydraulics horse power.

Bit Load: A range of terms are used to describe this parameter such as thrust, bit load, bit pressure, axial load or axial pressure, and Weight On Bit (WOB). Weight on bit is a basic controllable drilling variable. A bit load needs to be applied for the bit to drill. The amount of bit load applied in practice depends on many factors, which include the type of bit, the bit diameter, the presence of discontinuities in the rock mass, the type of drilling rig and equipment, etc., but it is primarily governed by the physical properties of the rock being drilled. This is because the bit penetrates the rock when the pressure exerted by the bit indenters exceeds the strength of the rock and feeds it forward. The weight on bit requirement depends on the size and geometry of the bit and the resistance (strength) of the rock. The rig must be capable of producing the required WOB with sufficient stability for drilling a given hole size with a selected bit size.

A number of authors have conducted tests to investigate the effect of WOB on drilling performance (Speer, 1958; Paone *et al.*, 1969; Schmidt, 1972; Clark, 1979 and 1982; and Osman and Mohammed, 1992). These investigations showed that low WOB results in free rotation of the bit, which produces low rate of penetration and poor chip formation, excessive bit wear because of the bit sliding over the surface of the rock. High WOB, above a critical value leads to the drill machine stalling. Maximum ROP is achieved when optimum value of WOB is reached, after which, an increase in WOB gives little increase in the penetration rate. The limiting value of WOB is determined by the torque capacity of the equipment. The above researchers have also concluded that the optimum WOB gives high penetration rate and low bit wear. Consequently, each drill has a characteristic optimum WOB for maximum penetration which corresponds to good indentation at the bit rock interface and to optimum indexing. The optimum WOB also depends on the other optimal drilling conditions.

Rotational Speed: The drilling process consists of a series of fracture generating events. The drilling rate for a constant depth of bit indenter, penetration will depend on the bit rotational speed. The relationship between rotational speed (RPM) and Rate Of Penetration (ROP) has been investigated by the previously mentioned authors. It has been confirmed that generally there is a near linear relationship between the two parameters in soft rocks. Drilling rate is not proportional to rotary speed in medium and hard formations due to the requirement that some finite time is required for fracture development in hard rocks. For a given penetration rate to be achieved, the bit weight and rotational speed should be continuously maintained, and adequate flush flow maintained to ensure rock cuttings removal from the hole. However, the increase in bit rotary speed result in greater wear on the bit and may also cause chatter, micro-chipping and cracking of cutting indenters or teeth of the bit. The rotational speed may also be restricted by the stability of the rig and the drill rods.

Drilling Fluid: The term "drilling fluid" includes all of the compositions used to remove cuttings from the borehole. An effective drilling process can only be continued, when the bottom of the hole is maintained clean. This is achieved by a sufficient flow flushing medium, which can be; air, water, oil, oil/water emulsion, mud or foam (Moore, 1958). Drilling rate is proved to be faster and bit life longer with air as compared to water or mud. Drilling was originally performed with air or water as a drilling medium used to cool the bit and flush away the drill cuttings. As these two media were usually, easily available, cheap and satisfactory for the shallow boreholes and hard formations being drilled at that time. To overcome problems such as borehole instability, a drilling fluid called mud was developed, consisting of water and bentonite clay. Mud has a number of properties such as its caking ability, its higher density, viscosity and its thixotropic properties, which make it particularly suitable for drilling deep and soft formations that would otherwise prove difficult to drill. However, water is still commonly used as a flushing medium and mud used only where necessary due to the drawback of the large quantities of bentonite needed to make the mud and the extra equipment, which result in extra costs (Gray and Young Jr, 1973). Although at the present time numerous brand names of drilling fluids are commercially available for a range of purposes and conditions, the main function of all these fluids is the successful, speedy and satisfactory completion of the well. The selection of the type of drilling fluid is largely determined by the expected hole conditions. The adjustment of drilling fluid properties is intimately related to the well depth, casing programme and the drilling equipment.

Hydraulic Horsepower: Hydraulics has long been recognised as one of the most important considerations in the design of drilling programmes. Improved bottom hole cleaning afforded by jet rock bits and high levels of bit hydraulic horsepower permit the use of the most effective combination of weight and rotary speed and minimises the risk of bit fouling. These benefits became apparent during the early days of jet bit drilling as contractors began to search for ways to maximise the effectiveness of their hydraulic systems. The results are extended bit life and faster penetration rates. An increasing number of commercial bits are becoming available with interchangeable nozzles, providing the flexibility of rig-site hydraulics optimisation. With these interchangeable nozzles, the hydraulic energy (or power) of the drilling fluid that is dissipated across the bit face can be adjusted to match that portion of the rig's hydraulic power that is available for the bit after other system losses have been considered. (Kendal and Goins, 1960; Randall, 1975; Tibbitts *et al*., 1979; Hollester and Kipp, 1984; and Kelly and Pessier, 1984). The degree to which drilling rate was affected by bit hydraulic horsepower depends on the rock/drilling-fluid combination.

Bit Type: Achieving the highest rate of penetration with the least possible bit wear is the aim of every drilling engineer when selecting a drilling bit. Because formation properties and bit type are the largest factors that affect penetration rate, and obviously, formation properties cannot be changed before drilling and thus selection of the correct bit type is of major importance in achieving high rates of penetration. The rapid evolution of the roller-cone bits and the perfection of techniques for manufacturing diamond-impregnated core bits, have profoundly influenced recent drilling practices. Bit footage and consequently, footage costs, have dramatically improved as a result of these developments. Advances in metallurgy and heat-treatment techniques and the development of lubricated sealed bearings have made possible the widespread introduction of journal bearings. The bearings have significantly prolonged bearing life.

Milled-tooth cutting structures are being replaced by shaped inserts of carbide composition, reducing the tooth abrasion of these cutting elements. The longer inserts make high penetration rates possible well within the life of the bearings, allowing lower over-all drilling costs to offset the increase in bit expenses. Cone offset and other features of milled tooth have been incorporated into the design of the carbide insert bit (Estes, 1971). The use of jets in the bit fluid bath has substantially improved hole cleaning and chip removal, and the use of jets in planned hydraulics programmes has become widespread (Kendall, 1960; Eckel, 1967; and Rabia, 1985). There are many proposed methods for bit selection and often more than one is used before reaching a decision.

Bit selection methods include:

1. Cost analysis.
2. Dull bit evaluation.
3. Offset well bit record analysis.
4. Offset well log analysis.
5. IADC bit coding.
6. Manufacturers' product guides.
7. Geophysical data analysis.
8. General geological considerations.

Literature Based on Tool Life

Some research papers related to drilling tool life are followings:

Luis Miguel Durao *et al.* (2014) analyzed the characteristics of carbon fiber reinforced laminates have widened their use from aerospace to domestic appliances, and new possibilities for their usage emerge almost daily. In many of the possible applications, the laminates need to be drilled for assembly purposes. It is known that a drilling process that reduces the drill thrust force can decrease the risk of delamination. In this work, damage assessment methods based on data extracted from radiographic images are compared and correlated with mechanical test results, bearing test and delamination onset test, and analytical models. The results demonstrate the importance of an adequate selection of drilling tools and machining parameters to extend the life cycle of these laminates as a consequence of enhanced reliability.

Peter Muchendu *et al.* (2014) analyzed the performance of drilling bits has a direct influence on cost and increase in the rate of penetration translates significantly to cost and time saving. From a total sample of 56 wells, approximately 450 tri-cone bits were consumed at a cost of KSh 200 Millions.

The primary objective of this study is to analyze and optimize 8½" tricone bits which were used to drill the 8½" diameter hole at Olkaria geothermal field. The pads had three wells each with the intention of exploring t in order to determine resource availability for massive power production. The exercise covered depth from 750 m to 3000 m using three rigs all with kelly drive systems. The data were compared in average between the daily and sectional drilling range for each well. Evaluation was on weight on bit, rev per minute and strokes in regard to their ROP. Olkaria formation is mainly trachytic and rhyolite with pyroclastic on surface. Also, occasional minor syenitic and deleritic dyke intrusive on bottom with temperatures above 250 degrees centigrade encountered at 3000 m total depth.

Yahiaouia *et al.* (2013), found The quality of innovating PDC bits materials needs to be determined with accuracy by measuring cutting efficiency and wear rate, both related to the overall mechanical properties. Therefore, a lathe-type test device was used to abrade specific samples. Post-experiment analyzes are based on models establishing coupled relations between cutting and friction stresses related to the drag bits excavation mechanism. These models are implemented in order to evaluate cutting efficiency and to estimate wear of the diamond insert. From here, an original approach is developed to encompass cutting efficiency and wear contribution to the overall sample quality toward abrasion. Four main properties of PDC material were used to define quality factor: cobalt content in samples that characterizes hardness/fracture toughness compromise, other undesired phase as tungsten carbide weakening diamond structure, diamond grains sizes and residual stresses distribution affecting abrasion resistance. PDC cutters were submitted to wear tests and a comparison between all these cutters requires an overlap of information. The PDC cutters evaluation tends to balance ability to withstand abrasive wear and to be efficient as long as possible. Archard's linear model permits an evaluation of wear rate but a long bit life could be related to a poor cutting performance. For this purpose, an exponential law properly associates cutting efficiency to excavation distance and led to determine a cutting efficiency coefficient. The cutting efficiency coefficient on wear rate ratio establishes a quality factor and associate to sample wear, aggressiveness of the rock field and energy spent to cut it.

Kadam and Pathak (2011), analyzed experimental investigation was conducted to determine the effect of the input machining parameters cutting speed, feed rate, point angle and diameter of drill bit on Hass Tool Room Mill USA made CNC milling machine under dry condition. The change in chip load, torque and machining time are obtained through series of experiments according to central composite rotatable design to develop the equations of responses. The comparative performance of commercially available single layer Titanium Aluminum Nitride (TiAIN) and HSS tool for T105CR1 EN31 steel under dry condition is done. The paper also highlight the result of Analysis of Variance (ANOVA) to confirm the validity and correctness of the established mathematical models for in depth analysis of effect of finish drilling process parameters on the chip load, torque, and machining time.

Nourredine Boubekri (2011), analised the current trend in the metal-cutting industry is to find ways to completely eliminate or reduce cutting fluid use in most machining operations. Recent advances in technology have made it

Figure 6: Workpiece

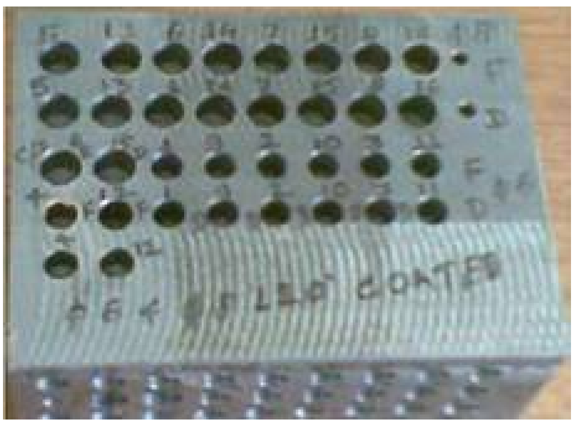


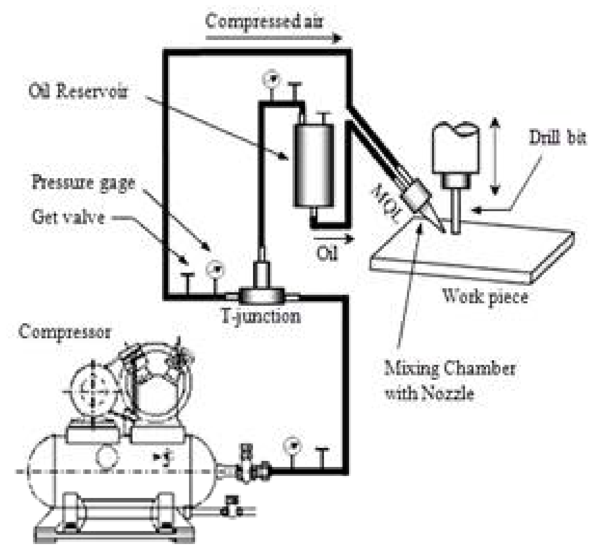
Figure 3: Factors and Their Level for Experimentation

Factor/level	-2	-1	0	+1	+2
Spindle rpm (X1)	800	1000	1200	1400	1600
Feed (X2)	0.10	0.12	0.14	0.16	0.18
Drill Dia. (X3)	6	6	6	8	8
Point angle (X4)	135°	120°	135°	120°	135°

possible to perform some machining without cutting fluid use or with Minimum-Quantity Lubrication (MQL). Drilling takes a key position in the realization of dry or MQL machining. Economical mass machining of common metals (i.e., tool and construction-grade steels) requires knowledge of the work piece characteristics as well as the optimal machining conditions. In this study we investigate the effects of using MQL and flood cooling in drilling 1020 steel using HSS tools with different coatings and geometries. The treatments selected for MQL in this study are commonly used by industry under flood cooling for these materials. A full factorial experiment is conducted and regression models for both surface finish and hole size are generated. The results show a definite increase in tool life and better or acceptable surface quality and size of holes drilled when using MQL.

Nazmul Ahsan *et al.* (2010) analised The growing demand for higher productivity, product quality and overall economy in manufacturing by drilling particularly to meet the challenges thrown by liberalization and global cost competitiveness, insists high material\ removal rate and high stability and long life of the cutting tools. However, high production machining with high cutting velocity, feed and depth of cut is inherently associated with the generation of large amount of heat and this high cutting temperature not only reduces dimensional accuracy and tool life but also impairs the surface finish of the product. The dry drilling of steels (without using cutting fluids) is an environmentally friendly machining process but has some serious problems like higher cutting temperature, tool wear and greater dimensional deviation. Conventional cutting fluids (wet machining) eliminate such problems but have some drawbacks. They possess a significant portion of the total machining cost. Thus machining under Minimum Quantity Lubrication (MQL) condition has drawn the attention of researchers as an alternative to the traditionally used wet and dry machining conditions with a view to minimizing the cooling and lubricating cost as well as reducing cutting zone temperature, tool wear, surface roughness and dimensional deviation. In this work, improvements that were possible when minimum quantity lubrication was used in drilling AISI 1040 steel were examined.

Figure 7: Schematic View of MQL Setup



Results were compared with drilling under dry and wet conditions.

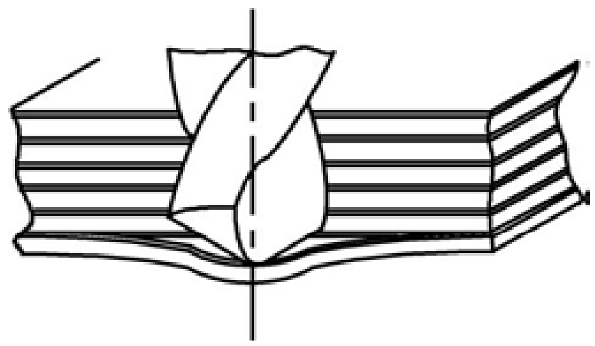
Wong *et al.* (2008) conducted an experimental investigation to determine the effect of drill point geometry and drilling methods on tool life and tool wear in drilling titanium alloy, Ti-6Al-4V. Uncoated carbide drills with different type of geometry under various cutting speeds and drilling methods were used in the investigation. Experimental results revealed that both the drill geometry and drilling techniques affect the tool wear and tool life performance when drilling Ti-6Al-4V. It was also found that peck drilling outperformed direct drilling in terms of tool life all cutting speeds investigated. Non uniform wear and chipping were the dominant failure mode of the tools tested under most conditions.

Hochenga and Tsao (2005), analyzed that the fiber-reinforced composite materials possess advantage for structural purpose in various industries. Delamination is considered the major concern in manufacturing the parts and assembly. Drilling is frequently applied in production cycle while the anisotropy and no homogeneity of composite materials affect the chip deformation and machining behavior during drilling. Traditional and non-traditional

Table 4: Mechanical Properties of Ti-6AL-4V

Properties	Value
Tensile Strength (MPa)	960-1270
Yield Strength (MPa)	820
Elongation (%)	≥8
Reduction In Area (%)	≥25
Density (g/cm^3)	4.42
Modulus of Elasticity Tension (GPa)	100-130
Hardness (HV)	330-370

Figure 8: Schematics of Drilling in Composite Materials



drilling processes are feasible for making fine holes for composite materials by carefully selected tool, method and operating conditions. In this article, the path towards the delamination-free drilling of composite material is reviewed. The major scenes are illustrated including the aspects of the analytical approach, the practical use of special drill bits, pilot hole and back-up plate, and the employment of non-traditional machining method.

Jaromír Audy (2013), analised experimentally the effects of TiN, Ti(Al, N) and Ti(C, N) as well as a M35 HSS tool substrate material on the drill-life of the GP-twist drills by drilling the Bisalloy 360 steel work material. All these experiments have been statistically planned in order to establish the 'empirical' drill-life-cutting speed equations for each of the three coatings as well as to compare statistically the effects of these different coatings on the drill-life. The results demonstrated that although the coated drills performed very well at conditions much higher than applicable for the uncoated drills, none of the three coatings offered any statistically significant advantage over another coating in terms of the drill life.

PROBLEMS DEFINITION

Nowadays there are several types of Drilling Tools with Different Tool Geometry and Various factors (Force, feeding Rate, MOQ, Tool Material, Tool Geometry, etc.), which are affecting the Drilling Tool Life. In this project will be focus only on Different tool Material with Constant Forces acting on the tool surface for analyzing the Deformation in Drilling Tool Geometry and Find out the Factor of Safety for optimizing the Drilling Tool Life. On Drilling Tool, there are many problems occur such as breakage, wear, rough surface finish, short tool life and so on. This problem affects finishing of machined product, life of cutting tool and reduces productivity of Drilling. Through this study, it will determine effects such as cutting forces and Tool Geometry on workpieces based on three different materials.

OBJECTIVE

The Objective of the Solidwork Modeling and Analysis are:

1. To study the effect of Drilling Tool Material and Forces variation on the drilled work piece.
2. To evaluate the Factor of Safety for Different material to analyze the Drilling Tool Life.

Thus we can optimize the drilling forces and tool geometry by analysis of deformation due to changing in drilling tool material. Finally we can analyze the deformation in drilling tool geometry and drilling tool life.

FUTURE ENHANCEMENT

By this project work and Analysis, we can optimized the Drilling Tool Life by considering the following factors,

- Drilling tool material.
- Drilling tool geometry
- Force on tool surface
- Drilling rate
- Minimum quantity of lubrication.
- Types of drilling machine.

Thus, we can optimize the drilling process by Mathematical Modeling, Software Modeling and Experimental Analysis for Improving the Drilling Tool Life.

REFERENCES

1. A1-Ameen S I, Talks M G, Waller M D, Tolley F P, Moreton G, Lomas M A and Yardley E D (1992), "The Prediction and Reduction of Abrasive Wear in Mining Equipment", Final Report on ECSC Research Project No. 7220-AE/821, University of Nottingham and British Coal TSRE, Bretby.
2. Ambrose D (1987), *Diamond Core Bit Performance Analysis*, Unpublished Ph.D. Thesis, University of Nottingham.
3. Ashton S M (1984), "Slim Hole Drilling in the Canning Basin: Philosophy and Application", Perth, pp. 521-531.
4. Atkins B C (1983), "The Utilization and Catagorisation of Manufactured Diamond Materials within the Mining Industry of Western Europe", February, Geodrilling.
5. Barr M V and Brown E T (1983), "A Site Exploration Trial Using Instrumented Horizontal Drilling", 5th Congress of International Society for Rock Mechanics, Melbourne, Australia.

6. Black A D (1977), "Drillability of Sandstone and dolDrite at Simulated Depth", ASME Petroleum Division Conference, September, pp. 8-22, Houston.

7. Bode D J, Noffke R B and Nickens H V (1989), "Well Control Methods and Practices in Small Diameter Wellbores, SPE 19526", Annual Technical Conference and Exhibition, October 8-11, San Antonio, Tex.

8. Bourgoyne A T, Millheim K K, Cheneverert M E and Young F S (1986), *Applied Drilling Engineering*, Society of Petroleum Engineers, p. 502, Richardson, TX.

9. Chur C, Engeser B and Wohlgemuth L (1989), "KTB Pilot Hole, Results and Experiences of One Year Operation".

10. Clark G B (1979), "Principles of Rock Drilling, Colorado School of Mines", *Quarterly*, Vol. 47, No. 2.

11. Clark I E and Shafto G R (1987), "Core Drilling with Syndax 3 PDC", *Industrial Diamond Review*, Vol. 47, No. 521, pp. 169-173.

12. Cumming J D (1956), *Diamond Drilling*, Hand Book, 2nd Edition, Published by J K Smith and Sons of Canada, p. 655, Toronto, Ontario.

13. Cunningham R A and Ecnink J G (1959), "Laboratory Study of Effect of Overburden, Formation and Mud Column Pressure on Drilling Rate of Permeable Formations", *Journal of Petroleum Technology*, Trans., AIME, Vol. 216, January, pp. 9-15.

14. Dah T (1982), "Swedish Group's Small Hole Shallow-Drilling Technique Cuts Costs", *Oil and Gas Journal*, April 19, pp. 98-100.

15. Eckel J R (1967), "Microbit Studies of the Effect of Fluid Properties and Hydraulics on Drilling Rate", *Journal of Petroleum Technology*, Trans., AIME, Vol. 240, April, pp. 451-546.

16. Ester J C (1971), "Selecting the Proper Rotary Rock Bit", *Journal of Petroleum Technology*, November, pp. 1359-1367.

17. Feenstra R and van Leeuwen J J M (1964), "Full-Scale Experiments on Jets in Impermeable Rock Drilling", *Journal of Petroleum Technology*, Trans., AIME, Vol. 231, March, pp. 329-336.

18. Flatt W J (1954), "Slim Hole Drilling Decreases Carter's Development Costs", University of Petroleum Technology Report, July, pp. 19-21.

19. Floyd K (1987), "Slim Holes Haul in Savings", *Drilling MagazIne*, July/August, pp. 24-26.

20. Garnier A J and van Lingen N H (1959), "Phenomena Affecting Drilling Rate at Depth", *Journal of Petroleum Technology*, Trans., AIME, Vol. 217, September, pp. 232-239.

21. Gray G R and Young Jr F S (1973), "25 Years of Drilling Technology Review of Significant Accomplishments", *Journal of Petroleum Technology*, December, pp. 1347-1354.

22. Hochenga H and Tsao C C (2005), "The Path Towards Delamination-Free Drilling

of Composite Materials", *Journal of Materials Processing Technology*, Vol. 167, pp. 251-264.

23. Holster J L and Kipp R J (1984), "Effect of Bit Hydraulic Horsepower on the Drilling Rate of a Polycrystalline Diamond Compact Bit", SPE 11949, Annual Technical Conference and Exhibition, October 5-8, San Francisco.

24. International Association of Drilling Contractors (IADC) (1987), "The IADC Fixed Cutter Bit Classification System", SPEIIADC 16142, Drilling Conference, March 15-18, New Orleans, LA.

25. Jaromir Audy (2013), "A Study of the Effect of Coatings on the Drill Life", *IJMET*, Vol. 2, No. 4, pp. 1023-1029.

26. Kadam M S and Pathak S S (2011), "Experimental Analysis and Comparative Performance of Coated and Uncoated Twist Drill Bit Dry Machining", *IJRMET*, Vol. 1, No. 1, pp. 33-37.

27. Kelly J L and Pessier R (1984), "How to Select Hydraulics for Minimum Cost Drilling", *Oil and Gas Journal*, April 9, pp. 75-81.

28. Kendall H A and Goins Jr W C (1960), "Design and Operation of Jet-Bit Programs for Maximum Hydraulic Horsepower", *Impact Force or Jet Velocity*, Trans., AIME, Vol. 219, pp. 238-250.

29. Luis Miguel P Durao, Joao Manuel R S Tavares, Victor Hugo C de Albuquerque, Jorge Filipe S Marques and Oscar N G Andrade (2014), "Drilling Damage in Composite Material", *Materials*, Vol. 7, pp. 3802-3819.

30. Lummus J L (1969), "Factors to be Considered in Drilling Optimization", *The Journal of Canadian Petroleum*, October-December, pp. 138-147.

31. Lummus J L (1970), "Drilling Optimization", *Journal of Petroleum Technology*, November, pp. 1379-1389.

32. Macfadyen K and Boyington W H (1986), "Slim Hole Exploration Drilling Program: Irian Jaya", Indonesia ADC/SPE Paper 14733, Drilling Conference, Dallas, Texas.

33. Madigan J A and Caldwell R H (1981), "Applications for Polycrystalline Diamond Compact Bits from Analysis of Carbide Insert and Steel Tooth Bit Performance", *Journal of Petroleum Technology*, Vol. 333, July, pp. 1171-1179.

34. Nazmul Ahsan A M M, Md. Golam Kibria, Md. Raju Ahmed, Md. Ariful Islam and Md. Mosharraf Hossain (2010), "Performance Evaluation of Minimum Quantity Lubrication (MQL) in Drilling Operation", *International Conference on Mechanical, Industrial and Energy Engineering*, pp. 23-28.

35. Nourredine Boubekri (2011), "An Investigation in Drilling 1020 Steel Using Minimum Quantity Lubrication", *International Journal of Applied Science and Technology*, Vol. 1, No. 5, pp. 60-67.

36. Peter Muchendu, Githiri J G and Engineer Njeri (2014), "Determination of Optimum Drilling Parameters Using 8.5 inch Tricone Bits in Olkaria Geothermal Steamfield,

Kenya", *IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)*, Vol. 2, No. 2, Ver. I, pp. 11-28.

37. Wong F R, Shari S, Kamdani K and Rahim E A (2008), "The Effect of Drill Point Geometry and Drilling Technique on Tool Life when Drilling Titanium Alloy, Ti-6Al-4V", International Conference on Mechanical & Manufacturing Engineering (ICME2008), May 21-23, pp. 26-33.

38. Yahiaoui M, Gerbaud L, Paris J-Y, Delbe K, Denape J and Dourfay A (2013), "A Study on PDC Drill Bits Quality", *Wear*, Vols. 298-299, pp. 32-41.