DEEPSOUTH CHEMICAL, INC.
Just The Right Chemistry

COMMITTED TO ADVANCING THE SCIENCE OF WELLBORE CLEANING TECHNOLOGY…

DEEP SOUTH CHEMICAL, INC.
SPECIALTY CLEANING TOOL DIVISION

PRINCIPLES FOR MECHANICAL WELLBORE CLEANING

MECHANICAL CLEANING AND SURFACE PREPARATION STANDARDS

Water base, oil-base, synthetic oil-base muds, and thread compounds can be especially hard to clean from casing to riser surfaces. With offshore rig rates ranging to over $200,000/day, it pays to get cleanup done right the first time, and to avoid causing formation damage to the wellbore.

The unique surface properties of synthetic drilling fluids can present quite a number of problems for wellbore cleaning professionals. At **DSC**, we have developed an effective wellbore displacement process utilizing both chemical and mechanical cleaning that has been laboratory tested and field proven.

Whenever two substances interact with each other, the surfaces and the interface created by the contact of the two surface controls the nature of the interaction. This rather obvious but often overlooked statement is of critical importance in such diverse fields as corrosion and wellbore cleaning. Both of these fields are interrelated by their dependence upon an understanding and control of surface phenomena.

Typically, when a wellbore is drilled using a synthetic mud it deposits a high concentration of oil wet solids on the face of the wellbore (filter cake) and casing walls (wall cake) in the form of a permeable cake. As the cake and drilled solids interact, the interaction (at least initially) is occurring at the uppermost molecular layers. The top few molecular layers of a drilling fluid wallcake is called its surface. Consequently, knowledge of the chemical composition of the various drilling fluids is essential to the wellbore cleaning process, as their properties can be different.

Surface Energy Explained

Atoms or molecules within the cake of a drilling fluid system (several molecular diameters away from the surface) are surrounded on all sides by other molecules or atoms. The forces that each atom or molecule experiences are uniformly distributed around it. Atoms or molecules that are at or near a surface, however, are in a non-uniform field; they experience a net attraction towards the cake. If a purely mechanical analysis of the forces between the molecules is performed, we find that a result of these unbalanced forces is a tensile force in the surface, called surface tension.

How Cake Destabilization Is Created

The layers of a typical wallcake consist of adsorbed water, oils, fatty acids, clays and other hydrocarbons. These thin layers of strongly bound materials must be completely removed during a displacement process. The removal process of the wallcake depends on several parameters. The energy required to remove the particles from a wallcake plays a critical role in the cleaning process. The lowering of the surface tension at the surface of wall cake and increasing the surface area can considerably lower the energy of activation of cleaning process. Cutting a wallcake using wire brush tool enhances the reactivity at the surface. Removal of these layers is accomplished by using a well-designed cleaning solvent system containing a suitable surfactant package. Both the mechanical scratching of the cake surface and a good solvent system are essential for a wellbore cleaning process. The chemical cleaning process is essential because the wallcake has a stronger affinity for the chemical wash and solvent cleaner.

Mechanical Cleaning Systems

At **DSC** we implement effective mechanical cleaning solutions by controlling the brush and process parameters which affect brush aggression and performance. Below are some guidelines to customize the parameters to suit your specific wellbore cleaning application.

BRUSHING SPEEDS

- **DSC** Gold brushes, like cutting tools operate most effectively when the correct rotating speed and pressure of the operation are properly matched to the demands of the operation. In most operations, the highest rotating speed and lightest pressure with ensure the fastest brushing action and longest brush life.
- Increasing the brush rotating speed increases the face cleanliness and brushing action; therefore a fine wire brush being run at a high speed will often produce the same results as a coarser wire brush being run at a slower speed.
- A maximum safe free rotating speed of 40 rpm is the maximum speed at which the brushes may be used safely.

BRUSHING PRESSURE

AVOID EXCESSIVE PRESSURE WHEN USING A WIRE BRUSH FILAMENT

- Excessive pressure causes over bending of the filaments and heat build up resulting in filament breakage, rapid dulling and reduced brush life.

- Instead of using excessive pressure the **DSC GOLD COMBO BRUSH** utilizes more aggressive cleaning action with increased filament diameter, trim length and brush configuration.

FILAMENT CONFIGURATION

Brush Design - Using the latest CNC controlled brush-filling machines; **DSC** utilizes the Chevron brush design. This design is especially effective in cleaning large areas at fast running speeds. It is ideally suited for "removing the first few layers of contaminants that are chemically adsorbed onto the casing surface in the form of wallcake."

A DYNAMICALLY CENTRALIZED DOWNHOLE BRUSH ASSEMBLY IMPARTS LESS ASSOCIATED WEAR TO THE BRUSH AND TO THE BRISTLES, RESULTING IN A CLEANER SURFACE AND LONGER BRUSH AND EQUIPMENT LIFE.

Operating Factors Affecting Quality and Brush Life

There are *five* basic ***OPERATING*** factors can affect brush life and surface cleaning:

1. **DEPTH OF ENGAGEMENT –** Increasing the depth of engagement (sometimes referred to as penetration) causes deterioration in the resulting surface finish. More heat is generated during operation, which shortens brush life and can cause thermal damage to the casing surface. Increased depth of engagement also results in greater filament deflection, which accelerates fatigue-related breakdown of the brush structure.

2. **ROTATIONAL SPEED –** Is probably the most frequently – adjusted operational factor. Up to a point 20-40 rpm, an increase in rotational speed results in a finer surface finish. Note that the maximum safe free speed is not the optimum for brush operation. Increasing the rotational speed increases the aggressiveness of the brush, allowing shorter cycle times. * **Note**: Due to centrifugal forces, increasing the rotational speed reduces the ability of the brush to follow the casing contours. I.e.: tool joints. The brush functions as though it were harder. Increasing rotational speed also increases the heat generated during operation, reducing brush life and possibly damaging the casing surface.

3. **ROTATIONAL DIRECTION –** Of the brush relative to the casing face is a significant factor in edge conditioning. Best results are obtained when the tangent formed by the rotating brush is at a right angle to the edge being conditioned rather than parallel. The most complete burr removal and radius is obtained using this orientation. The **DSC GOLD COMBO BRUSH** utilizes Metal-grip Strip Brushes (MGS) design. The brush design is profiled in the ***CHEVRON*** configuration. Especially designed for cleaning large areas at fast speeds. It is ideally suited for cleaning Casing walls.

4. **COOLING –** There is a cooling medium in the wellbore usually clear completion fluid or seawater. Solids free fluid is desirable and very helpful to the amount of heat build up in both the casing and the brush. The solids free completion fluid acts as a lubricant. It reduces heat build up by conduction. Lower brush temperature result in longer brush life.

5. **TOOL RIGIDITY -** Results in a better surface finish and longer brush life. Greater rigidity also reduces chatter, which causes surface imperfections.

Conclusion

Brushes are an effective means for removal of debris downhole during the displacement process. They can be used to remove deposits by deburring or radiusing, to alter the surface finish (prior to setting production packers) or to remove foreign material from the wellbore.

Note: *Brush life is not determined by the number of bristles in a brush but by how many times it strikes the metal – casing surface.*

PRODUCT PERFORMANCE TIPS FOR OPTIMUM CLEANING

FILAMENT DIAMETER	**SMALL**	**LARGE**
	Increased Brush Life	Short Production Cycles
FILAMENT DENSITY	**LOW**	**HIGH**
	Workpiece Flexibility	Fine Surface Finish
TRIM LENGTH	**SHORT**	**LONG**
	Finer Surface Finish	Uniform Random Finish

Design Factors Affecting Quality and Brush Life

There are *five* basic ***DESIGN*** factors, which affect brush life and surface cleaning:

1. **FILAMENT DIAMETER –** *Reducing the diameter of the filament* results in a more polished surface finish. It also results in increased brush life, and as much of brush failure fatigue, which increases as the square of the filament diameter. Brushes with smaller filament diameters tend to follow the contours of the casing surface more closely and produce a more uniform surface. Finer diameter filaments are less aggressive towards the casing surface and may result in longer life.

2. **FILAMENT DENSITY -** or the number of working filament tips per unit area (commonly referred to as points per square inch) has a significant impact on performance. Increasing filament density results in a finer, more uniform surface finish. However, the increased density makes it more difficult for the brush to follow the casing surface geometries. A denser filled brush is more aggressive to the casing surface due to the reduced filament flexibility and more working points in contact with the surface per brush revolution. Increased filament density also provides longer brush life.

3. **TRIM LENGTH –** is the radial length of the filament exposed beyond the brush structural components. Reducing the trim length results in a finer surface finish. *However, like a density increase, the reduced trim length impairs the brush's ability to follow the casing contour.* A brush with a reduced trim length is more aggressive to the casing wall. Note: Short trim lengths will wear out faster!

4. **THE SIZE AND TYPE OF ABRASIVE GRIT - In** synthetic filaments can be varied to alter performance. Silicon carbide abrasive is preferred for harder substrates, such as stainless steel. For softer substrates, Aluminum oxide is preferred because it produces finer surface finishes. Coarser abrasive grits result in a rougher surface finish and an increase in heat generated during brushing. This increased heat could lead to smearing of the synthetic resin filament are more expensive than similar wire brushes and should be used only when wire cannot deliver the desired performance.
5. **BRUSH CONSTRUCTION FEATURES –** can influence brush life. While many of these features. While many of these features are a function are brush supplier selected, there are some guidelines which should be considered.

- The more rigid and structurally solid a brush tool is, the finer the surface finish and the more *brush life is increased*.
- Brushes generate heat during operation. The more *friction or heat* generated has direct effect on brush life.
- For the toughest wellbore cleaning applications, 304 Stainless Steel Wire brushes are used to provide low flex, high impact cleaning action.

Brush Types

Brush fill material (filament) and brush construction normally classifies brushes. The two-classification systems are not mutually exclusive, as various fills can be used in a number of construction types.

The four general categories of fill are:

1. **STEEL WIRE**
2. **NON-FERROUS WIRE**
3. **SYNTHETIC MATERIALS**
4. **NATURAL VEGETABLE FIBERS**

There are many subgroups of each category offered by brush manufacturers and material suppliers.

- ***STEEL WIRE*** is the most common, widely used fill material, typically high –carbon (SAE 1070) or stainless steel (Type 302). Other alloys can also be used to meet specific application requirements. Steel wire is a hard material (Rc58 for carbon steel and Rc52 for stainless steel) which continually fractures to expose new sharp micro cutting edges. It is a good general-purpose material and is readily available in a variety of wire sizes and brush configurations. Generally, steel wire filaments give acceptable service life.

- ***NONFERROUS WIRE*** is typically brass, bronze or phosphor bronze. It is used where non-sparking properties are desired. These materials are much less aggressive than steel wire in the amount of work desired and have shorter service lives. Their cost is considerably greater than steel wire in equivalent brushes.

- ***SYNTHETIC FILL MATERIALS*** are available in more than a dozen different polymers, but nylon (Type 6 or 6 ½) and polypropylene are the most common. These materials stand up well to harsh environments. However, they have a severe temperature limitation of 140-180 degrees and tend to wear down faster than wire bristles. The relative softness of the material and the lack of sharp cutting edge make these filaments much less aggressive than wire filaments. Embedding them with abrasive particles can enhance the aggressiveness of synthetic filaments. Typically the abrasives are either silicon carbide or aluminum oxide, but others such as cubic boron nitride or diamond, are available. Various cross sections are also available in synthetic filaments. Round, rectangular and four lobed cloverleaves are the most common. Rectangular cross-sections are used to increase filament stiffness, and cloverleaf is used to increase coolant or fluid carrying ability.

- ***NATURAL VEGETABLE FIBERS*** are available in a variety of materials including Tampico, bassine, and palmyra. Tampico is the most commonly used in industrial applications. Natural fibers are used primarily because of their higher temperature resistance and enhanced ability to carry coolant fluids. They begin to deteriorate when exposed too moisture and have relatively poor wear life. While natural fibers have some natural abrasives, they are generally used with a working compound to enhance performance.

BRUSH SELECTION CRITERIA

The two general types of brush construction are *individual filament* and *knot types*.

There are many detail construction features for each type that are unique to different brush manufacturers. The individual filament brushes are composed of thousands of single filaments, each acting essentially independently. The filaments are mechanically retained in the brush by forming them into a hairpin or "U" shape around a central retaining ring or wire band. Sometimes adhesives are used to enhance filament retention.

Brushes can be single sections, or formed from brush strip wound into a helix. Single sections are stacked together to obtain the desired width. Individual filament brushes are available in wire, non-ferrous wire, synthetic filament and natural plant fibers. Fill materials other than natural fiber, may have a sinusoidal crimp in each stand to enhance the filament flexing action.

Knot type brushes are comprised of filaments twisted together to act as a single unit. These filament groups strike the substrate with much more momentum and impact than individual filaments, providing far more aggressive cutting action. The filaments are mechanically retained by inserting them through a hole or slot in a steel center disc, then twisting the individual strands, together in a similar fashion to wire rope or cable. Several *knot* styles are available, ranging from a tightly wound, hard solid mass to a loosely twisted bundle. *Knot* configuration is tailored to meet the needs of a specific application.

Knot brushes are available only in wire fill material and as individual sections. Sections can be ganged or stacked to obtain greater width.

Note: Brush life is not determined by the number of bristles in a brush but how much pressure is exerted on the brush and how many times it strikes the casing surface.

Glossary of Brush Terms

Bore - Inside diameter of a core or hub for a roller brush.
Bristle - Natural animal fibers used to create brush tufts.
Brush Part - The length of the brush area on a block or core. Brush Part can be the same or shorter than the Overall Length.
Core Diameter – Diameter of a cylindrical brush core.
Crimped - Filament that has been embossed with a wave pattern. Amplitude and frequency measure crimp.
Cut End - Part of a twisted-in-wire brush where the wire has been flush cut at the brush part end.
End Tuft - A twisted-in-wire brush where the filament has been gathered to create a tuft parallel to the twist wire.
Ferrule - A steel tube, seamed or seamless, that gathers and binds the bristle in a paintbrush.
Fiber - Any material used to create a brush tuft, but the term is normally reserved for vegetable fibers such as tampico and palmyra.
Filament - Extruded synthetic fibers used to create brush tufts.
Finger Loop - Part of a twisted-in-wire brush that has a loop in the end opposite the brush part to accommodate pulling with the index finger.
Flagged - Filament that has been run through a series of knives to splinter the ends and produce a softer tipped brush.
Flare - 1. The angle of a tuft respective of the block or core. A tuft perpendicular to the block has a flare of 0°. This is usually used as a descriptor on floor brushes and hand brushes.
2. The spread of the bristle in a tuft. Tufts can be cylindrical or conical; the spread at the bristle ends is called the tuft flare.
Flow-Thru - Any brush that is designed for use with a Fountain Handle.
Fountain Handle - A threaded metal handle with a 3/4" hose bib to accommodate attachment to a water or solution source.
Hole Diameter - The diameter of a tuft hole in a block or core.
Inside Diameter (ID) - The diameter of the inside of a metal grip coil brush.
Keyed Hub - A core hub with a key and two set screws.
Level - Filament that has been extruded straight, without crimp.
Loop End - Same as a Finger Loop.
Metal Grip Roller (MGR) - Metal-grip strip brush that has been coiled onto a cylindrical core.
Metal Grip Strip (MGS) - Continuous brush that is formed by placing filament in a dove tail shaped metal channel and held in place with a retaining wire.
Overall Diameter (OD) - The diameter of a cylindrical brush measured at the filament ends.
Overall Length (OAL) - The length of a brush, usually measured as the length of the block or core. See Brush Part.
Pattern - The distance between tufts usually given by a row and column distance measurement for block brushes and by tufts per circumference and spacing for cylindrical brushes.
Pitch - The distance between wraps on a coil brush. Also see Wraps per Foot.
Plastic Backed Stave (PBS) - A tufted strip brush with a plastic backing.
Poly Core Roller (PCR) - A cylindrical brush with a plastic core.
Poly Steel Core Roller (PSCR) - A cylindrical brush with a combination plastic, inner steel core and hubs.
Roller Brush - Any cylindrical brush.
Standard Key - A metal pin used to lock a hub to a shaft by positioning the key halfway in between. Standard keys are determined by the shaft or bore diameter.
Stave Brush - A tufted brush with one or more rows of tufts in a long rectangular wood or plastic block.
Strip Brush - A long brush either tufted or metal-grip in construction and usually with no flare.

Trim - The length of the brush filament from the block or core.
Turn-tuft End - A twisted-in-wire brush where the brush part end has been bent back on itself.
Wall Thickness - The thickness of a cylindrical core's wall.
Wood Backed Stave (WBS) - A tufted strip brush with a wood backing.
Wood Core Roller (WCR) - - A cylindrical brush with a wood core.
Wraps per Foot (WPF) - The number of wraps in a foot for a coil on a cylindrical brush. Also see Pitch.