FLUID EXTRACTOR

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ABSTRACT

Fluid Extraction Technology can improve down hole gas separation by employing material and fluid flow properties in ways that are not now effectively utilized. Downhole pumps that handle fluids are adversely affected by free and entrained gas entering the inlet of the pump. To separate the gas ahead of the suction of pumps in the bottom of a well, operators typically configure a path for the fluid to be redirected downward to allow the gas to rise while the liquid falls to the intake of the pump. Virtually all of the gas separators use single pass serial separators based on gravity. The primary separation is typically the tubing by casing annulus and the second stage of separation is the labyrinth of falling liquid and rising gas inside the mud anchor or packer assembly (see figure 1). This technology can be very effective but often times is not sufficient. In addition, the size and length of the equipment has a larger material footprint than necessary.

Fluid Extraction technology uses gravity but also uses mechanical and fluid properties to enhance separation. These attributes include wettability, fluid adhesion, gas nucleation and the concept of Liquid hold up or circulation cells. Integrating these concepts allows better use of the primary flow volume of the casing by tubing annulus. The general shape of the tool is shown in Figure 2.

FLUID PRINCIPLES-WETTING AREA

In all two phase flow involving gas as one of the phases, liquid is the wetting phase with definable surface tension or adhesion properties. As fluid flows up the casing by tubing annulus, the cross sectional area of the ID of the casing per foot is dramatically greater than the cross sectional area of the OD of the tubing. Table 1 illustrates various combinations. The nature of the fluid flow with conventional gas separation is for the liquid phase to be preferentially drawn towards the casing. Gas separation with Fluid Extraction technology integrates several properties to change the preference as to where the liquids want to concentrate. The first principle employed by the Fluid Extraction technology is to increase the relative amount of surface area near the tubing. Table 1 also shows the relative cross sectional areas for the different types of extractors. The relative areas in this table are calculated on the basis of smooth material. The total area is further enhanced many fold by the roughness of the surface. Unlike the milled casing that is smooth, the Fluid Extractor has a surface area that is made with a high roughness factor or texture. Together, the wetting surface for the fluid to be drawn towards is dramatically shifted towards the tubing rather than the casing.

FLUID FLOW – ADHESION

Anyone who has ever washed their hands in a sink and noticed the change in water direction as their hand touches the stream of water understands the concept of fluid adhesion. The liquid phase is being pulled towards a surface that the fluid has an affinity to wet. The surface tension between the molecules of water drag each other in the direction being pulled. The profile of each fin of the Fluid Extractor uses this same principle to pull the liquid towards the tubing, thereby concentrating the liquid on top or towards the center of each fin.

FLUID PRINCIPLES-GAS EVOLUTION SITES

As the fluid is produced from the formation into the wellbore, some of the gas is free gas and some of the gas remains in solution consistent with the properties of the particular reservoir at the pressures and temperatures that are encountered.

As the fluid rises, the hydrostatic pressure is reduced and gas comes out of solution. Depending on the oil cut of the well and the fluid properties, the gas coming out of solution can be substantial. The rate that solution gas evolves is also a function of time and the surface area from which the gas bubbles form.

Important attributes of solution gas include an understanding of where the gas evolves or breaks out of the oil, the impact on flow when the bubbles coalesce and the time involved for this process to occur. In the Fluid Extractor, the interaction with the fins and the roughness act to agitate the fluid. Second, close examination of the bubbles reveal that bubbles almost always originate from a surface interface. The extended amount of surface area contributes to the gas coming out of solution.

The evolution of solution gas is important for several reasons. First, solution gas is another source of gas that needs to be separated to improve pump efficiency. Second, the evolution of solution gas helps create the circulation cells that pull liquid down from above. The volume of gas moving away from the Extractor has to be replaced with liquid coming in behind the exiting gas. Lastly, the evolution of gas acts to "push" free gas away from the tubing where it can coalesce into bigger bubbles. Solution gas starts as small bubbles that begin to rise vertically above each fin until they hit the bottom of the next fin. As the bubbles expand, the gas is then redirected away from the Fluid Extractor tubing. Once the smaller bubbles reach the end of the fins and have less restriction to flow vertically, they occupy space and encounter free gas bubbles coming from below. The presence of these smaller bubbles leaving each fin pushes or "jets" the free gas away from the fin. Collectively, even if the evolution of solution gas represents a small fraction the total gas being separated, this gas serves important roles in the dynamics of the Fluid Extractor.

SURFACE TEXTURE

All of the principles cited above are amplified if the roughness of the surface is increased. In conventional separators, the geometry is created with slick milled surfaces. In the Fluid Extractor, the surfaces are intentionally manufactured with rough surfaces to enhance surface area, fluid adhesion, and gas evolution/nucleation. The effective ratio of surface area near the tubing to total surface area is perhaps as much as a factor of 10-100x.

PARALLEL PROCESSING-CIRCULATION CELLS

As discussed above, conventional separators favor a liquid rich environment near the casing. As gas coalesces and rises to the high side of the casing, a slight downward relative circulation cell/"hold up" cell/eddy current cell is created. The geometry of the Fluid Extractor amplifies this concept by creating physical circulation chambers (see Figure 3). The fins of the Fluid Extractor are angled in a way that allows liquid to flow on top of each fin towards the center. In addition, there are helical slots running the length of the fin section that allow the fluid to roll off into the chamber below. The offset caused by the helical orientation creates impingement areas that keep gas from directly running up the slot. The bottom of each fin is angled up from the center, allowing gas to rise and exit away from the Fluid Extractor.

In effect, each fin concentrates liquid downward and to the center in a parallel manner while thegas is directed upward and away from the center of each fin. The fluid in each chamber either falls into the chamber below or builds up and spills downward to the next chamber. The upward velocity of the liquid has been reduced relative to the fluid in the casing by Fluid Extractor annulus. Momentarily holding up the liquid near the Fluid Extractor fins allows the increasingly gas laden fluid to be sheared and continue up the hole, thereby improving the separation vertically in the larger annular space. Each chamber repeats this process, collectively creating vertical parallel processing. While each chamber holds up the liquid, the chambers communicate with one another vertically by way of the helical slot. The spacing, shape, and configuration of the fins can be varied in a number of ways to facility different types of crudes and gas/liquid mixtures. Downwardly concave, staggered "pedals" are another example of a configuration that that can constructed to create the same parallel processing effect.

While the geometry and materials create surface area to preferentially "pull" the liquid phase laterally towards the Fluid Extractor, the fins/cells provide mechanisms to "pull" the liquid down the tool while letting the more gas laden stream to be sheared off and continue to concentrate and separate up the annulus. Together, these combined processes create a powerful tool to improve gas separation in the primary separation annular volume.

BASIC TOOL APPLICATIONS

There are three basic applications of the Fluid Extractor. The following is a brief description of each application:

Perforated sub/mud anchor replacement: This version of the Fluid Extractor completely replaces the traditional perforated sub/mud anchor/gas anchor. The bottom fin section is modified to allow ports immediately above the fin. Liquid falling from the fin sections above drain into the Fluid Extractor ports. The ports receive liquid from the column of liquid stacked up in the fins next to the tubing, better utilizing the entire volume in the cavity next to the tool. Figure 3 shows a conceptual schematic of the Gas Extractor technology.

To insure adequate inlet fluid intake into the pump, multiple Fluid Extractors can be used series. If multiple Fluid Extractors are used, the ports in the lower sections can be smaller to create further parallel processing effects. Liquid that is scalped off in increments allows the gas to coalesce further up the hole.

The final component of using the Fluid Extractor as a mud anchor section is a short sub below the seating nipple with a vent hole to bleed off any gas that gets into the Fluid Extractor.

Annular extraction: Once the fluid enters the annular space between the casing and the tubing, versions of the tool can be run within the tubing strings that are compatible with conventional mud anchors. Since the interior flow area would be the same as the tubing, the room left on the outside of the tubing results in less fin length. However, the total cross section area in the annular space is still dramatically greater than slick tubing. The same basic principles still apply. The intent of the Fluid Extractor in this type of operation without an inlet port is to strip the liquid from the fluid towards the tubing and condition the gas. This conditioning includes releasing more solution gas, creating the circulation cells, and expelling the gas away from the tubing.

Bottom extraction: A version of the Fluid Extractor can be run on the bottom of the tubing string to precondition the fluid. This version is essentially the same as the gas separator version of the Fluid Extractor except that the center is solid rather than hollow. The solid profile allows it to be used as a bridge plug or as a combination bridge plug anode, depending on the material that is used.

BENEFITS:
Operators can benefit from the use of the Fluid Extractor in many ways, including:

Increased gas separation efficiency: By integrating more efficient use of fluid properties, material properties and geometry, the Fluid Extractor can improve gas separation efficiency. With greater gas separation efficiency, run time control can be improved.

Reduced Equipment: Improved gas separation is accomplished by using both the cross sectional area of the tubulars as well as the vertical section across a number of fins for more efficient separation. This more intense use of the cavity allows for a much shorter section, thereby reducing rig handling costs.

Reduced Environmental Footprint: This technology, applied in various combinations and tubular dimensions requires less materials and freight.

Improved solids handling: Beyond the improvement in the gas separation, many of the same principles can cause scale to precipitate before the fluid enters the pump, thereby reducing scaling issues in the more critical pump area. Scale buildup in fins is far less damaging than scale buildup in the pump.

Passive Cathodic Protection: As noted earlier, the version of the Fluid Extractor that is run on bottom can be made out of sacrificial anode material like zinc or aluminum. The cross sectional area of the tool along with turbulence of the flow can enhance the passive cathodic protection of the downhole assembly.

Table 1: Wetting Surface Dimensions

Tubing Size (in)	**Tubing OD Area/ft of Length (sq in)**	**Casing Size (in)**	**Casing ID area/ft of length (sq in)**	**Tubing area/ Casing area Ratio**
2-3/8	90	4-1/2	151	.59
2-3/8	90	5-1/2	188	.48
2-7/8	108	5-1/2	188	.58
Fluid Extractor – "2-7/8" mud anchor model				
	1617	5-1/2	188	8.5
		Including 10x roughness factor		85
Fluid Extractor – "2-7/8" mud anchor model				
	934	5-1/2	188	6.2
		Including 10x roughness factor		62
Fluid Extractor – "2-3/8" Version				
	1249	4-1/2	151	8.3
		Including 10x roughness factor		85
Fluid Extractor – "2-3/8" Version				
	203	4-1/2	151	4.7
		Including 10x roughness factor		47

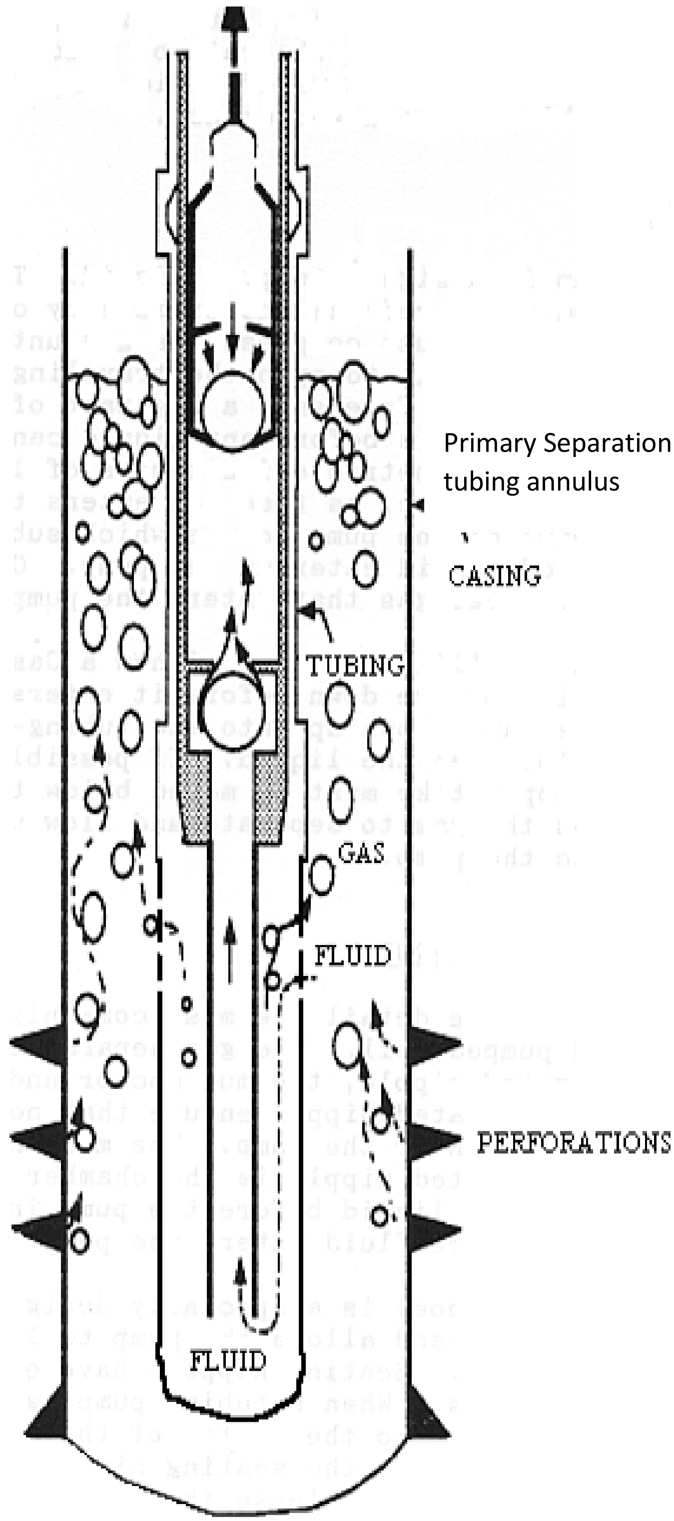
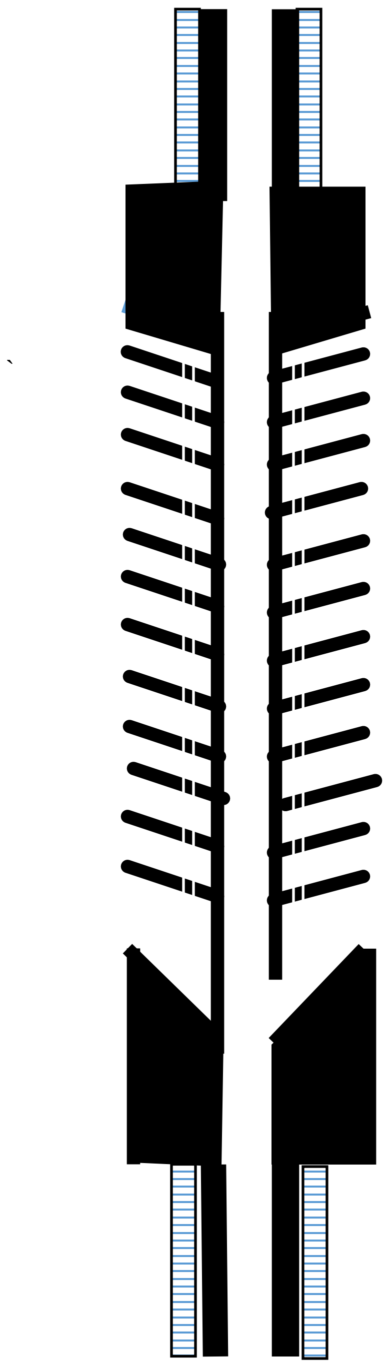


Figure 1-Conventional Mud/Gas Anchor



General notes:

- Not to scale
- Actual fin section spacing may vary but can be as little as ¼" in thickness
- Total number of fins not actually shown
- Dimensions dependent on actual tubular requirements
- Downward ports shown are actually helical channels
- The port into the cavity is three equally spaced rectangular slots
- All transitions/rounds/tapers not shown
- External dimensions limited to typical tubular collar diameters
- End threads will generally be cut to 8rd API

Figure 2-Fluid Extractor

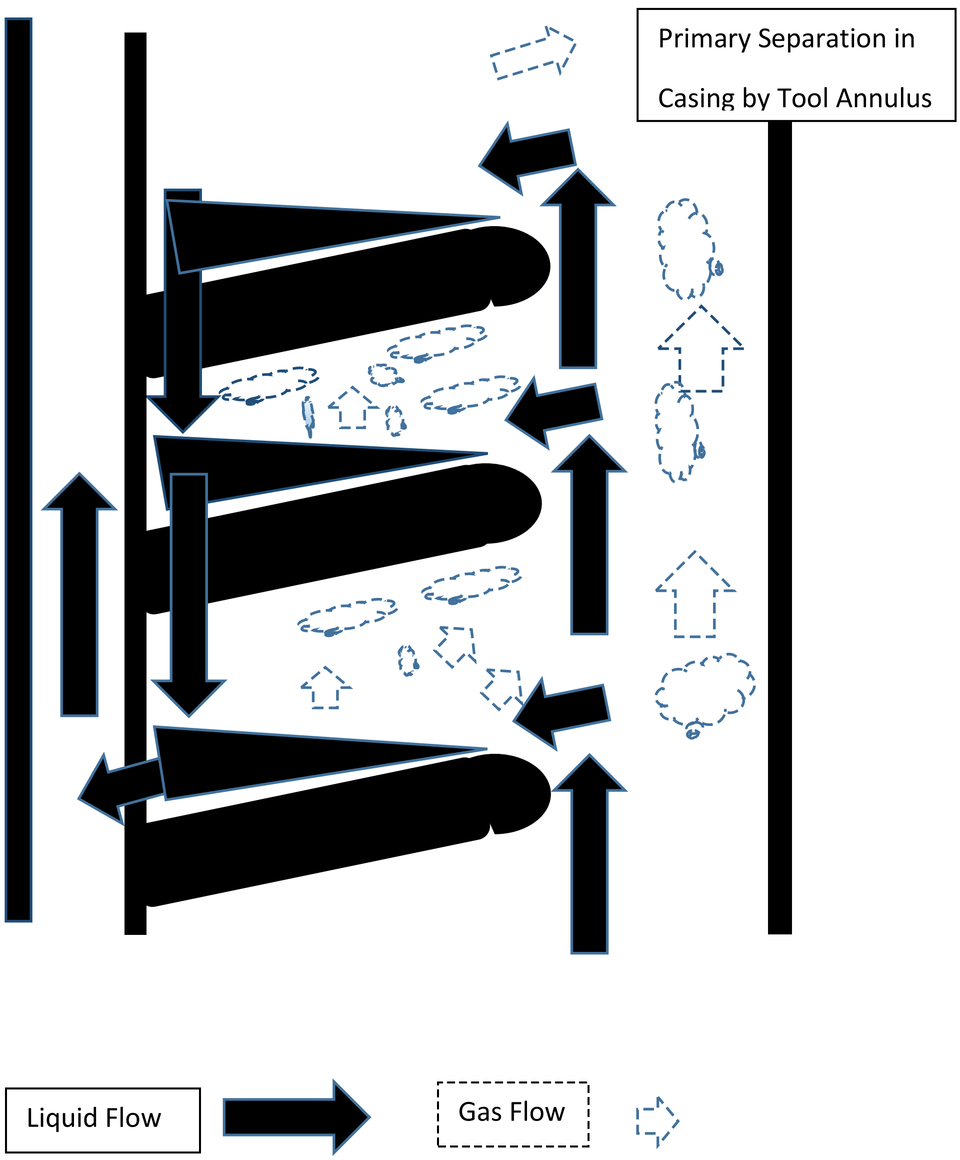


Figure 3 –Fluid Extractor Idealized Flow