MIXING MUD

How you do it makes a difference

by Darrell R. Holupko*

THE USE OF A fluid mixer in a drilling mud system has made it possible to have a maximum mud inventory ready at all times. The ability to change mud weight and viscosity quickly has meant substantial savings to the drilling contractor. In addition, further savings have been realized from lowering mud pump maintenance, longer bit life and higher penetration rates - along with easier utilization of weight material, gel and chemicals. The need for mixing is best demonstrated by examining the basic requirements of a drilling mud system.

The purpose of the surface mud system is twofold:

1) to maintain a minimum inventory of weighted mud, and
2) to reclaim and recondition used mud by removing the drilling solids.

If the agitation equipment used does not produce the optimum fluid regime (flow and shear stresses), neither of these requirements can be met to the fullest. Therefore, mud mixers are used in drilling mud operations for three basic functions:

1) suspension of drilling mud and drilling solids in the mud tanks,
2) addition of weight and gel materials to the mud system, and
3) dissolving of chemical reagents for addition to the mud system.

To better understand these basic functions, the purpose of mixing in the mud system should be understood.

Mixing Vs Results

The first requirement is the suspension of mud and drilling solids that are not removed by the shale shaker. To produce a uniform suspension of solids and eliminate any tendency of settling in the ends and the corners of the tanks, a vertical fluid velocity equal to or exceeding the settling velocity of all solids is required. This elimination of settled solids prevents a reduction in the mud inventory.

In the early days of drilling operations, mud pumps were used in conjunction with mud guns to produce this required fluid flow in the mud tanks. However, as reported by Rushton and Oldshue[1] mixing with high velocity nozzles is extremely inefficient. This can be best shown by reviewing the energy requirement in a flowing system which can be expressed as follows:

$$P = QH$$

Where:

P = power requirement of the system producing the mixing,

Q = flow produced by the system, and

H = total head of such a system

Since the suspension of drilling mud in solids requires a finite amount of flow in a given system, it is evident that the most efficient system to be used is the one that produces the least amount of head - thus requiring the least amount of power. Hence, a further investigation of the total head of the system results in the following equation:

$$P = QH$$

$$H = H_{KINETIC} + H_{PRESSURE} + H_{POTENTIAL}$$

The potential head can be eliminated from the above equation since either approach uses a closed loop system; hence, only the head produced by the dissipation of the kinetic energy and the pressure drop are remaining.

Since a turbine-type mixer operates in the tank, its only head loss is the dissipation of kinetic energy (flow). Therefore, the turbine-type mixer results in less power with the same degree of suspension when compared to a mud gun. This difference in power has been laboratory and field-tested, and is a factor of 200-400 percent difference.

Flow Patterns Vs Mixing Impellers

The word "impeller" is used to cover all classes of objects rotating in a mixing vessel. Impellers fall naturally into two general classifications: radial flow and axial flow. Within each class there are numerous types of impellers which LIGHTNIN has tested over the years; however, this discussion will deal basically with the most common types available.

The radial flow impeller (Fig. 1) is the basic type impeller that has been used in the mud mixer tanks for over 30 years. A number of variations of this type impeller have been used, varying from angling the blades to a high-pitch type open impeller (Fig. 2). LIGHTNIN has tested these types of impellers and, after investigating their effect on the total mud mixer system - as well as the basic requirement of suspending solids - we have standardized on the radial flow impeller for the following reasons:

1) The flow pattern produced sweeps the bottom of

**Darrell R. Holupko was recently appointed manager, technical sales, chemical process industries for Mixing Equipment Company, a unit of General Signal. He joined LIGHTNIN as an application engineer in 1970, and was promoted to senior application engineer in October, 1974.*

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the tank (Fig. 1) and eliminates the possibility of solids buildup.

2) The location of the impeller reduces tank erosion, reduces air entrainment and maximizes usable tank volume.

3) Impeller blades are cast steel – thus reducing erosion.

4) Simplicity in design for on-the-spot repairs.

Figure 1 depicts the flow pattern that is produced by a radial flow impeller located approximately 3-in. off the bottom of the mud tank. This radial flow turbine produces a flow pattern which sweeps the bottom of the mud tank to its furthest corners to eliminate any solids buildup at the bottom. The flow pattern produced by this impeller is sufficient to suspend all solids off the tank bottom and throughout the vessel.

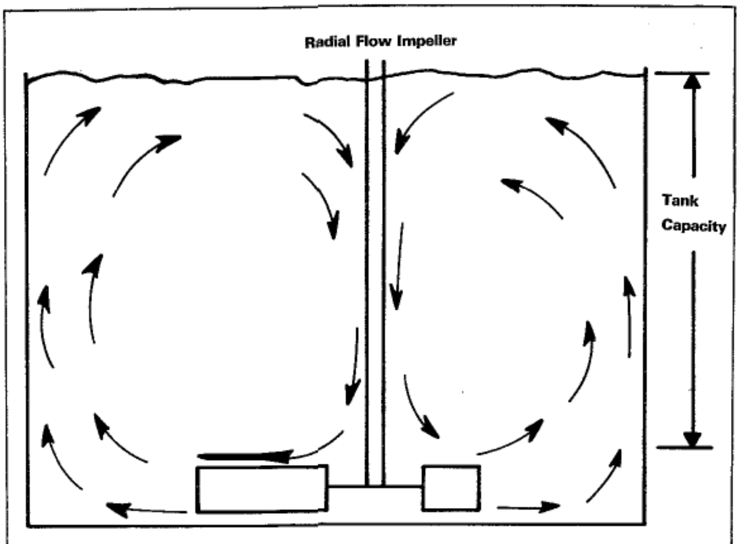

Fig. 1

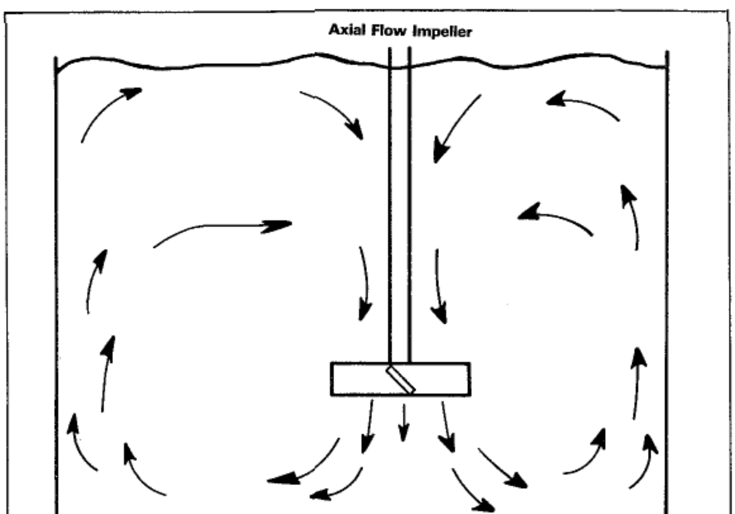

Fig. 2

Also note that the flow pattern is such that the high velocity flow coming from the impeller does not impinge on the bottom of the tank, thereby reducing tank erosion. In 1972, LIGHTNIN ran in-the-field tests using an axial flow impeller (Fig. 2). After many months of testing, it was found that this type of flow pattern accelerated tank bottom erosion, and was therefore not acceptable.

During this field test and in laboratory tests, it was also found that impellers produced by weldments were more susceptible to erosion than cast steel blades.

Furthermore, since all axial flow impellers should be operated approximately three-quarters of their impeller diameter off bottom, the usable tank volume is decreased in each tank (Fig. 2). Therefore, larger tanks and more mixers are required to obtain the same mud inventory on the surface. Finally, the flow pattern produced by axial flow impellers is such that a vortex can be easily formed at the surface, drawing air into the mud, and thus pumped down the hole.

Flow Vs Fluid Shear

Since mixing can have a direct effect on the overall efficiency of the drilling operation, including pump life, bit life and penetration rate, the fluid regime (flow and shear) should be reviewed.

The requirement of an agitator is to produce a uniform suspension of drilling mud and drilling solids to the cyclone desanders and desilters to control the batch viscosity through optimum flow and shear, and to supply a uniform dispersion of drilling mud to the mud pump. This second function of the mud mixer becomes traditionally complex when bentonite is used to control the gel strength of the mud. Since bentonite produces a thixotropic and pseudoplastic material which decreases in viscosity with shear and time (see Fig. 4), the impeller must be capable of producing sufficient fluid shear* to the fluid to:

1) disperse the bentonite, and

2) control the thixotropic and pseudoplastic characteristics of the mud.

Therefore, the agitator must produce an optimum fluid regime which meets the requirements of total pumping

**FLUID SHEAR DEFINITION: If the average velocity of the fluid leaving the blades of a radial flow turbine is measured at various positions above and below the impeller centerline, the distribution of radial velocities is typically as shown in Fig. 3. The velocity gradient at a point or across some chosen distance is defined as the fluid shear rate, either at the point or across the chosen distance increment. The size of the liquid droplet or solid particle of interest in the particular process determines the distance increment used in making the fluid shear analysis.*[2]

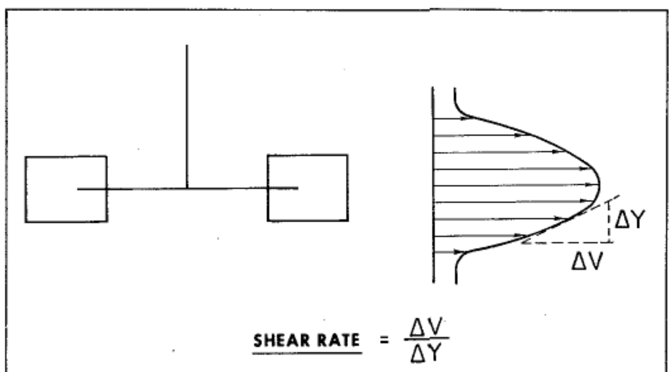

Fig. 3

capacity and fluid shear. If this requirement is not met by the mixing impeller it will have a detrimental effect on the complete drilling operation.

A properly sized mud mixer will produce a uniform suspension of solids at a viscosity which will allow a cyclone-type centrifuge to operate efficiently. It is a well-known fact that the cyclone efficiency decreases with increasing viscosity; therefore, if solids are not removed, not only is the life of the mud pump and the drilling bit affected, but according to Greene and Moerbe[3], it will have a detrimental effect on the drilling rate.

If drilling solids are not removed they will increase the density of the mud and its viscosity. An increase in density has a direct effect on the penetration rate (Fig. 5). This is due to the change in hydrostatic pressure versus formation pressure. They also pointed out that an increased viscosity and a constant shear rate (Fig. 6) will also reduce the bit penetration rate.

This increase in viscosity will also be carried back to the mud tanks, which will again decrease the efficiency of the cyclone centrifuge. Therefore, insufficient agitation can produce many undesirable results during drilling operations.

Practical Considerations

Baffles

It should be emphasized that the distinction between the axial flow and the radial flow impeller can only be made when the impellers operate in baffled tanks.

The advantages of baffled tanks over unbaffled tanks are:

1) Baffled tanks allow top to bottom turnover to produce a contrast to a swirling or rotating flow pattern typical of unbaffled tanks; a swirling tank tends to clarify solids rather than suspend them.

2) Unbaffled tanks produce a vortex which can cause air entrainment.

Internals

The positioning of tank internals is important, not only from a functional standpoint, but also from a fluid regime consideration. Fig. 7 depicts how a flow pattern can be disturbed and cause solids to settle out at the tank bottom.

The solids can deposit over a period of time, and if the flow pattern is changed - due to variation in liquid level or mud guns - these solids will be swept off the bottom, causing a sharp increase in density and viscosity. As discussed earlier, this could have a detrimental effect on the complete drilling operation.

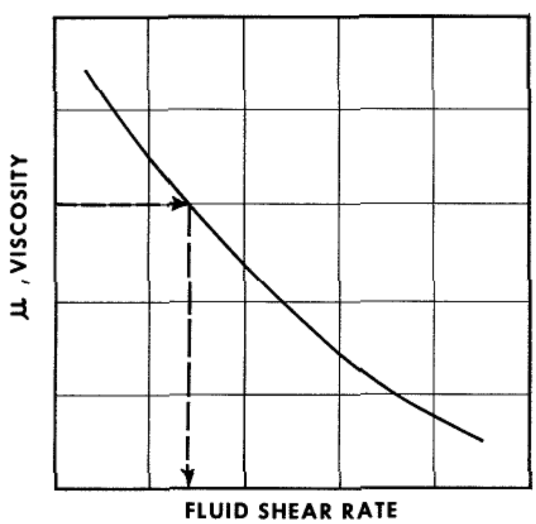

Fig.4

The proper installation of internals as shown in Fig. 8, places the pipe in such a position that it has a minimal effect on the flow pattern - thus reducing interference and eddies - which would allow solids to settle out.

Loading

It is impossible to predict the mud weight a mixer must handle from one drilling operation to another. Therefore, the mud mixer should be designed to suspend 20 lb mud without overloading the motor (impeller horsepower loading is directly proportional to the mud weight). This allows the mud engineer to adjust mud weight without fear

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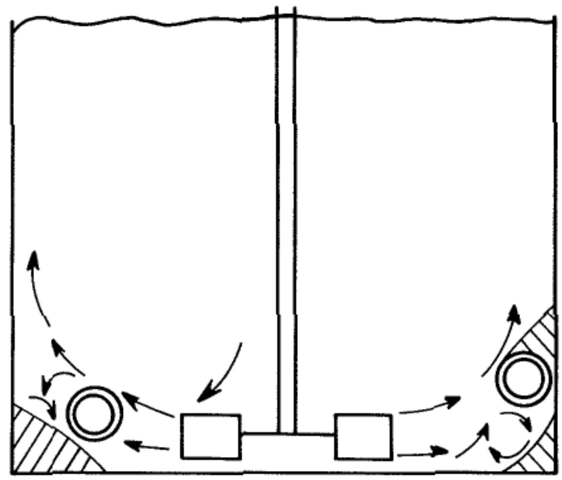

Fig.7

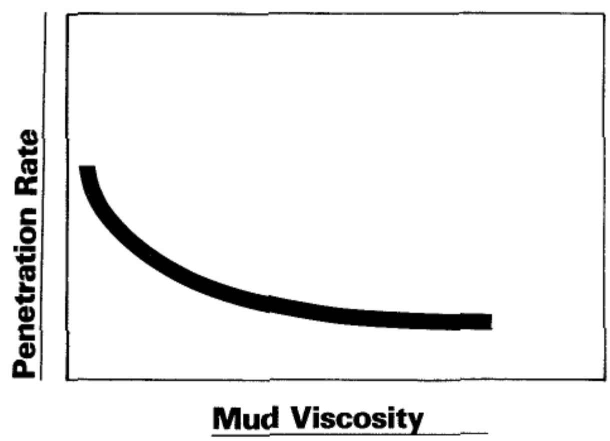

Fig.6

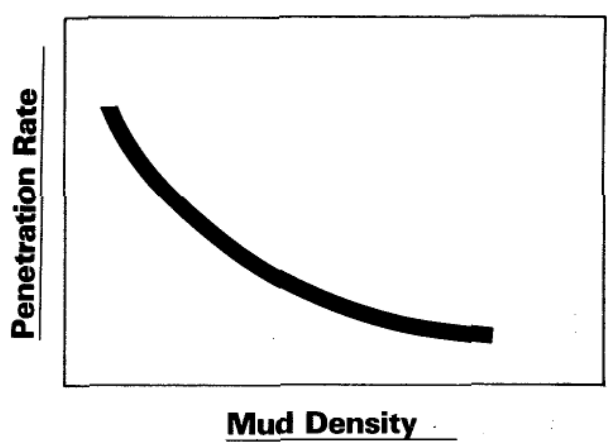

Fig.5

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of insufficient mixing, speed reducer failures or motor overloads.

The impeller location is also important. Radial flow impellers should be operated 3-6-in. off bottom. If installed at a higher elevation, the power draw will increase and the flow pattern will change. Hence, care should be taken that the correct tank height is known before installing the mud mixer.

Mechanical Design

The mechanical design and maintenance of mud mixers should be as simple as possible. Since a detailed discussion on mechanical design is beyond the scope of this paper, the following list of important features has been prepared. These features are a composite of LIGHTNIN's 30 years experience in the drilling mud system field — and should help you in evaluating the proposed equipment.

1) **Speed Reducers**

a. Splash lubrication - eliminates the need and maintenance of an oil pump.
b. High efficiency gearing - since less heat is transmitted to the lubricant, required oil changes are less frequent and bearing and gearing life are extended due to increased lubricity of the oil at lower temperatures.
c. Positive seal oil dam - eliminates oil leakage into the drilling mud.
d. Complete enclosure - protects all moving parts from the elements.
e. Low mixer profile - maximizes available tank height - and thus capacity.

2) **Impellers**

a. Simplicity - designed for easy repair and maintenance.
b. Materials of construction - the ability of the blades to withstand erosion.
c. Symmetrical design - for increased speed reducer and bearing life.

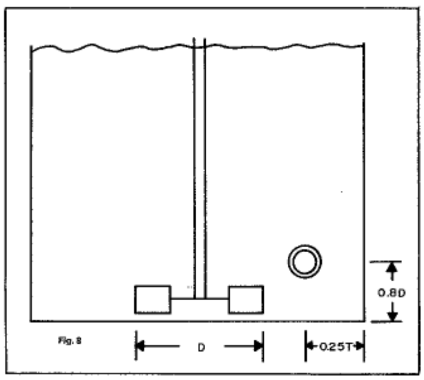
3) **Parts and Service**

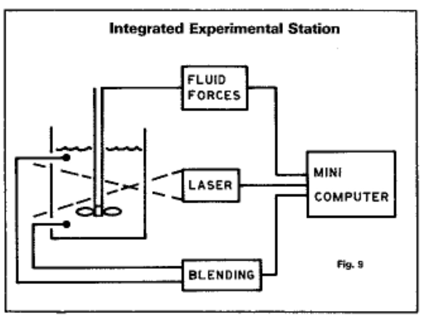
a. Local stock - complete units stocked near the oilfields.
b. Parts - complete line of spare parts should be available locally.

Experience Vs Testing

LIGHTNIN Mud Mixers have been tested both in the laboratory and the drilling field. Small-scale testing, using various size tanks, including a totally integrated testing system which utilizes a laser (to measure flow and shear), in conjunction with auxiliary measuring electronics to determine the optimum fluid regime (Fig. 9) has been performed.

This system measures the impeller flow, the total system flow and shear stresses, with the use of a laser which produces four beams that are focused on a common point anywhere in the tank. This laser has the ability to transverse in any direction, and measures the instantaneous velocity vector of the fluid.





Summary

As stated earlier, a mud mixer must meet the original overall objective of a surface mud system - that is, minimize mud inventory and reclaim and recondition used mud. If the mixer does not meet these objectives it can jeopardize the complete drilling operation.

When evaluating a mud mixer its purpose (as shown in Chart I) should be reviewed, in addition to the vendor's field experience, mud technology and reliability.

Nonmenclature

P	Power
Hp	Horsepower
D	Impeller Diameter
N	Impeller Speed
Q	Volumetric Flow from Impeller
H	Head
T	Tank Diameter

References

1) Rushton, J. H. and Oldshue, J. Y. **Mixing Theory and Practice.** Chemical Engineering Process (April, 1953).
2) Oldshue, J. Y. **The Spectrum of Fluid Shear in a Mixing Vessel.** Chemeca '70 (1971).
3) Greene, K. and Moerbe, E. **Drilling Mud. Drillinq-DCW** (August, 1977).

Chart I

Mixing Characteristics	Results
Solids Suspension	**No Solids Build-up** **Usable Tank Volume**
Uniformity	**Cyclone Efficiency** **Pump Life** **Drill Bit Life** **Mud Weight & Viscosity** **Penetration Rate**
Make-up	**Degree of Dispersion** **Time**

If these are not considered carefully, the actual cost of your mud mixer may far exceed its original purchase price.