MGNewell
We Make It Work Better.




Mixer Placement and More

In basic terms, mixing is simply defined as blending two or more materials into one single product. The individual components, each with their distinct properties (composition, temperature, density, etc) are considered “mixed” when the final product reaches the maximum state of uniformity and all individual differences (temperature, density, etc) have been eliminated. Mixing is a critical process because the quality of the final product and its attributes are derived by the quality of the mix. Improper mixing results in a non-homogenous product that lacks consistency with respect to desired attributes like chemical composition, color, texture, flavor, reactivity, and particle size.

Viscosity and Flow

The viscosity and flow properties of the individual components are important to understand in mixing. These characteristics determine the type of mixer, the power requirements and other properties.

> **Newtonian** – fluid viscosity is constant with change in shear rate or agitation
> **Pseudoplastic** – fluid viscosity decreases as shear rate increases (shear thinning)
> **Thixotropic** – fluid viscosity decreases with time under shear condition

Viscosity is a measure of internal friction or the resistance to flow. Viscosity is a characteristic of every fluid and can vary based on the shear applied to the product. Newtonian liquids have a constant viscosity and are not affected by changes in the shear rate. Examples include water, mineral oil and acetic acid. Other liquids, defined as non-Newtonian fluids, show drastic changes in viscosity when shear rates are increased. Pseudoplastic liquids show a decrease in viscosity as the shear rate increases (shear thinning). Examples include mayonnaise, peanut butter and hand lotions. Thixotropic materials also show a decrease in viscosity under shear however it is also time dependent. Examples include ketchup, yogurt and some gels.

Energy in the Mixing System

To ensure that the correct mixer type and motor are selected, it is necessary to calculate the power required by the system. This energy is based on:

1. The nature of the mixture – viscosity, density
2. The blender type – geometry and dimensions
3. The operating mode – rotation speed

$P \propto Q \; x \; S \; x \; SG$
Power is proportional to the flow (Q), Shear (S) and specific gravity (SG)

It is important to recognize that equal power does not result in equal mixing. The result is always a function of both impeller type and the speed and diameter of the impeller. The energy from a mixer is transmitted to the fluid in two effects – flow and shear. For a given power level, a mixture can be designed so that either the shear component or the flow component represents most of the power applied.

To calculate energy in a mixing vessel, there are some basic terms that you need to know.

Power number	$N_P = \dfrac{P}{\rho N^3 D^5}$	The drag coefficient of the impeller; it is a constant for each impeller type; power numbers are typically determined in water
Reynolds number	$N_{Re} = \dfrac{D^2 N \rho}{\mu}$	A dimensionless number that indicates the type of fluid motion produced – viscosity effect on mixing. A system is fully turbulent when Reynolds number is >10,000.
Horsepower	$P = N_P N^3 D^5 \rho$	The power required to turn the mixer/impeller (for Reynolds numbers in the range 10 – 10,000).

Greensboro Division / Corporate Headquarters
Phone: 336.393.0100 / 800.334.0231
Fax: 336.393.0140

Louisville Division
Phone: 502.459.7475 / 800.459.7475
Fax: 502.459.7633

Nashville Division
Phone: 615.822.3030 / 855.749.4820
Fax: 615.822.3031

www.mgnewell.com **sales@mgnewell.com** **espanol@mgnewell.com**

Where:	D	=	Impeller diameter
	ρ	=	fluid density
	μ	=	fluid viscosity
	N	=	impeller speed (rpm)
	P	=	shaft horsepower

This equation illustrates that, at a constant horsepower, as impeller size increases, more power is expended on flow. A large impeller running at a slow speed produces high pumping capacity (flow) and low shear. Conversely, a small impeller running at high speed produces low flow and high shear.

Some mixing processes require more than one impeller due to tank geometry or fluid characteristics. If using more than one impeller, the horsepower required will be multiplied.

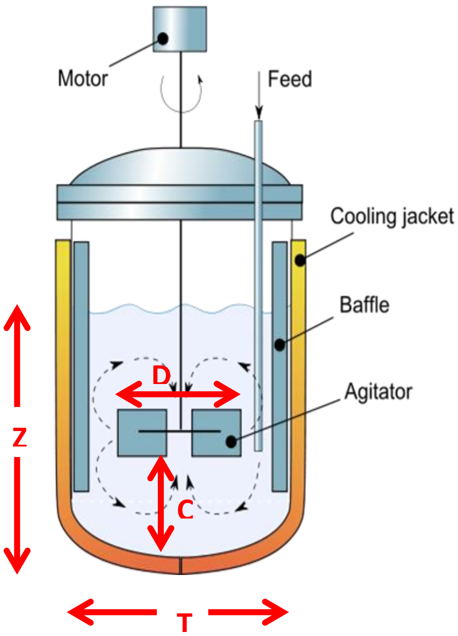
Viscosity does have an impact on the power required, but not as big as the impact from the impeller selection. As viscosity increases, the impeller power number may begin to increase which in turn, increases the horsepower required. Viscosity increases also affect the flow characteristics of the fluid as compared to water. These fluids should be checked in a lab to determine a correct viscosity profile.

Mixer Placement and Tank Design

Within a tank, whether jacketed or not, one or more impellers provide the shear and flow necessary to mix the fluid. It is critical that the impellers (and baffles when used) are in the correct position to insure proper mixing.

First, a few definitions:

T = Inside diameter of tank
Z = Depth of fluid in the tank
D = Impeller diameter
C = Distance from tank bottom to bottom of impeller
B – Width of each baffle



Mixer placement should be dead center for cylindrical tanks containing baffles. For unbaffled tanks, place the mixer 1/6 to ¼ tank diameter (T) off center. 1/6th will provide a stronger vortex, 1/4th will provide a less vortex.

The ratio D/T normally ranges from 0.2 – 0.5 for turbulent flow. A D/T that is too small may leave areas in the tank unmixed. Generally a lower D/T is suitable for low viscosity products. A D/T of 0.1 - 0.2 with high power input will produce high shear in the tank. Higher viscosity products typically require a minimum D/T in the 0.35-0.40 range.

The ratio Z/T describes the fluid level in the tank. If the Z/T ratio exceeds 1.2, additional impellers should be added

The ratio C/T indicates the amount of clearance at the bottom of the tank. The normal range of C/T is between 0.1 – 0.4. Bottom clearance may also be defined by the impeller diameter. For high shear mixing, 1 D off bottom is optimal. For low speed agitation, the clearance can be as low as ½ D.

Typically, four baffles are placed in a tank, equidistant apart along the wall. This standard baffling design provides near optimal performance and a high degree of mechanical stability.

For baffles, the normal ratio B/T = 1/12 tank diameter (T). The length of the baffle runs from the liquid level down to ~6 inches off the bottom. Baffle width is reduced as fluid viscosity increases, and may be eliminated completely for viscosities over 5,000 cps. In large tanks, surface baffles may also be required to break up surface waves. Another important design note in sanitary processing – gaps should be left between the tank wall and the baffle to permit flow when cleaning the tank. The recommended gap is 1/72 of tank diameter (T).