The Pellermix Ratio-ed Velocity gradient or G value for mixer design.

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1 Introduction

The velocity gradient for mixer design has been used for almost 80 years. In that time a number of authors have written various caution notes when using the velocity gradient for mixer design. This document is a summary of these cautions.

2 The Equation

The Equation for velocity gradient, G is:

$$G = (\text{Power} / (\text{Dynamic Viscosity} \times \text{Tank Volume}))^{1/2} \qquad \textit{(Eq 01)}$$

The units are:
Power = Watts = Joule /S = N m /S
Dynamic Viscosity = NS/m^2
Volume = m^3

3 The logic of the equation

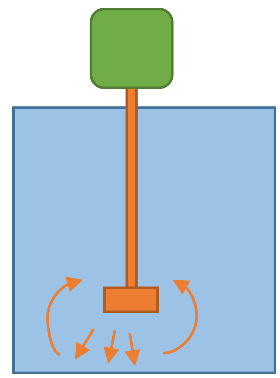
Power effect in the equation: G is Proportional to the Root of the power. If the Power rises then the G value will rise.

The Viscosity Effect in the equation: if the viscosity is increased the G value will reduce, so if the product changes from water to honey then the G value will reduce. Therefore to maintain the G value with the increase in viscosity then the power needs to increase.

The volume effect in the equation: If the volume is increased then the G value will reduce, so if a larger tank is used then we need to increase the power in order to maintain the velocity gradient.

The equation only looks at 3 properties: Power, Viscosity and Volume which is satisfactory if all the impeller types are the same. The equation's practicality is limited because it does not take into account the following 3 parameters: (1) flow distribution that can be generated by various types and sizes impellers, (2) the flow intensity generated by various impeller at various speeds and (3) various tank dimensional configurations and ratios.

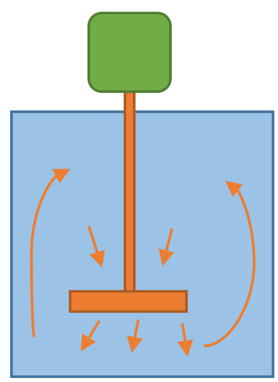
The equation can be used in a perfect state where all impeller types are the same, all mixer speeds are the same and all dimensional ratios of the mixing system are the same. With the invention of new impellers and the availability of huge speed variations the limitation of the velocity gradient equation becomes obvious. Here is an example:
Consider the following 2 mixing systems:



Mixing System A – Concentrated Flow System
Tank Volume: 1 m^3 (1.15 diameter x 1 m H)
Impeller Size: 300 mm diameter
Impeller Type: Pitch Blade Turbine
Viscosity 1 NS/m^2
Speed 100 RPM
Power : 11.25 Watts
Pumping capacity : 33.75 kg/S
Average tank velocity : 1.98 m/min

The G value will = $(11.25 /(1 \times 1))^{½} = 3.35$

System B – Distributed Flow system
Now let us take the same tank and use a high efficiency turbine at a slow speed.



Tank Volume: 1 m^3 (1.15 diameter x 1 m H)
Impeller Size: 480 mm diameter
Impeller Type: High Efficiency Incline turbine mixer
Viscosity 1 NS/m^2
Speed 64 RPM
Power : 11.25 Watts
Pumping capacity : 65.8 kg/s
Average tank velocity : 3.7 m/min

The G value will = $(11.25 /(1 \times 1))^{½} = 3.35$

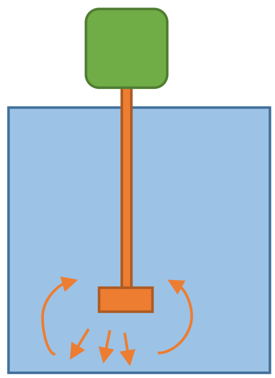
As you see the same G value can give 2 difference average tank velocities with 2 difference impeller conditions.

System A is better suited to systems that require concentrated flow velocities to prevent settling of heavy solids in a specific part of the tank .

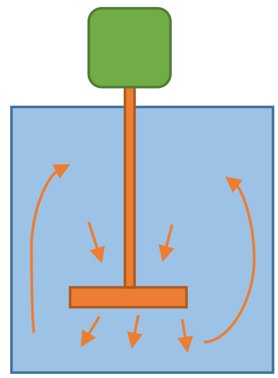
System B is better suited for systems such as low viscosity liquid- liquid mixing where good even tank flow distribution is required.

4 Concentrated Fluid Velocities Verses Distributed Fluid velocities

Mixing systems with small impellers and high speeds will result in highly concentrated velocities. The currents can be directed in narrow currents to the bottom or walls of tanks and stall resulting is concentrated mixing only and poor overall tank flow distribution.



Mixing System A – Concentrated Flow System



System B – Distributed Flow system

5 Recommendations

To overcome the limitations of specifying a velocity gradient value for a mixing system can be achieve by accompanying this value with a minimum impeller diameter or mixing speed. The minimum impeller diameter can be expressed as a % of tank diameter.

For example in the system above if I was aiming for an average tank velocity of 3.7 m/min that is well distributed then I would specify the follow: The G value must be greater than 3.35 and the impeller diameter must be at least 40% of the tank diameter. An alternative is to specify the system with a Pellermix ratio-ed velocity gradient. The "Pellermix ratio-ed velocity gradient is:

$$\mathbf{Gr = ((Power / (Dynamic\ Viscosity \times Tank\ Volume))^{1/2}) \times (Di^2/Dt^2)}$$

(Eq 02)

Where Di = impeller diameter m and Dt = tank diameter in meters.

In the previous example the velocity gradient could had been specified as being greater than 3.3. In place of this, the designer could specify the Pellermix ratio-ed velocity gradient as being greater than 0.5. Table 1 below demonstrates the results of this change.

	Mixer type 1	Mixer type 2
RG Value	0.228256467	0.584336554
G value	3.354101966	3.354101966
Power w	11.25	11.25
Dynamic Viscosity	1	1
Tank Volume m3	1	1
Impeller Diameter m	0.3	0.48
Tank Diameter m	1.15	1.15
Tanks height m	1	1
DT Di Area ratio	0.06805293	0.174215501

Table 1

The Pellermix ratio-ed velocity gradient will then consider impeller area to tank area which is another important consideration for successful fluid dispersion in a mixing system.