

ROTAMIX®

PROCESS MIXING SYSTEMS



by  **Vaughan®**

What is ROTAMIX?

Vaughan's Rotamix® system is today's most cost effective means of mechanical jet mixing, consisting of an engineered arrangement of floor mounted nozzles fed by a Vaughan® chopper pump. Using custom engineering software, each application is analyzed and sized by Vaughan in order to achieve the desired mixing effect. The Rotamix system may be applied in circular, rectangular, and oval tanks and basins, and other unique process configurations such as egg-shaped digesters, CSO tunnels and pump stations.

The Concept

The Rotamix system incorporates several basic principles of physics and hydraulics, including uniform field of flow, vortical field of flow, induced flow and surface contact. Combined together, this unique mixing system optimizes solids contact due to the homogeneous state.

Dual-Zone Mixing

The Rotamix dual-zone mixing pattern is a combination of both uniform and vortical fields of flow (see Figure 1). In a uniform field of flow, the entire contents rotates as a solid unit with the highest velocity at the outside. In a vortical field of flow, fluid velocities are the greatest at the center, thus creating a vertical-axis vortex. The Rotamix system combines both uniform rotation (ZONE 2), and a vertical-axis vortex (ZONE 1), creating unique *dual-rotational* zones. With dual-zone mixing, average velocities are higher and more steady (see Table 1). Solids are also prevented from settling in the center.

Induced Flow

High velocity nozzles also increase the effective mixing volume by *inducing* entrained fluid, thus significantly increasing the overall mixing effect (see Figure 2). High velocity nozzles induce flow over a long distance, thus generating an overall effect over a large volume.

Surface Contact

The Vaughan chopper pump not only eliminates nozzle clogging, but also optimizes surface contact by constantly reducing solids size, thus increasing total surface area.

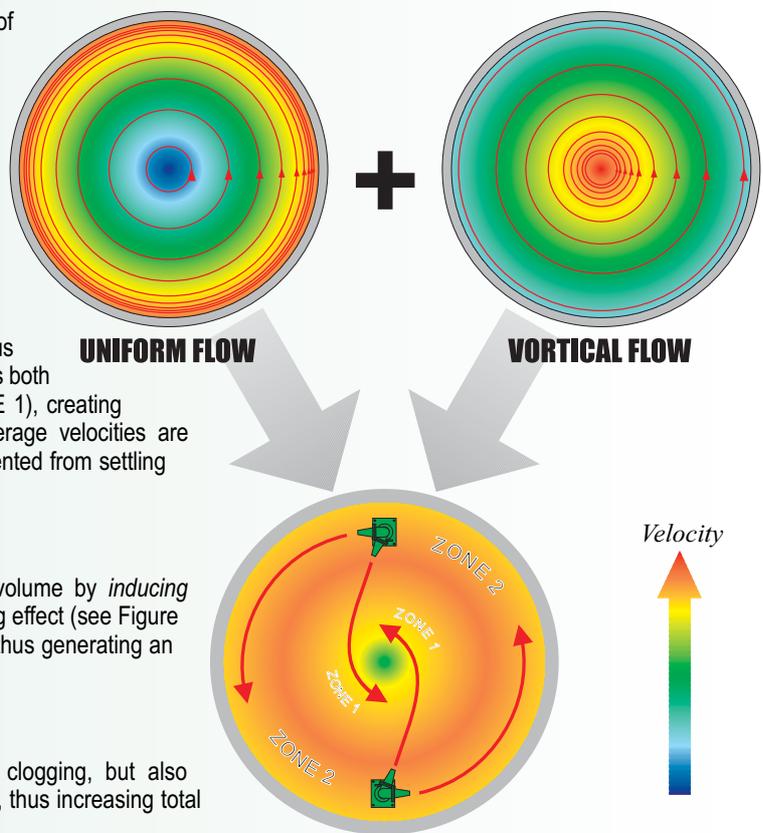


Figure 1 - Dual-rotational zones

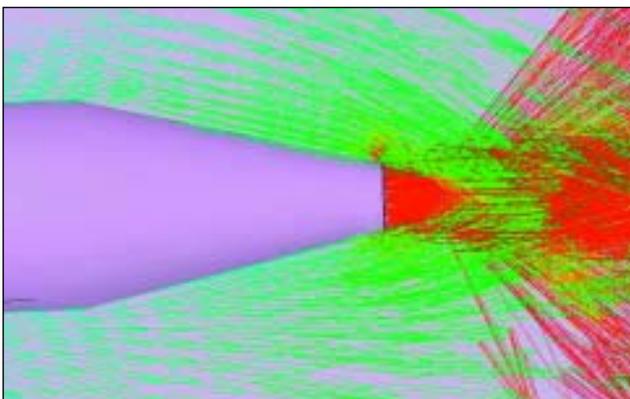


Figure 2 - Induced flow at nozzle

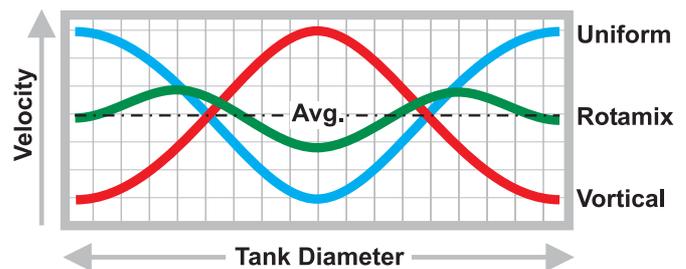
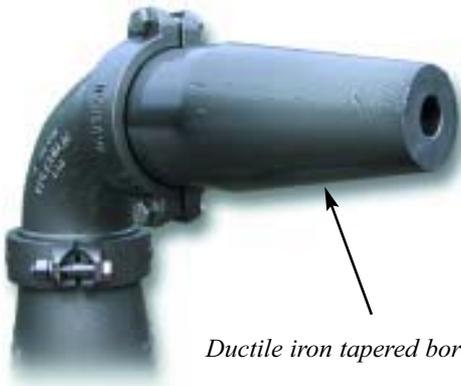


Table 1 - Cross sectional average velocities

Rotamix Nozzle Assemblies

The Rotamix system nozzle assemblies are offered in single and double nozzle (patent pending) configurations. Each assembly is designed for permanent installation without further adjustment or maintenance.

- Nozzle barrels are manufactured from up to 1-inch thick ductile cast iron, for long-term durability and corrosion resistance.
- All components are glass-lined at 73 Rockwell C Hardness for abrasion resistance and to reduce piping head losses, and then powder-coated with 3M™ Scotchkote™ 134 Fusion Bonded Epoxy.
- Each assembly includes a **10-year full warranty** *.



Ductile iron tapered bore nozzle

Double-nozzle assembly



The HEART of the System

Vaughan's chopper pump is the *heart* of the Rotamix system. Vaughan's proven technology over the past 45 years provides long-term, low maintenance, and the highest reliability of any chopper pump. Continuously chopped solids not only eliminate nozzle clogging, but enhance sludge quality. Digester efficiency is increased by further reducing solids size and increasing surface contact. Vaughan's unique features necessary to provide this reliability include:

- Patented chopping design eliminates nozzle clogging
- Wear parts heat treated to 60+ Rockwell C Hardness extends pump life
- Oversized shafting and bearings extends pump life
- Heavy duty "flushless" mechanical seal design assures leak-free operation (other seals also available).
- Back pull-out design allows adjustment of all cutting clearances *without disconnecting suction or discharge piping*
- **NEW** - Vaughan's new 8" and 10" self-primers allow mixing of below-grade tank installations up to 7000 GPM!

Configurations available include horizontal, vertical dry pit, submersible, self-priming, vertical wet well, and recirculating pumps. All Vaughan pumps include a written **Performance Guarantee*** - your assurance of clog-free pump operation.



Comparisons with Other Mixing Systems

Compared to other mixing systems, Rotamix offers advantages in several categories, including costs, maintenance, warranties and guarantees.

| COMPARISONS |  | MECHANICAL MIXERS | DRAFT TUBES | SUBMERSIBLE MIXERS | GAS |
|--|---|---|-------------------------|-----------------------|------|
| Initial Cost | Low | Medium to high | | | |
| Installation Cost | Low | Medium to high | | | |
| Operating Cost | Low | Medium to high | | | |
| Solids Handling | Chopper pump prevents fibrous material from reagglomerations and other material from creating maintenance and performance issues within the process | Systems may be susceptible to fibrous material reweaving, creating expensive maintenance and operational problems | | | |
| Lifting Apparatus | None required | Lifting hoist or crane required | | | |
| Mechanical Components in Process | None | Bearings and propellers | Bearings and propellers | Motors and propellers | None |
| Equipment Warranty within Process | Non-pro-rated 10 years | < 2 years | | | |
| Mixing Guarantees offered as a Standard | Yes | No | | | |

Applications

Wastewater

- Anaerobic Digesters
- Sludge Storage Tanks
- Lime Stabilization
- Bio-Solids Blending Tanks
- Equalization Tanks
- Secondary Digesters
- Anoxic Zone Mixing
- Aerobic Digesters
- Egg-Shaped Digesters
- Influent Channels
- CSO Tunnels
- CSO Retention Basins
- Pumping Stations

Water

- Alum Sludge
- Lime Slurry Storage
- Ground Storage Tanks

Industrial

- Mining Fine Solids Suspension
- Septage Waste Haulers
- Textile Waste
- Liquid Fertilizer
- Pulp & Paper Black Liquor
- Refinery Waste Containment



Field Process Testing

| Sample Number | Sample Point | Temperature °F | Variance from Mean |
|---------------|--------------|----------------|--------------------|
| 2-1 | 2 feet | 97.5 | 0.1 |
| 2-2 | 2 feet | 97.5 | 0.1 |
| 6-1 | 6 feet | 97.5 | 0.1 |
| 6-2 | 6 feet | 97.5 | 0.1 |
| 10-1 | 10 feet | 97.6 | <0.1 |
| 10-2 | 10 feet | 97.6 | <0.1 |
| 14-1 | 14 feet | 97.6 | <0.1 |
| 14-2 | 14 feet | 97.6 | <0.1 |
| 18-1 | 18 feet | 97.6 | <0.1 |
| 18-2 | 18 feet | 97.6 | <0.1 |
| 22-1 | 22 feet | 97.6 | <0.1 |
| 22-2 | 22 feet | 97.6 | <0.1 |
| 26-1 | 26 feet | 97.6 | <0.1 |
| 26-2 | 26 feet | 97.6 | <0.1 |
| 30-1 | 30 feet | 97.6 | <0.1 |
| 30-2 | 30 feet | 97.6 | <0.1 |
| Average | | 97.57 | |

Table 2 - Temperature Profile of a 90' anaerobic digester

Temperature Profile

Typical specifications for anaerobic digesters require temperature variations of no more than 1° F. Temperature profiles taken on digesters with Vaughan's Rotamix system have shown average temperature variations well within this requirement. Table 2 shows actual test results taken from a 90' diameter anaerobic digester at 8 different elevations off the tank bottom, with a maximum variation in temperature of only 0.1° F, and a variance from the mean temperature of <0.1° F.

Solids Profile

The Total Solids Test is an economical way to verify solids concentrations in most tanks or basins and can be performed at the same time as the Temperature Profile. Sampling takes place at various levels and locations within the tank or basin. The samples are then analyzed using an independent lab and must fall within a +/- 10 % acceptance window. Rotamix projects have met or exceeded the requirements of all process testing to date.

CFD Analysis

The CFD (Computational Fluid Dynamics) software used at Vaughan Co., Inc. for analysis is among the top programs available in the world for this type of detailed computer flow modeling work. The problem is solved using techniques similar to finite element stress analysis. Essentially, the fluid volume is broken down into hundreds of thousands of volume elements to be analyzed. Final results can be plotted in various formats including vector, velocity and streamline, on various tank configurations including cylindrical, rectangular and oval. Simulation of Tracer Washout testing can also be obtained using CFD analysis, eliminating the need for expensive on-site testing.

All Rotamix designs are supported by CFD analysis, either by standard modeled geometries, or using customized models individualized to meet specific application parameters on a consultation basis.

Velocity Plots

Velocity plots show variations in velocity as blended solid colors. Velocity plots have proven that small diameter nozzles producing high velocity provide more complete mixing than larger diameter low-velocity nozzle designs using equal amounts of energy. Higher velocity allows flow patterns to travel farther, while inducing significantly more entrained fluid.

In a theoretical comparison, larger-diameter low-velocity nozzles would be required if used with standard non-clog pumps, in an attempt to keep from plugging the nozzle openings with whole solids.

Figure 4 shows a vertical velocity cut in a circular tank.

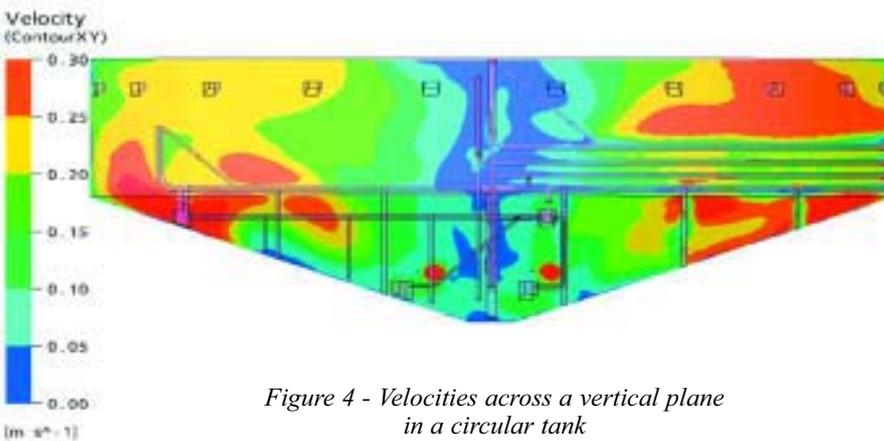


Figure 4 - Velocities across a vertical plane in a circular tank

Streamline Plots

Streamline plots illustrate the path of flow for a particle starting at any given point. The plotted path shows the actual movement of the particle around the tank, confirming both horizontal and vertical movement within the mixing pattern.

Figure 5 shows a streamline plot for a particle at steady state (a period of time determined long enough so that velocities are no longer changing within the tank). This plot proves not only that the rotational mixing has both horizontal and vertical movement, but also that a rotational stirring pattern around the tank's vertical axis is created.

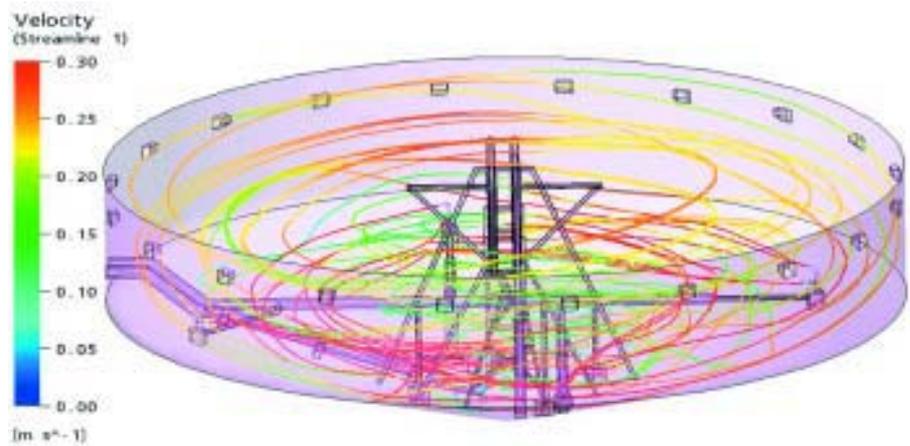


Figure 5 - Streamline plot of a single volume element

Tracer Washout Simulations

CFD analysis allows Vaughan to provide accurate simulations of a Lithium Chloride tracer washout test for a fraction of the cost of a physical 45-day test. This simulation as compared to actual field testing has proven to be within 98% accuracy. Simulations can be provided with the submittal package, saving thousands of dollars and weeks of field sampling.

Figure 5 shows a theoretical versus computer-simulated tracer concentration washout test result for an actual Vaughan Rotamix system, where an Active Volume Mixing value of 95.2% was calculated. Actual 45-day field test results on the same project showed 95-96% Active Volume Mixing - in excellent agreement with the CFD analysis.

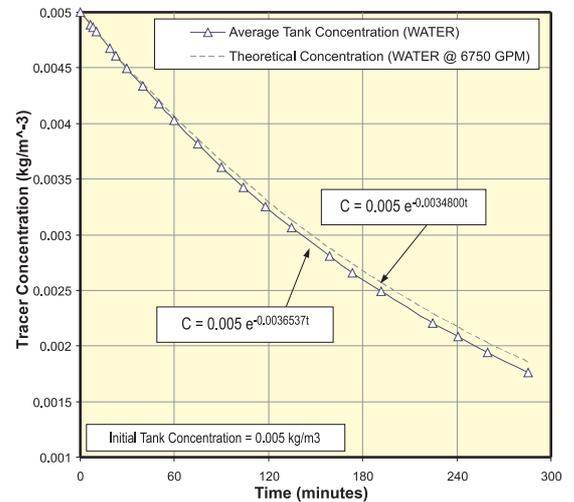


Figure 5 - Tracer Washout Simulations

Other Geometries

Rectangular Tanks

Rectangular tanks are difficult to mix using conventional systems. Solids collect in corners where mixing velocities are restricted. Figure 6 shows velocity plots in several planes for a large rectangular tank.

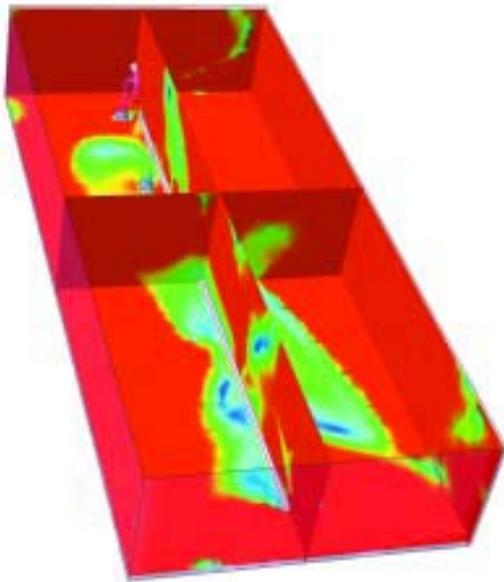


Figure 6 - Rectangular tank

Egg-Shaped Digesters

CFD analysis proves the Rotamix mixing system can even effectively mix egg-shaped digesters. The vertical velocity plot in Figure 7 shows mixing velocities throughout the entire diameter and depth.

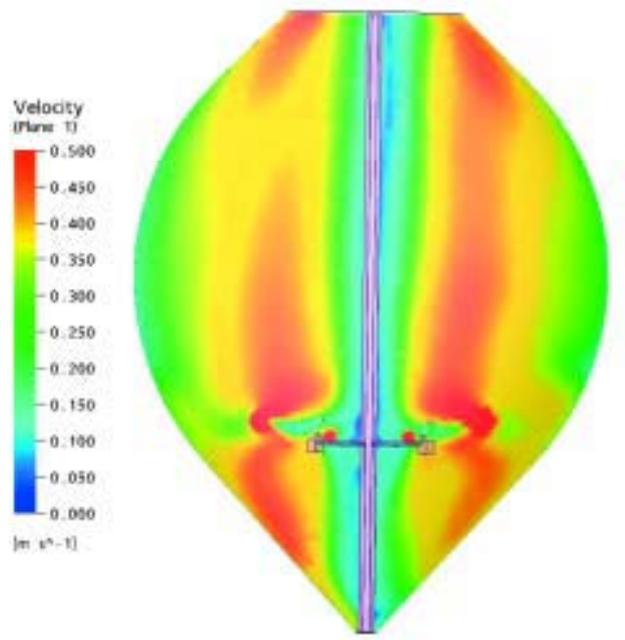


Figure 7 - Egg-Shaped Digester

Assured Quality and Performance

- Vaughan's experience with quality, mixing and solids handling products for over 40 years
- **Performance Guaranteed** *
- **10 year full nozzle warranty** *
- Verifiable with CFD modeling
- Passes chemical dispersion tracing (Lithium, Aluminum Chloride), and other performance tests including temperature profiling analysis and total solids concentration profiling



Rotamix System Advantages

Energy

- Ability to intermittently mix tanks after long periods of storage, offering power savings
- Allows intermittent operation of conventional process systems, further reducing energy costs

Operation

- Complete system operates clog-free while conditioning solids for better digestion
- Efficient mixing optimizes chemical consumption in sludge dewatering applications
- Operates without liquid level dependency
- Meets or exceeds high rate digester designs

Maintenance

- No scheduled nozzle assembly maintenance required
- No rotating equipment within the process
- Vaughan Chopper pumps virtually eliminate problems by ensuring clog-free system operation
- Reduces confined space entry into tanks for maintenance

Capital

- Ability to mix multiple tanks, using only one pump
- Ability to fill, mix and transfer using only one pump
- No access walkways, platforms or hoists required
- Complete installed Rotamix system typically costs less than equipment alone for other types of mixing systems
- Potentially reduces aeration requirements
- Easily retrofits into existing tanks
- Ability to work with flat floor design reduces construction costs

* Contact Vaughan for further details.

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