GV Static Mixer Product Bulletin

For Mixing & Dispersing Low Viscosity Liquids and Gases and Contacting of Immiscible Fluids to Enhance Mass Transfer

INTRODUCTION

The GV static mixer is considered a high intensity design that creates a homogeneous mix in just a few pipe diameters. It is made of corrugated plates that are stacked on top of each other in an alternating-crossing fashion to form open intersecting channels that are at a 45^o angle relative to the pipe axis. Adjacent mixing elements are oriented 90^o relative to each other to create 3-dimensional mixing.

The "GV" static mixer is used primarily in turbulent flow applications and creates a very high degree of mixing in a short length. Typical applications include the mixing of low viscosity liquids, mixing of gases, gas-liquid contacting and immiscible liquid dispersion.

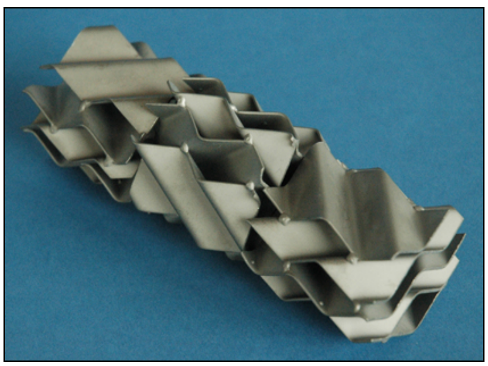


Figure #1: *GV static mixer with three (3) mixing elements. Each mixing elements has 5 corrugated plate mixing layers stacked at alternating 45^o angles relative to the pipe axis. 316 S/S construction with glass-bead blasted finish.*

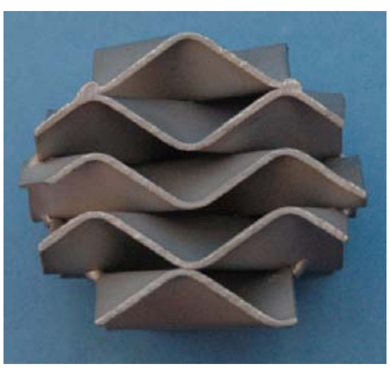


Figure #2: *Front View of GV static mixer shown in above Figure #1. Note 5 mixing layers.*

PRINCIPLES OF OPERATION

The GV static mixer continuously divides and recombines the process streams to be mixed along the entire length of the mixing unit. In gas-liquid contacting and immiscible liquid dispersion applications, the high shear field created at each of the crossing points of adjacent corrugated plates assures that intense mixing and contacting occurs over the entire volume of the mixer diameter and length. This generates small droplets/bubbles of a consistent size that are evenly distributed throughout the entire pipe diameter resulting in high mass transfer rates.

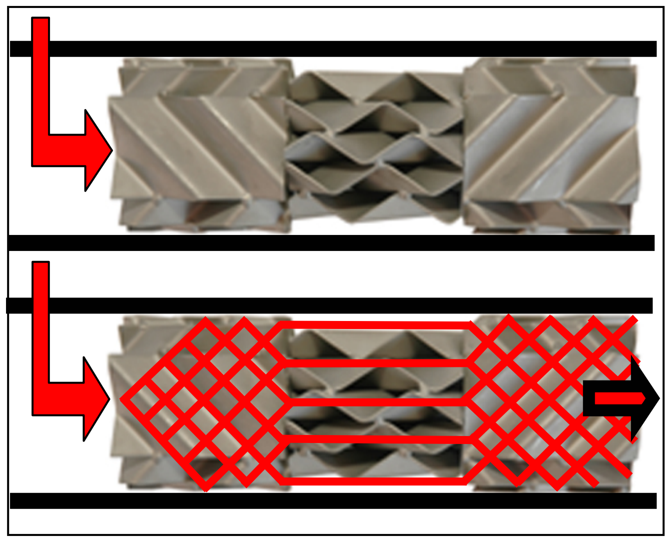


Figure #3: *Flow pattern through three (3) GV mixing elements of 5 layer construction. Note that adjacent mixing elements are oriented 90^o relative to each other.*

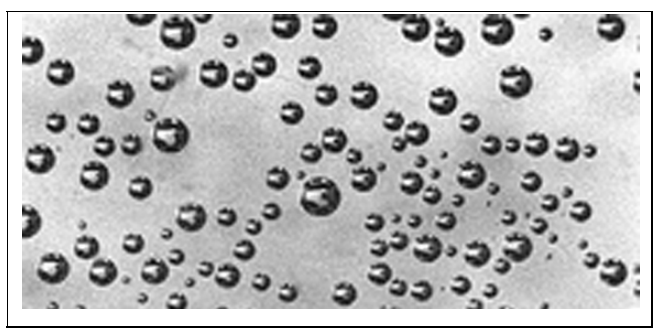


Figure #4: *The even shear field generated by the GV mixing element assembly creates droplets of consistent size in air-water and immiscible liquid systems and distributes them evenly over the entire pipe cross-section.*

GV STATIC MIXER DESIGN FEATURES

The GV mixing element design is unique among static mixers. It has the ability to "dial-in" the desired degree of mixing and pressure drop simply by varying mixing element geometric parameters. This is accomplished by varying the number of mixing layers (corrugated plates), corrugated plate angle relative to the pipe axis, mixing element L/D and the use of spacers between mixing elements to enhance homogeneity with little pressure drop.

- Number of Mixing Layers (corrugated plates)
  The standard GV mixing element consists of five (5) corrugated plates. In applications where high degrees of mixing, short length and high shear are critical parameters, the overall mixer length can be shortened by increasing the number of mixing layers (corrugated plates).
- Corrugated Plate Angle
  The standard GV mixing element has a corrugated layer angle of 45^o relative to the pipe axis. In applications where low pressure drop is required, the angle is decreased to 30^o which dramatically lowers pressure drop.
- Empty Pipe Space Mixing Between Mixing Elements
  The GV mixing element produces strong turbulent eddies downstream of each mixing element. In applications where pressure drop is of concern while length of mixing unit is not an issue, the installation of spacers between mixing elements will dramatically improve mixing for the expended pressure drop.

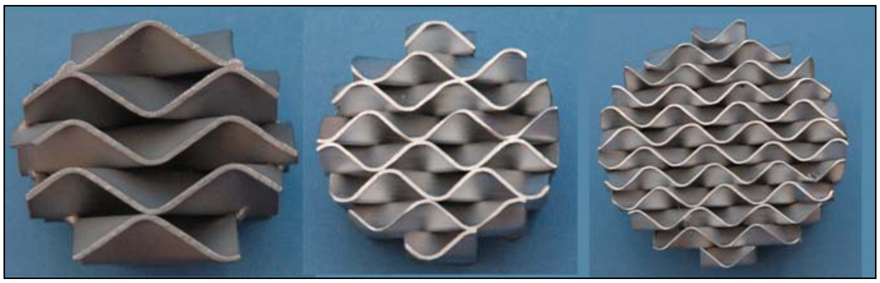


***Figure #5**: The GV mixing element is unique in its ability to "dial-in" the degree of mixing achieved by simply changing the number of mixing layers (corrugated plates) in a specific pipe size. The greater the number of mixing layers (corrugated plates) in a specific diameter, the higher the degree of mixing achieved in a fixed length. The example above shows, from left-to-right, 5 layer, 8 layer and 12 layer mixing elements that fit into the same pipe diameter.*

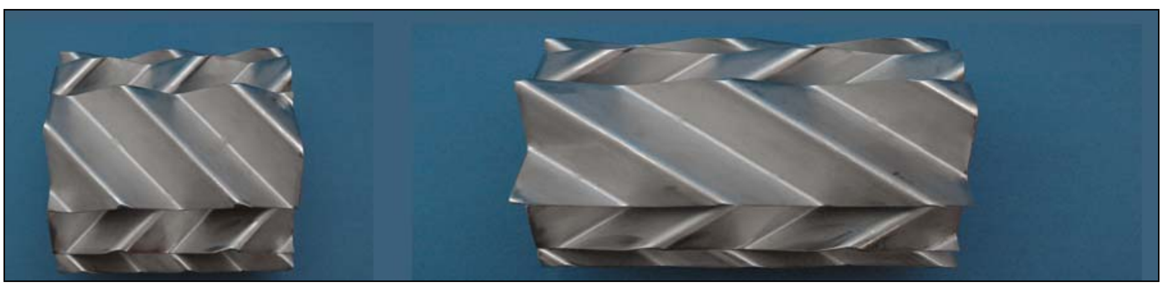


***Figure #6**: The GV mixing element pressure drop can be dramatically reduced by simply changing the corrugated plate angle relative to the pipe axis. Shown at left is the standard GV mixing element (L/D=1.0) with a 45^o corrugation angle relative to the pipe axis. At right is the lower pressure drop GV-L mixing element (L/D=1.73) with a 30^o corrugation angle.*

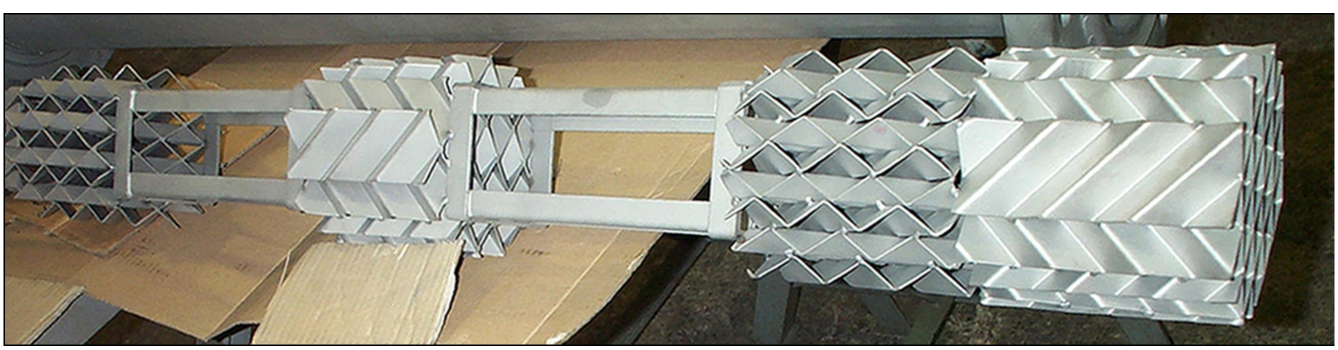


***Figure #7:** The incorporation of spacers between GV mixing elements improves the degree of mixing achieved by taking advantage of the strong turbulent eddies created at the outlet of each mixing element.*

HOMOGENEITY

The degree of mixing required varies by application, process function and customer experience/requirements. In some applications, “Pre-Mix Quality” Homogeneity is acceptable while in more demanding applications, “Good Homogeneity” or “Excellent Homogeneity” may be required. The degree of mixing achieved with the GV static mixer in turbulent flow applications is a function of mixing element geometry and the volumetric/physical properties of the materials to be mixed.

- <u>“Pre-Mix Quality” Homogeneity Requirement Application Examples:</u>
  Applications that are not very demanding where “Pre-Mix Quality” Homogeneity is acceptable have a characteristic feature that further processing normally occurs downstream. Examples include pH control where dilute acids/bases are used to neutralize process streams, addition of low viscosity polyelectrolyte in waste-water, addition of reactive chemicals for pre-feed into agitated reactors, pre-mixing of gases to reactors, etc.
- <u>“Good Homogeneity” Requirement Application Examples:</u>
  Applications that are moderately demanding where “Good Homogeneity” is required include those where large density, viscosity and volumetric ratios exist between components to be mixed and where empty pipe downstream mixing will not be effective or is not available. Examples include addition of dense 50% caustic to a water stream, addition of small quantities of high-viscosity polymer into water, dispersion of immiscible liquids to create emulsions or for extraction of materials from one phase into the other, etc.
- <u>“Excellent Homogeneity” Requirement Application Examples:</u>
  Applications that demand “Excellent Homogeneity” generally include those processes that are final point-of-use or packaging/dispensing, where reactions go to completion and where by-product formation must be minimized, where gas-liquid and immiscible liquid mass transfer is required, and where there is no additional meaningful contact occurring downstream of the mixing unit. Examples of such applications include the blending of additives into finished products, crude oil blending, blending materials with significant volumetric, viscosity and density differences just prior to packaging, gas-liquid reactors for oxygenation, ozone mixing, chlorination, etc.

To visualize homogeneity as described above, Figure #8 below is useful. The number of mixing elements required for the degree of mixing desired is noted Table #1 for turbulent flow applications.

<u>Figure #8:</u> *Cross-cuts along the length of a static mixing unit show the degree of mixing achieved with hardened resins.*
- ***Left Photo****: Feed Condition of a ~ 1:1 volumetric ratio of blue and white resin of similar viscosities.*
- ***2nd Photo****: “Pre-Mix Quality” Homogeneity with a C_oV ~0.2*
- ***3rd Photo****: “Good Homogeneity” with a C_oV ~0.05.*
- ***Right Photo:*** *“Excellent Homogeneity” with a C_oV ~0.01*

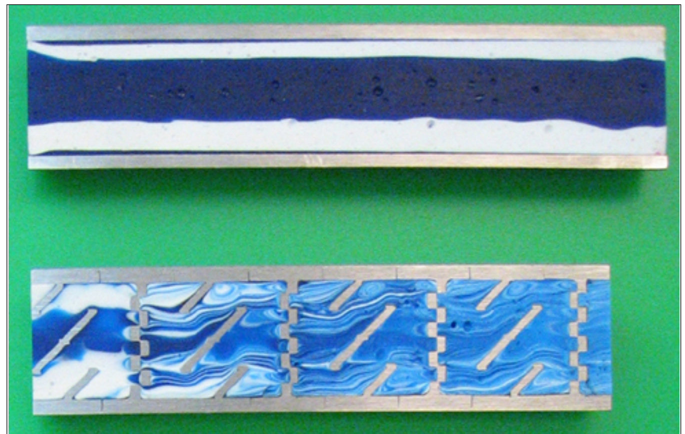
<u>TABLE #1</u>
REQUIRED NUMBER OF GV MIXING ELEMENTS IN TURBULENT FLOW APPLICATIONS BASED ON THE DEGREE OF MIXING DESIRED (see notes below table)

Volumetric Ratio of Components To Be Mixed A : B	Pre-Mix Quality Homogeneity 80% Degree of Mixing Achieved (C_oV = 0.2) Required Number of Mixing Elements (Pipe L/D)	Good Homogeneity 95% Degree of Mixing Achieved (C_oV = 0.05) Required Number of Mixing Elements (Pipe L/D)	Excellent Homogeneity 99% Degree of Mixing Achieved (C_oV = 0.01) Required Number of Mixing Elements (Pipe L/D)
1 : 1	1	2	4
9 : 1	2	3	5
99 : 1	3	5	7
999 - 1	5	6	9

<u>Notes</u> for Table #1
1) The number of mixing elements presented in the above table assumes liquid-liquid and gas-gas mixing applications in turbulent flow conditions. Also assumed is that the materials to be mixed have similar viscosity, density, are completely soluble in each other in all ratios and that the additive is introduced into the center of the pipe just upstream of the first mixing element.
2) Component A is bulk stream material and Component B is additive.
3) **C_oV** is the Variation Coefficient of additive in bulk stream at a distance of 2-pipe diameters downstream of last mixing element.
4) The Required Number of Mixing Elements in the above table assumes a standard GV mixing element with 5-Layers and a 45^o corrugation angle with a Length-to-Diameter ratio of 1.0 (L/D=1). In pipe sizes $\leq$ 4” diameter, the standard mixing element has an L/D=1.0 while in pipe sizes $\geq$ 6” diameter, the standard L/D=0.5 where two (2) L/D=0.5 mixing elements are required to satisfy the process performance of one (1) L/D=1.0 mixing element specified in the above table. Mixing elements with an L/D=1.0 in pipe sizes $\geq$ 6” diameter are not stocked but are available at no extra cost with a 4 week delivery.

stamixco Static Mixing, Reaction and Heat Transfer Technology

Static Mixing Technology is our only business. We offer a complete line of static mixer designs for both laminar flow and turbulent flow applications. Our designs are briefly described below.

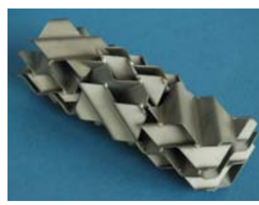


Mixing of blue and white resins in an empty pipe (top) and through a Type GXR static mixer (bottom).

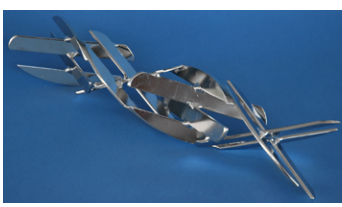
Type "GX": *High Performance*
Mixing of high viscosity liquids with similar and extreme viscosity and volumetric ratios; inducing plug flow; boosting viscous heat transfer; and the processing of molten polymers

Type "GXR": *High Performance*
Primary use is for Plastics Extrusion, Injection Molding, Silicone and Resin processing where a high degree of mixing in a short length and a nearly indestructible static mixer design is required.
* Licensee of Bayer AG, Germany

Type "GX-L": *Moderate Performance*
Primary use is heat transfer plug flow reactors and viscous mixing applications where pressure drop is an issue.



Type "GV": *High Performance*
Primary use is for turbulent flow, liquid-liquid and gas-gas mixing applications, immiscible liquid dispersion and gas-liquid contacting



Type "GX-LR": *Moderate Performance*
Primary use is for transitional flow applications with viscosity differences where low pressure drop and fouling service are issues.

Type "HT": *Low Performance*
Primary use is for small diameter simple turbulent and laminar flow mixing and heat transfer applications where low pressure drop and fouling service are issues.

stamixco
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A young company with over 50 years of employee accumulated experience in mixing technology.

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