stamixco

Stamixco AG
Kronaustrasse 10
CH-8404 Winterthur/Switzerland

Tel. +41 (0)52 338 17-11 Fax -33
Email info@stamixco.com
Home page: www.stamixco.com

Static Mixing Elements Family for Mixing/Dispersing of Viscous Fluids Comparison of Mixing Efficiency and Pressure Drop

Figure #1
GXM mixing element (GX-ME)

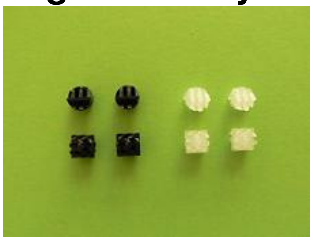

Figure #2
GXP mixing elements

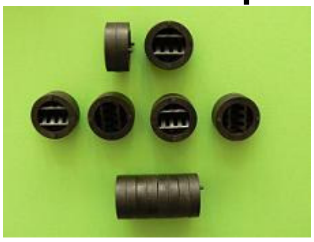

Figure #3
GXR-P doublet ME

Figure #4
GXF 8-rings chain unfolded and folded to one GXF-ME

Characteristics of the GX Mixers

GX is the designation of Stamixco Ltd. for static mixers, consisting of crossing bars. This mixer structure originally was invented by Bayer AG (BKM mixer). This mixer structure is since more than 25 years successfully used for mixing and/or dispersing of viscous fluids. They mix efficiently liquids of equal and/or very different viscosity to the degree of homogeneity as required by the specific application.

A significant manufacturing innovation was recently made that allows for the GX structure to be injection molded in a cost effective polymer construction. A family of GX mixing elements are now available, the GXP in Polypropylene or high strength 50% Glass-Filled Polyamide PA66 and GXR-P in high strength 50% Glass-Filled Polyamide PA66.

The GXF 8-rings chain mixing element design on the top right hand figure represents the most significant cost effective manufacturing innovation of the static mixing element. The GXF features the X-Grid structure and the high strength ring around with an innovative technique (Patent pending) where the entire chain of the mixing elements are injection moulded in Polypropylene in one shot with an hinge between each element (ring). Once the GXF rings are folded together, a complete mixing element assembly is obtained.

The design of the GXM static mixer is made to customer needs considering flow rates, viscosities, pressure drop, homogeneity required, etc. of the mixing duty. With the tables 1 and 2 below the number of GXM or respectively GXP, GXR-P and/or GXF mixing elements required for a certain application can be estimated.

Required number of GXM, GXP, GXR-P and GXF mixing elements for mixing at laminar flow conditions*

Comparison: 1ME GXM = 1 ME GXP = 2 ME GXR-P (doublets) or 4 GXR- P (singlets) = 0.5 ME GXF(folded)

Mixing ratio of components A : B	Viscosity ratio of components A : B	Pre-mixing (mixing degree 80%) CoV** = 0.2				Good homogeneity (mixing degree 95%) CoV = 0.05				Very good homogeneity (mixing degree 99%) CoV = 0.01			
		GXM	GXP	GXR-P doublet	GXF	GXM	GXP	GXR-P doublet	GXF	GXM	GXP	GXR-P doublet	GXF
1 : 1	1 : 1 – 100 : 1	**4**	**4**	**8**	**2**	**6-7**	**6-7**	**12-14**	**3-4**	**9-10**	**9-10**	**18-20**	**5**
9 : 1	1 : 1 – 100 : 1	**6**	**6**	**12**	**3**	**9**	**9**	**18**	**4-5**	**12**	**12**	**24**	**6**
99 : 1	1 : 1 – 100 : 1	**9**	**9**	**18**	**4-5**	**12**	**12**	**24**	**6**	**15**	**15**	**30**	**8**

Table 1 **CoV = Coefficient of variation of mixing

*The numbers of mixing elements given above are approximate. They can deviate from the given values depending on the viscosity behaviour of the media to be mixed. The validity of the table is limited to media which are under operating conditions in every mixing ratio completely soluble in each other.

If the viscosity ratio component A : component B is >100 : 1 (high viscous : low viscous), the numbers of mixing elements mentioned in table 1 have to be increased by the number of mixing elements mentioned in the table 2 below.

Viscosity ratio A : B	>100 - 300	>300 – 1'000	>1'000 – 3'000	>3'000 – 10'000
Additional GXM ME ***	**2-3**	**3**	**3-4**	**4**
Additional GXP ME ***	**2-3**	**3**	**3-4**	**4**
Additional GXR-P doublet ***	**4-6**	**6**	**6-8**	**8**
Additional GXF – ME ***	**1-2**	**1-2**	**2**	**2**

Table 2 *** additional ME required to be added to the number of ME estimated acc. to table 1 for high/low viscosity applications

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Calculation of the Pressure drop

Δp [bar] = K x Total Flow Rate [m^3/h] x Viscosity of the Mixture[Pas] x Number of corresponding ME-type

In case of non-newtonian liquids/melts the viscosity is depending on the shear-rate. Therefore, for the pressure drop calculation the viscosity corresponding to shear-rate in the mixer has to be used.

The shear-rate "Gamma" is calculated as follows:

Gamma [s^{-1}] = K_G x Total Flow Rate [m^3/h]

K and K_G Data

K and K_G values for ***GXM-ME:***

Nominal Pie Size		Standard-Pipe Dimension			Data of Mixing Elements GXM					
DN / NPS mm	in	O.D. mm	s_w mm	D_i mm	D_{ME} mm	L_{ME} mm	K bar / (Pas x m^3/h^{-1} x n_{ME})	K_G s^{-1} / (m^3/h^{-1})	$\Delta p_{max.\ adm.}$[bar] 100°C	300°C
10	¼	14.0	2.0	10.0	10.0	10.1	12.2	35650	>600	>500
12	3/8	17.2	2.3	12.6	12.4	12.4	5.28	16250	280	220
15	½	21.3	2.6	16.1	15.6	15.6	1.86	6400	150	115
20	¾	26.9	3.2	20.5	20.0	20.0	0.76	2780	95	75
22					22.0	22.0	0.76	2570	800	700
25	1	33.7	3.2	27.3	26.4	26.4	0.30	1130	80	60
27					27.0	27.0	0.41	1380	800	700
32	1 ¼	42.4	3.2	36.0	35.5	35.5	0.090	391	21	17
33					33.0	33.0	0.22	760	800	700
40	1 ½	48.3	3.7	40.9	40.2	40.6	0.065	275.7	32	25
50	2	60.3	3.9	52.5	52.0	52.5	0.0315	132.3	34	27
65	2 ½	76.1	3.6	68.9	68.2	69	0.012	53.4	19	15
80	3	88.9	5.5	77.9	77.1	78	0.00976	38.1	24	18
80	3	88.9	4.05	80.8	80.0	80	0.0085	33.6	22	17
100	4	114.3	6.0	102.3	101.3	102	0.00368	16.4	20	15
125	5	141.3	6.6	128.2	126.9	128	0.00193	8.49	22	17
150	6	168.3	7.1	154.1	153.0	154	0.00113	4.63	24	19
200	8	219.1	8.2	202.7	200.7	203	0.000475	2.11	20	15
250	10	273.1	9.3	254.5	252.0	255	0.000247	1.09	23	18
300	12	323.8	9.6	304.6	301.6	299	0.000158	0.64	25	20

Table 3

K: Coefficient for calculation of the pressure drop with laminar flow
K_G: Coefficient for calculation of the shear rate in the mixer

Execution: DN 10 – DN 32 and DN 50: cast design
DN 40 and DN 65 – DN 300: welded design

K-values for Plastic ***Disposable Static Mixers (GXP, GXR-P and GXF ME-types)***:

ME -type	Figure	K [bar / (Pas x m^3/h^{-1} x n_{ME})]	ΔP max. per ME @ room temperature [bar]
GXP-9.4-PP	#2 (white)	15.5	80
GXP-9.4-PA66 + 50% GF	#2 (black)	15.5	250
GXR-P-21- PA66 + 50% GF	#3	0.70	40 (for 1 ME = 2doublets)*
GXF-10/6 (= 8-rings)	#4	13.1	15*

Table 4 * ΔP max. for a mixer = n_{ME} x $(\Delta P\ max)_{ME}$ – These values are given for room temperature only.