

# STAR LAMINATOR

STARLAM GROUP CLASS-30, -300, -3000, -30000

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*The StarLam family*

## Principle

The Star Laminators are the first real production tools of IMM for mixing purposes. They create an alternate, interdigital-type feeding array which is generated by stacking thin foils with star-like through-holes. In this way, a finely-dispersed injection of two fluid streams is achieved. The foil stack is inserted into the recess of a housing where it is tightened by applying compression.

The novel Star Laminators are large-capacity microstructured mixers reaching volume flows up to the  $\text{m}^3/\text{h}$  domain. The apparatuses yield at higher flow rates a mixing efficiency which compares the high performance of today's low-capacity (l/h) micromixers. Therefore, continuity from the "real" micromixers over the herein described high-throughput tools to conventionally manufactured static mixers with even higher flow rates is given. A classification of the mixing efficiency versus the power input con-

firms this continuity as well. For the Star Laminator StarLam 3000 e.g. a throughput of about  $3 \text{ m}^3/\text{h}$  at a pressure loss of 0.7 bar was determined for watery systems. In this way, the StarLam series expands the range of operation from pilot-scale microstructured mixers of the Caterpillar series into production applications.



StarLam 30000



StarLam 3000



StarLam 300



StarLam 30

## Technical Data

Name	Star Laminator 30000	Star Laminator 3000	Star Laminator 300	Star Laminator 30
Order number	StarLam 30000	StarLam 3000	StarLam 300	StarLam 30
Mixing principles	Multi-Lamination	Multi-Lamination	Multi-Lamination	Multi-Lamination
Size (L x B x H)	220 x 425 x 480	95 x 95 x 150	40 x 40 x 64	40 x 40 x 64
Connectors (Inlet/Outlet)	DN 80/DN 50	DN 15/DN 25	8 mm/10 mm	8 mm/10 mm
Standard mixing channels ( $\mu\text{m}$ )	250	250	100	50
Standard material	Body: 1.4571 Foil: 1.4401	Body: 1.4571 Foil: 1.4401	Body: 1.4571 Foil: 1.4401	Body: 1.4571 Foil: 1.4401
Options	Other materials like Hastelloy, Monell or Titan on request	Other materials like Hastelloy, Monell or Titan on request	Other materials like Hastelloy, Monell or Titan on request	Other materials like Hastelloy, Monell or Titan on request

## Operating Conditions

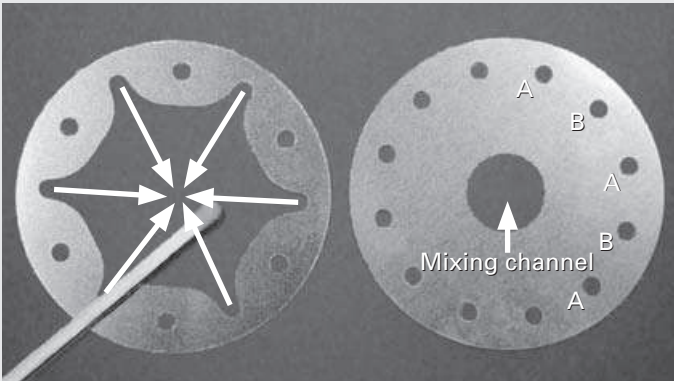
Order number	StarLam 30000	StarLam 3000	StarLam 300	StarLam 30
Temperature ( $^{\circ}\text{C}$ )	for FKM: -20 to +220; for FFKM: -20 to +315; for graphite: -100 to +500 (old StarLam versions)			
Pressure stability (bar)	100	100	100	100
Flowrate (l/h)	5000 – 30000	600 – 8000	80 – 1000	12 – 150
Residence time (ms)	180-1100	72 – 960	1.7 – 220	24 – 840
Inner volume (ml)	1500 (623 mix section)	160	5	2.8
Max Viscosity (mPas)	10000	10000	10000	10000
Leakage Class	< L <sub>0.001</sub>	< L <sub>0.001</sub>	< L <sub>0.001</sub>	< L <sub>0.001</sub>

# STAR LAMINATOR

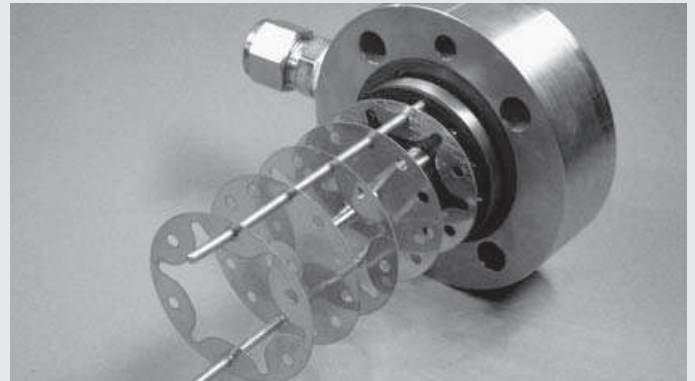
STARLAM GROUP CLASS-30, -300, -3000, -30000

52

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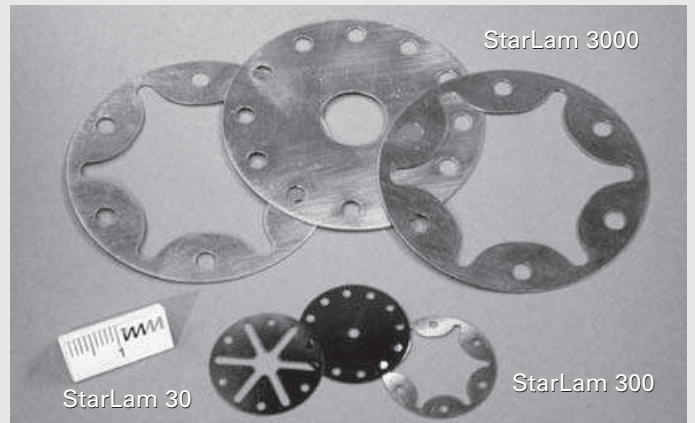
The feed plates of the StarLam series (here StarLam 3000), which are alternately stacked. A star-like plate serves for fluid injection; another plate with circular conduit serves for forming the mixing channel and separation of the plates. The plates of each layer are turned by 30° so that separate feeds result.



StarLam 3000 foils during assembly on the assembly rods



StarLam 30/300 disassembled



Feed plates of StarLam 30, 300 and StarLam 3000

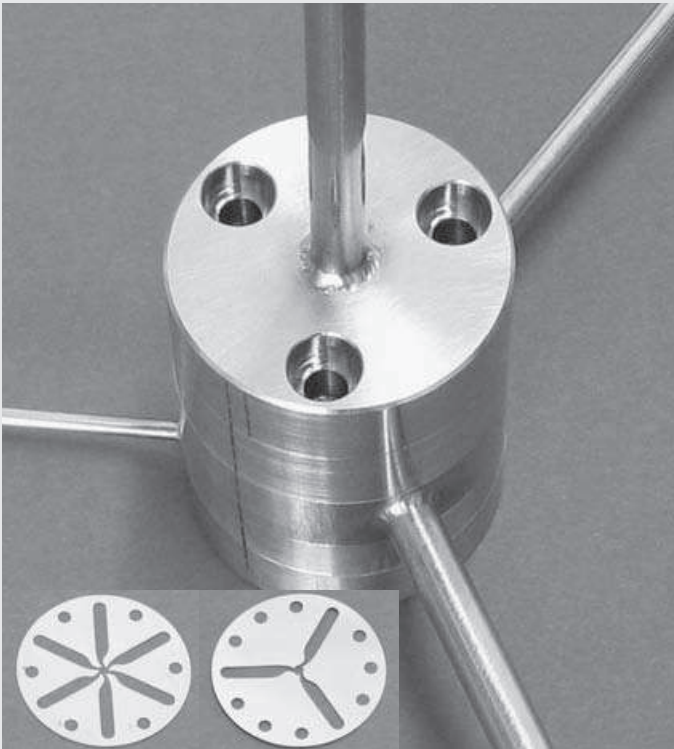
Concerning the high flow rates used for practical applications, mixing occurs by turbulence. As to be expected, the StarLam apparatus cannot be used at very low flow rates, as simulations and reaction-type mixing experiments confirm. In this flow regime, a segregation of fluid layers is given so that mixing is here not effective enough. On the contrary, at high flow rates experimental characterization of mixing efficiency by using competitive reactions shows that by increased turbulent action an increasing mixing performance of the Star Laminators is reached which then compares with the high quality of the smaller micro mixers, supplied by IMM. When plotting mixing efficiency versus pressure drop it becomes evident that a continuity is given to the Caterpillar series, i.e. at the same pressure drop an equal mixing efficiency is yielded independent which microstructured mixer is chosen as to be expected for a turbulent mixing scheme.

As for any microstructured mixer, the feeding section is most sensitive to particles and fouling. However, owing to their simple reversible assembly, which is a mounted foil

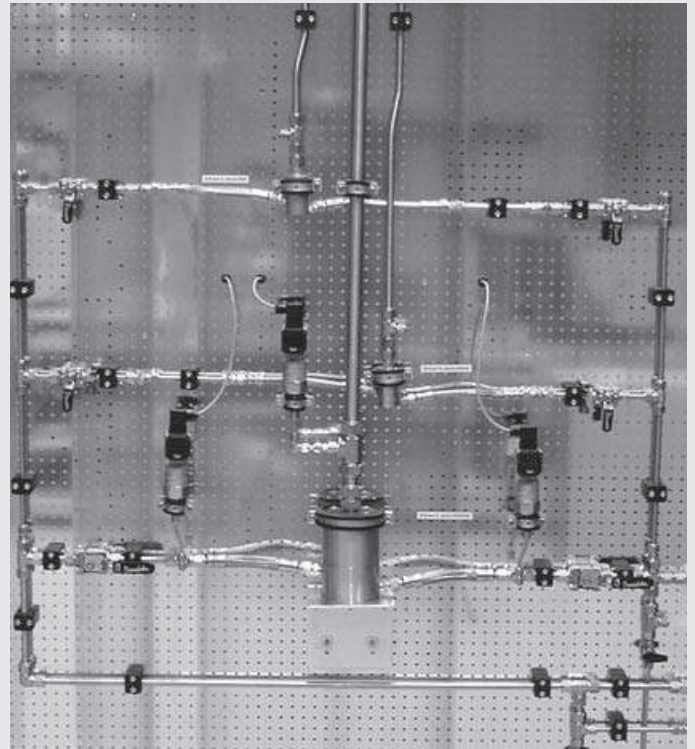
stack, the StarLam series can be cleaned in a straightforward manner, e.g. if fouling was noted. The circular outlet channel has macroscopic dimensions so that also here particles will not be detrimental.

The foils of the Star Laminators are fabricated by laser cutting; the housing is made by precision machining.

Due to the geometry of the StarLam a multicomponent mixing can be easily realised by re-allocating the 12 single holes, e.g. 2 educts via 2x6 holes (standard), 3 educts via 3x4 holes or 6 + 2x3 holes (cf. p. 53 detail in photo top left), 4 educts via 4x3 holes or... For such an application the conventional housing needs only other housing bottom parts as to feed those single holes accordingly. Despite the fact that such a 3-, 4- component housing can be easily rebuilt as 2 component housing, the feeding of the educts can also be adjusted by the mixing foil thickness as to enable mixing ratios of up to 1:100. Finally, the housing of StarLam30 and StarLam300 are identical and those mixers vary only in height and inner geometry of the mixer foil stack.



StarLam for mixing 3 components at once, 3CSL



StarLam 30/300/3000 connected in a multi-testing pilot plant

