

## Optimization of Kenics static mixers

***Citation for published version (APA):***

Galaktionov, O. S., Anderson, P. D., Peters, G. W. M., & Meijer, H. E. H. (2001). *Optimization of Kenics static mixers*. Poster session presented at Mate Poster Award 2001 : 6th Annual Poster Contest, .

***Document status and date:***

Published: 01/01/2001

***Document Version:***

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

***Please check the document version of this publication:***

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

***General rights***

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

[www.tue.nl/taverne](http://www.tue.nl/taverne)

***Take down policy***

If you believe that this document breaches copyright please contact us at:

[openaccess@tue.nl](mailto:openaccess@tue.nl)

providing details and we will investigate your claim.

# Optimization of Kenics static mixers

O. S. Galaktionov, P. D. Anderson, G. W. M. Peters, and H. E. H. Meijer  
 Eindhoven University of Technology, Department of Mechanical Engineering

## Introduction

The mapping approach was used to optimize the geometry of the in industry widely used Kenics static mixer. The mapping approach [2] describes the concentration evolution from one cross-section to another using pre-computed mapping matrices and combining them in an appropriate sequence.

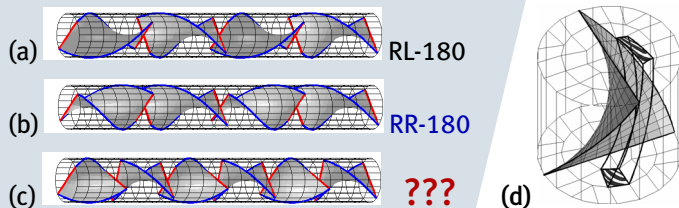


Figure 1 Steps towards Kenics optimization: (a-c) Various layouts of the Kenics static mixer, “RL” and “RR” denote mixers with uni-directional and alternating blade twist; d) computing the mapping matrix: tracing the flow tube between two cross-sections.

Hobbs and Muzzio [3] analysed a few mixer layouts, demonstrating that the key parameter to change is the blade twist and that the standard Kenics mixer with the blade twist  $180^\circ$  (fig.1a) can be improved. This work deals with the optimization of the blade twist of the Kenics static mixer.

## Mixer optimization

The principles of Kenics mixer operations (distributions obtained using mapping technique) are illustrated in Fig.2: the material striations are repeatedly re-oriented, stretched and cutted. It looks like the standard mixer has a too large blade twist, since it is preferable to have the striations parallel to the trailing edge.

The mixture quality (intensity of segregation,  $0 \leq \mathcal{I} \leq 1$ , characterizes the concentration uniformity:  $\mathcal{I} = 0$  for a perfect mixture,  $\mathcal{I} = 1$  for completely unmixed state), obtained by different mixers at the cost of the same pressure drop was compared (see Fig.3a). The mixer with the blades twisted on  $140^\circ$  achieves the fastest homogenization. The optimal twist angle is barely influenced by shear-thinning behaviour of the fluid.

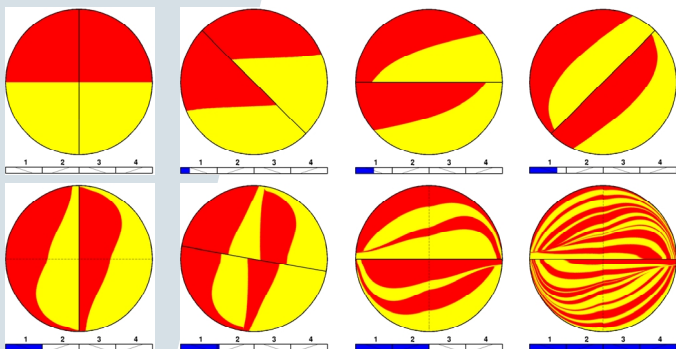


Figure 2 How the Kenics mixer works: the evolution of concentration patterns within the first four blades of the RL-180 mixer. The total number of the blades passed is shown under each image.

## Interface generation

The incorporation of statistical microstructure description [2] allowed to study the interfacial area generation in the mixer.

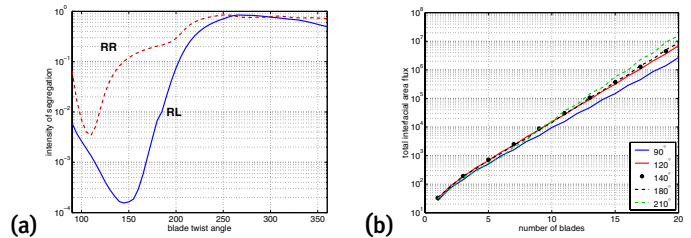


Figure 3 a) Efficiency of RL and RR Kenics mixers: intensity of segregation achieved at the cost of the pressure drop, equivalent to 12 blades of “standard” RL-180 mixer. b) The growth of the total interfacial flux with the number of blades.

The increase in interfacial area flux per blade is nearly the same in the wide range of blade twist angle (see Fig.3b). However, since the longer blades with larger twist (the blade pitch was fixed) require larger pressure drops, the mixers with short blades tend to generate more interface (see Fig.4a). These interfaces, however, are distributed extremely non-uniformly in the mixer cross-section. The most iniform distribution of interfaces across the mixer is achieved when the twist angle is close to  $140^\circ - 150^\circ$ .

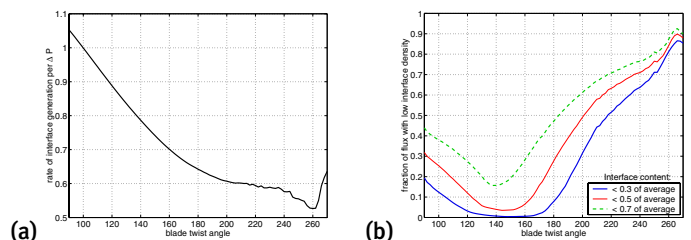


Figure 4 a) The exponential rate of the interface flux growth. b) The fraction of the volumetric flux of the fluid, carrying the interface density less than 0.3, 0.5 and 0.7 of the average level.

## Conclusions

- The Kenics mixer achieves the best macroscopic homogenization efficiency with the blade twist  $140^\circ$ .
- This configuration provides also reasonably uniform interface distribution.
- Mapping approach is a usefull engineering tool for static mixers optimization.

It was found, however, that the decrease of the blade twist angle in Kenics mixers leads to increased stagnation effects near the tube surface. A possible solution may be to combine short and long blades in a more complex mixer layout.

## References:

- [1] Galaktionov, O. S., Anderson, P. D., Kruijt, P. G. M., Peters, G. W. M., and Meijer, H. E. H. (2001). *Comput. Fluids*, 30, 271–289.
- [2] Galaktionov, O. S., Anderson, P. D., Peters, G. W. M., Tucker III, C. L. A global, multi-scale simulation of laminar fluid mixing: The extended mapping method. *Int. J. Multiphase Flows*. (Accepted).
- [3] Hobbs, D. M. and Muzzio, F. J. (1998). *Chem. Eng. Sci.*, 53, 3199–3213.