

Supplementary Information

CFD Analysis of Inlet Configurations in a Split-and-Recombine Micro Mixer for Asymmetric Flow Rate Ratios

Torben Frey, Rieke Schlütemann, Sebastian Schwarz,
Philip Biessey, Marko Hoffmann, Marcus Grünewald, Michael Schlüter

Governing Equations

Mass conservation (continuity)

$$\frac{\partial \varrho}{\partial t} + \nabla \cdot (\varrho \mathbf{v}) = 0 \quad (1)$$

Momentum conservation (viscous-laminar model)

$$\frac{\partial}{\partial t}(\varrho \mathbf{v}) + \nabla \cdot (\varrho \mathbf{v} \mathbf{v}) = -\nabla p + \nabla \cdot \bar{\bar{\boldsymbol{\tau}}} + \varrho \mathbf{g} \quad (2)$$

with

$$\bar{\bar{\boldsymbol{\tau}}} = \mu \left[(\nabla \mathbf{v} + \nabla \mathbf{v}^T) - \frac{2}{3} \nabla \cdot \mathbf{v} \mathbf{I} \right] \quad (3)$$

Energy conservation

$$\frac{\partial}{\partial t}(\varrho E) + \nabla \cdot (\mathbf{v}(\varrho E + p)) = \nabla \cdot \left(k \nabla T - \sum_i h_i \mathbf{J}_i + \bar{\bar{\boldsymbol{\tau}}} \cdot \mathbf{v} \right) + S_E \quad (4)$$

with

$$E = h - \frac{p}{\varrho} + \frac{v^2}{2} \quad (5)$$

and

$$h = \sum_i Y_i \int_{T_{\text{ref}}}^T c_{p,i} dT + \frac{p}{\varrho} \quad (6)$$

Species conservation and reactive model

$$\frac{\partial}{\partial t}(\varrho Y_i) + \nabla \cdot (\varrho \mathbf{v} Y_i) = -\nabla \cdot \mathbf{J}_i + R_i \quad (7)$$

with

$$\mathbf{J}_i = -\varrho D_{i,m} \nabla Y_i \quad (8)$$

and

$$R_A = M_{w,A} \cdot (-k_1[A][B] - k_2[A][C]) \quad (9)$$

$$R_B = M_{w,B} \cdot (-k_1[A][B]) \quad (10)$$

$$R_C = M_{w,C} \cdot (k_1[A][B] - k_2[A][C]) \quad (11)$$

$$R_D = M_{w,D} \cdot (k_2[A][C]) \quad (12)$$

Appendix

Description	Symbol	Unit	Comment
Specific heat capacity	c_p	J kg ⁻¹ K ⁻¹	
Diffusion coefficient	D	m ² s ⁻¹	
Specific energy	E	J kg ⁻¹	
Standard gravity	g	m s ⁻²	
Specific enthalpy	h	J kg ⁻¹	
Species component	i	n.a.	$i = [A,B,C,D]$
Species concentration	$[i]$	kmol m ⁻³	
Unit tensor	$\mathbf{I}$	-	
Diffusion Flux	$\mathbf{J}$	kg m ⁻² s ⁻¹	
Heat conductivity	k	J m ⁻¹ s ⁻¹ K ⁻¹	
Reaction rate constant	$k_{1,2}$	m ⁶ kmol ⁻² s ⁻¹	
Molecular weight	M_w	kg kmol ⁻¹	
Pressure	p	Pa	
Reactive rate	R	kg m ⁻³ s ⁻¹	
Time	t	s	
Temperature	T	K	
Velocity	$\mathbf{v}$	m s ⁻¹	
Mass Fraction	Y	kg kg ⁻¹	
Density	ϱ	kg m ⁻³	
Stress tensor	$\overline{\overline{\tau}}$	kg m ⁻¹ s ⁻²	