

Supplementary material

Stepwise membrane fouling model for shear-enhanced filtration of alfalfa juice: experimental and modeling studies

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Table S1 Parameters of SMDM for fouling process of MF

	Step	β (m ⁻¹)	γ	R^2	TMP_i (bar)
MF (VRR1)					
2500 rpm	Step 1	$\beta_1 = 4.38E+08$	$\gamma_1 = 0.54$	0.996	
2000 rpm	Step 1	$\beta_1 = 7.40E+08$	$\gamma_1 = 0.52$	0.996	
1500 rpm	Step 1	$\beta_1 = 1.34E+09$	$\gamma_1 = 0.48$	0.991	
	Step 2	$\beta_1 = 1.04E+10$ $\beta_2 = 2.07E+10$	$\gamma_1 = 0.56$ $\gamma_2 = 0.53$	0.995	1.50
1000 rpm	Step 1	$\beta_1 = 1.88E+09$	$\gamma_1 = 0.46$	0.995	
	Step 2	$\beta_1 = 3.63E+10$ $\beta_2 = 2.08E+10$	$\gamma_1 = 0.48$ $\gamma_2 = 0.48$	0.989	1.00
500 rpm	Step 1	$\beta_1 = 3.22E+09$	$\gamma_1 = 0.42$	0.996	
	Step 2	$\beta_1 = 4.67E+10$ $\beta_2 = 3.73E+10$	$\gamma_1 = 0.44$ $\gamma_2 = 0.45$	0.996	1.00
		Step 3	$\beta_1 = 6.98E+11$	$\gamma_1 = 0.60$	0.993
MF (VRR3)					
2500 rpm	Step 1	$\beta_1 = 4.79E+08$	$\gamma_1 = 0.43$	0.994	
	Step 2	$\beta_1 = 4.20E+09$ $\beta_2 = 1.80E+10$	$\gamma_1 = 0.45$ $\gamma_2 = 0.46$	0.998	1.50
2000 rpm	Step 1	$\beta_1 = 7.64E+08$	$\gamma_1 = 0.40$	0.993	
	Step 2	$\beta_1 = 4.26E+09$ $\beta_2 = 2.67E+10$	$\gamma_1 = 0.43$ $\gamma_2 = 0.44$	0.992	1.25
1500 rpm	Step 1	$\beta_1 = 1.18E+09$	$\gamma_1 = 0.38$	0.993	
	Step 2	$\beta_1 = 6.66E+10$ $\beta_2 = 1.82E+10$	$\gamma_1 = 0.41$ $\gamma_2 = 0.41$	0.993	1.00
		Step 3	$\beta_1 = 4.72E+11$	$\gamma_1 = 0.55$	0.994

1000 rpm	Step 1	$\beta_1= 1.89\text{E}+09$	$\gamma_1= 0.36$	0.991	
	Step 2	$\beta_1= 1.62\text{E}+11$	$\gamma_1= 0.39$	0.993	0.75
		$\beta_2= 8.44\text{E}+10$	$\gamma_2= 0.40$		
	Step 3	$\beta_1= 5.07\text{E}+12$	$\gamma_1= 0.53$	0.998	2.50
500 rpm	Step 1	$\beta_1= 3.37\text{E}+09$	$\gamma_1= 0.33$	0.991	
	Step 2	$\beta_1= 2.17\text{E}+11$	$\gamma_1= 0.40$	0.992	0.75
		$\beta_2= 9.08\text{E}+10$	$\gamma_2= 0.35$		
	Step 3	$\beta_1= 7.90\text{E}+11$	$\gamma_1= 0.50$	0.995	2.50
MF (VRR6)					
2500 rpm	Step 1	$\beta_1= 5.68\text{E}+08$	$\gamma_1= 0.35$	0.994	
	Step 2	$\beta_1= 4.59\text{E}+09$	$\gamma_1= 0.39$	0.994	1.50
		$\beta_2= 3.60\text{E}+10$	$\gamma_2= 0.40$		
	Step 3	$\beta_1= 5.07\text{E}+11$	$\gamma_1= 0.52$	0.994	2.50
2000 rpm	Step 1	$\beta_1= 8.58\text{E}+08$	$\gamma_1= 0.32$	0.992	
	Step 2	$\beta_1= 3.90\text{E}+10$	$\gamma_1= 0.40$	1.000	1.25
		$\beta_2= 1.57\text{E}+10$	$\gamma_2= 0.36$		
	Step 3	$\beta_1= 1.33\text{E}+12$	$\gamma_1= 0.51$	0.991	2.50
1500 rpm	Step 1	$\beta_1= 1.26\text{E}+09$	$\gamma_1= 0.30$	0.993	
	Step 2	$\beta_1= 4.08\text{E}+10$	$\gamma_1= 0.38$	0.998	1.00
		$\beta_2= 5.54\text{E}+10$	$\gamma_2= 0.35$		
	Step 3	$\beta_1= 5.22\text{E}+12$	$\gamma_1= 0.49$	0.991	2.50
1000 rpm	Step 1	$\beta_1= 2.10\text{E}+09$	$\gamma_1= 0.29$	0.995	
	Step 2	$\beta_1= 4.88\text{E}+11$	$\gamma_1= 0.36$	0.997	0.75
		$\beta_2= 1.16\text{E}+10$	$\gamma_2= 0.34$		
	Step 3	$\beta_1= 6.35\text{E}+11$	$\gamma_1= 0.45$	0.994	2.25
		$\beta_2= 7.03\text{E}+12$	$\gamma_2= 0.46$		
500 rpm	Step 1	$\beta_1= 3.41\text{E}+09$	$\gamma_1= 0.27$	0.998	
	Step 2	$\beta_1= 1.07\text{E}+12$	$\gamma_1= 0.35$	0.992	0.75
		$\beta_2= 3.40\text{E}+11$	$\gamma_2= 0.31$		
	Step 3	$\beta_1= 3.47\text{E}+11$	$\gamma_1= 0.41$	0.998	2.25
		$\beta_2= 9.50\text{E}+12$	$\gamma_2= 0.43$		

Table S2 Parameters of SMDM for fouling process of UF

	Step	β (m^{-1})	γ	R^2	TMP_i (bar)
UF (VRR1)					
2500 rpm	Step 1	$\beta_1= 5.87\text{E}+09$	$\gamma_1= 0.28$	0.998	
2000 rpm	Step 1	$\beta_1= 6.52\text{E}+09$	$\gamma_1= 0.22$	0.996	
	Step 2	$\beta_1= 4.62\text{E}+10$	$\gamma_1= 0.22$	0.993	4.50
		$\beta_2= 5.58\text{E}+10$	$\gamma_2= 0.24$		

1500 rpm	Step 1	$\beta_1= 6.98E+09$	$\gamma_1= 0.20$	0.998	
	Step 2	$\beta_1= 5.50E+10$	$\gamma_1= 0.21$	0.998	4.00
		$\beta_2= 2.12E+11$	$\gamma_2= 0.23$		
1000 rpm	Step 1	$\beta_1= 8.56E+09$	$\gamma_1= 0.16$	1.000	
	Step 2	$\beta_1= 6.28E+10$	$\gamma_1= 0.21$	0.986	3.00
		$\beta_2= 2.33E+11$	$\gamma_2= 0.20$		
	Step 3	$\beta_1= 7.80E+11$	$\gamma_1= 0.28$	0.985	5.00
500 rpm	Step 1	$\beta_1= 9.89E+09$	$\gamma_1= 0.14$	1.000	
	Step 2	$\beta_1= 4.06E+11$	$\gamma_1= 0.20$	0.990	3.00
		$\beta_2= 1.22E+11$	$\gamma_2= 0.18$		
	Step 3	$\beta_1= 2.60E+12$	$\gamma_1= 0.26$	0.993	4.50
UF (VRR3)					
2500 rpm	Step 1	$\beta_1= 6.13E+09$	$\gamma_1= 0.18$	1.000	
2000 rpm	Step 1	$\beta_1= 6.80E+09$	$\gamma_1= 0.16$	1.000	
	Step 2	$\beta_1= 1.52E+11$	$\gamma_1= 0.17$	0.984	4.50
		$\beta_2= 1.42E+11$	$\gamma_2= 0.22$		
1500 rpm	Step 1	$\beta_1= 7.20E+09$	$\gamma_1= 0.13$	0.994	
	Step 2	$\beta_1= 3.34E+11$	$\gamma_1= 0.17$	0.986	4.00
		$\beta_2= 2.20E+11$	$\gamma_2= 0.20$		
1000 rpm	Step 1	$\beta_1= 8.64E+09$	$\gamma_1= 0.12$	0.998	
	Step 2	$\beta_1= 4.81E+11$	$\gamma_1= 0.16$	0.984	3.00
		$\beta_2= 4.42E+11$	$\gamma_2= 0.19$		
	Step 3	$\beta_1= 9.37E+11$	$\gamma_1= 0.25$	0.991	4.50
500 rpm	Step 1	$\beta_1= 9.98E+09$	$\gamma_1= 0.11$	0.996	
	Step 2	$\beta_1= 6.05E+11$	$\gamma_1= 0.15$	0.987	3.00
		$\beta_2= 4.65E+11$	$\gamma_2= 0.17$		
	Step 3	$\beta_1= 3.00E+12$	$\gamma_1= 0.22$	0.910	4.00
UF (VRR6)					
2500 rpm	Step 1	$\beta_1= 7.28E+09$	$\gamma_1= 0.07$	0.999	
2000 rpm	Step 1	$\beta_1= 8.04E+09$	$\gamma_1= 0.05$	0.999	
	Step 2	$\beta_1= 1.34E+11$	$\gamma_1= 0.10$	0.997	4.00
		$\beta_2= 9.43E+11$	$\gamma_2= 0.16$		
1500 rpm	Step 1	$\beta_1= 8.68E+09$	$\gamma_1= 0.05$	0.993	
	Step 2	$\beta_1= 1.93E+12$	$\gamma_1= 0.09$	0.999	4.00
		$\beta_2= 5.59E+12$	$\gamma_2= 0.15$		
1000 rpm	Step 1	$\beta_1= 1.01E+10$	$\gamma_1= 0.04$	0.997	
	Step 2	$\beta_1= 7.96E+12$	$\gamma_1= 0.08$	0.995	3.00
		$\beta_2= 2.36E+12$	$\gamma_2= 0.13$		
	Step 3	$\beta_1= 9.96E+12$	$\gamma_1= 0.22$	0.994	4.50
500 rpm	Step 1	$\beta_1= 1.23E+10$	$\gamma_1= 0.03$	0.994	
	Step 2	$\beta_1= 1.10E+11$	$\gamma_1= 0.07$	0.998	3.00
		$\beta_2= 6.77E+12$	$\gamma_2= 0.07$		
	Step 3	$\beta_1= 6.46E+12$	$\gamma_1= 0.12$	0.990	4.00
		$\beta_2= 3.98E+13$	$\gamma_2= 0.18$		