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Appendix A

A.1: Average pH and DO measurement

Time (Hours)	static pH	static DO
0	5.34	1.46
8	4.2	0.72
16	3.25	0.29
24	3.27	0.25
40	3.3	0.25
48	3.32	0.26
64	3.4	0.27
72	3.44	0.27
88	3.62	0.21
96	3.51	0.21
112	3.42	0.19
120	3.1	0.19
136	3.2	0.18
144	3.12	0.18
160	3.12	0.17
168	3.11	0.15
184	3.11	0.12
192	3.1	0.13

Appendix B

B.1 Reactor drawing



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Appendix C

C.1 Mathematical model

AQUASIM Version 2.0 (win/mfc) - Listing of System Definition

Date and time of listing: 10/07/2013 10:28:17

Variables

A: Description:
 Type: Constant Variable
 Unit:
 Value: 0.0099
 Standard Deviation: 1
 Minimum: 0
 Maximum: 10
 Sensitivity Analysis: inactive
 Parameter Estimation: inactive

A_Monod: Description: Middle part of Monod Equation for rate limiting
substrate

 Type: Formula Variable
 Unit:
 Expression: $C_G/(K_S+C_G)$

B: Description:
 Type: Formula Variable
 Unit:
 Expression: 1

Bio_F: Description:
 Type: Dyn. Volume State Var.
 Unit:
 Relative Accuracy: 1e-006
 Absolute Accuracy: 1e-006

C: Description:
 Type: Constant Variable

Unit:
Value: 0.36
Standard Deviation: 1
Minimum: 0
Maximum: 10
Sensitivity Analysis: inactive
Parameter Estimation: inactive

C_C: Description: Concentration of Cellulose
Type: Dyn. Volume State Var.
Unit: g/l
Relative Accuracy: 1e-006
Absolute Accuracy: 1e-006

C_Cin: Description: Concentration of Cellulose
Type: Constant Variable
Unit: g/l
Value: 0.01
Standard Deviation: 1
Minimum: 0
Maximum: 10
Sensitivity Analysis: inactive
Parameter Estimation: inactive

C_G: Description: Concentration of glucose
Type: Dyn. Volume State Var.
Unit: g/l
Relative Accuracy: 1e-006
Absolute Accuracy: 1e-006

C_Gin: Description: Initial Concentration of Glucose
Type: Constant Variable
Unit: g/l
Value: 32.567
Standard Deviation: 1
Minimum: 0
Maximum: 50
Sensitivity Analysis: inactive
Parameter Estimation: inactive

C_X: Description: Concentration of Biomass
Type: Dyn. Volume State Var.
Unit: CFU/l
Relative Accuracy: 1e-006

Absolute Accuracy: 1e-006

C_Xin: Description: Initial Concentration of Biomass
Type: Constant Variable
Unit: CFU/l
Value: 1.5e+008
Standard Deviation: 1
Minimum: 0
Maximum: 1e+009
Sensitivity Analysis: inactive
Parameter Estimation: inactive

De: Description: Decay
Type: Formula Variable
Unit: CFU/d
Expression: -K_D*C_X

F_W: Description: Ist part
Type: Formula Variable
Unit:
Expression: -A*W^2+B*W+5

K_D: Description: Decaying Rate
Type: Formula Variable
Unit: 1/d
Expression: 0.1

K_G: Description: Rate of glucose depletion
Type: Formula Variable
Unit: g/l d
Expression: 0.336

K_S: Description: Concentration giving one half of the maximum rate
Type: Formula Variable
Unit: g/l
Expression: 20

U: Description: Maximum Cellulose Growth
Type: Formula Variable
Unit: g/l
Expression: 0.475

U_Xmax: Description: Maximum Specific Growth
Type: Formula Variable

Unit: CFU/d
Expression: 4.707

W: Description: Omega/ Rotational speed
Type: Formula Variable
Unit: RPM
Expression: 30

Processes

Biomass_Growth: Description: Growth of Biomass
Type: Dynamic Process
Rate: $((U_Xmax * A_Monod * C_X) - De) * F_W$
Stoichiometry:
Variable : Stoichiometric Coefficient
C_X : 0.01

Cellulose_Growth:
Description: Growth of Cellulose
Type: Dynamic Process
Rate: $(U * A_Monod * C_C) * F_W$
Stoichiometry:
Variable : Stoichiometric Coefficient
C_C : 0.8

Glucose_Depletion:
Description: Depletion of Glucose
Type: Dynamic Process
Rate: $-K_G * C_G$
Stoichiometry:
Variable : Stoichiometric Coefficient
C_G : 1

Compartments

Glucose_Depletion:
Description:
Type: Mixed Reactor Compartment
Compartment Index: 0
Active Variables: C_G, C_X, C_C

Active Processes: Biomass_Growth, Cellulose_Growth, Guucose_Depletion

Initial Conditions:

Variable(Zone) : Initial Condition

C_G(Bulk Volume) : C_Gin

C_X(Bulk Volume) : C_Xin

Inflow: 0

Loadings:

Volume: 2.75

Accuracies:

Rel. Acc. Q: 0.001

Abs. Acc. Q: 0.001

Rel. Acc. V: 0.001

Abs. Acc. V: 0.001

Definitions of Calculations

Glucose_Depletion:

Description: Depletion of Glucose

Calculation Number: 0

Initial Time: 0

Initial State: given, made consistent

Step Size: 0.001

Num. Steps: 20

Status: active for simulation

inactive for sensitivity analysis

Plot Definitions

Biomass_Growth:Description: Growth of Biomass

Abscissa: Time

Title: Microorganism Growth

Abscissa Label: Time [day]

Ordinate Label: Concentration of Microorganism [CFU/d]

Curves:

Type : Variable [CalcNum,Comp.,Zone,Time/Space]

Value : C_X [0,Glucose_Depletion,Bulk Volume,0]

Biomass_Growth_Sp:

Description: Growth of Biomass

Abscissa: Time

Title: Microorganism Growth
 Abscissa Label: Time [day]
 Ordinate Label: C_X/C_Xin
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : C_X [0,Glucose_Depletion,Bulk Volume,0]
 Value : C_X [0,Glucose_Depletion,Bulk Volume,0]

Cellulose_Growth:

Description: Growth of Cellulose
 Abscissa: Time
 Title: Growth of Cellulose
 Abscissa Label: Time [day]
 Ordinate Label: Cellulose Growth [g]
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : C_C [0,Glucose_Depletion,Bulk Volume,0]

Glucose_Depletion:

Description: Depletion of Glucose
 Abscissa: Time
 Title: Depletion of Glucose
 Abscissa Label: Time [day]
 Ordinate Label: Concentration of Glucose [g/l]
 Curves:
 Type : Variable [CalcNum,Comp.,Zone,Time/Space]
 Value : C_G [0,Glucose_Depletion,Bulk Volume,0]

Calculation Parameters

Numerical Parameters: Maximum Int. Step Size: 1
 Maximum Integrat. Order: 5
 Number of Codiagonals: 1000
 Maximum Number of Steps: 1000

Fit Method: secant
 Max. Number of Iterat.: 100

Calculated States

Calc. Num.	Num. States	Comments
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0	41	Range of Times: 0 - 40
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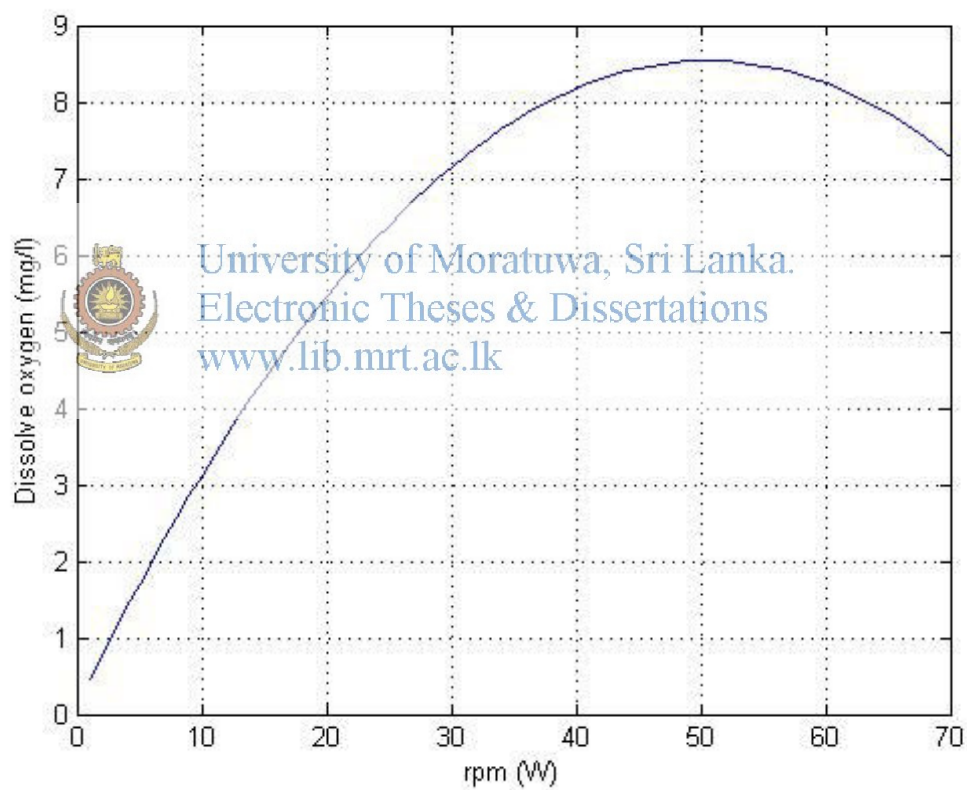
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Appendix D

D.1 Determination of K_{DO}

Data point:

rpm (ω)	DO (mg/l)
15	4.47
25	6.48
30	7.21
50	8.67
70	7.34



Plot of the graphs = $-a\omega^2 + b\omega + C$
From the graphs,

$$a = 0.009$$

$$b = 1$$

Appendix E

E.1 Published research papers

D.M.S.C. Dissanayake, F.M Ismail	
Comparison of Bacterial Cellulose growth in Rotating Biological Fermentation (RBF) and Static Fermentation (SF)	
2nd Sri Lankan Round Table on sustainable consumption and production (2nd SLRSCP) 2013, National Cleaner Production Center, Sri Lanka.	
Date of Publication	February 2013

D.M.S.C. Dissanayake, F.M. Ismail	
Mathematical modeling of bacterial cellulose production by <i>Acetobacter xylinum</i> using Rotating Biological Fermentor (RBF)	
27th European Conference on Modeling and Simulation (27th ECMS), 2013, Aalesund University College, Norway	
Date of Publication	May, 2013