

### Appendix A: Data Set

The experimental data of DMBP based on published data [16,21,26,27]. The plant is divided into sub-processes, consists of six batch stages [B (1-6)] to manufacture in four products A, B, C, D.

The Table shows the values for processing times  $\tau_{i,j}(h)$ , size factor for the units, cost data, and the production requirement for each product quantifying the uncertainty on the demand. Here, we assume that the demand of products A, B, C and D are uncertain following normal probability distribution function. The data set are summarized in the following Table A1 and Table A2.

Demand of the Product i(kg)		Processing Time $T_{i,j}$ (h)						Size Factor (1/kg)						
		B1	B2	B3	B4	B5	B6	B1	B2	B3	B4	B5	B6	
A	1500 ± 75	1.15	3.98	9.86	8.86	1.2	3.57	8.28	6.92	9.7	2.95	6.57	10.6	
B	1000 ± 50	5.95	7.52	7.01	7.01	1.08	5.78	5.58	8.03	8.09	3.27	6.17	6.57	
C	3000 ± 150	3.96	5.07	6.01	6.01	0.66	4.37	2.34	9.19	10.3	5.7	5.98	3.14	
D	6000 ± 300	2.75	4.05	8.02	8.02	1.05	3.54	2.3	5.15	8.05	3.5	5.75	5.45	
$\pi$		0.4	0.29	0.33	0.3	0.2	0.35							
Unit Price for Product i (\$/kg)		Coefficients $C_{i,j}$						Fermentor = \$63400V0.6						
								Micro and ultrafilters = \$5750V0.6						
$C_P$	$C_O$	B1	B2	B3	B4	B5	B6	Homogenizer = \$12100cap0.75						
A	0.7	0.08	0.2	0.36	0.24	0.4	0.5	0.4	Extractor = \$23100V0.65					
B	0.74	0.1	0.15	0.5	0.35	0.7	0.42	0.38	Chromatography = 360000V0.996					
C	0.8	0.07	0.34	0.64	0.5	0.85	0.3	0.22	(Volume V in liter)					
D	0.75	0.05	0.17	0.45	0.25	0.67	0.45	0.25						
		Operating Cost						Horizontal Time H						
		B1	B2	B3	B4	B5	B6	H = 6000h						
		$C_E$	20	30	15	35	37	18	Lower bound = 250 l					
									Upper bound = 10000 l					

**Table A1:** Data used in the problem of batch plant design.

Unit	Size	Cost
Fermenter	$V_j$ (m <sup>3</sup> )	$63400.V^{0.6}$
Micro and ultrafilters	$V_{\text{reterntate}}$ (m <sup>3</sup> )	$5750.V^{0.6}$
	$V_{\text{pernmeate}}$ (m <sup>3</sup> )	$5750.V^{0.6}$
	$V_{\text{filter}}$ (m <sup>3</sup> )	$2900.V^{0.6}$
Homogenizer	$V_{\text{holding}}$ (m <sup>3</sup> )	$5750.V^{0.6}$
	Cap (m <sup>3</sup> /h)	$12100.\text{cap}^{0.75}$
Extractor	$V_{\text{extr}}$ (m <sup>3</sup> )	$23100.V^{0.65}$
	$V_{\text{holding}}$ (m <sup>3</sup> )	$5750.V^{0.6}$
Chromatography Column	$V_{\text{chrom}}$ (m <sup>3</sup> )	$360000.V^{0.995}$
Storage Vessel	$V_{\text{sto}}$ (m <sup>3</sup> )	$5750.V^{0.6}$

**Table A2:** Cost coefficient.