06-720 Advanced Process Systems Engineering Spring 2011

Homework 7 Due: 3/30/11

1. Given is a batch plant that manufactures 4 products A, B, C, D. It is desired to produce 2 batches of A, 2 batches of B, 5 batches of C and 4 batches of D. Assuming a zero-wait policy, determine a cyclic sequence with minimum cycle time. Processing times (hrs)

	Stage 1	Stage 2	Stage 3
A	5	4	2
B	7	5	4
C	5	6	2
D	8	8	2

Assume that clean-up times between different products can be neglected.

2. Determine the optimal sizes and number of parallel units for the following multiproduct batch problem operating with single product campaigns:.

Plant: 3 stages, 2 products
Demands: Q_A = 200,000, Q_B = 100,000 kg
Horizon: 6000 hrs
Cost units: $250V^{0.6}$ (V in L)
Lower bound volume: 250 L
Upper bound volume: 2500L
Maximum number of parallel units: 3

Size factors (L/kg)

	1	2	3
A	2	3	4
B	4	6	3

Processing times (hrs)

	1	2	3
A	8	20	8
B	16	4	4

3. Repeat problem 2, assuming that the demands for Q_A = 80,000 kg. Q_B = 50,000 kg., and that only one unit per stage is allowed. Determine the sizes required for single product campaigns, and for mixed product campaigns with ZW and UIS policy. In all cases clean-up times can be neglected.

4. Repeat problem 3 for the case of single product campaigns assuming that the equipment sizes are available as follows:

V = {250, 750, 1000, 1500, 1750, 2500} L

How does your solution compare with the one in which the sizes obtained in problem 3 are rounded to the next highest value?

5. a) Draw the State-Task-Network for the case where three products A, B and C require mixing, reaction and separation operations in sequence (i.e. flowshop structure)

b) Use the processing times in Problem 2, formulate an STN problem that maximizes net sales (product sales – raw material costs).

6. Consider the NLP for the design of a multiproduct batch plant with one unit per stage, mixed product campaign and UIS:

$$
\begin{aligned}
Min \quad & \sum_{j=1}^{M} \alpha_j V_j^{\beta_j} \\
s.t. \quad & V_j \geq S_{ij} B_i, \qquad i = 1,\ldots N, j = 1,\ldots M \\
& \sum_{i=1}^{N} \frac{Q_i t_{ij}}{B_i} \leq H, j = 1,\ldots M \\
& V_j^L \leq V_j \leq V_j^U, j = 1,\ldots M, \qquad B_i \geq 0, i = 1,\ldots N
\end{aligned}
$$

where t_{ij} are the processing times for product i in stage j, S_{ij} are the size factors, and N and M are the number of products and stages, respectively.

a) Using an exponential transformation, show that this problem has a unique solution.

b) Extend this problem as an MINLP to also determine the optimal number of parallel units in each stage. Comment on the nature of the reformulation and solution.