Problem C-2

Goal: Optimum Batch Time using Golden Section Search Excel Macro

X	F	T, days	T, hours	Cs
0.000	$0.00			$710.70
0.001	(178434.29)	0.004	0.095	$709.33
0.2	($161.23)	0.596	14.31	$465.80
0.25	$21.48	0.710	17.04	$413.74
0.3	$185.09	0.823	19.76	$365.33
0.3822	359.68	1.024	24.57	$293.72
0.45	438.75	1.221	29.31	$242.10
0.4722	454.26	1.295	31.08	$226.67
0.5226	473.50	1.484	35.61	$194.31
0.5278	474.36	1.505	36.12	$191.16
0.5397	475.59	1.555	37.33	$184.16
0.5503	**$475.89**	1.602	38.44	$178.10
0.5568	475.71	1.631	39.15	$174.43
0.5622	475.37	1.656	39.75	$171.49
0.5674	474.88	1.681	40.34	$168.64
0.5951	469.74	1.818	43.64	$154.24
0.6178	462.75	1.941	46.58	$143.31
0.64	453.85	2.070	49.69	$133.33
0.7	$422.15	2.471	59.29	$109.97
0.7634	381.22	2.984	71.61	$91.02
0.8	$356.04	3.327	79.85	$82.76
0.9	$287.40	4.465	107.16	$70.21
0.999	225.28	5.920	142.09	$72.21
1.000	$236.87	5.937	142.49	$72.30

Search Limits:		0.001	**To**	0.999	
The Maximum Feasible Region is	**X =**	0.4722	**To**	0.6178	
Function Values	**Y =**	454.2597	**To**	462.7498	
The best value obtained was	**X =**	0.5278			
with function value	**Y =**	474.3576			

Search Limits:		0.450	**To**	0.640	
The Maximum Feasible Region is	**X =**	0.5397	**To**	0.5674	
Function Values	**Y =**	475.5899	**To**	474.8758	
The best value obtained was	**X =**	0.5503			
with function value	**Y =**	475.8857			

Function Accuracy	**=**	0.0277	= fraction of initial 0-1 range
		2.77%	= % of initial 0-1 range

Discussion:

Near the maximum, between 1.5 and 1.7 days (± 2.5 hours) reaction time the profit changes by less than $2/batch or ± 0.4% of maximum profit

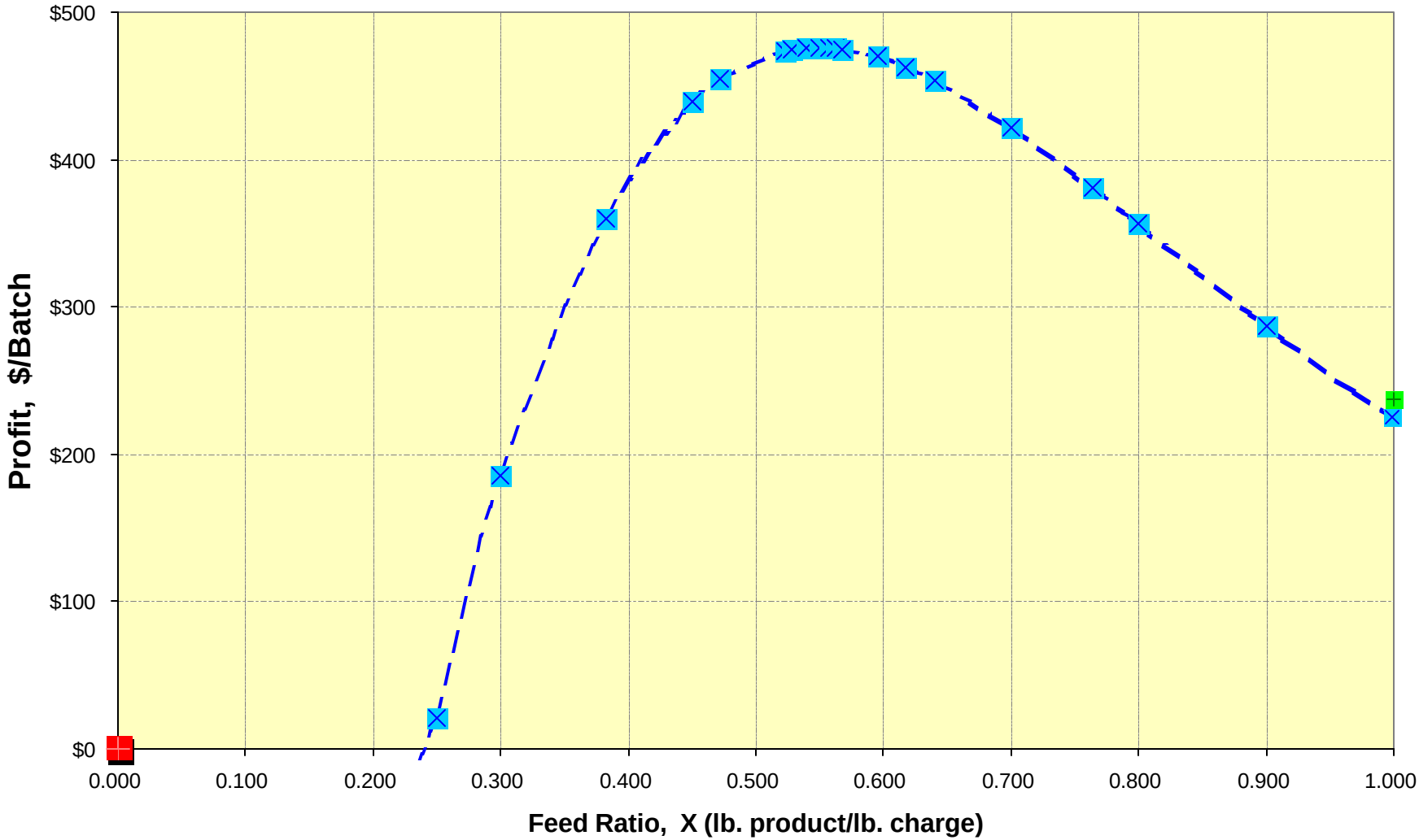
color code cells:
- lt. Yellow - initial broad search bounds
- lt. Green - narrow optimum refinement search bounds
- **Yellow, Bold - Best Maximum Result**
- gray - fill in the result curve manual added calculation points
- green - Discontinuity at End Points, manual added calculation points

1.484	$2.39	0.50%	
1.681	$1.01		

Sensitivity to ± 0.1 days (2.4 hours)

					delta profit from maximum	
0.5265	$474.16	1.500	35.99	$191.95	$1.72	0.36%
0.5715	$474.38	1.700	40.80	$166.45	$1.51	0.32%

C-2 Optimum Batch Time



Golden Section Consulting

Memo

EXAMPLE OF GOOD MEMO

To: Dr. David Drown

From: [redacted]

CC:

Date: 11/9/98

Re: Optimization NEED MORE SPECIFIC TITLE

The objective of the batch process optimization was to optimize the batch time, which in turn maximizes the gross profit. Naturally, the optimization was required to fall within normal operating limits and not exceed safety standards. To achieve optimization, the following COST equation was ~~derived~~ USED:

$$P = (1/T) * (2000*x - 100*T - C_s)$$

Where P = Profit

T = Time (days)

X = Feed Ratio (lb product / lb charge)

C_s = Separation Costs ($ / batch) TO OPTIMIZE W HIGH VARIABLE ?

Utilizing the golden section search method, the range considered for x was 0.438 to 0.494. This region yields a batch time of 1.2 to 1.4 days, and $415.30 to $437.9 profit. The best point within this range is x=0.472, at which batch time equals 1.3 days, and profit is $464.60. This solution appears reasonable within range of experimental data. The system is relatively insensitive to two-hour changes. A batch time of 1.4 days results in a profit loss of $50.00, or a 10% loss. 1.2 days batch time realizes a profit loss of $27.00 or a 6% loss. The result is the overall optimum region although local optima exist at endpoints. A multimodal response is observed when end points are included but is unimodal inside the region.

CHANGED TENSE HAS TO IS

In conclusion, it is suggested the batch process be maintained and continuously run at a batch time of 1.3 days and a feed ratio of 0.472. This status maximizes the profit. Raw calculations are included as an appendix. If any questions arise, please feel free to contact me.

Golden Section Search

Optimum Batch Time

Choose Feed Ratio as Independent Variable, X

1. Select Feasible Region

   Lower Limit = $0 \leq X \leq 1.0$ = upper limit

2. Evaluate at Two Points:

   Region Length $L_1 = 1 - 0 = 1$

   $d_1 = 0.382 * 1$ $\quad X_{1B} = 0 + 0.382$

   Read Graphs:

   $X = 0.382 \quad T = 0.9 \quad C_s = 300$

   $R = \frac{1}{0.9}(2000 * 0.382 - 100 * 0.9 - 300) = \$415.6$

   $X_{1B} = 1 - 0.382 = 0.618$

   $X = 0.618 \quad T = 2.2 \quad C_s = 150$

   $R = \frac{1}{2.2}(2000 * 0.618 - 100 * 2.2 - 150) = \$393.6$

3. Eliminate Region $0.618 \rightarrow 1.0$

   Remaining Region $0 \rightarrow 0.618 \quad L_2 = 0.618$

   $d_2 = 0.382 * 0.618 = 0.236 \quad X_2 = 0 + 0.236$

   Read Graphs:

   $X = 0.236 \quad T = 0.5 \quad C_s = 430$

   $R = \frac{1}{0.5}(2000 * 0.236 - 100 * 0.5 - 430) = \$-16.00$

4. Eliminate Region $0 \rightarrow 0.236$

   Remaining Region $= 0.236 \rightarrow 0.618 \quad L_3 = 0.382$

   $d_3 = 0.382 * 0.382 = 0.146 \quad X_3 = 0.618 - 0.146$

   Read Graphs:

   $X = 0.472 \quad T = 1.3 \quad C_s = 210$

   $R = \frac{1}{1.3}(2000 * 0.472 - 100 * 1.3 - 210) = \$464.6$

5. ELIMINATE REGION 0.236 → 0.382

REMAINING REGION 0.382 → 0.618 $L_4 = 0.236$

$d_4 = 0.382 * 0.236 = 0.090$ $X_4 = 0.618 - 0.090$

READ GRAPHS:

$X = 0.528$ $T = 1.7$ $C_5 = 180$

$R = \frac{1}{1.7}(2000 * 0.528 - 100 * 1.7 - 180) = \$415.3$

6. ELIMINATE REGION 0.528 – 0.618

REMAINING REGION 0.382 → 0.528 $L_5 = 0.146$

$d_5 = 0.382 * 0.146 = 0.056$ $X_5 = 0.382 + 0.056$

READ GRAPHS:

$X = 0.438$ $T = 1.2$ $C_5 = 230$

$R = \frac{1}{1.2}(2000 * 0.438 - 100 * 1.2 - 230) = \$437.9$

7. ELIMINATE REGION 0.382 → 0.438

REMAINING REGION 0.438 → 0.528 $L_6 = 0.090$

$d_6 = 0.382 * 0.090 = 0.034$ $X_6 = 0.528 - 0.090$

READ GRAPHS:

$X = 0.494$ $T = 1.4$ $C_5 = 210$

$R = \frac{1}{1.4}(2000 * 0.494 - 100 * 1.4 - 210) = \$455.2$

8. ELIMINATE REGION 0.494 → 0.528

THIS IS ABOUT AS CLOSE AS GRAPHS ACCURACY

(5.6% of ORIGINAL REGION)

REMAINING REGION 0.438 → 0.494

BATCH TIME 1.2 → 1.4

PROFIT $437.9 → $415.3

BEST POINT X = 0.472 LB PRODUCT/LB CHARGE

T = 1.3 DAYS

PROFIT = $464.6

CHECK FOR DISCONTINUITIES AT END POINTS

DO NOTHING ..... ALTERNATIVE !

$X = 0 \quad T = 0 \quad C_s = 0 \quad \therefore R = \$0$

WHICH IS BETTER THAN OPERATING BETWEEN $X > 0$ UP TO $X \sim 0.24$

RUN TO COMPLETION & ELIMINATE SEPARATION

$X = 1.0 \quad T = 6 \quad C_s = 0 \quad R = \$233.33$

$R = \frac{1}{6}(2000 - 600 - 0) = \$233.33$

JUST SHORT OF COMPLETION

$X = 0.999 \quad T = 5.99 \quad C_s = 60$

$R = \frac{1}{5.99}(2000 * 0.999 - 100 * 5.99 - 60) = \$223.50$

RESULTS ANALYSIS :

SOLUTION APPEARS TO BE REASONABLE WITH RANGE OF EXPERIMENTAL DATA.

RELATIVELY INSENSITIVE TO 2 HOUR CHANGES.

ACTUALLY 0.1 DAYS = 2.4 HOURS

BEST POINT ± 0.1 DAYS RESULTS IN ± \$50

+ 0.1 DAY RESULTS IN −\$50 ≈ 10% LOSS

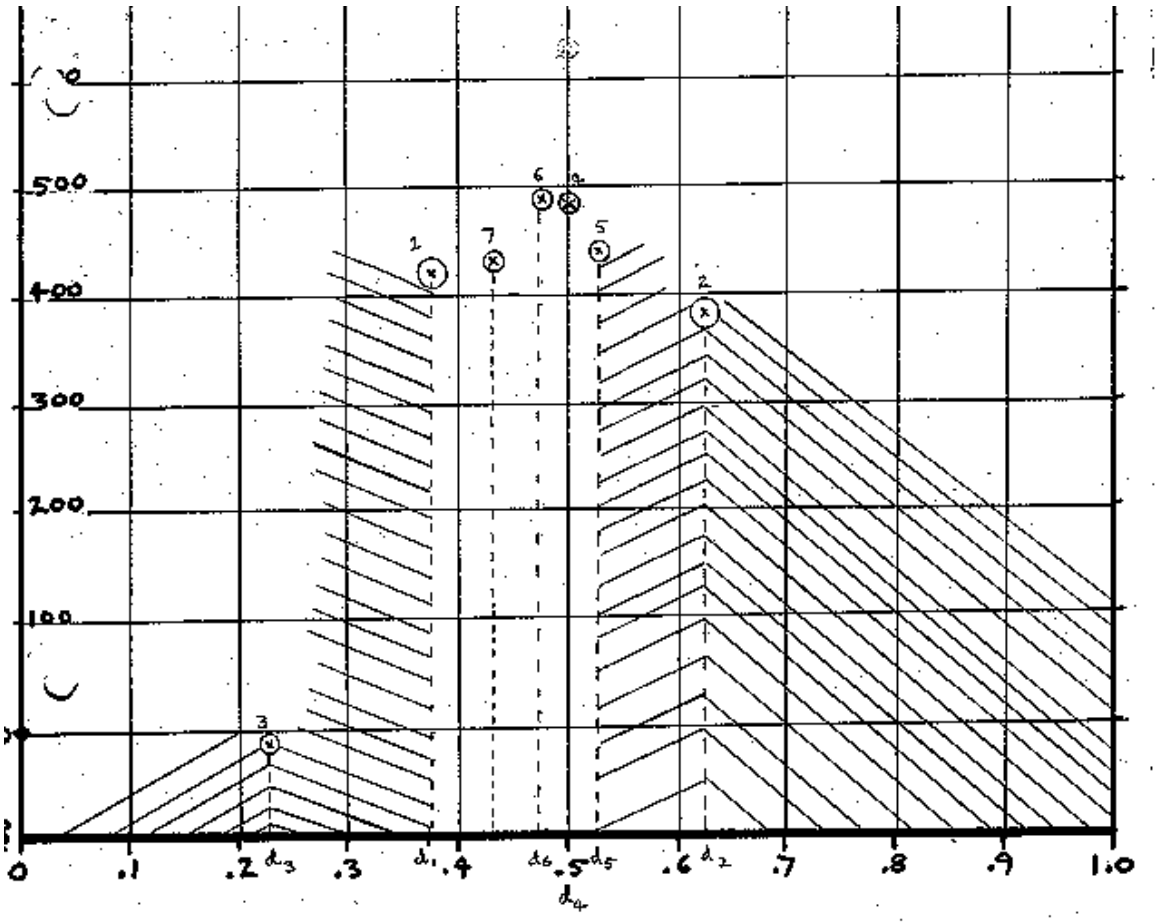
− 0.1 DAY RESULTS IN ~\$27 ≈ 6% LOSS

RECOMMEND IMPROVED DATA COLLECTION IN RANGE OF OPTIMUM TO REFINE RESULTS.

RESULT IS THE OVERALL OPTIMUM REGION ALTHOUGH LOCAL OPTIMA EXIST AT END POINTS.

RESULT IS MULTI-MODAL WHEN THE END POINTS ARE INCLUDED.

RESPONSE APPEARS UNIMODAL INSIDE THE REGION.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