MMCS Assignment 1: A Refinery Model

Overview

Scottish Petroleum has commissioned an analysis with the aim of determining the optimal distillation column operating policy. The main purpose for study is to analyse the economics of an increase in production. The refinery is made up of three distillation columns (A, B and C) and a blender. Each column splits crude oil into amounts of butane, fraction 1, fraction 2, fraction 3, tar and waste. Butane and tar are considered to be finished products whereas fractions are sent into the blender to produce petrol, kerosene and diesel.

Part I: Current Operating Practice

The current company policy is not to try to sell more than the demand for each product. All excess output or waste must be disposed off at a cost. It was decided to build a model of the current operating practice was using Xpress_MP, all the costs and parameters where fed into the model. The objective was specified as being to maximise profits. [For model details please refer to mosel file]

The resulting optimal practice was found to be to operate column A and B for 24 hours and column C for 4 hours and 17 minutes (4.29 hours). This produced a total disposal cost of £ 3,484.31, the total operational cost was found to be £ 582,189 and the total sales from the finished products produced £ 1,351,072 which gave a maximum profit of £ 765,398. For a detailed breakdown of expenses and sales please refer to Appendix.

As can be seen in the table below almost all products were manufactured up to the demand except for Kerosene.

Product	**Manufactured (Tonnes/Day)**	**Demand (Tonnes/ Day)**	**Difference (Tonnes/Day)**
Butane	3000	3000	0
Petrol	2000	2000	0
Kerosene	1168.37	1500	331.63
Diesel	1750	1750	0
Tar	500	500	0

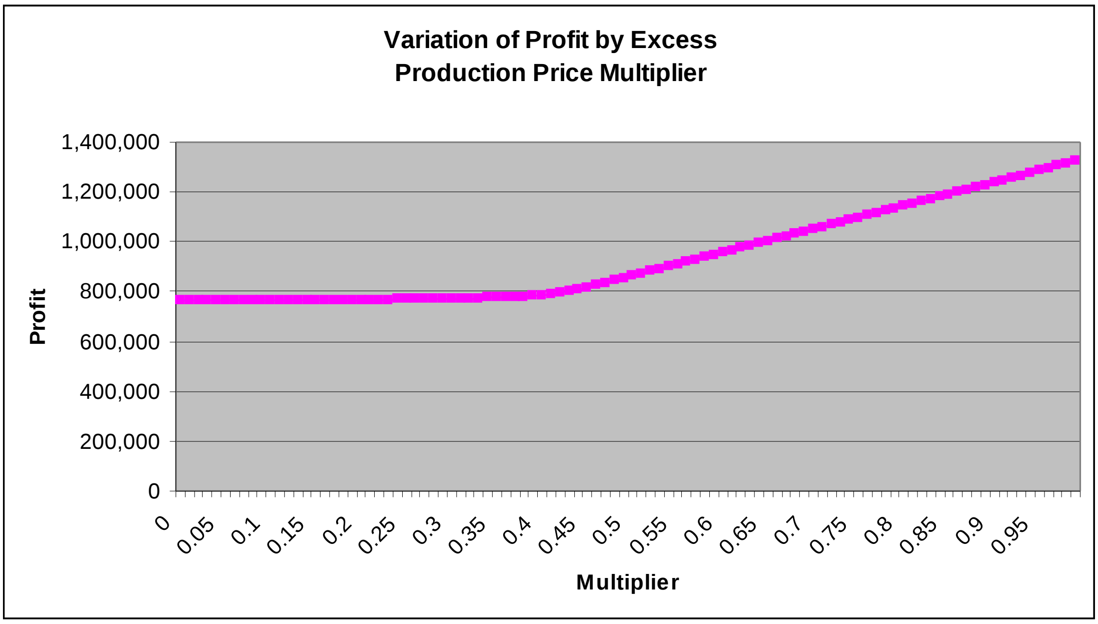
PART II

An increase in the company's production was analysed, it was assumed that any production above the demand could be sold as a price that is a multiple of the price up to the demand. This scenario was modelled using Xpress_MP, the prices for excess production were set to take values from 0 up to the normal product sale price. The optimal operating policy was calculated for each multiplier.

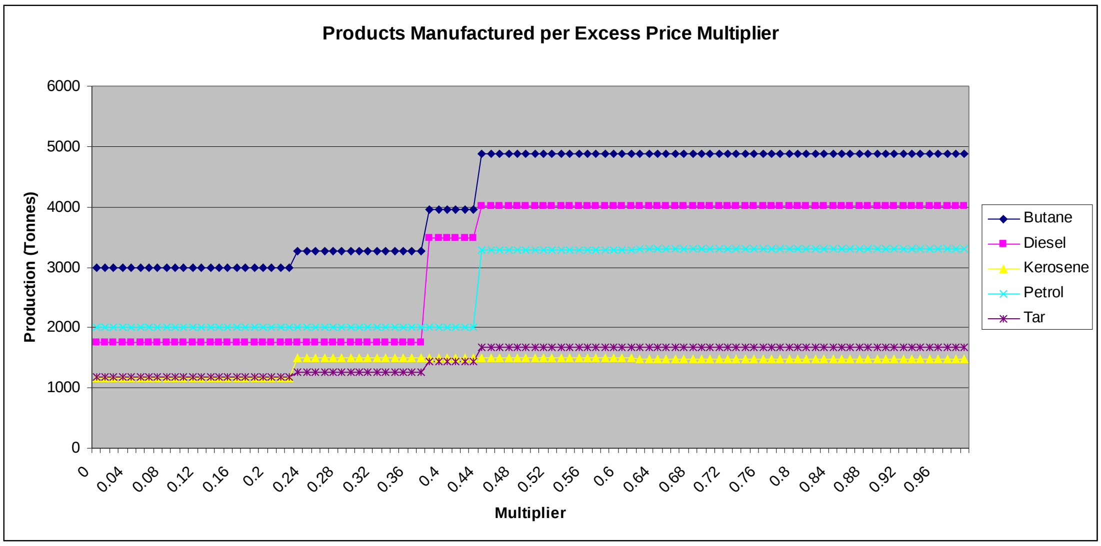
The table below shows how the optimal policy varied by the changes in multiplier applied. The minimum value of the multiplier for which each distillation column operates for 24 hours per day was found to be 0.44.

	Optimal Operating Policy (Hours)		
	Columns		
Multiplier Range	**A**	**B**	**C**
0 - 0.22	24	24	4.29
0.23 - 0.37	24	24	7.06
0.38 - 0.43	24	24	14.26
0.44 - 1	24	24	24

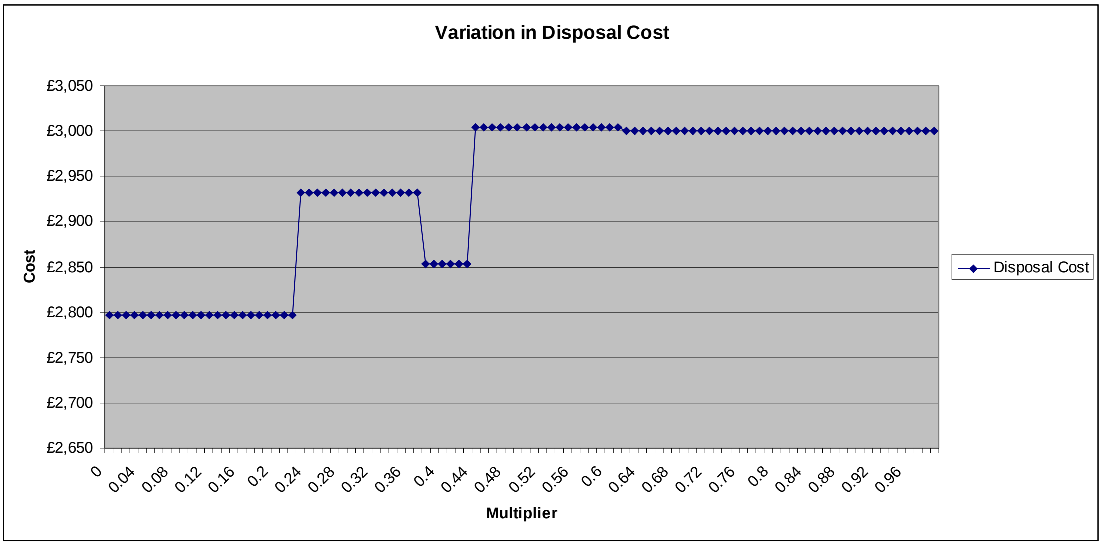
This result is also reflected in the graph below which displays the maximum profit obtained from the optimal policy for each multiplier. As can be seen the profits increase linearly past the 0.44 multiplier.



Looking at the variation in the amount of tonnes manufactured per product for each optimal strategy for different multipliers we immediately notice a sharp increase in products manufactured, the largest increases were for Butane and Diesel production.



The disposal cost varied by approximately £ 200 across all the multipliers considered, this difference is almost negligible when taking into consideration the variations in revenues generated by sales of excess products and also the variation in operational cost.



Recommendations

The results clearly show that if it were possible to sell excess products manufactured at a price which is at least 44% of normal price, it would be worth switching to an operating policy where each column runs for 24 hours straight. The revenue generated by the product sales would outweigh any increase in operating costs and disposal costs incurred.

APPENDIX

Part I

Product	Manufactured (Tonnes/Day)	Price (£/Tonnes)	Total Revenue (£/ Day)
Butane	3,000	200	600,000
Petrol	2,000	160	320,000
Kerosene	1,168.37	140	163,571.8
Diesel	1,750	150	262,500
Tar	500	10	5,000
Total			**1,351,072**

Table 1: Revenue per Product per Day for optimal policy

Column	Operating Time (Hours)	Running Costs (£/Hour)	Total Cost (£/Day)
A	24	8,000	192,000
B	24	12,500	300,000
C	4.29	21,000	90,090
Total			**582,090**

Table 2: Operating Cost per Column for optimal policy

Column Outputs	Disposed (Tonnes)	Disposal Cost (£/Tonne)	Total Cost (£/Day)
Butane	0	0.5	0.00
Fraction 1	60.58	0.5	30.29
Fraction 2	0	0.5	0.00
Fraction 3	518.56	0.5	259.28
Tar	687.37	1.0	687.37
Waste	2507.37	1.0	2,507.37
Total			3,484.31

Table 3: Disposal Cost per Output for optimal policy