7.0 ECONOMIC EVALUATION (TASK 5)

This section evaluates the economics of wax hydrocracking. The evaluation is achieved by comparing two upgrading complex flow schemes. In the base case, Arge wax is hydrocracked to distillate. In the alternate case, the hydrocracker is removed and the Arge wax is sent to the fuel oil pool. Each flow scheme is detailed in Section 6.1 (Task 4).

One financial technique used to evaluate the economics of wax hydrocracking determines the increased value of the feedstock (or the product from the Fischer-Tropsch reactor) due to wax hydrocracking vis-a-vis burning it as fuel oil. In the two cases, the products from the upgrading complex, namely, LPG, gasoline, diesel and fuel oil, were assigned market values. Feedstock (condensate, wax, etc.) value was determined once an expected return on investment was assigned.

The next economic approach assigned market values to feedstock (condensate, wax, etc.) as well as to products (LPG, gasoline, diesel and fuel oil) in the upgrading complex. The change in rate of return was determined due to the addition of the wax hydrocracker. Also, a study was completed to determine the effect of blending the external low value refinery stream (LCO) on the feedstock value, as well as on the rate of return. Again, the two economic techniques previously discussed were used.

7.1. CALCULATION METHOD

The economic evaluation calculations were done using a standard discounted cash flow calculation to find an internal rate of return (IRR). The object of each calculation was to either calculate an IRR directly, or determine the feedstock value so that the IRR for the complex was 20%. If an actual economic analysis for a complex showed a 20% IRR, then the complex would be economically attractive. This analysis assumes that one cannot obtain a 20% return by investing that money elsewhere. The calculation method is described in Appendix G.

7.2 PROCESS UNIT COST ESTIMATES

Erected cost estimates were made for each process unit in the complex. Variable and fixed costs were also estimated. Table 7.1 presents a cost summary for the base case flow scheme. Table 7.2 provides the same information for the alterrate case.

7.3 BASIS FOR ECONOMIC ANALYSIS

The feedstock and product prices used for this study are shown in Tables 7.3 and 7.4. These prices are reasonably accurate for a scenario where the price for oil is $18-19 per barrel.

The price per gallon for gasoline and diesel were kept constant, but the $/MT values vary slightly because the density depends on the material balance for the particular case.

7.4 F-T PRODUCTS UPGRADING COMPLEX: ECONOMIC EVALUATION

As described in the introduction, two topics are discussed in the economic analysis. The first subject is to show that the F-T wax is a valuable product, and the second is to show the effect of F-T product cost on the upgrading complex economics.

7.4.1 F-T Wax Value

The feed stream of the greatest interest in the complex is the F-T wax. The wax has previously been regarded as a F-T product whose value can be increased by upgrading. The first point of the economic analysis was to test the validity of that hypothesis. The test was done by determining the change in the IRR for the base (with hydrocracker) and alternate (without hydrocracker) cases. If the base case has a higher IRR, the conclusion is that upgrading the wax into distillate products with a hydrocracking unit is attractive.

The calculations were started with the alternate case. The values for the three F-T product streams (LPG, condensate and wax) were assumed to be equal. These values were varied until the IRR for the complex was 20%. From this point on, these F-T product stream values were used in all the economic calculations. This is a rational approach as it is difficult to assign market value to F-T product streams. The second step in the evaluation was to add the HC Unibon unit to the complex and recalculate the IRR for the complex. The results of these calculations are shown in Table 7.5. The calculations also show the effect of adding LCO into the diesel pool. The detailed calculations for each case are included as Appendix H.

The first pair of results in Table 7.5 shows the effect of the HC Unibon unit if LCO is not blended in the diesel pool. An F-T product value of $121/MT gives a 20% IRR for the complex that does not include an HC Unibon unit. If the hydrocracking unit is added to the complex, the IRR increases to 31% (Figure 7.1). The next three pairs of results show the effect of different amounts of LCO in the diesel pool.

LCO has only a marginal effect on the complex economics for the alternate cases without the hydrocracker. The F-T product value increases from $121/MT with 0% LCO to $124/MT with 60% LCO in the diesel pool. The IRR for the base case increases to 36%, compared with 20% for the alternate case, when the diesel pool contains 60% LCO (Figure 7.1).

These calculations show that including a hydrocracking unit in the complex is economically attractive. The erected cost for the complex will increase significantly, but the added cost is justified by the value added to the F-T wax stream. The erected cost for the alternate case was estimated at $50 MM, including an allowance for offsites. Adding an HC Unibon unit to the complex increases the complex Estimated Erected Costs (EEC) to $109 MM. The added cost includes the costs for the HC Unibon unit, larger process units in the complex, and larger offsite facilities. To understand the effect of Estimated Erected

Costs on F-T wax upgrading economics, the costs were increased by more than 50%. For the base case, increasing the Estimated Erected Costs to $168 MM from $109 MM, drops the IRR from 31% to 20%.

The next step in the evaluation was to determine the value added to the F-T wax by including the hydrocracking unit in the complex. This calculation was done by adjusting the F-T wax value for the base case until the complex IRR was 20%. The results are shown in Table 7.6.

Assuming a constant 20% IRR and no LCO, adding an HC Unibon unit to the complex increases the F-T wax value from $121/MT to $146/MT -- an increase of $23/MT (Figure 7.2). This is a very large change. It is equivalent to an increase in value for the wax of over $21,000,000 per year.

The effect of LCO on the complex economics is also illustrated in Table 7.6. The effect is minimal for the alternate case, because the diesel product is a small portion of the overall product slate. The effect is much larger for the base case, because the fuel oil product is eliminated. Blending LCO so that the diesel pool contains 60 wt-% LCO increases the F-T wax value $18/MT (from $146/MT to $164/MT) over the base case without LCO. It must be kept in mind that the effect of LCO on the complex economics is based on a price differential between LCO and diesel. All the LCO required for blending in the diesel pool may not be economically available and may have to be substituted by a similar low cetane, highly aromatic blending component.

The incremental value added to the F-T wax when a hydrocracker is included in the complex increases when LCO is blended into the diesel pool. The added value is $23/MT with no LCO, but it increases to $38/MT when the diesel pool contains 60 wt-% LCO (Figure 7.2).

7.4.2 Effect of F-T Product Cost on Complex Economics

The final step in the economic evaluation was to determine the effect of the overall F-T product value on the complex economics. This was done by simply calculating the complex IRR for different F-T product values. This analysis was only done for the base case. The results are shown in Table 7.7 and Figure 7.3.

The complex economics are highly dependent on the cost of the F-T products. The costs for raw materials will determine if an upgrading complex is economically attractive.

7.5 CONCLUSIONS

Fischer-Tropsch wax is a valuable feedstock. Hydrocracking the wax is economically attractive. The value added to the wax during conversion is high enough to justify the expenditure for a hydrocracking process unit.

Hydrocracked wax yields an excellent diesel product. The diesel is of such high quality that it can tolerate the addition of low value LCO up to 60 wt-% of the diesel pool. The increase in the value of LCO blended in the diesel pool adds to the economic attractiveness. This assumes that a price differential exists between LCO and diesel.

On a relative basis, adding a hydrocracker to a Fischer-Tropsch upgrading complex is justified. On an absolute basis, the economic success of the complex is a strong function of the costs for raw materials, that is, the cost of converting coal into liquid hydrocarbons.

Table 7.1

Capital and Operating Cost Summary
Fischer-Tropsch Upgrading Complex

Base Case
4th Quarter 1987 $

Process Unit	Cat. Con.	DHT	NHT + Splitter	CCR Plat.	Penex/Molex	HC Unibon
Feed Rate, MT/D	1008.6	243.4	1601.4	1042.2	551.2	3142.3
EEC, $MM	13.7	4.6	7.1	14.1	8.2	27.0
Utility Consumptions						
Power, kW	1175	190	600	778	299	2300
HPS, M lb/hr*	38.8	0.0	0.0	(12.5)	0.0	18.0
MPS, M lb/hr	0.0	0.0	0.0	0.0	7.8	8.0
LPS, M lb/hr	0.0	0.0	0.0	0.0	17.2	0.0
BFW, M lb/hr	0.0	0.0	0.0	21.5	0.0	0.0
Cooling Water, M gal/hr	46.2	3.2	8.4	34.6	0.2	72.0
Fuel, MM Btu/hr	58.0	6.8	55.8	82.8	0.0	130.0
Utility Costs, $MM/yr	2.57	0.18	1.14	1.42	0.76	3.74
Catalyst Loading, lb	309,080	24,442	17,951	67,439	38,285/47,623	72,008
Catalyst Loading, $MM	0.510	0.066	0.048	0.604	0.507/ 0.405	0.720
Expected Life, yr	0.24	5	4	3.5	3/5	5
Catalyst Costs, $MM/yr	2.124	0.013	0.012	0.172	0.169/ 0.081	0.144
Catalyst Work. Cap., $MM	0.51	0.07	0.05	2.72	1.28/ 0.40	0.72
Royalty, $MM	1.30	0.40	0.70	1.00	1.10/ 1.10	3.00
Labor-Operators/Shift	2	2	1	2	2	3
Labor Costs, $MM/yr	1.24	1.24	0.62	1.24	1.24	1.86

(*) HPS - High Pressure Steam, 600 psig, Superheated to 725-750°F
MPS - Medium Pressure Steam, 150 psig, Saturated
LPS - Low Pressure Steam, 50 psig, Saturated
BFW - Boiler Feed Water

Table 7.1

Capital and Operating Cost Summary
Fischer-Tropsch Upgrading Complex
(Continued)

Base Case
4th Quarter 1987 $

Process Unit	Cat. Con., $MM/yr	DHT, $MM/yr	NHT + Splitter, $MM/yr	CCR Plat., $MM/yr	Penex/Molex, $MM/yr	HC Unibon, $MM/yr
Operating Cost Summary						
Variable Costs						
Utility Costs	2.57	0.18	1.14	1.42	0.76	3.74
Catalyst Costs	2.12	0.01	0.01	0.17	0.17/0.08	0.14
Total Variable Costs	4.69	0.19	1.15	1.60	1.01	3.89
Fixed Expenses						
Labor Costs	1.24	1.24	0.62	1.24	1.24	1.86
Maintenance	0.23	0.09	0.14	0.28	0.16	0.54
Taxes and Insurance	0.18	0.07	0.11	0.21	0.12	0.41
Total Fixed Expenses	1.65	1.40	0.87	1.74	1.53	2.81
Fixed Charges						
EEC Depreciation	1.17	0.46	0.71	1.41	0.82	2.70
Offsite Depreciation	0.59	0.23	0.35	0.71	0.41	1.35
Total Fixed Charges	1.76	0.69	1.06	2.12	1.23	4.05

Table 7.2

Capital and Operating Cost Summary
Fischer-Tropsch Upgrading Complex

Alternate Case
(No HC Unibon Unit)
4th Quarter 1987 $

Process Unit	Cat. Con.	DIH	NHT + Splitter	CCR Plat.	Penex/Molex
Feed Rate, MT/D	1008.6	243.4	670.0	284.6	382.1
EFC, $MM	11.7	4.6	4.2	6.5	6.6
Utility Consumptions					
Power, kW	1175	190	251	212	207
HPS, M lb/hr	38.8	0.0	0.0	(3.4)	0.0
MPS, M lb/hr	0.0	0.0	0.0	0.0	5.4
LPS, M lb/hr	0.0	0.0	0.0	0.0	11.9
BFW, M lb/hr	0.0	0.0	0.0	5.9	0.0
Cooling Water, M gal/hr	46.2	3.2	3.5	9.4	0.1
Fuel, MM Btu/hr	58.0	6.8	23.4	22.6	0.0
Utility Costs, $MM/yr	2.57	0.18	0.48	0.39	0.53
Catalyst Loading, lb	309,000	24,442	7,511	18,415	26,542/33,016
Catalyst Loading, $MM	0.510	0.066	0.020	0.165	0.352/ 0.281
Expected Life, yr	0.24	5	4	3.5	3/5
Catalyst Costs, $MM/yr	2.124	0.013	0.005	0.047	0.117/ 0.056
Catalyst Work. Cap., $MM	0.51	0.07	0.02	0.74	0.89/ 0.28
Royalty, $MM	1.30	0.40	0.29	0.27	0.76/ 0.76
Labor-Operators/Shift	2	2	1	2	2
Labor Costs, $MM/yr	1.24	1.24	0.62	1.24	1.24

Table 7.2

Capital and Operating Cost Summary
Fischer-Tropsch Upgrading Complex
(Continued)

Alternate Case
(No HC Unibon Unit)
4th Quarter 1987 $

Process Unit	Cat. Con., $MM/yr	DHT, $MM/yr	NHT + Splitter, $MM/yr	CCR Plat., $MM/yr	Penex/Molex, $MM/yr
Operating Cost Summary					
Variable Costs					
Utility Costs	2.57	0.18	0.48	0.39	0.53
Catalyst Costs	2.12	0.01	0.01	0.05	0.12/0.06
Total Variable Costs	4.69	0.19	0.48	0.44	0.71
Fixed Expenses					
Labor Costs	1.24	1.24	0.62	1.24	1.24
Maintenance	0.23	0.09	0.08	0.13	0.13
Taxes and Insurance	0.18	0.07	0.06	0.10	0.10
Total Fixed Expenses	1.65	1.40	0.77	1.47	1.47
Fixed Charges					
EEC Depreciation	1.17	0.46	0.42	0.65	0.66
Offsite Depreciation	0.59	0.23	0.21	0.32	0.33
Total Fixed Charges	1.76	0.69	0.63	0.97	0.99

Table 7.3

Price and Cost Basis for Economic Analysis

	$/Gal	$/MT
LPG	0.30	140
Gasoline	0.52	193-199
Diesel	0.50	158-170
LCO	0.46	128
Fuel Oil	0.40	115
Hydrogen	2.20/M SCF	900
Fuel Gas	2.10/MM Btu	100

Table 7.4

Utility and Labor Costs

Power, $/kWh	0.04
High Pressure Steam, $/M lb	3.80
Medium Pressure Steam, $/M lb	3.40
Low Pressure Steam, $/M lb	3.30
Boiler Feed Water, $/M gal	0.80
Cooling Water, $/M gal	0.10
Fuel, $/MM Btu	2.10
Wage Rate, $/hr	20
Fringe Benefits, %	35
Supervision, %	25
Overhead, %	50

Table 7.5

Effect of HC Unibon Unit on Complex IRR

Case	Base	Alt	Base	Alt	Base	Alt	Base	Alt
HC Unibon	yes	no	yes	no	yes	no	yes	no
LCO in Diesel, wt-%	0	0	20	20	40	40	60	60
F-T Product Value, $/MT	121	121	122	122	123	123	124	124
Complex IRR, %	31	20	32	20	33	20	36	20

Table 7.6

Value Added to F-T Wax by the HC Unibon Unit

Case	Base	Alt	Base	Alt	Base	Alt	Base	Alt
HC Unibon	yes	no	yes	no	yes	no	yes	no
LCO in Diesel, wt-%	0	0	20	20	40	40	60	60
IRR, %	20	20	20	20	20	20	20	20
F-T LPG, $/MT	121	121	122	122	123	123	124	124
F-T Condensate, $/MT	121	121	122	122	123	123	124	124
F-T Wax, $/MT	146	121	149	122	154	123	164	124

Table 7.7

Effect of F-T Product Value on Complex Economics
Complex IRR for Various F-T Product Values

Case		Base	Base	Base	Base
HC Unibon		yes	yes	yes	yes
LCO in Diesel, wt-%		0	20	40	60
F-T Product Value, $/MT	100	49%	50%	52%	57%
	120	32%	33%	35%	40%
	140	13%	15%	18%	23%

FIGURE 7.1

ECONOMIC EFFECT OF LCO ADDITION TO DIESEL POOL

(INTERNAL RATE OF RETURN, % vs. LCO CONTENT IN DIESEL POOL, %)

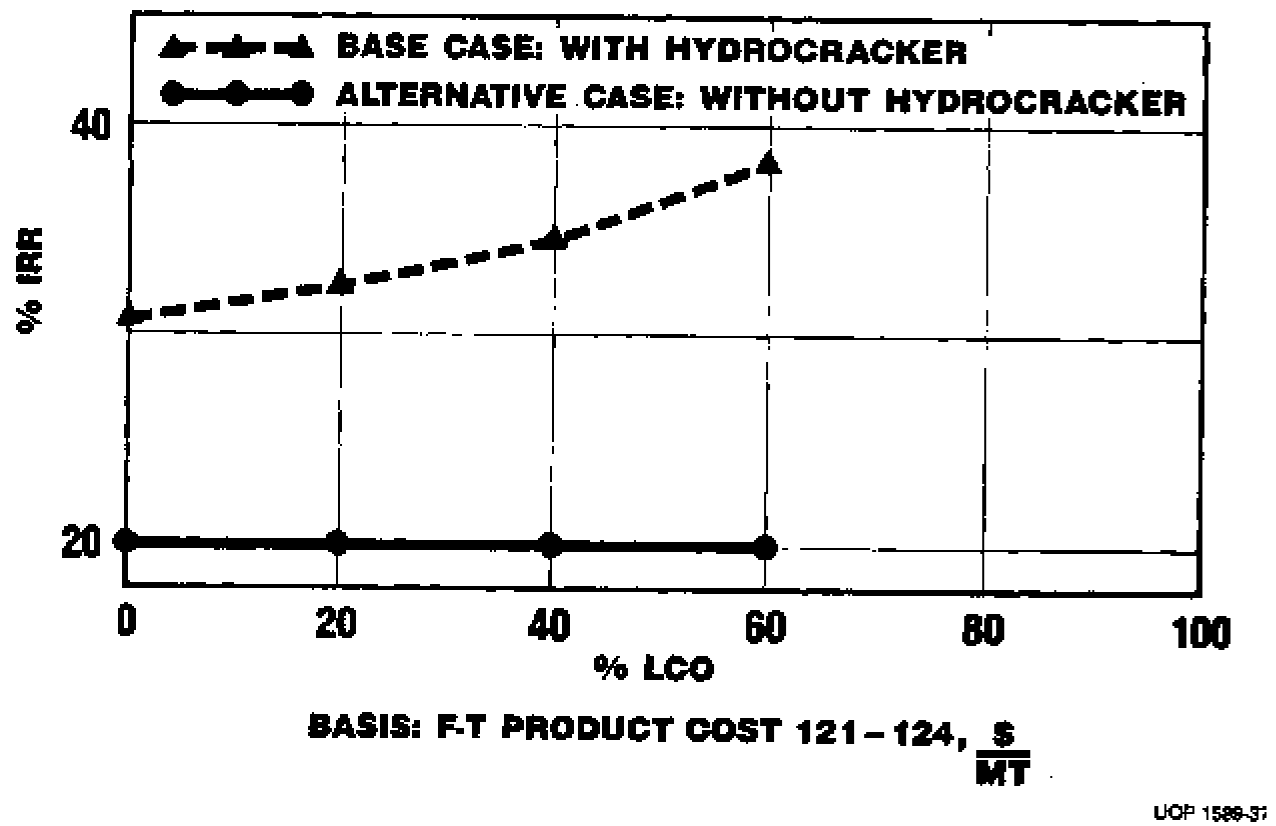
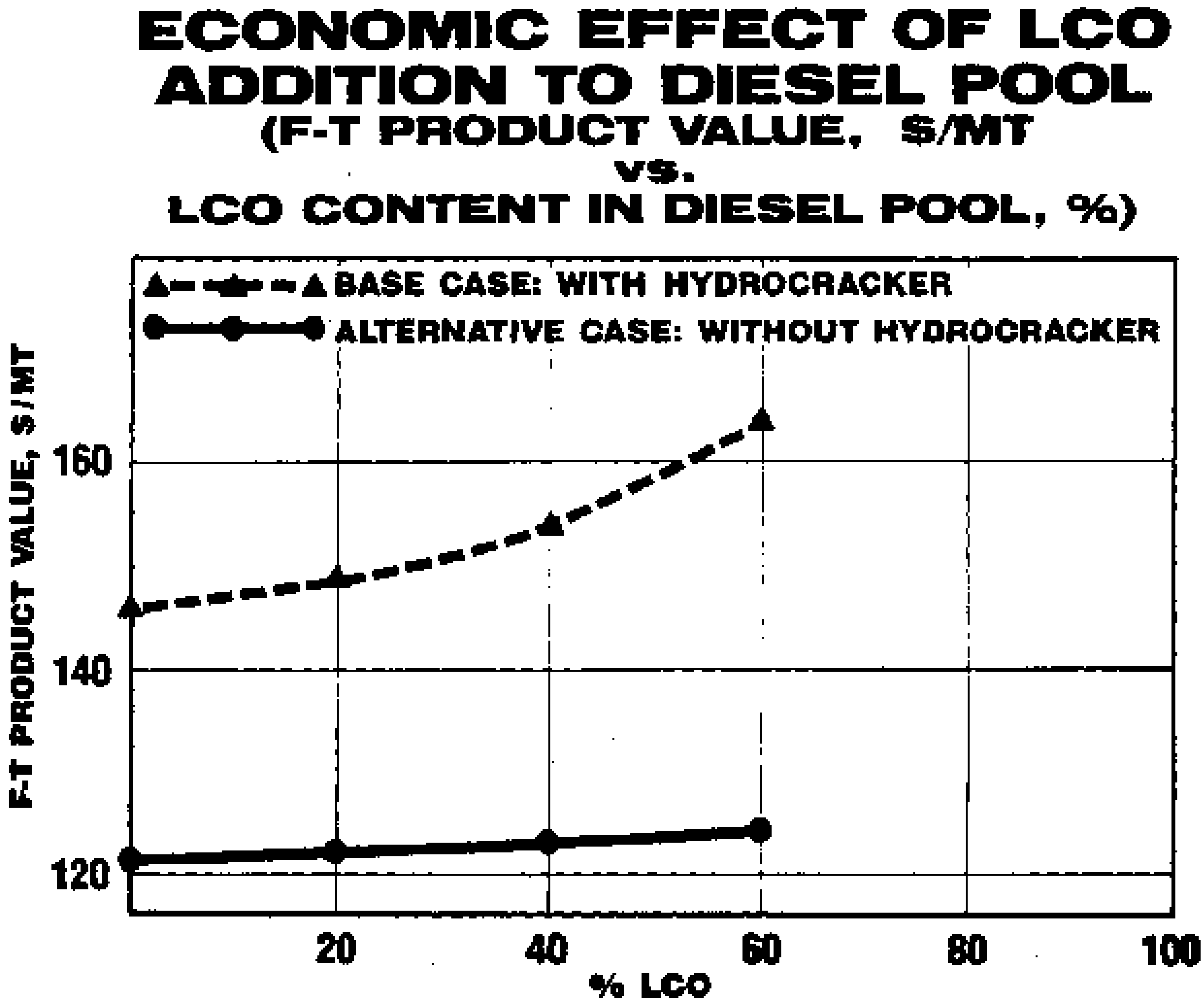


FIGURE 7.2



BASIS: FIX INTERNAL RATE OF RETURN (IRR) AT 20%

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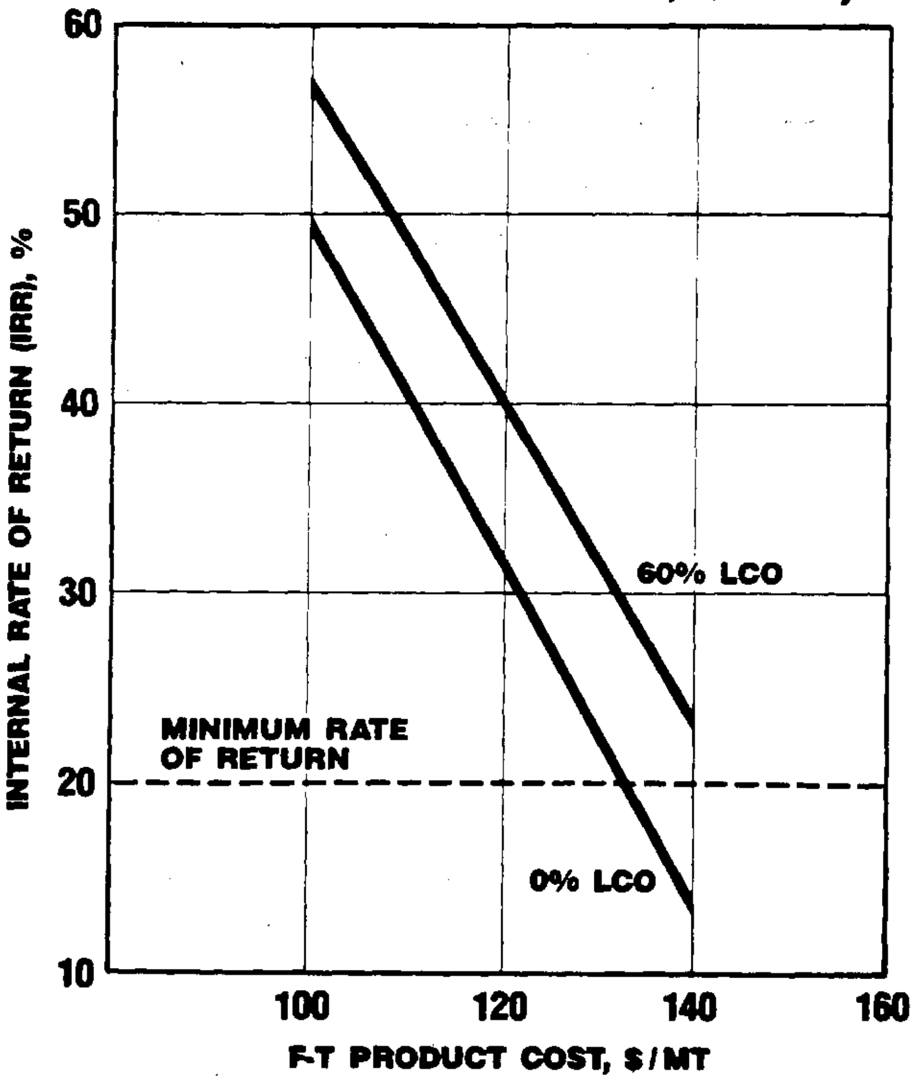
FIGURE 7.3

ECONOMIC EFFECT OF F-T PRODUCT COST

(INTERNAL RATE OF RETURN, % vs. F-T PRODUCT COST, $/MT)



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