CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

Based on the experimental and analytical study carried out at UAF on technical and economic feasibility of transporting GTL products through TAPS, the following main conclusions are drawn.

Cold restart of TAPS following an extended winter shutdown is the main transportation issue that will govern the technical feasibility of moving GTL products through the pipeline.

It was found that GTL samples and crude oil readily developed miscibility when mixed at ambient temperature and pressure conditions.

The trend of both density as well as viscosity reduction as a function of increasing temperature is clearly evident for all the tested samples.

The dilution of crude oil by GTL causes a major reduction in both density as well as viscosity.

The measured density and viscosity data can be correlated using non-linear regression techniques. It is demonstrated that the developed correlations are capable of reproducing the measured data with reasonable accuracy and reliability.

A trend of increasing yield stress with increasing wax content was clearly observed. Gel strength tests at –20°F for the GTL 1 and TAPS crude oil blends had to be abandoned owing to very high yield stress (beyond measurable limits of the apparatus) already encountered at temperatures higher than –20°F.

The results indicate that light GTL samples had measurable gel strength whereas significant gel strength problems were observed for heavier GTL and crude oil blends.

The GTL 2 sample (FT diesel) produced high gel strength, but when it was blended with TAPS crude oil, a significant reduction in gel strength was observed.

No gel strength measurements could be reported at temperatures of –20°F for the GTL 2 and TAPS crude oil blends due to very high yield stress (beyond measurable limits of the apparatus). The high gel strength can be attributed to the chemical composition of the GTL 2, which is highly paraffinic in nature.

The flow model equations developed in this study was analytically solved for predicting the pressure gradients encountered in the batch and commingled flow modes of transporting GTL products and Crude Oil through the Trans-Alaskan Pipeline System (TAPS).

The derived flow equations presented here can be modified under specified operating conditions or constraints of the Trans-Alaskan Pipeline System (TAPS), using live GTL or Crude Oil data.

Mixing at the Oil-GTL interface in the case of batch mode transportation poses flow modeling and simulation difficulties.

The pressure gradients obtained from the batch flow calculations are higher than those obtained from that of commingled flow.

Because GTL products have higher gel strength than crude oil or GTL-crude oil blends, feasibility of batch mode of transportation will be limited by TAPS cold restart requirements.

The thermodynamic model developed in this study shows good agreement between calculated and measured oil temperatures, proving validity of the model.

Heat loss in the below ground section of TAPS is higher than heat loss in the above ground section, which is because of the absence of insulation in the below ground section.

Heat loss from GTL flow is less than heat loss from crude oil flow for both below ground and above ground pipeline. This is due to a reduction in mass flow rate for GTL.

Exit temperature of the GTL is slightly lower than the exit temperature of the crude oil. Lower mass flow rate has lower heat content and cools down further.

The heat loss is more in January than in March both for crude oil and GTL. The increased heat loss in January is because of the low ambient temperatures. The temperature difference between the fluid and the ambient air is greater which results in more heat loss.

The temperature of oil arriving at Valdez is 57°F for crude oil from the calculations. Temperature reported by Alyeska Pipeline Service Comapny is 60°F. This minor difference may be due to the assumptions made in the calculations.

The economic analysis shows that the modern batching approach consistently gave the highest return on investment and is recommended for transporting the GTL products from the North Slope of Alaska to Valdez.

The major concern with batching is the length of the mixing zone or interface and the purity of the GTL products as they arrive the Marine Terminal in Valdez. Since experience shows that the length of this interface is independent on volume pumped, it becomes an optimization issue to find the optimum holding capacity on the North Slope that can give the minimum number of batches at any given production period. The optimum fluid velocity in the pipeline should be determined with reasonable accuracy based on the density and viscosity difference of the two products to be transported to ensure minimum interface.

One reason for the low numbers in the rate of return analysis is that the project life assumed is not long enough to enable the project make adequate profits after pay out. Considering the investment pattern, train 2 and 3 for example barely had enough time to pay out and start making profit. Typical payout times are shown in the Figure 7.1 below:

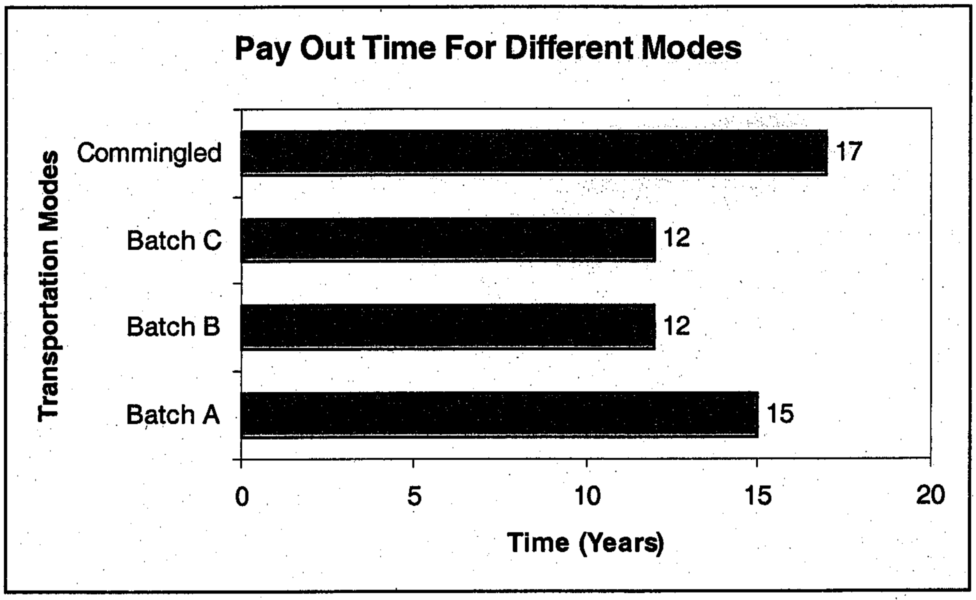

FIGURE 7.1 Summary of Payout Time (Capex $25,000/DBL, Oil $21/bbl)

From Figure 7.1 above, it is evident that the project has not had enough time to make sufficient profit for the 20-year evaluation. One quick way to make projection after the twenty years period is to make a plot of the ROR progress over the observed years and make forecasts. Figure 7.2 shows these results.

From Figure 7.2, the projection on the ROR curve shows that the project still has about 8 years before the project life chosen would not matter anymore. Since this study is focused on a comparative analysis of the transportation modes, the magnitude of the rate of return is not the key concern.

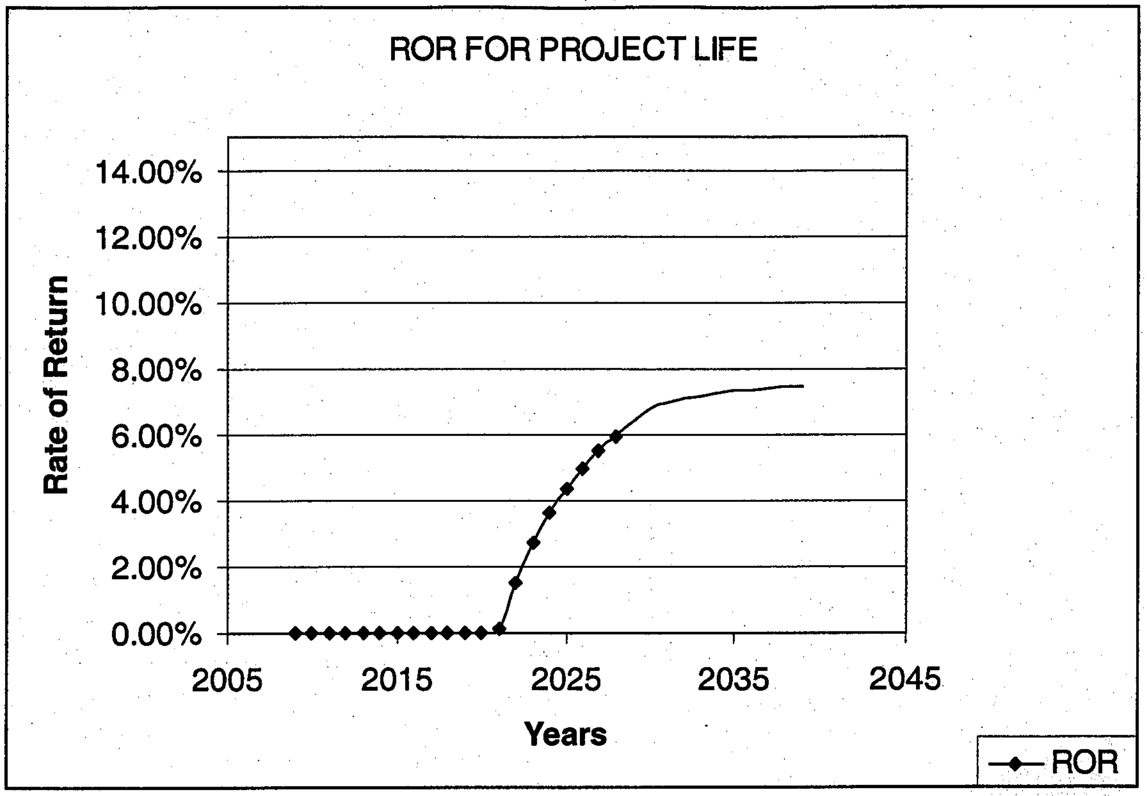

FIGURE 7.2 Project Life Evaluation Time.

7.2 RECOMMENDATIONS

It is evident from the results of this study that the logistics of transporting GTL products from the Alaskan North Slope to the markets through TAPS is extremely complicated. This study by no means should be considered as the final word on this issue. Many transportation issues were identified, which pose unique operational challenges in GTL transportation through TAPS and need to be examined. The following recommendations are made for continuing work in this area.

This study indicates that even the light GTL (LaPorte type) or FT diesel can pose problems for transportation through TAPS from the cold restart point of view. Rigorous studies are needed to identify the upper limit on the quantity and nature of paraffins in GTL that can be accepted for transportation through TAPS.

Since high molecular weight paraffins are not likely to be acceptable, it may be necessary to include a hydrocracking unit in the GTL plant considerations for the North Slope. Studies are necessary to recommend the composition and upgrading options for GTL to be produced in the North Slope.

Blending of GTL and crude oil may be effective in lowering the ultimate yield stress values. However, it will be worthwhile to determine if the effect of blending is reproducible with varying crude oil composition.

Along with gel strength, Reid vapor pressure (RVP) is also an important parameter that will determine transportability of any fluid through TAPS. Therefore, RVP measurement studies on GTL products and their blends with crude oil need to be performed.

Although modern batching technique appears to be the transportation mode of choice at this time, batching GTL products through the same pipeline that carries crude oil is likely to create significant problems of GTL product contamination. Wax, sulfur, asphaltene and other assorted solids deposited on the inside of the pipeline can potentially re-dissolve in the slug of pure GTL. Since GTL is a clean, zero sulfur fuel, this type of contamination could defeat the very purpose of gas to liquid conversion. Further studies are necessary to investigate the effect of GTL contamination from the pipe-wall residue.

After studying the operational issues, it will be necessary to re-visit the economics of GTL transportation. For example, the economics of batching mode could potentially include an additional cost of purifying contaminated GTL products. The blending mode, on the other hand, may make it feasible to have a cheap GTL plant producing low grade GTL, thus reducing capital expenditure.