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White Paper

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Performance Monitoring in a Refinery using Linear Programming tools

Abstract

The use of Linear Programming (LP) tools for both long-term planning and day to day scheduling is fairly common in any Refinery. However, usually there is a gap between the LP run plan output and the actual operations. These variations can be attributed to both external or market forces and the internal operational constraints. There are many approaches followed for finding and attributing the $ values of these variations in performances. Use of LP tools is one of the best ways for identifying and quantifying these variations. Depending on the level of business and IT tools adoption in an organisation the challenges can be in either in making a "retro" LP model or in defining the framework for performance evaluation or in data consolidation and validation for the LP run. As far as benefits are concerned, apart from the obvious benefits of performance monitoring, use of the same LP model which was used for planning helps in fine tuning of the model itself and also helps in identifying further areas of GRM boosting.

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Introduction

The refining business is piloted on the basis of a "Business Plan" which is usually developed using a Linear Programming package. The LP tool is an optimiser whose objective function is the GRM (Gross Refining Margin) of the refinery and it attempts to maximise this GRM subject to many constraints which are modeled. Both strategic and operational factors can be reduced to mathematical constraints in the model and the optimum run thus obtained is used as the guideline for running the business. While planning is an important part of the cycle, it is equally important to study the variation from the plan.

Due to the very nature of the oil business, there will be deviations from the plan. These variations may be due to internal factors like plant equipment downtime, catalyst ageing and other operational inefficiencies or they can be due to external factors like crude availability, crude and product prices, a nearby refinery shutting down or a not so cold winter. Due to all this while the decision to process sweet crudes while planning for the month looks like a good one, it appears quite dumb, if the sweet sour differential goes up substantially during the course of the month.

Due to variations in external conditions, it is difficult to do a performance evaluation of the different functions based on the plan which was run around a month ago, However, there are 3 main benefits of doing these backcasting runs. They are

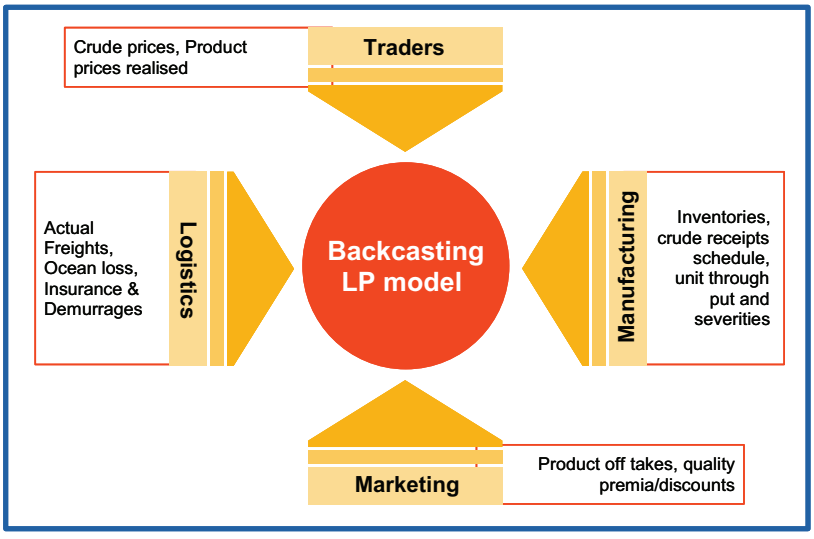
- To attribute $ value to the variations from the plan for different functions. Thus it helps in quantifying good or bad performance by say marketing or trading or manufacturing functions
- To get the delta vectors for the LP for tuning the model. The yields of column or conversion units can be fine tuned if there are consistent deviations in a particular direction.
- To identify margin improvement opportunities. The optimiser can look at many different combinations across crude buying to scheduling to blending components for coming out with GRM boosters.

Methodology

Inputs: The LP model which was used for the monthly plan has to be used as the basis for this study. It is a good practice to rerun the model and compare the GRM obtained with the plan number. Small updates or changes in the model also have the potential to distort the study and hence it is necessary to be consistent. For doing the retro runs the following data are required as shown in the next page.

The variations that would have crept in after the plan was frozen are listed below

- Variations in prices
- Variations in crude arrival schedule
- Variations in the preference for a crude
- Variations in crude processing combinations
- Variations in the product quality actually shipped out
- Variations in unit operations



These variations are to explained and quantified by use of the retro runs.

Case1 Base Run: There is little control over the prices and hence the effects of prices need to be removed while comparing the GRMs. To offset the effect of prices, either the old plan prices are used and the other runs are done using the old prices or the prices are also updated in base runs and in all the other runs. In this case it is important to be consistently using a standard set of prices for the base and the other runs.

Case2 Manufacturing: In this run, all other conditions are kept constant and only the crudes which were actually processed in a week are forced in. In this run, the optimiser looks at utilising the forced crudes in the best possible way. This run helps in validating the yield vectors which come out of the LP. For e.g. when a particular crude goes through the Crude Distillation Unit (CDU), it is expected that there will be a particular distribution of products. If however there is a variation on the product slate there might be need to look at the column from the point of flooding, separation efficiencies etc. Also, it helps in looking at the capacity utilisation of secondary processing units. If the composition and quantities of a product slate change, the downstream processing units capacity utilisation get affected. These can be compared with the actual capacity utilisations for fine tuning of the model.

The GRM obtained is then compared with the actual GRM and the difference is attributed to the manufacturing inefficiencies

Case3 Crude Blending: In this run, the model is allowed to process any crude, which is available in inventory and arriving. In this however, the crude arrivals are forced. This helps in the model choosing the best blends from whatever has actually arrived. This determines the complimentary crudes which the model identifies as those which need to be scheduled and blended together for giving the maximum benefit to the refinery.

The GRM obtained is compared with the above case2 run and the difference in GRM is attributed to the Crude blending carried out by the operations and scheduling group.

Case4 Crude Selection: In this run, the model is allowed the freedom to choose from the available universe of crudes and that available from the inventory. In this even the term crudes that are normally forced in the planning runs are kept open. If a term crude is not chosen or chosen considerably lower than the plan quantities, then this needs to be kept in mind when the "terming up" plans are done for the following year. It may indicate deterioration in quality of a particular grade or the fact that its price has gone up relative to other similar grades. The GRM obtained is compared with the case2 GRM and the difference in GRM is attributed to the crude selection process.

Case5 Product Quality giveaways: In this run, the only change is the actual product quality that was dispatched. Frequently, the blending group would prepare blends which would have superior quality than what the customer had actually specified. This would result in higher manufacturing costs due to running of units like hydrotreaters, consumption of hydrogen etc. By identifying and quantifying these "giveaways" the blending tools are fine tuned so that these giveaways in quality are minimised.

Challenges

It would appear from above that it is just a matter of doing 5 runs using the LP for monitoring the performance of different functions of the refinery totally. Unfortunately, it is not so simple. Following are some of the reasons, which make performance monitoring using LPs a challenge.

- Interdependability of the different factors involved in the optimisation. E.g. a change in crude schedule due to a problem in a well or a tanker or jetty could be attributed to the logistics group but this may result in two not so agreeable crudes getting processed together reflecting poorly on the manufacturing division as capacity utilisation of units may go down.
- Data Interphasing issues with a variety of groups and from different systems for getting the input data frequently results in use of inconsistent data resulting in incorrect results. Many times due to the delay in getting authentic and verified data and then doing the retro study results in making the study itself an academic exercise with little use for the next plan.
- The LP models themselves have limitations in the way they calculate the GRMs for multiperiod and multiplant runs. By doing these runs with small variations the problems of local optima and other inventory valuation norms need to be identified and overcome.

- The operations group may have been using other tools like the kinetic model for optimising the performance of their secondary units and the LP will not have all the yield vectors from the kinetic models. This results in these units subsidising the performance of other units thus giving a wrong picture of the performance.

Conclusions

While it may not be very simple to pinpoint the reasons for all the deviation from the plans, doing retro or backcasting runs is a very good way of looking at the performance of all groups in the refinery. The fact that $ values are attributed to each of the deviation helps in understanding their impact and in prioritising the areas on which more efforts are needed. Some of the above issues can be addressed using the following suggested ways, even though they also do not totally address all the issues raised.

- There is a definite need for a system or application which would capture all the data required from the different groups as inputs to the model. Thus, there is a need to capture the inventory data, crude prices which may be on ERP, Laboratory info from LIMS, crude grades and their specs from the traders . This helps in getting consistent data from reliable sources very early and retro runs have meaningful impact on the subsequent plan.
- There is need for applications which can calculate the GRM for these mutliperiod and multiplant runs on the basis of the accounting practices followed by the company. The LP tool has its own complex method of calculating the GRM and use of simpler applications can result in better performance tracking.
- The need for integrating the LP model and the kinetic models cannot be overstated. By using an integrated model it will be possible to pinpoint the different units whose performance had been good or needed improvements.

About the Author

K.Balasubramanian (Bala) is a chemical engineer with more than 11 years experience in the petroleum and petrochemical sector. His experience has been with Reliance Industries Limited who operate a world-scale refinery and petrochemical plants in India. In his present role, Bala is working as a domain consultant in Infosys Ltd for the Energy & Utilities sector. He can be contacted at balasubramanian_k@infosys.com

References

LP tools offered by product vendors like Aspen Tech, KBC and Invensys.