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"THE CHALLENGES OF CHANGE"

RAISING THE FOCUS OF REFINERY OPERATIONS TO ON-LINE
PROFITABILITY

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THE PROBLEM

Refiners are having to adapt to ever changing economic conditions with existing facilities. Capital expenditure on environmentally driven projects such as Clean Air Act and California Air Resources Board programs has left little in the coffers for economically driven process improvements. The profitability of existing units must be increased while maintaining the flexibility required to respond to rapidly changing market and operating conditions.

CURRENT PRACTICE

Many refiners have made use of mathematical optimization techniques (linear programming for example) to make the most of the equipment they have. The following concepts are central to any optimization process:

- (1) Variables (operating parameters)
- (2) A quantifiable measure of performance (operating profit)
- (3) Controllable degrees of freedom (operating flexibility)
- (4) Quantifiable restrictions on variables (operating limits)

The mathematical model links these quantities together in order to identify the point of maximum value of the objective function (profit) within the region defined by the constraints. Basically it is a set of equations that simulate the processes involved and allow the optimizer to perform experiments in its search for regions of improved profitability.

DEFINING THE SYSTEM

The definition of the boundary of the process system to be optimized is important. Optimizing a local system in isolation (for example, the FCC unit, a reformer, the steam system) may change the marginal values of the process streams and utilities associated with that system. These changes may adversely affect the economics of other systems and the local optimization may not be tantamount to improving overall refinery profit. A consistent set of global marginal values must be utilized to ensure true optimization of the refinery as a whole.

THE MANAGEMENT INFORMATION CHAIN

The optimization procedure generally involves an economics and planning group receiving data from the refinery and the marketing division. The results of the mathematical optimization are typically reviewed with refinery management every two to four weeks and instructions to retrim the plant are passed back down to operations as necessary. The response to unexpected changes in operating conditions can be very slow. One example could be the temporary loss of a steam boiler.

PROFITABILITY, A PROCESS CONTROL VARIABLE

Modern distributed control systems (DCS) allow operators to closely maintain temperatures, pressures, flows, etc. but provide no indication of how economics are impacted by changing process variables.

Providing a means by which operators and plant engineers can visualize instantaneously the economic ramifications of changes may lead to operation of the refinery closer to the optimum on a semi-continuous basis. Making profitability a "visible" process control variable is a new concept that can be achieved through "Plant Economic Performance Control" (PEPC).

PLANT ECONOMIC PERFORMANCE CONTROL - THE PROFIT FUNCTION

PEPC utilizes a software advisory system that resides in a computer above the DCS and periodically polls plant information from the DCS. The software derives instantaneous plant profitability through a series of on-line calculations that is known as the "Profit Function".

$$\begin{aligned}P(t) &= \sum (F_n(t) \cdot V_n) \\PI(t) &= [P(t) + (N \cdot P(t-1))] / (N + 1) \\PF(t) &= A \cdot (P(t) + B) + C\end{aligned}$$

Where:

P(t)	is the instantaneous hourly profit at time t
F _n (t)	is the instantaneous flow rate of component n
V _n	is the marginal value of component n
PI(t)	is the damped hourly profit at time t
N	is the damping period in minutes
PF(t)	is the "PROFIT FUNCTION" \$/hour
A, B, C	are constants

In simpler terms, the profit function is a timed average sum of all the flow streams leaving a process multiplied by their respective marginal values, less the sum of all the flow streams entering a process multiplied by their marginal values. For the profit function to be meaningful, all flow streams must be accounted for, including utility streams. The process can be defined over a single piece of equipment, a group of process equipment such as the FCC unit or across the whole refinery.

OPERATOR INVOLVEMENT IN MAXIMIZING PLANT PROFITABILITY

The displayed profit function can have a dramatic impact on operator's involvement in shift rivalry to see which shift can make the most profit. Prior to the installation of the advisory software, it was common practice to over reflux a tower to ensure an easy time at the console, or to allow too much excess air to the furnace. This type of lax operation is pervasive in the industry because it is difficult for the operators to see how a little overcontrol could make any significant impact on overall profitability.

RAISING THE FOCUS OF REFINERY OPERATIONS TO ON-LINE PROFITABILITY

The graphic display of the advisory system is designed to raise the focus of refinery operations to on-line profitability by visualizing the impact on profitability through the change of process variables.

ADVISORY SOFTWARE A MATURE PRODUCT

The advisory software is now a mature product developed by ICI in the 1980's. It is currently installed in over 100 facilities. With the current cost of hardware, software and customization, the usual pay back period after implementation of the system is less than 12 months with frequent examples showing payback periods less than 6 months.

THE ADVISORY SOFTWARE INCORPORATES THE LP RESULTS

We are developing this concept to the next level and integrating this advisory software with the refinery LP program run off-line (see Figure 1). The LP program (such as Bechtel PIMS, an industry standard refinery LP software program run under Microsoft Windows) is capable of optimizing the profit function of the whole refinery. This is achieved while taking into account the various possible feed crude prices, product prices, unit capacities and other constraints. A converged solution of the LP for a full major refinery is usually completed in less than 5 minutes depending on the installed CPU. The results include the optimum product slate, all the intertransfer stream flow rates and their respective marginal values. These parameters are determined at the refinery's global optimum profit function.

For refineries that incorporate advanced control on certain units (such as the FCC unit), it is important that the local advanced control system incorporates the latest intertransfer stream marginal value. This value is used in the calculation of an economic optimum in the advanced control program.

Following a fully approved LP run by the refinery planning group, the results of the run are transmitted to the operators electronically, via the advisory software. The profit function is recalculated at the unit level with the latest set of refinery globally consistent marginal values. The discrepancy of current operations (flows and profit function) is displayed alongside optimal values calculated by the LP.

IMPACT OF REGULATIONS

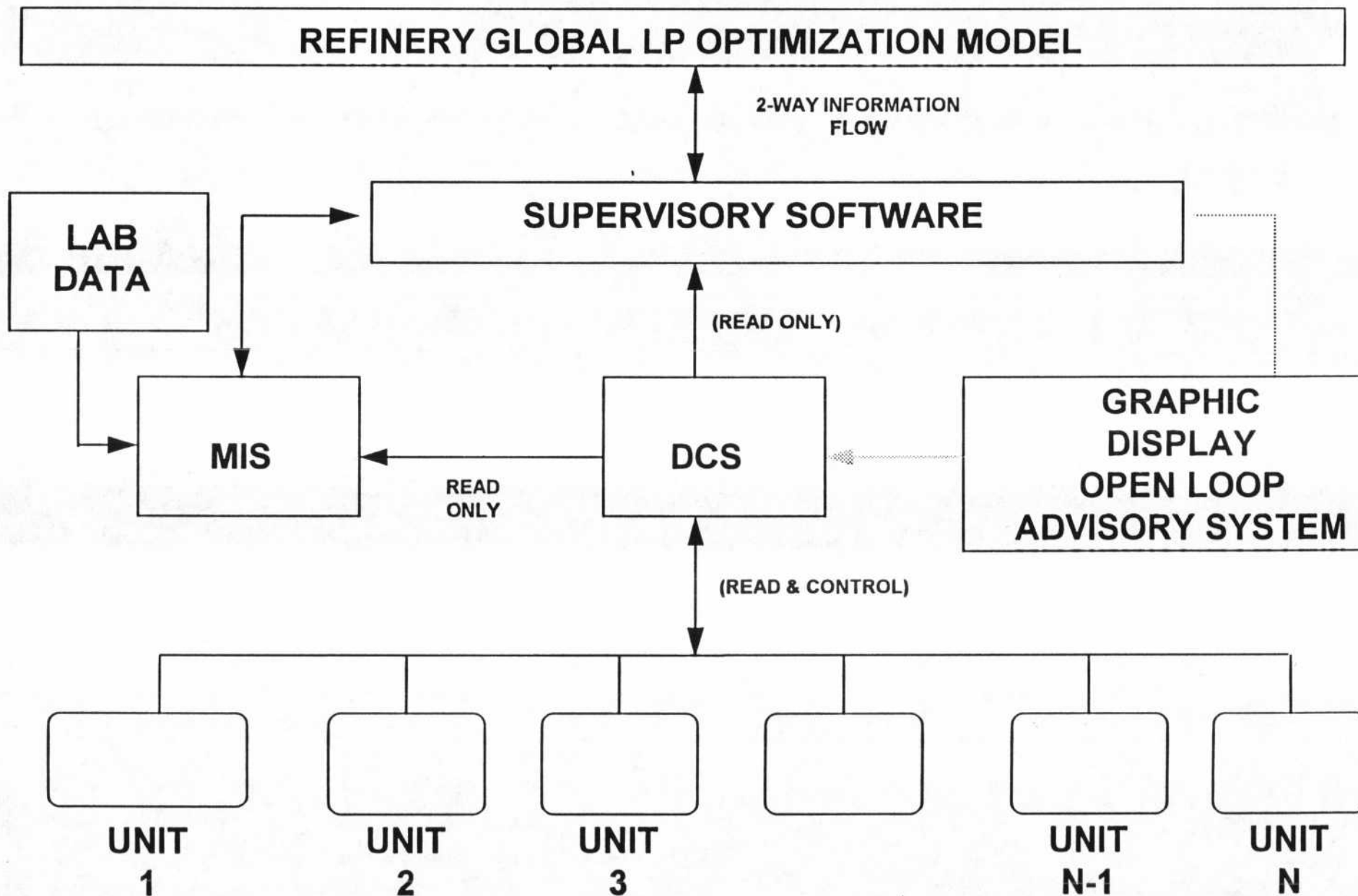
The LP model is adaptable to add further constraints set by new regulations. These new constraints such as needed to meet RECLAIM, and CARB gasoline will alter the LP profit function.

The revised solution will drive the model to reset the product slate and reselect crude usage. This new information is now incorporated into plant operation through the advisory software.

TO SUMMARIZE: TIMELY RESPONSE MINIMIZES THE ECONOMIC IMPACT OF PLANT FAILURES OR TAKES ADVANTAGES OF TEMPORARY SUPPLY & DEMAND IMBALANCES

The planning group, running the LP model, are now able to respond quickly to plant outages, environmental constraints, etc. This is achieved through marshaling the operators to retrim the refinery to mitigate against profit loss. The operators now have the critical information needed on how to reach the new targeted optimum profit function and a means to quantify the profit potential gain to help prioritize this effort.

Following the enforcement of the CARB gasoline regulations in 1996 it is anticipated that refinery product prices will fluctuate considerably in the LA basin as the competitive forces and supply and demand gyrate. A refinery able to react successfully in a timely fashion to these marketing forces is predicted to be able gain a significant profit advantage over those refineries unable to respond so favorably so quickly!



MIS = MANAGEMENT INFORMATION SYSTEM

FIGURE 1