Oil movements and storage: justifying automation

Myke King
Whitehouse Consulting

Many refineries are turning their attention to improved automation of oil movements and storage facilties, but the problem is in identifying sufficient benefits to justify the cost. This article describes some practical experiences and suggests where significant benefits might be found.

Increasing attention is being paid to the oil movements and storage areas of many refineries, particularly with regard to automation. Most refineries, however, find it difficult to generate an economically attractive project for a full upgrade. Many settle for better control of blenders; many others have no project at all. High costs are usually the difficulty, particularly if significant additional field instrumentation and long cable runs are required. Further difficulties arise from being unable to identify all the benefits.

Usually the first area to examine is product blending. Most refineries have some giveaway against limiting product quality specifications and there are many examples of refineries successfully eliminating such giveaway.

One refinery eliminated a gasoline RVP giveaway of 0.05kg/cm^2 by injecting additional butane, and improving profitability by \$2 million a year. Another eliminated a cloud point giveaway of 0.5°C in gasoil by reducing kerosene addition and saving more than \$1 million a year.

A similar reduction in kerosene cutter stock in fuel oil reduced density giveaway by 0.006. But great care must be taken is assessing such benefits. Often the impact of reducing giveaway is not just simply diverting one component stream from one finished product to another. There will usually be some impact on the process operation, on other blended products and possibly on crude selection. Ignoring these effects can result in serious errors in benefit estimates to the point where valuable opportunities may be neglected, or costly equipment installed with no significant benefit.

If after such an analysis the refiner concludes that insufficient benefits exist, then other aspects should be considered before abandoning the project. One refiner, although justifying the project on gasoline giveaway reduction, actually found little improvement in giveaway after commissioning. It was found, though, that the new blending system was producing the same quality product but with a much less costly blend formulation. Most blend control packages contain some optimisation function to exploit any degrees of freedom in the blend recipe. In this particular case this function regularly identified recipes that would not otherwise have been considered by the refinery planning group, and it resulted in far greater savings than those anticipated from giveaway reduction.

Another refinery found that its giveaway, even if eliminated completely, was not sufficient to justify the investment. Further examination disclosed that good quality control was only being achieved through much manual attention. Blends were stopped several times while laboratory samples were taken and checked. The refinery planner was frequently called in to resolve blend correction problems occurring part way through the blend.

The blender itself was often switched over to another grade while waiting for laboratory results and correction recipes. The implementation of blend automation enabled the refinery to reduce the number of laboratory technicians and, with other savings, the number of process operators. It also allowed blends to be completed in less than half the time, freeing blender capacity.

Some refineries now have so much confidence in their blending systems that they will blend directly into ships or pipelines and use the on-stream analysers, rather than the laboratory, for certificates of quality. As a result of this, one refinery was able to segregate two similar gasoil products which it had previously made to the more limiting product specification. Giveaway against the less demanding specification was then almost eliminated.

Capturing the benefits may not be straightforward. Many refineries blend products by sequentially pumping components into the finished product tank and then mixing. Full blend automation requires that all components are pumped simultaneously, so that the recipe can be continuously adjusted based on the readings from on-stream analysers. The cost of installing the necessary pumps, valves and pipework may preclude blend automation. But those refineries that already have such a configuration should normally be able to justify full automation. Those that cannot justify the installation of the additional pumping facilities can still capture at least part of the benefit in the blending area.

An integration plus

Better monitoring of tank inventories will ensure that the planned recipe is adhered to. Integration with the laboratory information system will give more reliable predictions of blend quality. Records of previous blends will be valuable in maintaining linearised blending correlations. Recent developments are also bringing down the cost of such systems. For example, lower cost near infrared (NIR) analyser technology has proved its value in some locations as a substitute for the knock engines traditionally used to measure gasoline octane.

The advantage of starting with the blending area – if economically viable, standalone – is that the systems installed provide some of the infrastructure required for full oil movements and storage (OM&S) automation. The incremental cost of extending to full OM&S automation is therefore likely to be significantly smaller than that of a standalone project, making justification that much easier. For example, it may be necessary to upgrade the tank gauging system to support the blend optimisation package (to ensure that inventory limits are not violated).

Tank gauging is also a main requirement of full OM&S automation. The blending package ideally also needs access to laboratory analyses of blend component qualities. This, too, is of importance to full OM&S automation. The blending system will also bring with it investment in power supplies, control system consoles, control room improvements and so on, which are also part of the necessary infrastructure for the full system.

One of the major benefits of OM&S automation is in avoiding the line-up errors that can often occur with entirely manual systems. Line-up errors can result in simple downgrading of product or very costly contamination. There are records of single incidents each costing more than $1 million.

In one study, very few line-up errors were a matter of record; certainly not enough to justify the cost of automation. But further probing, mainly through informal meetings with process operators, revealed a far greater number of such incidents. Only the very public incidents had been formally recorded; many of the others proved to be just as costly, providing sufficient justification for the investment.

At the other end of the spectrum, a refinery had meticulously recorded every such incident over the previous four years. More than 200 incidents were recorded and the cost of each accurately quantified. Of these, more than 75 per cent had been avoidable with full OM&S automation – saving almost $1 million a year.

Jump-overs

Many refineries have installed additional jump-overs for special purposes, often for one-off situations. Because they are so rarely used, operators can easily forget about them. This may result in line-up errors, but in one case the method was used to advantage. Because of operational problems the refinery was unable to blend fuel oils as usual. But since OM&S automation provided systematic analysis of all possible routings, it was able to identify the possible use of jump-overs, installed for entirely different reasons, in overcoming this problem.

This single example saved the refinery an estimated $2 million.

The application of such technology does not necessarily require that all valves in the OM&S area be converted to remote operated valves (ROV). At one site, more than 100 hand valves were in regular use. The cost of converting them with the associated signal and power cabling would have been prohibitive. Instead, the refinery was able to install an almost equally effective system by automating less than 10 per cent of the valves and relying on portable radio-linked data terminals for the remainder.

These terminals relay operator instructions from the main system and wait for acknowledgement that the instruction has been executed. They incorporate barcode readers to ensure the operator is working with the correct valve. Although not as foolproof as ROVs, such an approach offers almost the same level of security but at a fraction of the cost.

Other developing technologies are also helping to bring down the price of such systems. For example, battery powered radio transmitters can be fitted to limit-switches on hand valves to transmit the valve position to the system. Without the cost of power or signal cables this technology can be very advantageous. Earlier systems required a great deal of custom software to manage the complexity of the OM&S area in terms of the multiplicity of possible routings and selection criteria.

The more experienced vendors have now developed a much more pragmatic approach to the problem and, with the use of modern database techniques, significantly reduced the cost of customisation. A large proportion of the benefits may be captured by the implementation of purely monitoring functions. Since these can usually be less costly to install, this may improve the overall project payback.

This approach may be better, but great care should be taken in identifying all the available benefits, and the lower cost options, before the scope of the project is finalised. The experience of most refineries that have taken this approach is that either the full automation project will now never be implemented or that a costly upgrade of the monitoring system was necessary to make it compatible with full automation.

Some refineries have been able to justify OM&S automation at least in part by the reduction of hydrocarbon inventory. A refinery planned a major refinery upgrade that would have involved the construction of additional tankage. Careful study revealed that the existing storage facilities could support the revised refinery configuration but not without investing in better automation systems.

The cost of such automation was less than the cost of the additional tankage which would otherwise have been required. This opportunity does not present itself in most sites but there are nevertheless usually many other smaller potential reductions in inventory. For example, the reduction in product blending times allowed the refinery to reduce inventories by the equivalent of 12 hours production.

The ability to fully utilise OM&S equipment also occurs elsewhere. It is possible to more closely approach limits such as storage temperature, tank high and low levels and pumping rates – in some cases permitting the limits to be widened. It becomes possible to schedule movements to occur at the most cost effective time rather than compete for the use of shared equipment. OM&S data become more readily available to the refinery planners so that they can better schedule imports and exports. A 100 000bpd refinery, reducing its inventory by 24 hours production, would save almost $200 000 a year in interest charge on working capital.

A number of other benefits can arise from improved planning decisions. A refinery was in a position to buy spot cargoes. It needed to be able to quickly assess the value of such a cargo, in terms of likely product yield but also in terms of the impact it would have on refinery logistics. This required immediate access to current and projected inventories of crudes and products, crude import and product lifting plans, crude processing and blending plans.

The OM&S system was attributed with helping to increase profitability by $300 000 a year from being able to properly exploit such opportunities. Another refinery was incurring demurrage charges of $2 million a year, due mainly to problems in jetty occupancy, pumping limitations, product availability and early arrival of ships. Scheduling aids implemented with the OM&S system helped reduce these costs by about $100 000 a year.

Errors

Many of the problems in preparing a reliable and timely refinery mass balance arise from the OM&S area. Often, most OM&S measurements must be recorded manually, with the results therefore prone to error in both magnitude and timing. Often, flow-meters are shared between a number of different routings and, although their measurements may be collected reliably, there is no automatic collection of the timing of routing changes. In concept, OM&S measurements should be a more accurate way of determining the mass balance.

Many meters are associated with custody transfer or tax calculations and are therefore regularly maintained and calibrated. Tank dips, if collected over a relatively long period, are a very accurate way of determining product flows. OM&S systems permit this accuracy to be exploited.

Using a statistical data reconciliation package, a refinery was able to accurately reconcile plant flows with OM&S flows. Among other problems, this helped the refinery identify that a costly unnecessary recycle was in service. The reconciliation package also reliably identified suspect measurements leading to a more effective instrument maintenance, selective upgrades to instruments identified as key to an accurate mass balance and a general improvement in the reliability of process data.

Another refinery was able to validate process flows, supporting the suspicion that product yields were low and likely to be caused by minor equipment damage. Without the OM&S data the refinery would not have had sufficient confidence in its analysis to shut the plant for repairs until the next routine shutdown 18 months later. In another incident, a refinery was able to rapidly diagnose the loss in kerosene yield as being caused by a faulty stripping steam meter, and it was able to resolve the problem rapidly, which would otherwise have gone undetected for several months.

Such reconciliation has been exploited in other ways. In one refinery accurate ship to shore reconciliation saved over $4 million a year in import shortfalls and underbilled exports.

Data reconciliation is also an important part of oil loss management. A refinery had a reported loss of more than 0.5wt%, but with a standard deviation of 0.45wt%. It was therefore not possible to say with any confidence whether the magnitude of loss was reasonable or a cause for concern. With the implementation of OM&S automation and a number of other measures a significant improvement was made to the confidence interval and a real reduction of 0.15wt% in oil loss was achieved. Attributing a third of this reduction to the OM&S system, in a 100 000bpd refinery, results in a saving of almost $1 million a year.

The historical data stored by such systems can also be of great value. A refinery was able to diagnose an incident of discoloured jet fuel which had, in fact, been caused several weeks earlier in the OM&S area as a result of a leaking valve.

Without the system the incident would certainly have recurred, costing about $200 000 each time. Another refinery, without such records, overestimated a product volume incurring a tax bill of $200 000. Without the historical data it was unable to convince the authorities of the error. Another refinery was prone to spurious claims because it did not have adequate records for defending them and had built itself a reputation for readily paying for small claims rather than fully investigating them.

A number of refineries have benefited from a reduction in slop production. OM&S automation quickly draws the operator's attention to changes in slop production and can quickly identify the source. Apart from the inventory and rerunning costs, slop production can prove particularly costly in sites operating against throughput bottlenecks. One refinery crude unit was limited by overheads cooling.

Reprocessing naphtha type slop requires a reduction of 6kb of crude for every kb of slop processed. The loss of margin increased the debit of running slop on this unit from $0.75/bbl to $3.75/bbl. OM&S automation was attributed with reducing slop production by 50 000bbl/yr, saving almost $200 000 a year. Similar situations exist in other refineries which are sulphur limited. Rerunning high sulphur slop utilises limited hydrotreater capacity ultimately resulting in an increase in the purchase of more costly low sulphur crude.

Many opportunities exist for energy reduction in the OM&S area. Fewer blend corrections and transfers reduce the number of pump starts and associated high power demand. Mixers can be configured to switch on and off automatically, minimising their use. Since blend automation almost eliminates tank layering then much less mixing is required. Unnecessary or excessive line clearing is avoided, again reducing pumping costs.

Tank heating can be automated to keep heating to a minimum. In one refinery, these savings were found in total to be worth about $100 000 a year. In some refineries there can also be large benefits in making short term reductions in electrical power consumption. Violating previously agreed peak demands can prove very costly in terms of tariffs. In some countries power producers are paid premium prices if they export power during exceptionally high domestic demands.

Large parts of the OM&S area can generally be shut down for short periods without detriment to the refinery operation, provided this is done in a well managed way. A refinery determined that a timely response to peak demands, only possible with automation, was worth more than $600 000 a year.

Once the project has been proved to be economically viable great care should be taken with the selection of technologies and their integration. It is unlikely that OM&S automation can be considered entirely as a standalone project. The system itself requires data from a number of other sources and is also a provider of data for use throughout the refinery.

A typical refinery information system is shown in Figure 1. OM&S automation should be considered in the context of the site's overall information system plan. Not to do so is likely to significantly reduce the value of the information it collects and result in large re-engineering costs as the demand for better integration grows. Many refineries have taken the approach of installing, over several years, low cost equipment dedicated to basic functions. In the longer term this proved to be a false economy, resulting in costly retrofitting and special modifications.

The performance of existing systems to be incorporated into OM&S automation should also be reviewed. A tank gauging system in one refinery was adequate for manual operation but failed when polled more frequently by the OM&S system, resulting in an unscheduled and uncosted addition to the project.

Last, but not least, similar consideration needs to be given to the associated organisational changes. One refinery, for example, had to delay commissioning its blend automation system while it resolved the organisational issues associated with moving the responsibility for blend recipe definition and adjustment from its planning group to OM&S operations. This delay which, with hindsight, could have been avoided, adversely affected the return on investment, reducing the site's enthusiasm for similar investments. □

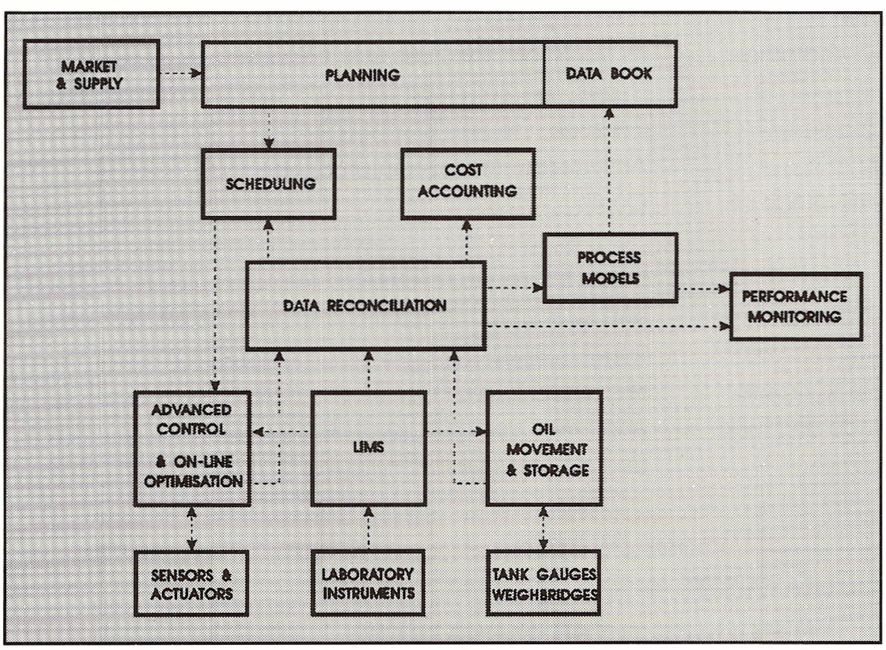

Figure 1. Integrated process information and planning system.

Myke King *is a director of Whitehouse Consulting, Southampton, UK. He is responsible for consultancy services, assisting clients with the development and execution of advanced control and information system projects.*