PLANT-WIDE OPTIMIZATION

A BETTER WAY

Honeywell

INTRODUCTION

Once content to simply apply model-based controls or optimization strategies to a single operating unit, many control engineers now turn their attention to a bigger prize: optimization of an entire facility.

What is quickly realized, however, is that this problem is exponentially more challenging than that of the control or optimization OF a single unit.

Trying to apply the standard APC technologies or alternative rigorous modeling techniques to multi-unit optimization has proved difficult as the problem scale is increased. The performance, veracity and maintainability of these ambitious and well-intentioned solutions suffer. To be successful, one needs a new approach. This paper examines one such approach, Honeywell Forge APC Plant-Wide Optimizer.

ALTERNATIVES

Many approaches have been suggested to solve the Plant-Wide Optimization problem. Concepts such as a "Big APC", steady state rigorous optimization, and directly driving optimization from the LP have been tried. But each has their pros and cons.

Regarding the Big APC Controller approach, there are some good aspects of this method. It does run quickly and is built on well-vetted dynamic models that are derived from actual plant responses.

It can handle some nonlinear aspects, either through gain updating or the use of a nonlinear models. On the negative side, it can get stuck in a local optimum, not manage control vs optimization trade-offs very well and can be extremely complicated due to the sheer number of manipulated and controlled variables in the problem. When the control engineer is unable to interpret or to explain the results to others, faith in the solution is quickly lost.

What are the pros and cons of a steady state rigorous model approach? The application of (typically) unit-based rigorous, model based Real Time Optimization solutions to a plant-wide does problem does have some upside. It produces very detailed results, including product quality and component predictions. It also inherently handles any non-linear aspects, extrapolates well and can find an interior (unconstrained) optimum. However, even a single unit RTO can require a significant annual engineering hour commitment to maintain, one can easily imagine the required effort when there are multiple RTO solutions at a given site. This approach does require data reconciliation, triggered by a steady state check, which may not come around all that often as the scope is expanded. And certainly, the argument that a global optimum may be reached by deploying many independent, standalone RTOs is a tough one to make.

Some have suggested that the best way to optimize the plant is to put the plant's LP online. The LP is built to handle a large scope and will typically have the profit function for the site already built in. But LPs are not really designed to run on-line; they are big, have a lot of detail to them and can be slow to execute. And critically, since the LP is an abstracted, or simplified, representation of the site, it could well generate solutions that are either infeasible or suboptimal.

The ideal solution needs the best parts of both big and multiple small application approaches. Certainly, the re-use of models, not just control models, should be done wherever possible. The objective function should be representative of the plant's true profitability, not just several local, somewhat independent objective functions cobbled together. Additionally, the solution should be robust in the face of changing process conditions and easy to maintain. The next section examines what Honeywell believes is the best solution

HONEYWELL'S APPROACH

Honeywell introduces innovative techniques for Plant-Wide Optimization, bringing a holistic approach to integration of planning and execution layers

To meet the challenges of Plant-Wide Optimization and provide the opportunity to integrate the planning and execution layers, new approaches are required. As problem size and complexity increases, it has become necessary to provide an optimization layer which can simplify a wide scope optimization problem into a reduced problem size. Being able to create an optimization application which contains only the critical global optimization variables, but which still respects any potential constraint within the lower level APC applications, allows a more effective optimization to be achieved. It also simplifies the user interface and makes commissioning and maintenance tasks significantly easier.

Honeywell Plant-Wide Optimizer, part of the Honeywell Forge APC offering, is an optimization layer which is designed to sit above multiple APC or optimizer applications. The user can select individual variables which are connected between the Plant-Wide Optimizer and APC / Optimization layers. This gives considerable flexibility to specify only the critical, enterprise-wide variables, without requiring detailed modeling of lower level constraints and relationships.

Honeywell Plant-Wide Optimizer performs a comprehensive check of potential constraints in the lower level controller (ie. ensures feasibility of any optimizer generated solution). Additionally, Honeywell Plant-Wide Optimizer utilizes standard Forge APC components and connectivity,

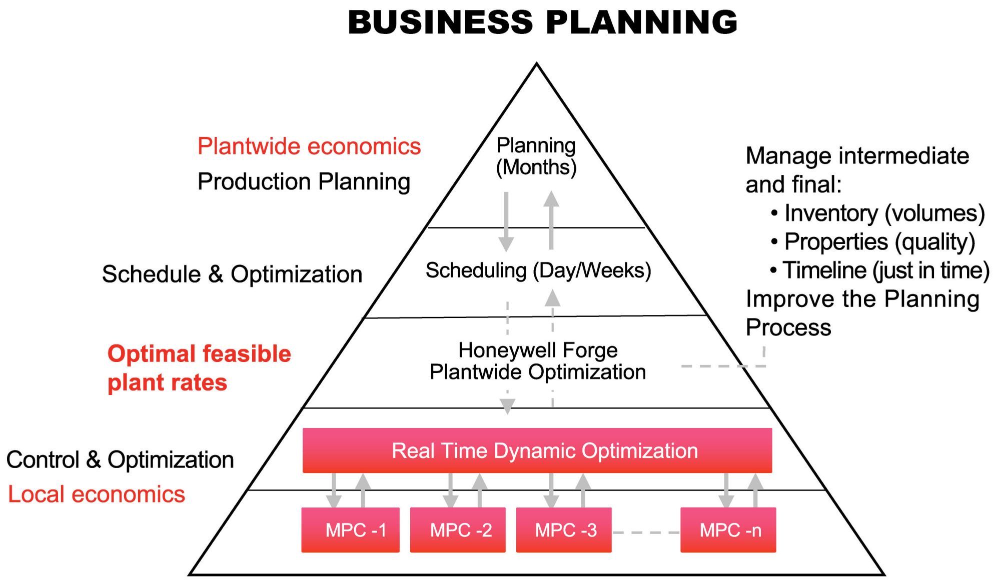

Figure 1: Honeywell Plant-Wide Optimizer

The key to providing this consolidation of the detailed lower level constraints into a reduced variable set at the site-wide optimizer level is the use of Proxy Limits. Proxy Limits are a representation of the feasible optimization space available within each APC level application and provide this information as CV or MV constraints to the site-wide optimizer layer. Calculation of these Proxy Limits happens dynamically at the APC level, at the request of the optimizer. There is no additional modeling or configuration effort required to support this calculation at the APC level. Model changes to the APC applications, which may come from actions such as gain updating or maintenance tasks, will be automatically recognized by the proxy limit calculation.

Engineering configuration for the Plant-Wide Optimizer application is focused on developing the gain matrix of the optimizer application level. This may be derived from broad first principles assumptions (i.e. known mass balance), from planning system data (ie. yield vectors) or from historical data. There is no need to replicate the detailed modeling of the lower level APC applications. Additional CV's or MV's relevant only to the global optimization may also be added to the optimizer layer without having to add them to any individual optimizer application.

The advantages of this approach include:

- Reduced problem size – The optimizer application consists of only the critical variables relevant to achieving the site-wide optimization objectives. Less variables are required to be transferred between applications, and the user interface for operators is consolidated and clearly presented.
- No loss of fidelity in constraint control – While individual constraints are not seen explicitly by the optimizer layer, the use of the proxy limits ensures the Plant-Wide Optimizer maintains a feasible solution and can control accurately to any potential lower level constraint.
- Better ability to handle time-scale differences – Slower dynamic CVs will typically exist at the optimizer level, whereas the faster ones exist in the lower level APC's. The Plant-Wide Optimizer can be independently scheduled to execute at low frequencies needed to handle slow dynamic CVs without impacting the handling of fast dynamic CVs
- Better usability (separation of responsibility and focus) – The Plant-Wide Optimizer is responsible for production optimization and inventory balance, whereas the APC's can independently maintain responsibility for unit control and stability.

CASE STUDIES

Example: Upstream Field Management

Operation of upstream oil and gas facilities is a complex process involving numerous assets that may be dispersed over a wide geographic area. These assets may include production platforms, gas-gathering networks, transmission pipelines, gas treatment plants and mid-stream NGL or LNG production facilities. Maximizing the production rate of valuable hydrocarbons from these facilities requires careful and continuous co-ordination between the assets. Any point within the production system may be a bottleneck, and disruption of operations at any asset may require a response that affects the whole system.

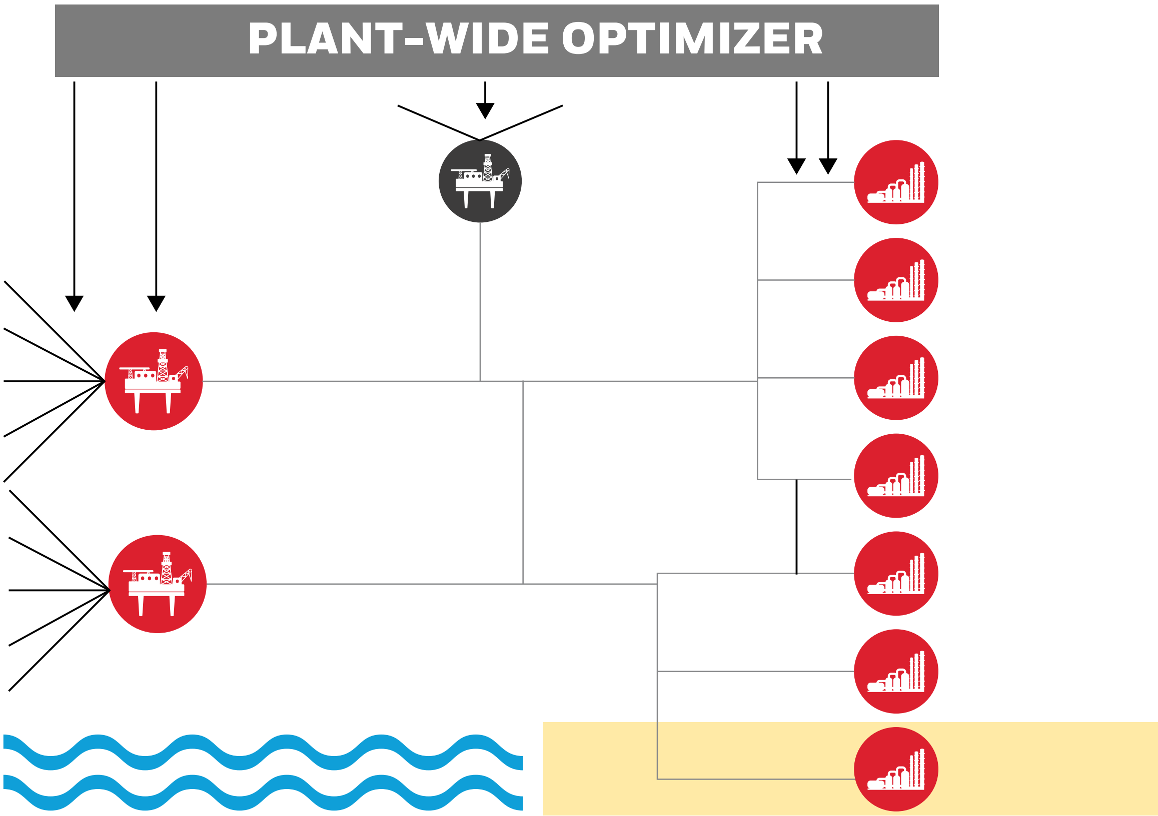

Figure 2: An example of a complex upstream production network Honeywell Forge APC Plant-Wide Optimizer has been deployed to manage these complex upstream networks. The optimizer objective in this case is to maximize the production of valuable hydrocarbon products from the overall facilities, manage the pressure and other constraints within the piping networks, and set the throughput of the various gas processing facilities onshore. The dynamic interactions between variables are recognized, back-pressure effects are accounted for, and production is distributed between downstream facilities in the most efficient way. The Plant-Wide Optimizer delivers maximum utilization of the available assets, leading to higher hydrocarbon production and improved yield of high-value products. The flexibility and responsiveness of the system to any external changes, such as ambient conditions, is also greatly improved.

Example: End to End Optimization of an Oil Refinery

From a functional perspective, control and planning departments in an oil refinery are almost always dependent on one another. Planning relies on control to implement its' operating plan, while control relies on planning to set the operating targets for the entire plant at the most profitable operating point possible.

The problem, historically, is that these two functions have not always worked together in an optimum way. For example, operating targets produced by the planning department might call for a unit charge rate that is not currently attainable due to constraints on the unit. In this case, operations must determine what the unit charge rate should be. In an ideal world, this feedback, the fact that the planning target is not achievable, should be shared with Planning, but how often does this happen? And doesn't that throw the validity of the planning solution into question; the fact that it was predicated on a unit charge rate that was not feasible? There are issues on the other side of this problem as well. What if the planning model assumes, for example, a unit charge rate maximum limit that is less than that which is currently achievable? This would appear to mean that money has been "left on the table". It seems like there should be a better way.

Honeywell's Honeywell Forge Plant-Wide Optimizer solution fills this void. The coordinating optimizer uses a pre-existing planning yield model to provide an initial steady-state gain matrix, and the relevant model dynamics can be fleshed out from the historical operating data of the facility. It controls the product inventories, manufacturing activities, and product quality. Its embedded economic optimizer, which is furnished with the same planning model structure and economics, reproduces the off-line planning optimization on-line and in real time.

The cascading layers provide the coordinating Honeywell Forge Plant-Wide Optimizer with future predictions of secondary CVs/MVs and the operating constraints inside every unit. With this supplemental information, the real-time planning solution of the two-tier MPC cascade has real time feedback and will now honor all the unit-level operating constraints and guarantee feasibility.

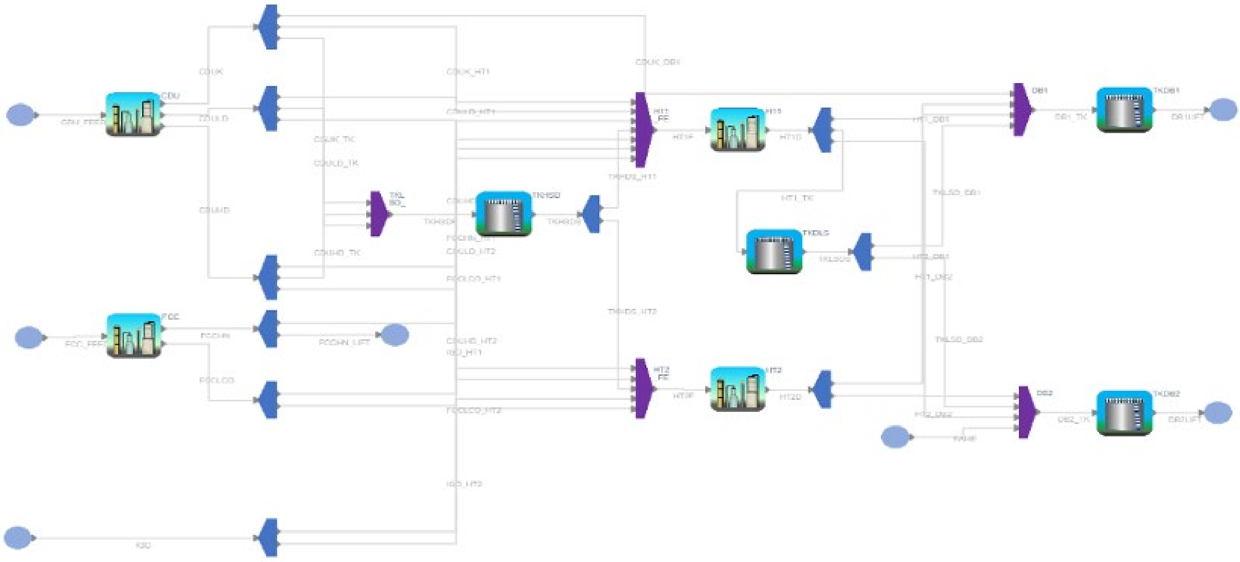

Figure 3: An example of an oil refinery network

Jointly, the MPC cascade provides simultaneously decentralized controls at the low level with fine-scale MPC models and centralized planning optimization at the high level with a coarse-scale yield model, all in one consistent cascade control system.

The main benefit areas for refiners are to reduce product quality giveaways, optimize intermediate component production (tied heavily to the first benefit), to make more high value products with same feed, or to potentially handle new feed type.

Another area to consider is the way in which planning of the on-site process unit and off-sites, or blending, is typically executed. There is typically a plan generated that sets the process unit key operating targets such as rates, cut points and reactor severities, with the ultimate goal of meeting final product demand in the most optimum (economical) way possible. In parallel with this, there is often a rigorous planning exercise in the off-sites areas, considering the blending component volumes, qualities, inflows, and of course the final product quantities and volumes. This is also an economic optimization. As can be seen, however, these two processes, tend to operate in a somewhat independent manner. Another point to be made is that the Blend Planning executed in the Off-sites areas never has the luxury of driving the component volumes or qualities, by reaching back and setting the process unit key operating parameters. They are essentially “making the best” of the lot that they are given. So, while it is commonplace to think that a top-shelf off-sites operation will drive quality giveaways down to a minimum, this is virtually impossible to do in the steady state sense unless the process units are actually producing component volumes and qualities in alignment with product demand and optimum component recipes. This “Tale of Two Planners” story is another problem that Plant-Wide OPtimizer seeks to resolve; by solving the on-site and off-site planning problems simultaneously.

CONCLUSION

APC Engineers are always looking for the next challenge, new ways to add value to their site.

As they turn their sights on the implementation of Plant-Wide Optimization strategies, several things become clear. First off, the traditional control and optimization tools like APC and steady state Optimization, while they can certainly be a part of a plant-wide solution, cannot do it alone. Additionally, reusing existing model information, such as a planning model, can provide a good foundation for a site wide strategy. Incorporating Honeywell's Plant-Wide Optimizer effectively provides a solution that combines the broad optimization objectives of a planning model with the up to the minute constraint awareness of an APC controller. The technology can and has been applied to a variety of vertical industry problems, including a metal production complex, upstream oil and gas facilities and oil refineries.

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Nic joined Honeywell Process Solutions in 1998 as an APC Engineer. With over 20 years experience in process optimization in different roles with Honeywell and across a wide range of industries, Nic is now a **Technical Solutions Consultant based in Perth Australia**.

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For more information

Learn more about how Honeywell Forge Advanced Process Control Visit: http://hwll.co/AdvancedProcessControl or contact your Honeywell Account Manager.

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