

Honeywell Provides Advanced Process Control to Meet Robustness Challenge at Furfural Extraction Unit at Grupa Lotos Refinery in Gdansk, Poland

Profit® Controller, Honeywell's Advanced Process Control (APC) solution using Robust Multivariable Predictive Control Technology (RMPCT), is a software package designed to optimise technological processes via existing process control systems implemented at a customer's site. The schematic of a general Honeywell APC solution strategy is shown in Figure 1.

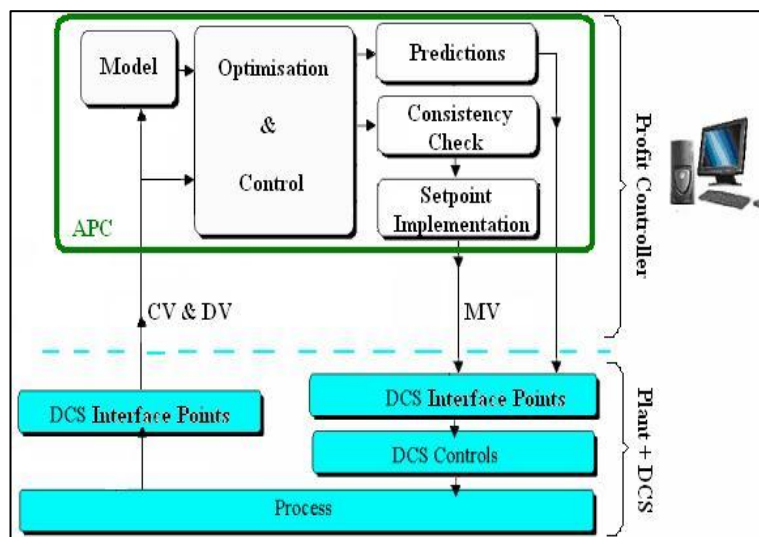


Figure 1. Honeywell APC structure

In 2007, Honeywell carried out several APC projects at the Grupa Lotos S.A. (GLSA) refinery in Gdansk, Poland, including implementation at the furfural extraction unit. In this article, the APC methodology and benefits from the Profit Controller implementation are briefly described.

The furfural extraction unit is designed for base-mineral lube oil production. The technology is fairly straightforward, but the process has many renewable circuits which render dependencies and correlations between process variables hard to determine. This APC project utilised Honeywell's RMPCT multivariable controller, and was designed to control 42 process variables (CV) and account for five disturbances variables (DV) through 15 manipulated variables (MV). Multi-input-multi-output (MIMO) technology has been fully applied here.

GLSA's main objectives of the APC application were as follows:

- Maintain a raffinate refractive index between high and low limits with minimal giveaway (+/- 0.0002 RI)
- Maintain furfural flow subject to solvent-to-feed ratio limits while maximising raffinate yield

There were also some other objectives required by the GLSA refinery's lube department management and local process engineers such as maintaining optimal feed temperature to the extractor column, maintaining optimal extractor column delta and top temperature, maintaining pseudo-raffinate temperature subject to pseudo-raffinate flow to extraction column, keeping feed within ratio limits, managing furnace pass flows to maintain the required

temperature differences (pass coking rate management), maintaining furnace coil outlet temperature at a specific temperature range whilst honouring furnace loading constraints, maximising feed subject to process/controller constraints (this objective was secondary to maximising yield) and minimising steam flow to the columns. Overall, the task was to minimise energy consumption/furfural losses where possible. To achieve all the tasks listed above, the APC strategy shown in Figure 2 was developed.

The Honeywell RMPCT package is a predictive, model-based controller. A model of the furfural plant is represented by a transfer matrix which was derived from step tests carried out on site. Based on the step test responses of properly chosen variables, CVs/MVs and CVs/DVs, specific transfer functions can be evaluated. When the process model is known, a prediction for all investigated variables can be easily obtained and used for a controlled outputs evaluation. Profit Controller outputs are calculated based on the Range Control Algorithm (RCA) while optimisation in Profit Controller can be achieved by either linear or quadratic programming (LP or QP). A particular method is chosen depending on optimisation variable conditions and limits.

During the controller design it turns out that the main challenge for Honeywell engineers was to develop and tune the APC controller in such way that it would provide benefits for four different feedstocks producing seven different grades of lube oil. In other words, the controller had to be robust enough to handle a wide range of feed grade types, from very light (SN-140 through SAE-10/95, SAE-10/85, SAE-30/95, SAE-30/80) to the heaviest ones (BS-30/95 and BS-30/90.) For this reason, the whole step test and model identification procedure was performed for different feedstocks to obtain the difference between transfer functions for each grade. Grade SAE-30/95 has the most mid-sized properties, so all controller tuning and optimisation coefficients were matched for this type of feedstock.

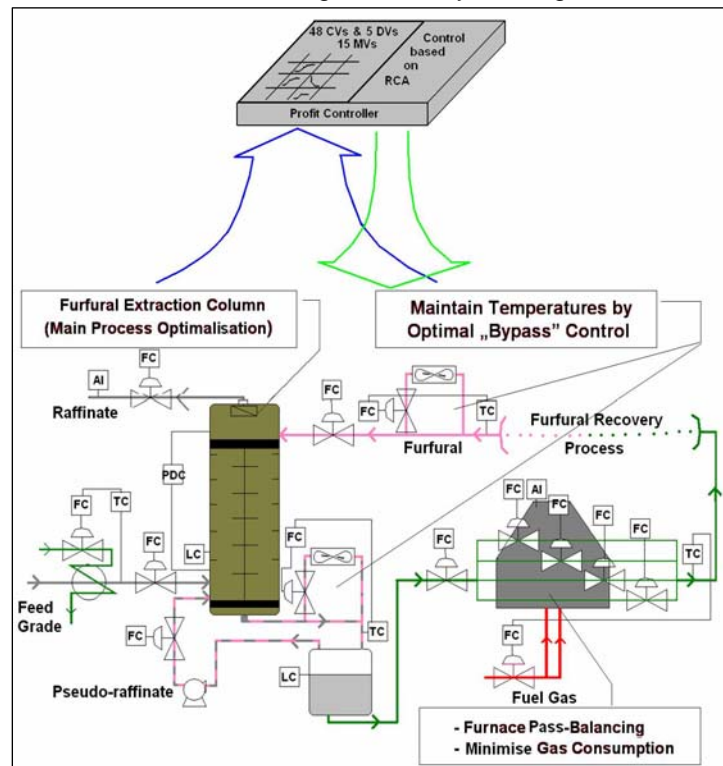


Figure 2. Simplified representation of the APC strategy for furfural unit.

After proper tuning, tremendous results were achieved. The APC is able to control and optimize furfural extraction process at GLSA for all four feedstocks and seven product grades, and is capable of dealing with all kinds of disturbances. Not only those which were modeled, such as ambient temperature and oil feed refractive index, but also with those which turn out to be unpredictable, such as level control for pseudo-rafinate stripper, while very heavy grades are fed to the extraction column. Such a highly robust solution through RMPCT technology is the result of problem-conditioning defined by offline scaling (primarily for engineering units) and online scaling where a URV threshold method is used. The robustness of the solution at the furfural extraction unit was also achieved because Profit Controller can prevent exploiting weak response models. Moreover, a built-in RCA engine includes other online robust features such as funnels and minimum move solutions. All these features enable a RMPCT controller to work with high performance, reject disturbances and push the process to an optimum region in a timely manner. Furthermore, RMPCT provides

mechanisms to avoid controller instability when control effort is sensitive to error. Results of post-Profit Controller application on the furfural unit are shown in Table 1.

Feedstock Grade	SN-140	SAE-10/95	SAE-30/95	BS-90 Grade
Raffinate Yield Change	+2.09%	+1.39%	+0.18%	+3.80%

Table 1. Results of the post- Profit Controller application on furfural unit at GLSA

The benefit calculations are based on hourly averaged data retrieved from the Honeywell PHD database, together with laboratory results. The data is analyzed for benefits by season (summer and winter operation modes) to take into account the different feed costs and product prices. The basis for estimating benefits via analysis of before-control data is to calculate how much the mean of the key-process variable can be moved in a profitable direction. An assumption is made that the data fits a normal distribution. The result of Profit Controller implementation is a reduction of process variability measured by the standard deviation change. The commonly accepted reduction in standard deviation for this type of solution is 25%-50%. In this instance a 52% reduction was achieved. This reduction allows the unit to operate closer to its constraints. Depending on process specification limits and obtained results, the following methods for profit calculation are applied: the same limit rule, the same percentage rule and the final percentage rule. These methods are well known and published in several international journals. Obtained benefits were recalculated by the GLSA production planning department, approved by lube production managers and confirmed by local process engineers and operators. To summarize, the Honeywell APC application at the Gdansk refinery is best expressed by K. Kowalczyk, lube plant manager, "At process steady condition APC will always guide process more effectively and optimally."

Based on the numbers shown above it can certainly be said that the process improvements and achieved benefits after APC implementation are clearly visible. In Table 1, only profit which comes from raffinate yield change is presented. There are many profits which were not quantified, but have made the process smoother, more profitable and user-friendly for operators.

The total audited and agreed benefit resulting from an increase in raffinate yield turns out to be \$2,321,481 per annum. This amount significantly increases earnings of the GLSA refinery.

It is important to mention that the ability to achieve such a huge success derives from close cooperation between Honeywell consultants and local DCS engineers. The plant management's experience and feedback was indispensable. To mention but a few who contributed to this success: Mr. K. Kowalczyk, A. Staskiewicz, A. Sobolewski, M. Zienkiewicz and M. Jarzemski from GLSA, and K. Walters, A. Frydrych, M. Hynek and G. Oleszczuk from Honeywell.

After the fruitful experience gained on this project at the furfural unit, both the GLSA refinery and Honeywell are looking forward to working together on future APC projects.