Benchmarking effectiveness of APC, from a process engineers' point of view.

Abstract

This paper is useful for process engineers working in continuous plants, which need to operated optimally. Typically, such plants have APC and/or optimizer systems, which in turn are being maintained by in-house or vendor's specialist engineers.

The paper gives logical, experienced based APC benchmarking method, which does not need any calculations.

APC is now a regular feature in most of plants in refining, oil & gas, fertilizer, petrochemical, chemical, metal, paper, plants.

Introduction

This paper has following parts

1. Need for APC benchmarking- for ensuring optimal plant operations, making investments in APC/APC modifications/Optimizer/Optimizer modifications.
2. A brief example and few terminologies
3. Defining "operator trust" on APC to control any particular plant parameter
4. Qualitative ranking of APC for supervisory control and optimizer
5. What does SEPARATE optimizer, over and above APC, do?
6. What is the required optimizer frequency
7. Summary/conclusion

1. Need for APC benchmarking- for ensuring optimal plant operations, making investments in APC/APC modifications/Optimizer/Optimizer modifications.

APC is typically installed in plants, which need to be optimally operated. It is believed that as long as APC is "working" plant is optimally operated. While installing APC, there is typically an investment justification in terms of better plant performance- more profits.

APC vendors claim that benefits of APC are typically 10 times more than cost of APC. However, there are occasions when APC performance needs to be verified/questioned/benchmarked. Such occasions are

a) APC needs an upgrade and investment needs to be justified
b) Operator complains lack of trust on APC
c) Management questions whether APC is making any significant impact on plant performance, or just justifying its cost.

On such occasions, either

APC engineers give long calculations or report of hundreds of APC related parameters, claiming that APC is working well. Typically, these are neither understood nor believed, by process engineers/management.

Or

APC vendor is able and dares to present direct money benefits actually accrued, which process engineers/management are afraid (yes) to agree or disagree, on paper!

Therefore, this paper gives an approximate, non-quantitative, non-money based, method, to arrive at a consensus about effectiveness of APC, at a high level. It is NOT the purpose of this paper to teach APC engineers, how to do good APC.

2. A brief example and few terminologies

This paper is written for engineers working in industry, not a research paper, hence instead of defining abstract parameters and stating a theory based on such parameters, an example is presented, based on which the concept/methodology of qualitative APC performance benchmarking is explained. Here is our example plant

Feed is heated in a furnace, up to a temperature-COT. COT can be varied, based on feed composition. Heated feed is then fed to a column, to separate into several products, say 9 products, in this example. There are properties of these products to be controlled, product flows can be varied. Example of product property are LPG weathering, O2% in stack, innerts in loop, iodine number, etc. Typically, these are lab determined, sometimes analyzer measured.

We have feed, flow of which is set by operator, APC neither controls or decides the flow. Such parameters are called as “DV” by APC folks.

APC is supposed to maximize yield, while controlling product properties. These are called as “product property CV” by APC engineers. Typically, these are lab determined, as well as “inferred” in APC, i.e. APC calculates these product properties.

Then there are parameters like COT, product flows, which are operator handles to control product properties. These are called as “MV” by APC engineers.

3. Defining “operator trust” on APC to control any particular plant parameter

To control and optimize plant operations, operator gives “LIMITs” to CV, MV within which APC has to operate. I.e. APC decides the actual value of that CV/MV, but WITHIN the limits given by the operator. The nature of limit shows operator trust on APC.

Let us take example of a product flow. Say the control valve can manipulate the product flow from 0% to 100%, but typical flow is between 70% to 100%.

Now, if the operator sets a limit of this product flow as 70% to 100%, that means operator trusts APC fully, to decide this product flow.

Alternatively, if the operator sets the product flow limit as 78% to 82%, this really means that operator doe NOT trust APC to decides this flow. Operator has worked out 80% as the right flow and given a narrow limit of 78% to 82% to APC. The product flow is really decided by operator, not by APC, even if APC is “ON”.

It is difficult to give a generic quantified formula for narrow or wide limits, but it should not be particularly difficult for process engineer in a particular plant, to define so, for the MVs in that particular plant.

To test whether operator trust APC as a whole for a particular plant, make following table, for ALL APC MV in that plant, in our example

Sr.No	*MV*	*Limit is narrow or wide?* *If MV is "dropped" consider limit as narrow*
1	COT	Narrow
2	Product Flow1	Wide
3	Product Flow 2	Narrow
4	Product Flow 3	Dropped- Narrow
5	Product Flow 4	
6	Product Flow 5	
7	Product Flow 6	
8	Product Flow 7	
9	Product Flow 8	
10	Product Flow 9	

Now summarize, for example,

Total Number of MV= 10

Number of narrow Limit MV= say 1, COT

Number of wide Limit MV= say 9, all product flows

Rule of thumb- if MOST, i.e. 80% or more, MV have wide limits, then operator trusts APC as a whole, for the entire plant.

If MOST of the MVs have narrow limits, then operator does not trust APC, even if APC is seen as "ON".

4. Qualitative ranking of APC for supervisory control and optimizer

APC does two major functions

First, SUPERVISORY CONTROL- i.e. ensuring that CVs are within limits, by changing MV values within operator set limits. In our example, this means ensuring that product properties are within limits, by changing product flows, COT, but within the limits set by operator.

Second- OPTIMIZATION- here, APC has an objective “configured”, in our case, it is the yield, and APC tries to maximize the yield WHILE controlling product properties (CV) and changing product flows (MV). “configured” means, APC has been told to optimize. Otherwise, APC can do good supervisory control-without optimization, as well.

Thus,

Deciding MV (COT, product flows) changes for optimization AND control, at the same time, is FULL functionality of APC

If operator trusts APC, supervisory functionality of APC is benchmarked as good. If operator does not trust APC, then optimal parameters are decided by operator, and not by APC.

Based on above, APC can be benchmarked into 4 levels

Sr. No	*APC benchmark performance*	*Test*
Level 1	Ideal best performing APC. APC doing good supervisory control APC capable to optimize, and optimizes- if configured to optimize.	ALL MV have wide limits
Level 2	Practically good APC APC doing good supervisory control	MOST (more than 80%) MV have wide limits

Sr. No	*APC benchmark performance*	*Test*
	Does some optimization- if configured to do so, but not fully, operator has to work out optimal parameters	
Level 3	Non-optimizing, sub-performing APC APC doing some supervisory control Certainly not capable of optimizing	MOST (80% or more) MV having Narrow limits
Level 4	Bad APC Basically, operator is optimizing as well as doing supervisory control, even if APC is "ON"	ALL MV have narrow limits

The purpose of APC benchmarking is not to give a character certificate, but to decide investments/actions related to APC. Although it is impossible to give generic rule, following is applicable many times-

Sr. No	*APC benchmark level*	*APC action needed*	*Optimizer action needed*
1	Level 1	No action needed	No action needed, no separate optimizer needed <u>IF</u>

Sr. No	*APC benchmark level*	*APC action needed*	*Optimizer action needed*
			optimizer configured in APC
2	Level 2	Action needed to bring ALL MV to wide limits	If the narrow limit MV impact optimal plant performance, then separate optimizer needed, over and above APC
3	Level 3	Needs action to correct APC	Separate optimizer may be needed, over and above APC, even if APC corrected
4	Level 4	Needs action to correct APC	Separate optimizer may be needed, over and above APC, even if APC corrected

5. What does SEPARATE optimizer, over and above APC, do?

Such optimizer may be needed, if APC is Level 1 and not configured to optimize, or APC is of Level 2,3,4. This is the pure technical justification for optimizer, over and above APC. However, the real justification for such optimizer is amount of additional yield/profit generated-over and above APC!

This SEPARATE optimizer, over and above APC,

1. Typically has a process model and optimizer

2. Is very accurate (much more accurate than typical steady state simulation models), as the job of optimizer is to decide fine changes for operating parameters, which are already in a narrow range-as the plant is already fabricated and has a SOP. Steady state simulator work in a wide range of parameters, mostly, before the plant is fabricated,
    a. To decide type of equipment e.g. packed column or tray column
    b. To decide process operating regimes e.g. low temperature reaction with lower yield but higher selectivity OR high temperature reaction with higher yield but with lower selectivity

The most interesting is what this optimizer, over and above APC, does. It says, "right now, yield is 78%, there is opportunity to increase yield to 80%, by changing COT, product flows within the typical operating range, and these will be the values of product properties, COT, product flows, and all other process parameters, for 80% yield, given the composition and flow of feed, RIGHT NOW"

This is exactly what the operator works out/should work out, before giving limits to APC, depending upon trust level on APC!

6. What is the required optimizer frequency

The optimal state is disturbed by

1. Feed composition/flow changes.
2. Environmental disturbances, e.g. ambient temperature, cooling water temperature, deterioration of equipment

The frequency of optimizer has to order of magnitude same or more, than the highest frequency of disturbance. E.g. if feed changes every week, the optimization of parameters has to be done weekly, or more than once weekly.

7. Summary/conclusion

Of all the process plants in world, very few (10%?) have systems to optimize performance like APC, optimizer. Many are operating such systems as a matter of compliance or just "installed but not working" Of these 10% plants few (10%- i.e. 1%

of all the process plants in the world) have the real enthusiasm, real sincerity to run a plant optimally. This paper is written for those 1%.

Therefore, this paper is not to demoralize those 1% brave people, but to help them, overcome "political" challenges, and to help to continue the rare good work they are doing in running the plants optimally, using APC/optimizer or with no special system.

There is no summary of paper-kindly read whole of it, otherwise it won't make sense.

Author- Samir Gijre, 53, lives in Pune India, and is APC engineer at heart. Samir.Gijre@benchmark1.in