Manual: 4. Advanced Process Optimizer (APO)

Operating a plant is a complex task for the operators who have to make many detailed decisions every few minutes on how to modify the set-points of the plant in order to respond to a number of external factors. The plant must always deliver what its customers demand and it must respond to changes in the weather and the quality of its raw materials among other things.

Plants are operated in shifts. A frequent observation during a shift change is that the new shift believes that it knows better than the previous shift. Therefore, a number of set-points are modified. The plant, due to its size, may require a substantial period of time to reach equilibrium after this happens. Some eight hours later, at the next shift change, the scene is repeated. As a result, the plant is rarely at the optimal point.

Not only is this true because of the divergent beliefs of the various shifts. It is also due to information overload as a plant may have ten thousand sensors that cannot possibly be looked at by human operators. So each operator must, by training and experience, decide which few sensors to use for their decision making. Those few sensors provide a lot of information but not all of it.

Automation and control systems are usually local and designed from the bottom up. They do well on encapsulated systems such as a turbine, furnace, boiler and such. An overarching methodology is very difficult for these systems and seldom considered. It is in the interplay of all the components of a plant that the potential for optimization lies untapped.

So let us consider the entire plant as a single complex system. It is a physical device and thus obeys the laws of nature. Therefore, the plant can be described by a set of differential equations. These are clearly very complex but they exist. This set of equations that fully describes the plant is called a model of the plant. As the model represents the physical plant in every important way, this model is often called a digital twin of the plant.

There are two basic ways to obtain a model. We might develop it piece-by-piece by putting together simpler models of pumps, compressors and such items and adding these into a larger model. This approach is called the first-principles approach. It takes a long time and consumes significant effort by expert engineers both to construct it initially and also to keep it up-to-date over the lifetime of the plant.

The second way to get a model is to start with the data contained in the process control system and to empirically develop the model from this data. This method can be done automatically by a computer without involving much human expertise. It is thus quick to develop initially and is capable of keeping itself up-to-date. This approach is called machine learning.