An Overview of How ORTO Agents Work

Closed Loop Optimisation of Process Plants and Systems

The purpose of closed loop optimisation is to move the process to and then maintain it at the optimal operating point, whilst dealing with any process change which may occur. In almost all cases, predefined limits (also referred to as constraints) must be adhered to. The optimum point may lie on a constraint, at the vertex of two constraints or somewhere within the constraint bounds. If changes cause limits to be exceeded, the optimiser must move the process back to within the limits.

Common process changes which can impact the optimal operating point:

- Change in feed or other material qualities
- Varying ambient conditions
- Equipment efficiency changes, e.g., due to wear, fouling, etc,
- Changes in equipment availability and equipment in service
- Product quality specifications which change based on demand
- Changing economics
- Operator adjustments

The optimal operating point is the solution of a defined objective function. It is commonly expressed by considering marginal process economics. For example, where the difference between the value of the products being produced and the cost of production including feedstocks, additives, chemicals and energy is at a maximum.

Often it is simpler to determine a proxy for the economic value, where the proxy always delivers the most cost-effective operation. Common proxy values used include maximising impurity levels in products against the permitted quality specification, which in turn increases yield and feed rate but may also reduce energy use and increase catalyst life.

Solving the Optimisation Objective Function Using ORTO

Like almost all closed loop optimisers, ORTO uses a proprietary gradient based method and thus seeks out the optimum operating point closest to the initial starting point.

An ORTO scheme consists of one or more ORTO agents. ORTO agents are paired with a single manipulated variable (MV) in much the same way as a PID-to-PID controller cascade. ORTO agents can therefore be easily configured by process control engineers, who are familiar with building regulatory control schemes.

Agents assigned to an optimisation scheme work together, moving the optimisation variable (OV) to solve the optimisation objective function. The OV can be a single measured value, e.g. product flow, or it can be a calculated value imported from the control system or it can be calculated directly in the ORTO software, e.g. product flow per unit energy consumed.

The agents can be assigned the same constraints to adhere to, or they can be different for each agent. This has the benefit of allowing operating knowledge to be used to determine which manipulated variable manages which constraint(s).

Constraints are defined in the ORTO software and are logical statements constructed from single measured values, e.g. ‘AI100>10’ or from multiple measured values e.g. ‘AI100>10 & FI120<25’.

If the optimisation problem requires more than five agents, two or more instances of the ORTO software are needed, with the objective function set the same for all instances. Depending on the nature of the optimisation problem, there may need to be common constraints between the instances of the software but in many instances this will not be necessary.

Calculating Process Adjustments

ORTO is 'model-free' i.e. it does not require any form of process model. This significantly reduces the expertise needed to build the optimiser. It also radically reduces the cost to build and maintain the optimiser, reduces the time to value and increases the return on investment.

When building an agent, a group of configuration parameters need to be set, akin to setting configuration parameters for a PID controller. For example, the user needs to define a maximum move size and a push direction for each agent. Each agent is also assigned a cycle time. This should not be less than process time delay but will typically be lower than process settling time. For every configuration parameter, tuning guidelines are provided.

The sequence of processing is as follows:

1. Data is accessed from the control system using OPC (DA or UA).
2. If the quality of the data from the control system is bad, any agent using that data suspends processing.
3. If any pause flag for an agent is active or the agent is switched off, the agent back-initialises and tracks its adjusted MV setpoint. Pause flags are set up during configuration and are used to suspend a single agent if its associated regulatory controller in the control system is not in the right mode for closed loop optimisation. It can also be used to suspend optimisation during specific operating modes (e.g. grade changes) or for other reasons.
4. Signal noise, e.g. on process measurements, is inherently dealt with within the ORTO software using a proprietary noise reduction algorithm.
5. The proprietary ORTO algorithm determines the moves each agent makes. Inputs to the algorithm include:
    a. The gradient of the OV. This is affected by the action of all agents within the scheme. The contribution to the rate of change of the optimisation variable, made by each agent, is calculated using a proprietary algorithm.
    b. The proximity to constraints. If constraints are exceeded, the agent will make corrective adjustments to bring the process back within constraints. Constraint lines will be followed, if needed, to reach the permitted optimum value.
    c. The agent's configuration parameters, defined by the engineer. For example, the cycle time and maximum move size determines the rate at which an agent contributes to solving the optimisation problem.
    d. MV limits defined by the engineer which cannot be exceeded.

Evaluation

The ORTO agent technology has been rigorously tested. Example external validation tests include:

- Optimisation of a reactor and separator system using a hi-fidelity training simulator model of the process. The company who evaluated this had been unsuccessful in applying existing closed loop optimisation technologies, whereas ORTO found and then

tracked the optimum and was shown to respond effectively to very large changes in feed quality. The configuration of the agents was completed in less than a week whereas the older technology took many weeks to set up, due to the need to build a model of the process. Unfortunately, this test is still proprietary and further details cannot be shared.

- By a third-party consultancy which specialises in advanced control and closed loop optimisation. These tests were against benchmark models of industrial processes. The tests were successful and have been thoroughly documented by the consultants who performed tests. Not only did the optimiser work as expected but it was found to be very easy and fast to configure. The report can be shared on request.

Further Information

Further information is available on the ORTOmation website: https://ortomation.io/

Paul Oram and Andrew Ogden-Swift will be happy to answer further questions. Feel free to contact us via our website.