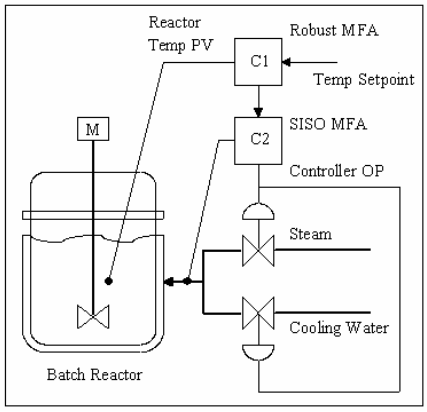
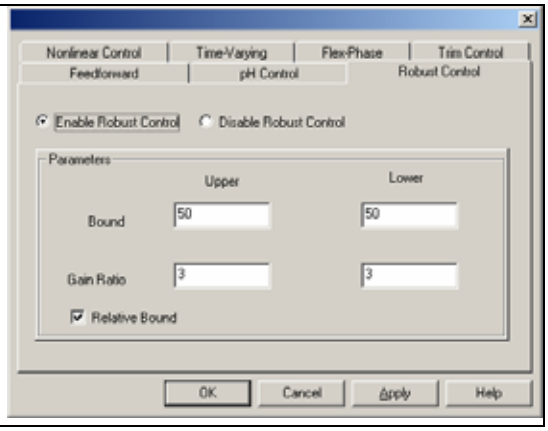
# Model-Free Adaptive Control of Batch Reactors

| *Use of MFA Control* | *Benefits* |
|---|---|
| Automatically controls reactor temperature during all batch stages, process dynamics changes, and disturbances. | Safer and smoother operations, higher quality and yield, and less intensive labor. |
| Robust MFA controller protects reactor temperature from running too high or too low during stage changes. | Enables automatic control of reaction temperature with user defined temp boundaries. |
| SISO MFA adapts between heating and cooling stages. | No controller manual tuning is required. |




**Left:** Cascaded MFA control system with a Robust MFA as C1 to control reactor temp and a SISO MFA as C2 to control the steam and cooling water flow using the control output split-range design.
**Right:** Configuration menu of Robust MFA. Users can define the Upper and Lower bounds for reactor temp with related gain ratio to protect the temp from running too high or too low.




## *CyboSoft's Chemical Batch Reactor Automatic Control Solution*

**Batch Reactor:** Chemical batch reactors are critical operating units and automatic control of the reaction temperature is desirable. Due to its complex nature, a large percentage of batch reactors running today cannot keep the temp in automatic control throughout its operating period resulting in lower efficiency, wasted manpower and materials, and inconsistent product quality.

**Batch Stages:** An exothermal batch reactor has 4 operating stages:

1. Startup Stage: ramps up the reactor temperature by use of steam to a predefined reaction temperature.
2. Reaction and Holding Stage: holds the temperature by use of cooling water while chemical reaction is taking place and heat is being generated;
3. No-reaction and Holding Stage: holds the temp by use of steam after main chemical reaction is complete and heat is not being generated;
4. Ending Stage: ramps down the reactor temp for discharging the products.

**Problems:** During the transition period from Stage 2 to 3, the reactor can change its nature rapidly from heat-generation to heat-consumption. It happens without any triggering signal because the chemical reaction can end at any time depending on the types of chemicals, their concentration, catalyst, and reaction temperature. Within a very short period of time, the reactor temperature can drop significantly.

**Objectives:** Control system must react quickly to cut-off the cooling water and send in a proper amount of steam to drive the reactor temperature back to normal. PID cannot control the temp during this transition if it is tuned to control the process for Stages 1 and 2. In practice, reactors are switched to manual control and rely on well-trained operators during critical transitions.

**Solution:** To avoid or ease this tedious and nerve-wracking task that can result in low product quality and yield, a Robust MFA and a SISO MFA based cascade control system provides an effective solution.

**Split-Range Control:** Since steam and cooling water are used to provide heating and cooling to maintain the reaction temp during different stages, split-range control is used but can cause large process gain changes. A SISO MFA is well suited to control this loop.

**Plant Safety:** Since an exothermal reactor can be a run-away process, great caution has to be taken in using an automatic control system. All plant safety procedures including manual override, safety shutdown, watchdog flags, safety alarms, backup valves, onsite operator monitoring, and redundant control systems and I/Os are still critical to implement.