CHAPTER VIII
MISCELLANEOUS LOOP CONTROLS

There are a number of miscellaneous controls which can be treated independently. Generally they are handled by simple two mode controllers. Examples of such miscellaneous controls are condensate flow control and primary air temperature control.

CONDENSATE FLOW CONTROL

Control of condensate flow is basically to hold the deaerator level. Since the draw down from the deaerator is due to feedwater flow, it is logical to have condensate flow follow feedwater flow, with trimming control from deaerator level.

Fig. 8.1 shows a typical control system for condensate flow control, including the scaling for transmitters which operate on a 16 ma signal level.

![Diagram of condensate flow control system](image)

FIGURE 8.1
Fig. 8.2 is a block diagram including the process response (response of condensate flow to signal to pump couplings and response of deaerator level to error between feedwater flow and condensate flow). For tutorial purposes, units are identified including the scaling between process variables and controller signal levels.

For instance, from the pump curves the gain of flow to signal to couplings is established as 2000 lbs/sec per ma. The flow response is characterized by a dead time of 4 secs in addition to a time constant of 10 secs.

In adjusting controller parameters, we recognize a subloop (flow control) and an outer loop (level control).
First, the flow control subloop is adjusted to yield well damped but fast response.

The process function is:

\[
\frac{2000 \, e^{-4s}}{1100 \, (1 + 10s)}
\]

Reasonable tuning values can be derived either by time response methods as explained in Appendix F or by frequency response techniques. A proportional gain \( K_p = 0.5 \) and an integral gain \( K_i \) of 0.05/sec is recommended.

This corresponds to a proportional band of 200% and repeats/min of \( \frac{0.05 \times 60}{0.5} = 6 \).

With such settings the closed loop response of condensate flow to a change in demand should be characterized by a 10 to 15 second time constant.

The remaining parameter is the proportional gain \( K \) of the deaerator level control. This gain is set considering the stability of the outer loop which can be described as in Fig. 8.3.

![Diagram](image_url)
For a well-damped response one should aim to keep crossover at frequencies below 1/15.

Aiming at a crossover at \( \omega_c = 1/30 \), \( K \) should be approximately \( \frac{14}{1100} \times \frac{2500}{30} = 1.06 \).

The phase angle at crossover is 90\(^\circ\) for the function \( \frac{1}{2500s} \) and 26.6\(^\circ\) for the function \( \frac{1}{1 + 15s} \), i.e., a total of 116.6\(^\circ\).

**PRIMARY AIR FLOW CONTROLS**

Cold and hot air dampers are controlled to (1) provide the required amount of primary air flow to each individual mill, (2) maintain the desired temperature of the mixture of cold and hot air.

Fig. 8.4 shows a common configuration of primary air flow controls. The flow loop acts to open or close both hot air and cold air dampers. The temperature loop acts to open one damper while simultaneously it closes the other to modify the ratio of hot air to cold air as necessary.

The flow loop response is fast, basically made up of the damper response. The temperature loop on the other hand exhibits the thermocouple response time constant, in the order of 30 secs, hence the temperature loop must be adjusted by an order of magnitude slower than the air flow loop.
For ideal noninteraction between the loops the system of Fig. 8.5 would be logical. It is not used because of the expense and complication of introducing multipliers in analog systems, and because, with the two loops fairly well decoupled in bandwidth, interaction is not a problem.

Obviously such sophistications would not be any problem in direct digital control systems (Chapter XI).

\[ \text{Primary Air Flow} \]

\[ \text{Primary Air Flow Set Point} \]

\[ \leq \]

\[ \text{Controller} \]

\[ \text{X} \]

\[ \text{Cold Air Damper} \]

\[ \text{1.0} \]

\[ \text{Hot Air Damper} \]

\[ \text{Temp. Set Pt.} \]

\[ \leq \]

\[ \text{Controller} \]

\[ \text{0 to 1} \]

\[ \text{Air Temp.} \]

FIGURE 8.5