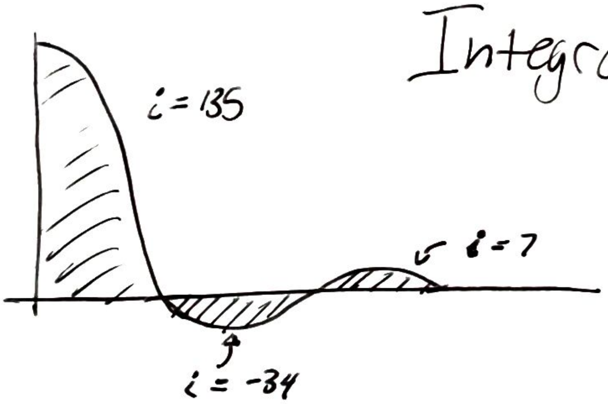
Humidifier Power Test (No ventilation)

- Test humidity rate of change at different speeds along the scale

St	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	FS
50	74	81.5	86.9	88	90.5	91	93	93.5	93.5	94.3	105
49.5	71.5	81.5	87.25	90.3	91.85	93	93.95	94.75	95.3	95.85	160
											215
											270
											325

Integral Explained!



- Integral of Error only shrinks whe e(t) = negative
- The integral of errors will level out & reach a residual point; that is continually added to the update value!

* It's this residual sum that eliminates offset

$$CO = CO_{bias} + K_c \cdot e(t) + \frac{K_c}{T_i}\int e(t)\,dt$$

P I

* With an integral (residual), the e(t) can be Ø yet there is still a value to add/subtract from the CO_{bias} to form a final CO.

* As long as there is any error @ all, -/+, the integral will grow or shrink to effect the CO.

* The changes in CO will only cease when pv - sp = 0 for a sustained period

* This residual value from integration, when added to CO_{bias}, essentially creates a new overall bias value that corresponds to the new level of operation.

* "In effect, integral action continually resets the bias value to eliminate offset as operating as operating levels change"

Controller Design & Tuning:

#1 Establish the design level of operation (DLO), which is the normal or expected values for set point & major disturbances

#2 Bump the process & collect controller output (CO) to process variable (PV) dynamic process data around this DL

#3 Run the system & get behavior data

#4. Use the model params from step 3 in rules & correlations to complete the controller design & tuning.

Non-Linear Process: Increasing Humidity
lag or rapid response

Choosing a DLO appropriate to expected non linear rates of change.

Step 1: Establish DLO

* It is important that the dynamic process test data be recorded @ a pre-determined level of operation.

* Explore the dynamic process with an expected typical PV & SP

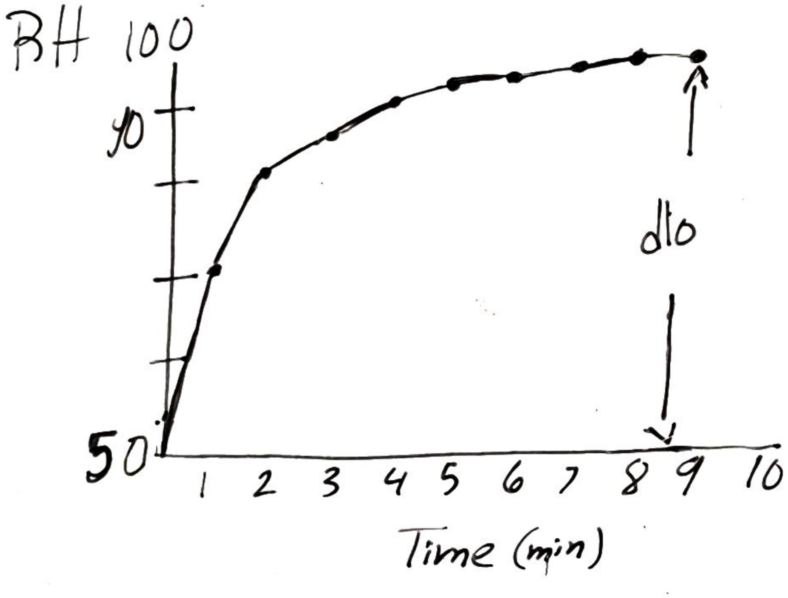
Record the effect of Disturbances as well; e.g. ventilation @ various speeds, or ventilation w/ circulation.

* <u>Process Gain</u>: The "How Far" Variable

<u>Step 2.</u> Collect Dynamic Process Data around DLO
- Bump test, step up the CO incrementally & observe CO
- Start bump test from default settled point

* The goal is to learn about the effect of CO on PV

* Bump test Humidity Up to Max AND <u>down to minimum.</u>



* Double Test: Two CO pulses in rapid succession & opposite directions

* Process Data, Dynamic Modeling

② collected a proper data set rich in dynamic process information around this design level

③ approximated the behavior revealed in the process data with a FOPDT dynamic model

① Determined the DLO

* To do a FOPDT just need the model parameters; K_p, T_p, θ_p, & the dynamic process data

#1. Calculate Process Gain

$$K_p = \frac{\Delta PV}{\Delta CO} = \frac{\text{steady state change in Measured PV}}{\text{steady state change in CO}}$$

//Aside: No disturbances, actually start from steady default state

* K_p, describes the sensitivity of the system, large K_p means its a sensitive system; therefore smaller CO adjustments should be made

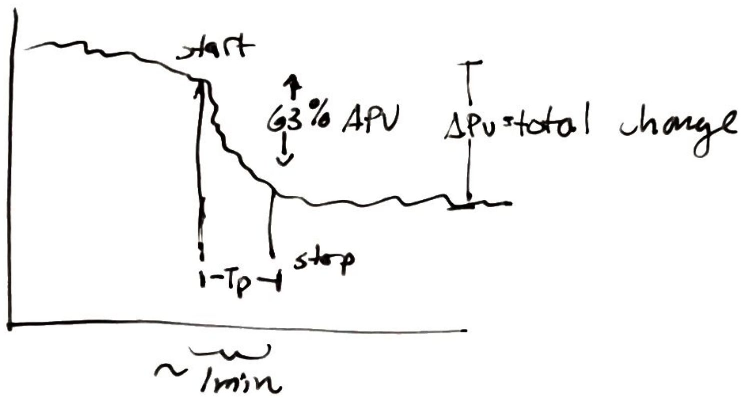
☆ Big K_p, process gain, should have a controller w/ small controller gain, K_c (& vice versa)

$$K_c = \frac{1}{K_p} \frac{\tau_p}{(\theta_p + \tau_c)} = \frac{1}{K_p}$$

use the K_p sign to determine if the process is up-up or up-down.

#2 Calculate Process Time Constant

T_p: the time constant, describes how fast PV moves in response to change in CO. must be in units of mins or seconds (at min 12s)



* Run Process & find when PV changed 63% of its total: (Time to 63% ΔPV) - (PV start to responsd time)

#3 Calculate Dead Time

* There is sizeable dead time, maybe, for decreasing humidity... but not actually not if I turn on Exhaust I bet

- dead time is the 12s sample time?
- humidity sensors slowly dropping their readings despite humidity being exhausted.

* Time from initiating CO till change detected. So it will be in increments of 12s; unless I reduce wait time

☆ θ_p is compared only to T_p; if θ_p is > T_p tight control will be hard.

If Dead Time is much larger than T_p, a dead time compensator should be used.

$$K_C = \frac{1}{K_p}\frac{T_p}{(\theta_p + T_c)} \qquad \tau_i = \tau_p$$

- Since θ_p is in denominator of the K_c calculation, a larger $\theta_t \Rightarrow$ smaller K_c

θ_p min is the loop sample time

Bring it all together: Example

$K_p = -0.53$ °C/% Process Gain
$T_p = 1.3$ min Time Constant
$\theta_p = .8$ min Dead Time

* try a more aggressive T_c than 12s; e.g. 7s

$$T_p \frac{dPV(t)}{dt} + PV(t) = K_p \cdot CO(t - \theta_p)$$

So the dynamic behavior of the process can be approximated as

$$1.3 \frac{dPV(t)}{dt} + PV(t) = -0.53 \cdot CO(t - .8)$$

t [=] min, $PV(t)$ [=] °C, $CO(t-\theta_p)$ [=] %