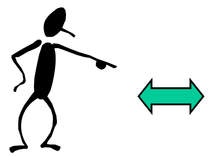
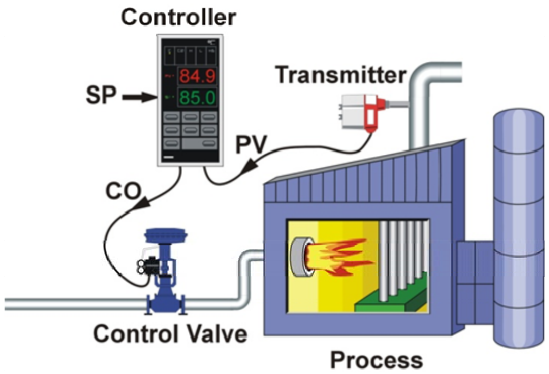
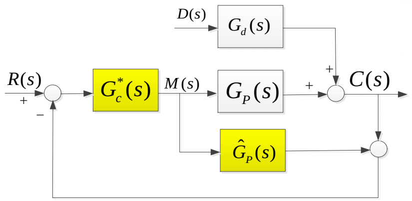
IMC Turning







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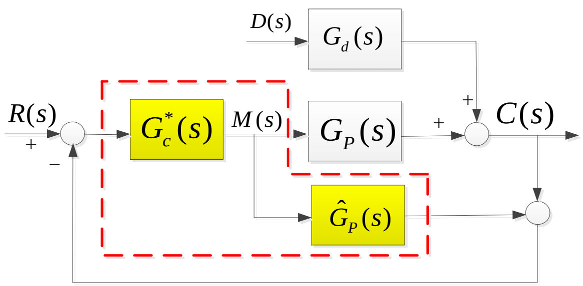
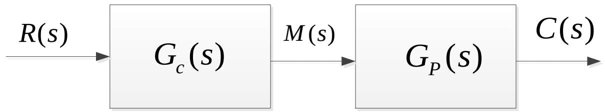
IMC Principle and Structure

The IMC philosophy relies on the internal model principle. Accurate control can be achieved only if the control systems encapsulates (either implicitly or explicitly) some representation of the process to be controlled.



Example



Suppose $\hat{G}_p(s)$ **is a model of** $G_p(s)$

Setting $G_c(s)$ **as the inverse of the model**

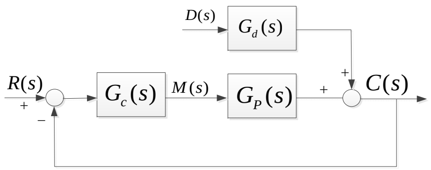
$$G_c(s) = \hat{G}_p(s)^{-1}$$

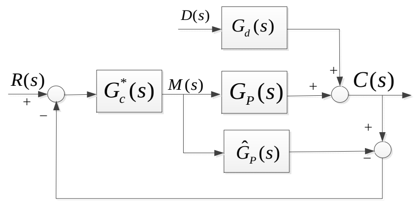
Assuming that $\hat{G}_p(s) = G_p(s)$

The output $C(s)$ **will track the setpoint** $R(s)$ **perfectly**

However in this example no feedback, i.e. not robust w.r.t. model inaccuracies and disturbances.

IMC vs. Classical Control



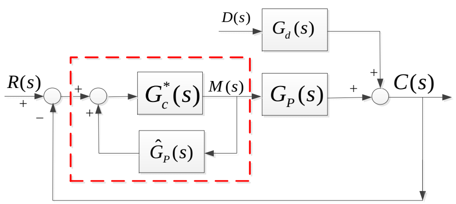


$$C = \frac{G_c G_p}{1+G_c G_p} R + \frac{G_d}{1+G_c G_p} D$$

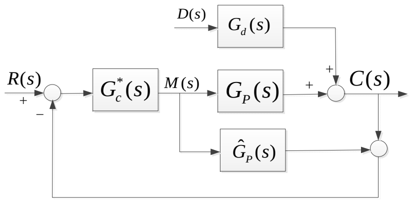
$$C = \frac{G_c^* G_p}{1+G_c^* G_p - G_c^* \hat{G}_p} R + \frac{\left(1-G_c^* \hat{G}_p\right) G_d}{1+G_c^* G_p - G_c^* \hat{G}_p} D$$

$$\frac{G_c G_p}{1+G_c G_p} = \frac{G_c^* G_p}{1+G_c^* G_p - G_c^* \hat{G}_p}$$

$$G_c = \frac{G_c^*}{1-G_c^* \hat{G}_p}$$



IMC: Ideal Case



$$\hat{G}_p = G_p$$

$$C = \frac{G_c^* G_p}{1 + G_c^* G_p - G_c^* \hat{G}_p} R + \frac{\left(1 - G_c^* \hat{G}_p\right) G_d}{1 + G_c^* G_p - G_c^* \hat{G}_p} D$$

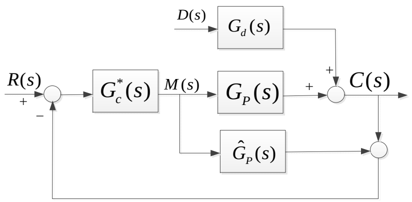
⇓

$$C = G_c^* G_p R + \left(1 - G_c^* \hat{G}_p\right) G_d D$$

$$G_c^* = \frac{1}{G_p} \quad \Rightarrow \quad C = R + (0) G_d D$$

Perfect setpoint tracking and perfect disturbance rejection.

IMC: Non-Ideal Case



$$\hat{G}_p = G_p^- G_p^+$$

$$C = \frac{G_c^* G_p}{1 + G_c^* G_p - G_c^* \hat{G}_p} R + \frac{\left(1 - G_c^* \hat{G}_p\right) G_d}{1 + G_c^* G_p - G_c^* \hat{G}_p} D$$

$$\hat{G}_p = \frac{K_p (1 - \tau_1 s) e^{-\theta s}}{(\tau_2 s + 1)}$$

$$G_p^- = \frac{K_p}{(\tau_2 s + 1)}$$

$$G_p^+ = (1 - \tau_1 s) e^{-\theta s}$$

⇓

$$G_c^* = \frac{1}{G_p^-} f(s) \qquad f(s) = \frac{1}{(\tau_f s + 1)^p}$$

$$C = \frac{f}{G_p^-} G_p^- G_p^+ R + \left(1 - \frac{f G_p^- G_p^+}{G_p^-}\right) G_d D$$

$$C = f G_p^+ R + \left(1 - f G_p^+\right) G_d D$$

Perfect setpoint tracking is not possible and perfect disturbance rejection.