EEM 451 Industrial Control Systems
Controller Design

Hakkı Ulaş Ünal
Dept. of Electrical-Electronics Eng.
Anadolu University, Turkey
Delay appears everywhere in our life,

- Shower
- Traffic
- Internet,
Delay appears everywhere in our life,

- Shower
- Traffic
- Internet,

Delay in industry

- A heated tank with a long pipe
- Transportation
- Chemical reactions
Smith Predictor

Delay Phenomena: While small delays destabilize the system or worsen the system performance, large delays may improve the system performance.
Smith Predictor

Delay Phenomena: While small delays destabilize the system or worsen the system performance, large delays may improve the system performance.

It is not possible to control all plants with PID controller with a satisfactory performance.
Smith Predictor

Delay Phenomena: While small delays destabilize the system or worsen the system performance, large delays may improve the system performance.

It is not possible to control all plants with PID controller with a satisfactory performance.

Smith predictor is proposed in the late 1950’s. It is simple and design idea is based on the remove the delay from feedback loop.
Figure: Smith predictor based control systems

\[ Z(s) = P(s) - Pe^{-hs} \]

Assume \( v = 0 \) and no modelling error.

\[
\begin{align*}
y + \eta &= P(s)e^{-hs}u(s) + Z(s)u(s) \\
&= P(s)u(s) \\
&= P(s)e^{-hs}u(s)e^{hs} = ye^{hs},
\end{align*}
\]

which implies

\[ \eta(s) = y(s)e^{hs} - y(s). \hspace{0.5cm} Prediction! \]
\[ \eta(s) = y(s)e^{hs} - y(s). \]  

*Prediction!*

The feedback signal \( \eta \) predicts the output. 
Delay can be moved to output if there does not exist modelling error and \( v = 0 \).
Figure: Smith predictor based control systems

\[ \hat{e}(s) = r(s) - y(s) - Zu(s) \]

\[ \hat{e}(s) = r(s) - P(s)e^{-hs} u(s) - P(s)u(s) - (-P(s)e^{-hs} u(s)) \]

\[ u(s) = C(s)\hat{e}(s) \]
Figure: Smith predictor based control systems

Figure: Smith predictor based control systems 2
Figure: Smith predictor based control systems 2

\[ \hat{e}(s) = r(s) - P(s)e^{-hs}u(s) \]

\[ u(s) = C(s)\hat{e}(s) \]

\[ y(s) = P(s)e^{-hs}u(s), \]

can be transformed to
Smith predictor design

- Design controller $C$ to meet design requirements for delay free part of plant!
- Incorporate with smith predictor $Z(s) = P(s) - P(s)e^{-hs}$