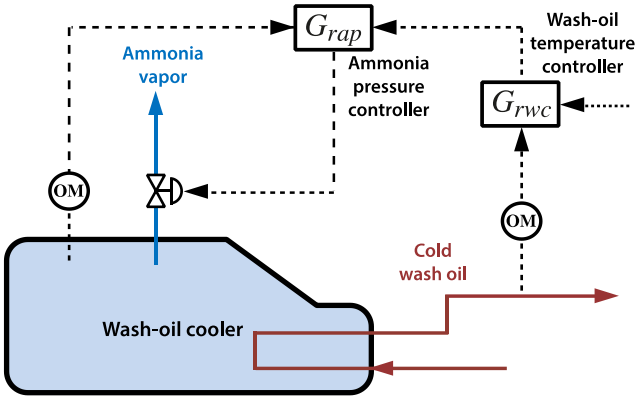
c) Under a constant torsion stress M_w, and command α_c, and without compensation ($G_{FF} = 0$), evaluate the total rotation at steady state α_r of the root of the blade.

d) Design an adequate compensation for G_{FF}. Under a constant torsion stress M_w, and command α_c, what is the effect on α_r at steady state?

e) Under a constant torsion stress M_w, and command α_c, what is the static error of the system $\frac{\epsilon}{\alpha_c}$ at steady state?

f) Explain the utility of the feedback controller, and the utility of the feedforward controller.

5) **(20 points)** A cascade control system of the wash oil temperature is considered due to a sticky valve. It was observed that ammonia pressure responded much quicker to changes in valve position than the wash oil temperature. The set point of the wash oil temperature is controlled by an operator.



a) Draw the block-scheme of the control system. Identify the variables in the system (inputs, outputs, disturbances). Discuss briefly the dynamical properties of the inner and outer loops and the complexity of the corresponding controllers.

b) For the given transfer functions $\frac{T_{wo}(s)}{P_{av}(s)} = \frac{e^{-2s}}{s}$ and $\frac{P_{av}(s)}{q_{av}(s)} = \frac{s-2/3}{s^2+11s+10}$, where T_{wo} denotes the wash-oil temperature at the output, P_{av} the pressure of the ammonia vapor and q_{av} the flow of the ammonia vapor controlled by the valve:

i) Find a P controller that ensures the stability of the inner loop such that the value of its parameter is in the middle of the allowed range.

ii) Find the parameters of the simplest PID-like controller (K_R or K_R, τ_D or K_R, τ_I or K_R, τ_I, τ_D) for the outer loop such that it ensures the zero steady-state error of a step response (use the 1st order Padé approximation to approximate the delay).

Student name: Sciper no: