TPC5 - Air Fuel Ratio Control in a Gasoline Engine

Grupo - TP13

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The control of the AFR essential influences the quality of the combustion processes and the performance of the engine in terms of fuel consumption and emissions. AFR value is imposed to be 1±5% and is controlled by the quantity of fuel injected in each cylinder.

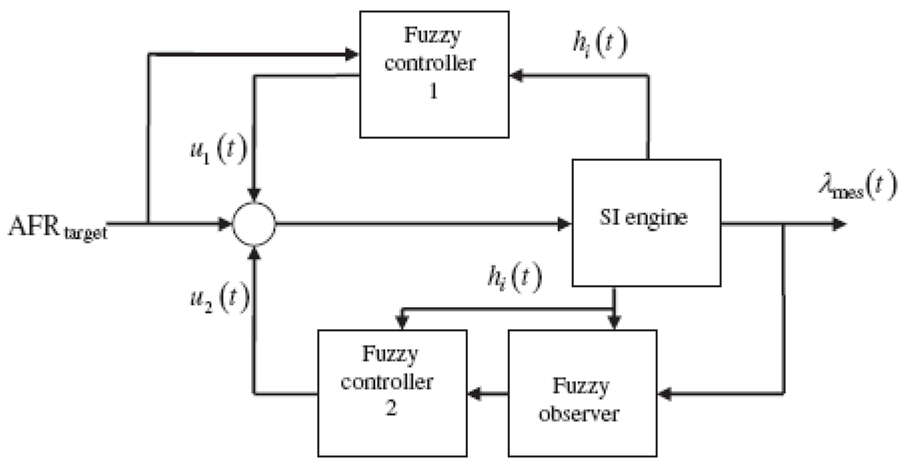
First attempt of control AFR were with linear tools but these controllers were not robust for desire measurements and the delay introduced by the lambda sensor. Then it was used the PI controller that lock into account the lambda sensor and works for a region of values near a desired point although limited for fast transient response of the throttle valve. Non linear tools were used after with an adaptive sliding mode control that was supposed to compensate the drawback of the time delay. Another solution was to use an accurate estimation of the AFR in each cylinder but would seriously decrease the performance.

In the article is supposed a controller that should coupe with the time delay and also ensures a good AFR regulation even during fast transient of the throttle and is applied equally to all the cylinders.

The AFR control model is split in three parts, the cylinder air-mass flow, the fuel mass flow dynamics, and the sensor model. For engine control MVEM is used if adapts perfectly to IC engine control design coupling with the dynamics of the variables involved for a wide range of operation points.

The cylinder air mass flow is decided by the speed density equation. The fuel mas dynamic flow is described by anon linear model being necessary to deal with the phenomenon of the residual fuel film on the inlet pipe of each cylinder. The AFR model is deduced taking into account a variable time delay of the transport of the gas flow from the cylinder and the lambda sensor. With all equations and relations it is possible to know the stat-space representation.

The plant's model is described through a Takagi-Sugeno fuzzy model.



This model allows to represent exactly the non-linearity properties in a compact set of the state variables, including a bounded varying time state delay variable - τ (t) < τ

$$\begin{cases} \dot{x}(t) = A_z x(t) + D_z x(t - \tau(t)) + B_z u(t) \\ y(t) = C_z x(t) \end{cases}$$

There are two fuzzy controllers, each one working by its own control law. The Fuzzy controller 1, producing u1 (t), working in a feedforward control, is derived according to the model without considering the varying time state delay variable. The Fuzzy controller 2, producing u2(t), is supposed to cope with the time-varying delay.

A Fuzzy observer is designed to provide a more accurate state-vector for the Fuzzy Controller.

$$\begin{cases} \dot{\hat{x}}(t) = A_z \hat{x}(t) + D_z \hat{x}(t - \tau(t)) + B_z u(t) + K_z (y(t) - \hat{y}(t)) \\ \hat{y}(t) = C_z \hat{x}(t). \end{cases}$$