LPV-Modeling of a Low-Power Gas Turbine

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Gas turbines are important and widely used prime movers in transportation systems, such as aircraft or cars. Besides of this area, gas turbines are also found in power systems where they are the main power generators. At the same time gas turbines are known to be nonlinear systems which present a challenge for their control.

The nonlinear dynamic model of gas turbines is derived from first engineering principles which consists of differential conservation balances completed by algebraic constitutive relations. This nonlinear dynamic model can then be transformed into input-affine form:

$$\frac{dx}{dt} = f(x) + \sum_{i=1}^{m} g_i(x)u_i \tag{1}$$

The coordinate-functions of the state equation $f(x)$ have very complicated algebraic structures, while the functions $g_i(x)$ are constants assuming the standard inputs u_i being the mass flow rate of fuel [1]. Because of this fact, the nonlinear dynamic analysis of the model, such as investigation of controllability and stability, can only be performed with difficulty or in some cases it can not be done [2].

To solve this problem and to investigate the controllability and stability of the model in a more effective way the nonlinear dynamic model has to be transformed into LPV (Linear Parameter-Varying) model, where ρ is the parameter-vector:

$$\frac{dx}{dt} = A(\rho)x + B(\rho)u \tag{2}$$

This LPV-model can then be effectively used to develop some types of controllers to improve the dynamic response of the engine.

In this paper we show the possible ways and steps of the transformation being neither obvious nor unique and the final form of the LPV-model of a pilot-plant gas turbine, which is installed in the Budapest University of Technology and Economics, Department of Aircraft and Ships on a test-stand [1].

References

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[2] P. Ailer, G. Szederkényi and K. M. Hangos. Modeling and Nonlinear Analysis of a Low-Power Gas Turbine. *Research Report of the Systems and Control Laboratory SCL-1-2001.* Budapest, MTA SZTAKI, 2001. 25p.