

Stochastic Model of a Pneumatic Actuator

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Abstract: *Intensive research in the field of mathematical modelling of the pneumatic cylinder has shown that its mathematical model is nonlinear and that a lot of important details cannot be included in the model. Selection of the model and the identification method have been conditioned by the following facts:*

- a) *The nonlinear model of the system can be approximated by a linear model with time-variant parameters*
- b) *There is the influence of the combination of heat coefficient, unknown discharge coefficient and change of temperature on the pneumatic cylinder model. Therefore it is assumed that the parameters of the pneumatic cylinder are random (stochastic parameters)*
- c) *In practical conditions, observations have a non-Gaussian distribution.*

Due to the abovementioned reasons, it is assumed that the pneumatic cylinder model is a linear stochastic model with variable parameters. The Masreliez-Martin filter (robust Kalman filter) was used for identification of parameters of the model. For the purpose of increasing the practical value of the filter, the some heuristic modifications were performed. The behaviour of the new approach to identification of the pneumatic cylinder is illustrated by simulations.

Keywords: *pneumatic actuator, stochastic model, time-variant parameters, non-Gaussian distribution, robust filter*

1 INTRODUCTION

Since pneumatically driven systems have a lot of distinct characteristics of energy-saving, cleanliness, simple structure and operation, and high efficiency and are suitable for working in a harsh environment, they have been extensively used for many years in robot driven systems and industrial automation [1].

However, the problem with complex nonlinear models, such as the pneumatic servo cylinder, is that it is difficult to choose the large number of physical parameters involved in the model. Although a lot of parameter values are known a priori with reasonable accuracy, a large number of parameters are only known within a certain range, and some are even completely unknown. This may be due to manufacturing tolerances, or due to the fact that manufacturers do not provide parameter values because they consider them as proprietary information.

Furthermore, it is extremely difficult to accurately acquire some system parameters (such as component dimensions, internal leakage coefficients, static and dynamic friction forces, etc.) because the mentioned parameters cannot be

directly measured or calculated. This causes a great difficulty in system modelling and control.

The consequence of these problems is that the theoretical model is often not useful for quantitative analysis of the pneumatic servo-system behaviour.

The purpose of this paper is to use the theory and findings of system identification to obtain a mathematical model, so that the controller can be designed on the basis of the model.

Östring et al. [2] identified the behaviour of an industrial robot in order to model its mechanical flexibilities, while Johansson et al. [3] used a state-space model to identify the robot manipulator dynamics. Assuming most parameters in pneumatic servo system do not change during operation, Shih and Tseng [4] performed the identification offline and adjusted servo-control before the operation accordingly. Furthermore, they investigated the impact of different parameters (sampling time, order model, different supply pressures, etc.) in the identification process.

The mentioned references consider the linear models of the pneumatic cylinder which are ad hoc adopted, without considering justification

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