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The Development of Mechanical and Numerical Simulators Duplicating Human Breathing Patterns

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Summary

Recently, the importance of a reliable mechanical respiratory simulator has been increased. By simulating the specific respiratory patterns, the mechanical respiratory simulator can be used to study the lung pathologies and evaluate the performance of the auxiliary devices for breathing disorders such as positive airway pressure (PAP). Mešić *et al* (2003) developed the real-time feedback control system of the mechanical simulator using PID controller. The study showed that the mouth pressure and flow of the simulator was matched to that of a fibrotic patient. However, it is difficult to be applied to the measurement of the flow changing aspect assembling breathing devices because the flow of the simulator can't be changed due to the feedback controller. In this study, the mechanical respiratory simulator was made and its numerical model was generated by the characteristic experiment.

The mechanical respiratory simulator consists of four main parts: (1) actuators, (2) controllable valve, (3) sensors and (4) control program. The actuator is composed of the cylinder with the volume of 5 L and the piston which is driven by a motor in order to describe the function of the pleural membrane and thorax. The controllable valve plays an important role in the airway resistance for the various respiratory patterns. The sensors measuring the pressure and the flow rate can be used as the validation parts. The valve characteristic coefficient was defined from the relation of the pressure and flow rate. Also, the piston motion was controlled by the numerical model based on the perfect-gas law. The numerical model was improved by the predictor-corrector algorithm. As a result, the profile of the pressure and the flow rate for a normal breathing and three patterns of breathing disorders were generated by the numerical model using MATLAB and were simulated by the real time control of the valve signal and the piston motion in the mechanical simulator.

keywords: Respiratory system, Numerical model, Mechanical simulator, Breathing patterns, Characteristic experiment.

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