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Batch-Capable Fabrication Approach for a Highly Efficient Miniaturized Magnetic Valve

Introduction

Down-scaling in process automation requires small-size components in pneumatics as well. Current miniature valves on valve terminals feature a minimum mounting dimension of 4.5 mm. This is due to standard magnetic actuation technology as the magnetic actuation principle almost scales with volume. One advantage of magnetic actuators is their high energy density. Hence, the reluctance principle is widely used in valve applications. The downscaling behaviour of magnetic actuators is advantageous when *polarized* magnetic circuits are utilized only. At the same time, polarized magnetic circuits allow a bistable operation of the valve's armature in its end positions. Thus, one can abandon the permanent current feed for the opened as well as for the closed state.

Magnetic Micro Valve and Fabrication Methods

Reluctance-based actuators have to be reset. A second magnetic circuit can be integrated instead of a return spring. The presented micro valve comprises two parallel polarized magnetic circuits in connection with a jointly used magnetic coil. Within this assembly, the spring-guided armature can be switched between two end positions in which the armature releases or locks the valve seat. The main parts of this valve are the housing, the magnetic coil, a spring, a seal and an armature (Fig. 1).

In precision machining, these parts are fabricated separately and they are finally assembled into a valve module. In micro systems, the integration is usually performed on a substrate carrier for many devices at once and finally, the almost completed systems are separated.

Miniaturized valves require optimized materials for all key parts. Any precision mechanics approach is unsuitable due to the required precision and the drastically increasing costs. For these reasons, a novel "monolithic" integration approach of optimized materials by using micro system technologies is used in combination with magnetic actuation for developing a miniaturized valve.

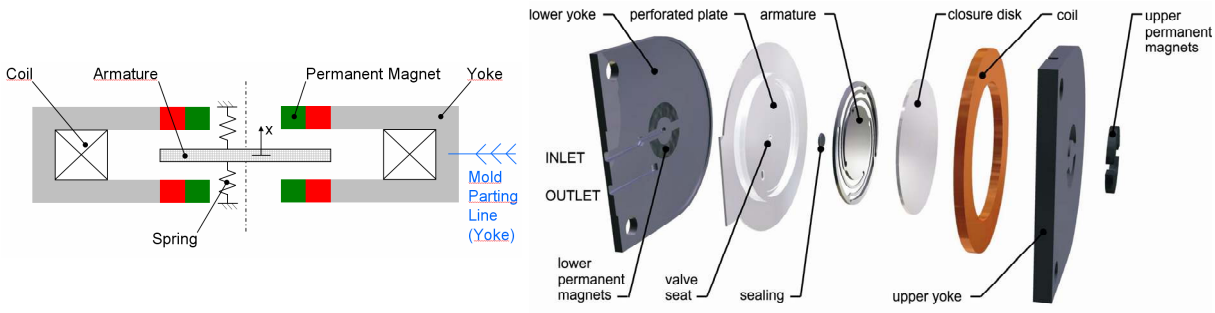

Fig. 1 Magnetic circuit (left) and exploded view (right) of the micro valve.

The valve allows switching media pressures up to 10^6 Pa and features 0.1 mm nominal width. The armature is the most important part of the valve. Firstly, it is the movable part within the magnetic actuator. At the same time, the armature is the component that releases and locks the valve seat. Thirdly, it features its own spring guide. On one hand, the dynamic parameters of the armature during its movement are defined by the spring constant and the armature mass. On the other hand, the spring provides guidance and energy for armature motion. Thus, the potential energy of the armature in its end positions is not lost but stored until the next switching operation is started.

One key fabrication process is micro-electroplating using polymeric pre-forms made from photoresists. For the meander spring structures of the armature, a mechanically favorable nickel-iron-alloy is chosen. The magnetically conductive part of the armature is made of an iron-cobalt-alloy which shows magnetically soft properties. Variations of the electroplating process allow optimizing the spring constant as well as the magnetic performance for the armature, but at the same time they also allow to integrate them on “substrate level” and to combine them to one component. The solid metal parts are fabricated by metal injection molding (MIM), another batch-capable technology.

The valve is launching a new generation of magnetic micro valves by means of its mounting dimension (0.1 mm) and its diameter of 20 mm only.

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