Alternative Operating Concepts for Decentralised Automation of Pneumatically-Controlled Hygienic Process Valves

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Abstract

This paper presents two concepts for local operation and display that can be used for pneumatically-controlled hygienic process valves. The first concept is based on coded magnetic fields applicable for a simple manual override or for a wireless magnetic keyboard. Using this purely mechanical keyboard, a control device can be operated in the field in a convenient, cost-effective and safe way without needing to be opened. The other concept for application-specific integration of indicators and displays into housings makes use of an innovative internal selective metallic coating technology for plastics in combination with laser technology. The most stringent hygiene and environmental requirements are fulfilled at reasonable costs.

Both concepts have been successfully implemented in a new control head and have proven to be very effective for this kind of application.

KEYWORDS: wireless magnetic keyboard, selective metallic coating of plastics

1. Introduction

Decentralised automation concepts have become increasingly important for the food, beverage and pharmaceutical industries but also for the production of cosmetics. Highly integrated electro-pneumatic positioners have been very well established for some decades (/1/, /2/). New (electronic) components and (plastic) materials in combination with a rising percentage of fieldbus based equipment have given more options for cost-efficient decentralisation. Thus, there is a rising number of relatively

simple devices for binary activation and position monitoring of pneumatic process valves.

Due to the character of the plants, the requirements for these devices – often called control heads or control tops – are very challenging. Hygienic cleaning combined with a field-proven degree of protection, a bright status indicator that can be seen from a distance, intuitive and quick setup, good serviceability and a long life cycle are all highly important. In addition to the remote control and diagnosis capabilities provided by fieldbus systems such as AS-Interface or DeviceNet, a simple, safe and low-cost solution for local operation and display is needed for maintenance purposes.

The following requirements for local operation and display should be considered:

- Manual opening/closing of the process valve with closed housing
- Prevention of unintentional operation
- Bright all-around indication of valve and control device status
- Scalability of the status indicator (three-coloured LED, various displays)
- Good chemical resistance against cleansers at a field-proven degree of protection
- Attractive and hygienic industrial design blending well with stainless steel process valves
- Zero or very low additional costs for local operation

Most existing products for controlling process valves have mechanical or electrical manual overrides which are only accessible by partially or completely opening the housing. Others have expensive wired or wireless options for data transfer or traditional means for local operation such as front-foil covered keys. Integrating displays usually requires more effort in the housing design or has disadvantages in the degree of protection or chemical resistance.

The following sections will show some alternatives.

2. Operating concept based on coded magnetic fields

2.1. General idea

As an alternative solution for local operation of control devices for pneumatic process valves, two or more magnetically sensitive sensors (e. g. hall sensors) are used. These sensors are located on a printed circuit board in a non-magnetic shielded geometric arrangement preferably within a plastic housing. The sensor signals are processed by

the device's microcontroller evaluating both field strength and field direction. A tool with strong permanent magnets or electromagnets arranged equidistantly is used to operate the device from the outside. The number of possible different actions depends on the number of sensors but also on the geometric arrangement, movements, characteristics or way of activation in the case of electromagnets. Using pulse-width-controlled electromagnets, it is even possible to transfer larger amounts of data to the device.

In addition to the possibility of multiple coded actions, the application of 2 or more sensors/magnets prevents unintentional operation. Thus, the geometric arrangement, field strength and field direction have to be carefully considered with respect to the environmental conditions of the target applications.

2.2. Simple manual override

A basic implementation of the concept based on coded magnetic fields can be used for a very cost-effective manual override (open/close process valve). The principle of this basic coding using 2 hall sensors and 2 antiparallel permanent magnets is shown in **Figure 1**. The optimised arrangement and characteristics of the sensors and magnets enable precise localisation within a range of only a few millimetres.

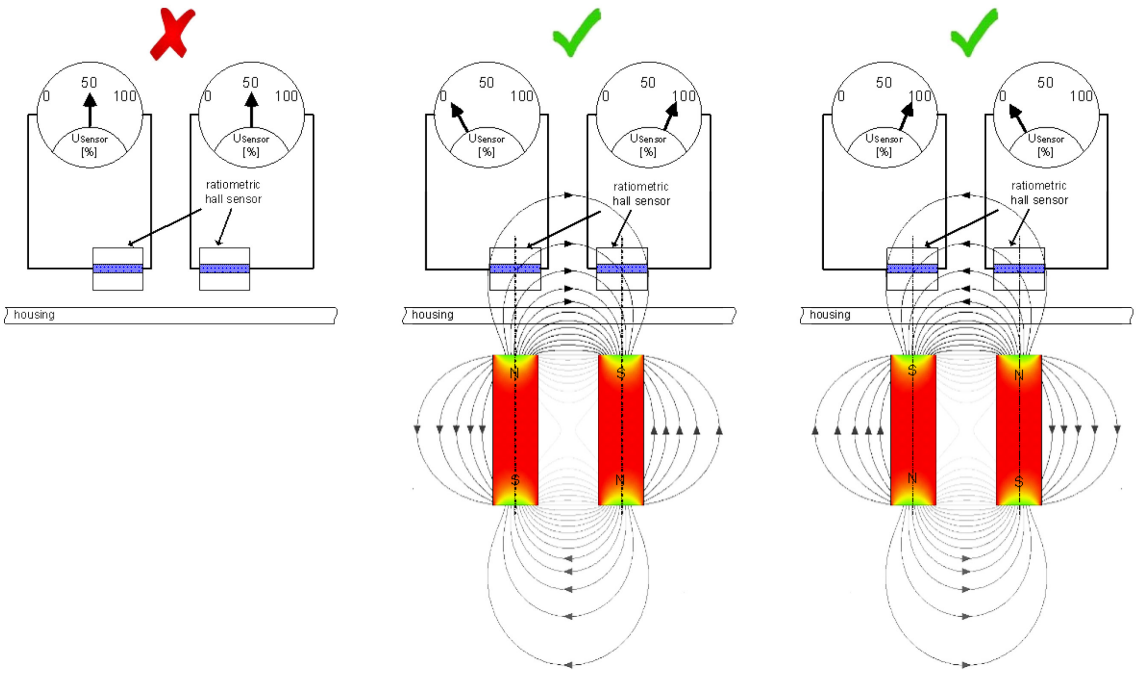

Figure 1: Principle of the magnetic manual override

The left picture shows a status with no magnetic tool present so that both hall sensors are not influenced by any magnetic field. This results in a sensor signal of 50 % of the supply voltage. The pictures in the middle and on the right side of Figure 1 show a status with a magnetic tool present. In the position shown, the magnetic fields influencing each of the hall sensors are at an angle of 180°. This produces a voltage of either 0% or 100% and this maximum difference is ideal for ensuring that the desired outcome is generated from a correct signal combination.

Figure 2 shows an example of a magnetic manual override. The diagram on the left side illustrates the basic functionality of a control head with 2 integrated hall sensors. A special tool containing 2 strong antiparallel permanent magnets needs to be positioned within some millimeters from the markings shown in the picture on the right side. After approximately 3 sec the signals are considered valid and the electro-pneumatic actuators are switched in order to open the pneumatic drive which is usually part of a process valve. Bright status LEDs on top of the device indicate this manual override action. Closing is done in the same way.

For further safety reasons, the functionality of the local manual override can be enabled or disabled via a local serial interface using a PC or via a fieldbus system such as DeviceNet. Thus, it is possible to authorise local operation only for a limited period of time for maintenance purposes.

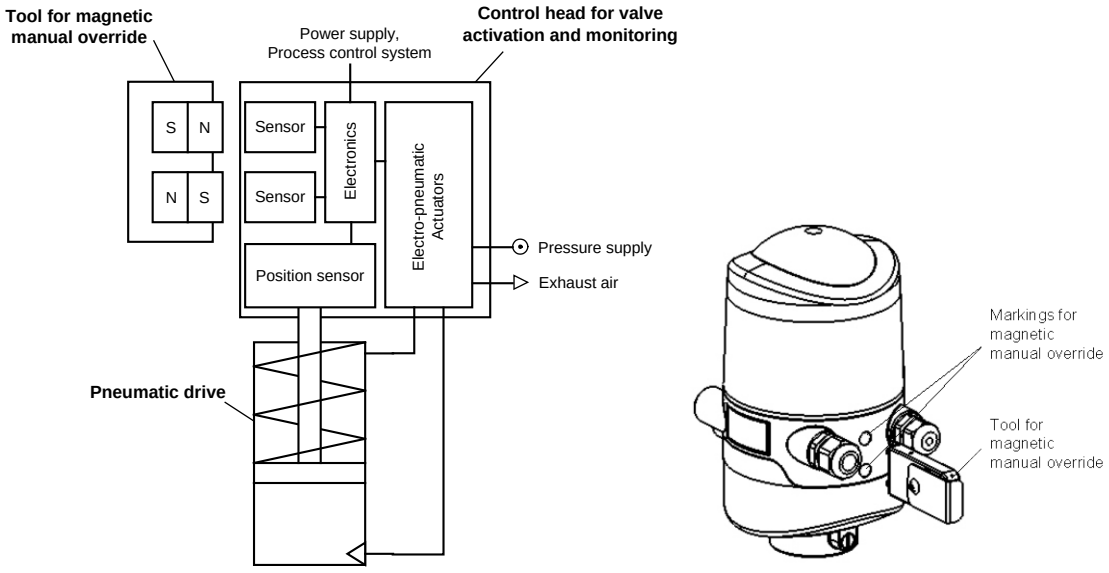

Figure 2: Example of magnetic manual override

2.3. Wireless magnetic keyboard

In addition to the options available from an implementation as described above, there are many other possibilities. Even relatively simple devices like a control head for process valves have numerous additional functions (e.g. position tune algorithms, adjustment of tolerance zones) or functions for diagnostics or preventive maintenance. In order to activate these functions or adjust parameters, not only via a PC or fieldbus system, it is desirable to provide adequate means for local operation – without the need for opening the housing.

The application of magnetic fields is a very efficient and cost-effective alternative compared to sophisticated wire-bound or wireless communication systems.

Figure 3 illustrates the basic principle of a wireless magnetic keyboard. Single permanent magnets are moved on the outside of the housing in a defined path resulting in a changing magnetic field detected by a hall sensor. The number of actions depends on the number of sensors, the number of magnets and their geometric arrangement and possible movements.

A magnetic keyboard does not need a fixed connection with the device. It only needs to be temporarily positioned in a defined distance from the hall sensors. Simple mechanical means to easily position the keyboard are sufficient.

No external power supply is required if the magnetic keyboard consists exclusively of permanent magnets.

A possible implementation of a magnetic keyboard is shown in **Figure 4**. Two pairs of antiparallel permanent magnets are used. Each of the magnets can be moved separately.

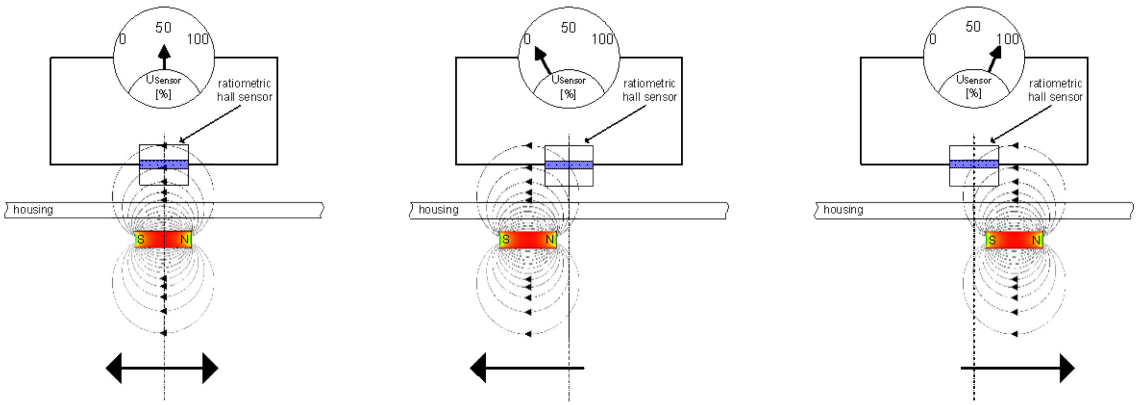

Figure 3: Principle of the wireless magnetic keyboard

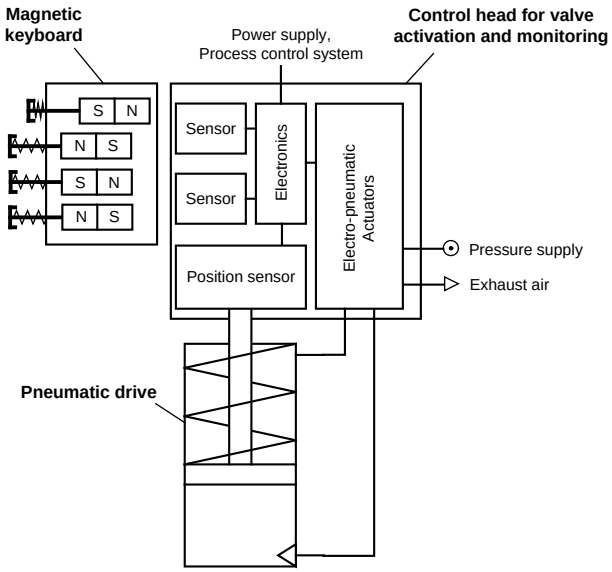

Figure 4: Example of a wireless magnetic keyboard

The keyboard shown in Figure 4 can either be used for activating pre-defined functions of not only a relatively simple control head but also in combination with a graphic display for a high-end control device with hundreds of parameters.

3. Display integration using internal selective metallic coating of plastics

Integrating a status indicator or graphic display into a field device is usually quite demanding because of the numerous requirements as described above. Existing solutions have some disadvantages:

- Transparent housings provide insufficient light protection for internal parts or have a rather poor focus / selectivity for certain indicators.
- Housings with inserted parts or 2k/3k housings are quite complex and have some restrictions concerning design.
- Stainless steel housings are expensive and need integrated transparent parts with suitable sealing and more effort for the assembly. Moreover, it is quite complicated to include means for lead-sealing (necessary in some food processing plants or in an explosive atmosphere).
- Known external metallic coating technologies for plastics do not provide sufficient mechanical and chemical resistance.

Due to the drawbacks of existing solutions, an alternative technology was investigated. This technology is mainly based on selective vacuum coating. The inner surface of transparent plastic housings is metallically coated resulting in products as illustrated in **Figure 5**. The figure shows a new control head with up to 3 integrated solenoid valves

for pneumatic actuation of a process valve /3/. Its contactless position measurement system is used for monitoring the valve's stroke. There is a large transparent area on top of the cover which is laser-finished for excellent visibility of the bright green, yellow or red LED status indicator.

Figure 5 also shows a typical arrangement of process valves with control heads. The good visibility of the bright status indicator is of great advantage for plant operators.

This coating technology ensures the best possible chemical resistance because the plastics can be used in their pure form (without coloured additives). Moreover, it provides excellent light protection.

In combination with laser technology, not only is there a great deal of flexibility for integrating indicators or graphic displays but also for customising logos or design elements.

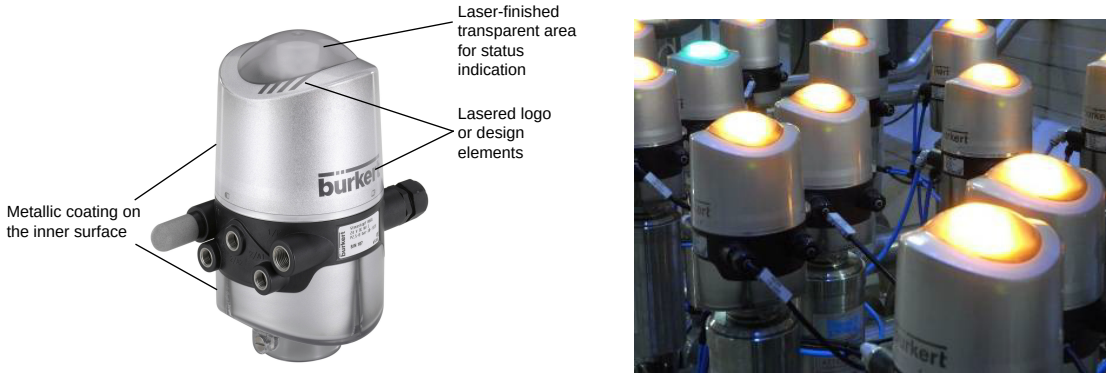

Figure 5: Example of a product using selective metallic coating

4. Conclusion and Perspective

The concepts presented here for local operation and integration of indicators or graphic displays into field devices are well-suited to meeting the requirements of hygienic applications. They allow a high level of flexibility for modern product design and their effectiveness has already been proven through implementation with a control head for pneumatic process valves. More than 20,000 of these devices have been delivered already. Other applications of these efficient concepts will follow.

5. References

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