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Actuators: Solenoid beats Pneumatics

Comparison of the lifetime costs as exemplified by a project example of Kendrion IMS / energy consumption significantly lower

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Donaueschingen, September 2016. As exemplified by a real example it can be proven that in certain cases the use of electromagnetic actuators in factory automation provides significant cost benefits compared to conventional pneumatic equipment. The advantages of actuating magnets become particularly evident if the costs are considered over the complete lifetime. The total cost of ownership (TCO) approach is based on a holistic economic efficiency analysis of an investment which does not only take into account acquisition costs but also all other costs arising during the lifetime of the investment. The case study is based on project experience gathered by the company Kendrion IMS in Donaueschingen, a manufacturer of electromagnetic systems.

The Advantages of Solenoids

Designers and developers are becoming increasingly aware of the benefits of the electromagnetic actuator technology in comparison with pneumatics. In certain applications solenoids allow for more efficient and cost-effective solutions. To give an example, no compressed air supply needs to be installed. Electromagnetic systems can use decentralized supply. Among other things pneumatics must take into account leakage losses, while solenoids directly convert energy into movement. Furthermore, the electric solution produces less noise.

The case study presented below also shows:

- Compared to the pneumatic system the electromagnetic system requires lower investment costs.
- The energy costs of the electromagnetic system are lower.

The Example: Stoppers for Workpiece Carriers

Our starting point for the comparison was a current customer project. It was planned to use 20 stopper elements for an automated transfer

system consisting of 20 workpiece carriers and 20 machining stations. In the transfer system the stoppers are required to position the workpiece carriers one after another at a station for machining and afterwards release them for further transportation. The cycle time of the stoppers in the line was to be 10 seconds. The modes: always 5 seconds off (stopper on) and 5 seconds retracted (stopper off).

The technical requirements were specified as depicted in table 1. The weight of the workpiece carrier is neglected in this case.

Initial force	80 N
Duty cycles	10 sec (5 sec. on, 5 sec. off)
Running time	24 h x 365 days

Table 1: Requirements to the stopper system

To drive a mechanical stopper both a pneumatic solution and an electromagnetic actuator can be applied. From a technological perspective both systems are equally suitable, and the lifetime of the two technologies is comparable as well. Therefore, the question was: Which system proves to be more convincing in an economic efficiency analysis?

In order to clarify this question an electric solenoid from Kendrion IMS and a comparable pneumatic compact cylinder available on the market were contrasted (table 2).

	Pneumatic Cylinder	**Solenoid**
Stroke	10 mm	10 mm
Operating pressure	6 bar	--
Voltage	--	24 V
Rated current	--	2 A
Force	160 N	120 N
Piston diameter	20 mm	--

Table 2: Specifications of the pneumatic and electromagnetic actuator (Source: Mercateo, Kendrion IMS)

Based on the specified requirements and the data concerning the two linear drives the costs over lifetime shall be calculated. Apart from the investment costs these also include the operating costs.

Comparison of Acquisition Costs

To compare the investment costs the components which differ in price are considered. This is true for the actuator itself, for the control and for the compressor with periphery resp. the power supply unit with periphery. The mechanism of the stopper is regarded as identical and shall not be considered. Table 3 shows the costs of the components and the total investment costs of the systems: While the pneumatic solution amounts to acquisition costs of roughly € 7,900 the electromagnetic solution amounts to appr. € 5,300, resulting in a difference of € 2,600.

Pneumatic Actuator		**Electromagnetic Actuator**	
Component	**Price**	**Component**	**Price**
Compressor	€ 4,500		
Pneumatic cylinder Unit price € 45 Quantity 20	€ 900	Solenoid Unit price € 150 Quantity 20	€ 3,000
Control SPS S7 *€ 1,500* *Control valves* *€ 1,000*	€ 2,500	*Control SPS S7* *1.500,00 €* *Power electronics* *€ 500* *Power supply unit* *€ 300*	€ 2,300
Total	**€ 7,900**		**€ 5,300**

Table 3: Comparison of investment costs for 20 pneumatic or electromagnetic actuators and additional components

Comparison of Operating Costs

To compare the operating costs and the energy consumption (table 4) a full-time operation of the line is assumed. The system with 20 cylinders resp. solenoids is expected to run 24 hours and 365 days per year. Each of the 20 actuators performs 8,640 cycles per day. To calculate the running time of the compressor a typical compressed air net with processing, leakage and actor losses was assumed.

The norm cylinder with flow and return has a piston diameter of 20 mm and is operated with an average working pressure of 6 bar. Considering the technical data of the cylinder and the losses this results in a compressor running time of 9.05 hours per day. The running

time of the solenoids amounts to exactly half the operating time (12 hours per day). The power consumption of the pneumatic valves was not taken into account.

The energy costs are determined on the basis of the electricity price in 2015 (8.09 cent per kWh). Theoretically, in the case examined the electromagnetic actuators consume about 42 per cent less energy than comparable pneumatic solutions.

Pneumatic Actuator		**Electromagnetic Actuator**	
Runtime compressor per day	9.05 h	Runtime per magnet per day	12 h
Power consumption compressor (el.)	2.2 kW	Power consumption actuators (20 x 48 W el.)	960 W
Energy consumption per day	19.92 kWh	Energy consumption per day	11.52 kWh
Energy input per year	7,270.80 kWh	Energy input per year	4,204.80 kWh
Energy costs per year Electricity price 8.09 cent per kWh	**€ 588.11**	**Energy costs per year** Electricity price 8.09 cent per kWh	**€ 340.17**

Table 4: Comparison of energy consumption and energy costs of pneumatic and electromagnetic actuator

Total Cost of Ownership Calculation

A comparison of the two systems shows that the electromagnetic system has lower investment costs than the pneumatic system. Furthermore, the energy costs of the electromagnetic systems are lower as well.

	Pneumatic System in [€/a]	Electromagnetic System in [€/a]
Investment costs	€ 7,900	€ 5,300
Additional investment costs	€ 2,600	
Energy costs per year	€ 588.11	€ 340.17
Additional energy costs per year	**€ 247.94**	
Cost saving during runtime		**€ 3,393.40**

Table 5: Cost savings by investment in an electromagnetic stopper system

Conclusion

The calculation of the lifetime costs is based on the required 10 million duty cycles resp. an operating time of 3.2 years. The use of 20 electromagnetic actuators over the minimum lifetime thus results in a theoretical cost saving of **€ 3,393.40**.

Electromagnetic Solutions

The solenoids developed by Kendrion IMS for the automation and conveyor technology typically cover strokes between 3 and 35 mm. Their duty cycles start at 15 ms. Depending on the requirement they can be designed for forces from 0.5 to 1,550 N and starting masses of 650 kg. Performance increases are possible.

Kendrion IMS
Kendrion Industrial Magnetic Systems (IMS) with headquarters in Donaueschingen (Germany) is a company of the Holding Kendrion N.V. based in Zeist (The Netherlands). Kendrion IMS develops and manufactures electromagnetic components and mechatronic systems. Basic products are single-stroke and rotary solenoids, oscillating, spreader and holding solenoids as well as high performance solenoids and fast-acting electromagnetic systems for mostly short travels. Kendrion IMS is on its way to a systems supplier for electromagnetic actuators, mechanical assemblies and mechatronic solutions. Especially for customers in the market segments machine building, automation and plant engineering the company develops project-specific solutions. Further fields of application: agricultural technology, energy supply, lifts and railways, beverage industry, medical engineering, conveyor and sorting technology, explosion and fire protection, safety technology. Kendrion IMS employs 450 employees at nine locations worldwide. Since 1997 the business unit has emerged from the traditional and innovative German brands Binder, Neue Hahn Magnet, Thoma Magnettechnik and Magnet AG. The Holding Kendrion N.V. is listed at the Amsterdam Stock Exchange Euronext (ticker symbol: KENDR). The group employs 2,700 employees worldwide and achieved a turnover of € 442 mio. in 2015.

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