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DESIGN AND REALIZATION OF GRIPPERS WITH PERMANENT MAGNETS

Urgency of the research. Modern production requires simple and inexpensive component solutions for gripping large parts. The design of gripping elements using a permanent magnet in this aspect is a promising direction.

Target setting. The aim of the project was to realize a gripping component from a commercially available pneumatic drive supplemented with a neodymium permanent magnet and to revive the resulting assembly with a pneumatic portal manipulation device designed for educational activities at the department.

Actual scientific researches and issues analysis. Implementation of the project required a detailed market research focused on the tentacles of a similar concept and the study of the principles and properties of permanent magnets. By analyzing the information the project objective was optimized - design of cheap and reliable gripping element.

Uninvestigated parts of general matters defining. Available components were used for the resulting solution, with an emphasis on low acquisition costs. This was due to the fact that the output was intended for laboratory use.

The research objective. The aim of the research was to build a real functioning and reliably working gripping device usable as an object for educational activities in the education of our students.

The statement of basic materials. Design and practical implementation of the grippers with permanent magnets for gripping parts represented in the work. Activation and control of the grips is implemented by compressed air. The implementation of the output confirmed the correctness of considerations as well as the feasibility of the repeatability of this output while meeting the basic requirement for low costs. The project was based on the principles offered by leading companies, but the implementation output gives a higher gripping force at lower input costs. In addition, it provides the possibility of extension to the size range according to customer requirements.

Conclusions. The project was successful and its implementation also contributed to the improvement of the educational process at the department, which was one of the monitored benefits. It provides an illustrative demonstration of the possibilities of performing manipulation tasks with non-standard objects.

Keywords: manipulation task; automation; one-sided gripping; permanent magnet; pneumatic components.

Fig.: 9. References: 7.

Introduction. When designing automated workplaces that require the handling of some specific types of objects of manipulation (O_M), such as sheet metal or flat products (large dimensions in the X and Y axes of the basic coordinate system, but small dimensions in the Z axis), classical forms of gripping these objects cannot be used.

The technical solution is the principle of one-sided gripping. Perhaps the most common way of doing this is undoubtedly the manipulation with active vacuum suction effectors [5, 6]. However, some applications do not allow the use of vacuum, so they must be replaced by more appropriate methods.

This is how our solution was created as the output of the diploma thesis [1]. It is based on commercially produced effectors using a combination of compressed air and a permanent magnet to fixing the object of manipulation.

One-sided gripping. For automated O_M manipulating, it is necessary to clearly define the handling task. This consists in executing a chain of operations related to changing the position of the O_M in space, or changing its orientation in space, respectively both at the same time as a sequence of operations related to its grasp in the starting point, its fixation during the manipulation period and its release at the target site.

For this purpose, devices commonly called gripping effectors are used. Depending on the nature of action the gripping elements on the O_M , there are effectors with two-sided grip (or more-sided grip), one-sided grip and a specific type of grip where there is no mechanical contact at all, Fig. 1.

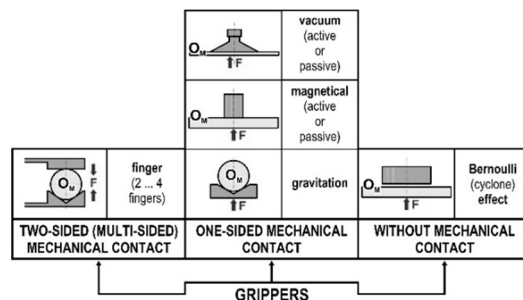


Fig. 1. Gripping effectors according to the nature of contact with O_M

Unlike double-sided (multi-sided) grasping, it is specific for unilateral grasping that the grasping effector's contact with the O_M is often at only one point (unless the stability of the O_M during the handling task is thereby impaired). If the force analysis for gripping by a single element does not suit, it is necessary to use a larger number (2 or more) of gripping elements and their arrangement should be solved by a suitable frame structure, Fig. 2.

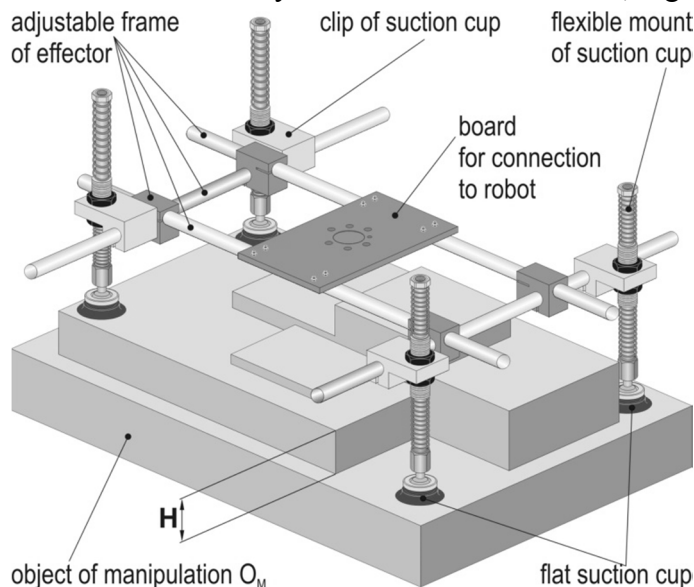


Fig. 2. Frame construction for one-sided gripping elements [6]

The physical principles used for one-sided gripping are varied [6, 7], Fig. 3.

The most commonly used are active vacuum suction cups, but also magnetic grippers with electromagnets and permanent magnets.

The decisive factor for their choice is application suitability and of course price.

The suitability of the application relates to the suitability of the selected physical principle for gripping a particular O_M (material and O_M surface quality, surface integrity, surface division, etc.).




GRIPPING FORCE PHYSICAL NATURE					
mechanical bond	vacuum	compressed air	electricity	magnetism	adhesion
					
needle	suction cup	cyclone cup	electro-magnet	permanent magnet	adhesive strip
GRIPPING FORCE TECHNICAL REALISATION					

Fig. 3. Physical principles used in unilateral grip

General effector model. To describe any effector (not just a gripper) it is possible to use the general theory (theory of systems) about the system view of functional units and machinery.

The effector, as a technical system (assembly), is made up of elements (modules, functional nodes). It can be defined and described by a generalized system model, Fig. 4. It consists of functionally separate elements and modules and links [5]:

- IF_1 flange connection to the robot
- IF_2 connection with the effector device
- M_M complementary motion micromechanism
- G gripping effector
- C position and orientation compensator
- T tool (technological effector)
- S special effector (combined)

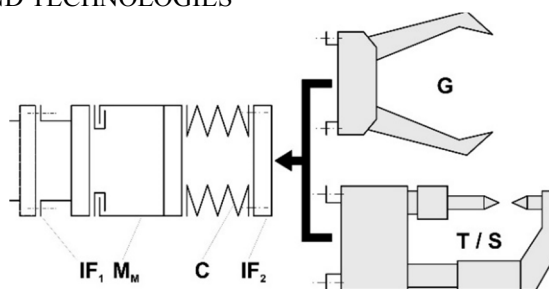


Fig. 4. System model of the effector [4], edited by the author

Construational designs of magnetic effectors [5] may have one of the system structures

$$IF_1M_M C IF_2 - G$$

$$IF_1M_M IF_2 - G$$

$$IF_1 C IF_2 - G$$

$$IF_1 IF_2 - G$$

The function of grasp - constriction - fixation of the passive gripper is accomplished by applying permanent magnets M_P in the gripper assembly G.

In the specific arrangement of our solution it is then possible to select the arrangement from the given classification

$$IF_1M_M C IF_2 - G$$

The starting point of the solution was the gripping effectors by GOUDSMIT [2], Fig. 5.

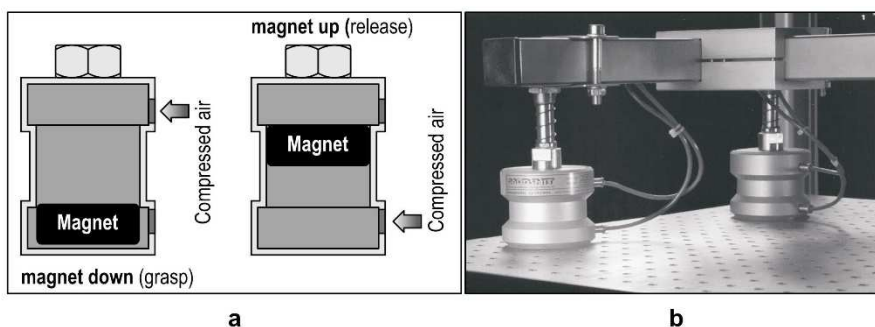


Fig. 5. Passive magnetic gripper with pneumatic control by GOUDSMIT [2]

Similar solutions in their offer have eg. SMC, SCHMALZ and others. To compare our acceptance, we present selected parameters of these effectors, tab. 1.

Table 1

Comparison of selected parameters of magnetic effectors of world producers

Manufacturer	Type	Gripping force [N]	Diameter [mm]	Pressure [MPa]	Price [EUR]
GOUDSMIT	HGR	35...3500	20...160	-0,07...0,55	151...960
SCHMALZ	SGM-HD	35...290	30...70	0,3...0,6	300...900
	SGM-HT/-HP	28...560	20...50	0,25...0,6	
SMC	MHM-X6400	30...80	30...80	0,25...0,6	150...200

Source of information: [2], [3], [4].

Project realisation. For the purpose of our solution, the concept of using the existing pneumatic compact drive CQ2B25-15D (SMC Corporation, Japan) [4] was used, on which a neodymium magnetic lens with a diameter of 20 mm and a height of 8 mm terminated with an M6 thread was mounted. This lens in a perpendicular direction provides a holding force of up to 140 N.

To eliminate the gripping force (release) between the O_M and the magnet at the O_M release location, the principle of detaching the lens from the O_M by the force of the pneumatic drive was used. To add the O_M in the place of its storage is used a separating body, which was produced by 3D printing. The assembly and the illustration of the effector are shown in Fig. 6.

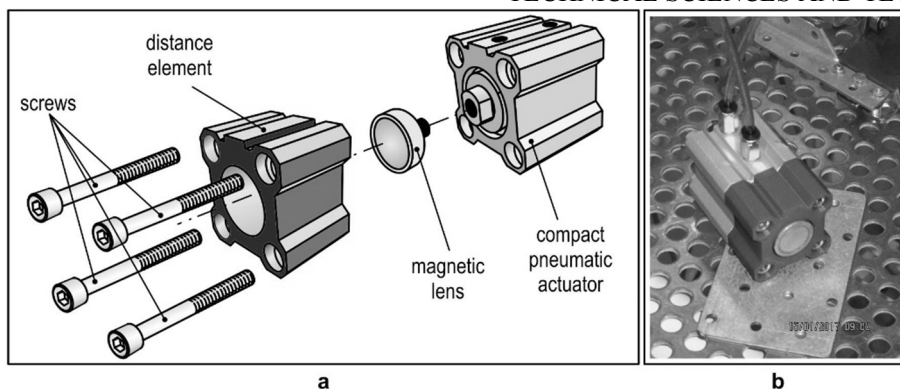


Fig. 6. Pneumatically operated magnetic gripper

The total cost of building our concept did not exceed EUR 50. The supply pressure for the pneumatic drive required to detach the magnet from the O_M was 0.5...0.6 MPa.

It should be emphasized that the effector was developed for demonstration purposes within the educational process at the department. therefore the figures given are for guidance only. A detailed analysis of effector characteristics (dynamic tests, etc.) is under preparation.

The gripping effector was used as an end effector on the laboratory pneumatic portal structure manipulation mechanism, Fig. 7.

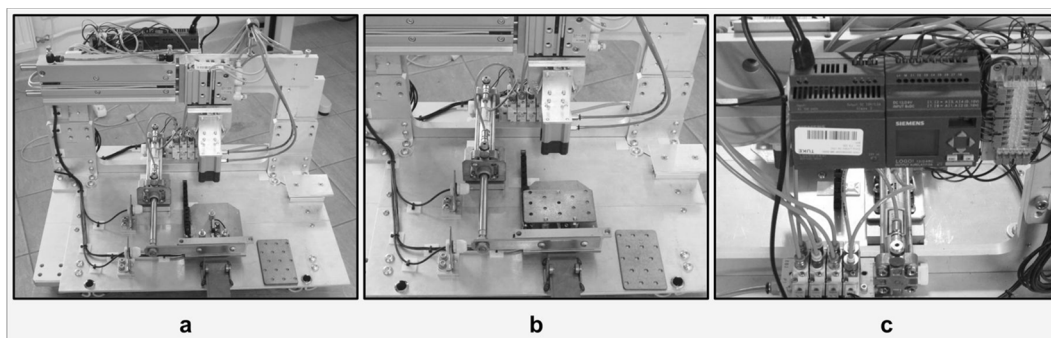


Fig. 7. Pneumatic portal mechanism (a, b) and its control unit (c)

Perforated sheet blanks with dimensions of 100x60x2 mm were determined as O_M 's intended for manipulation with the effector.

The mechanism is controlled by the logic controller SIEMENS LOGO! (0BA6 ...). FBD handling cycle program built in LOGO! Soft Comfort v. 8.0 shows Fig. 8.

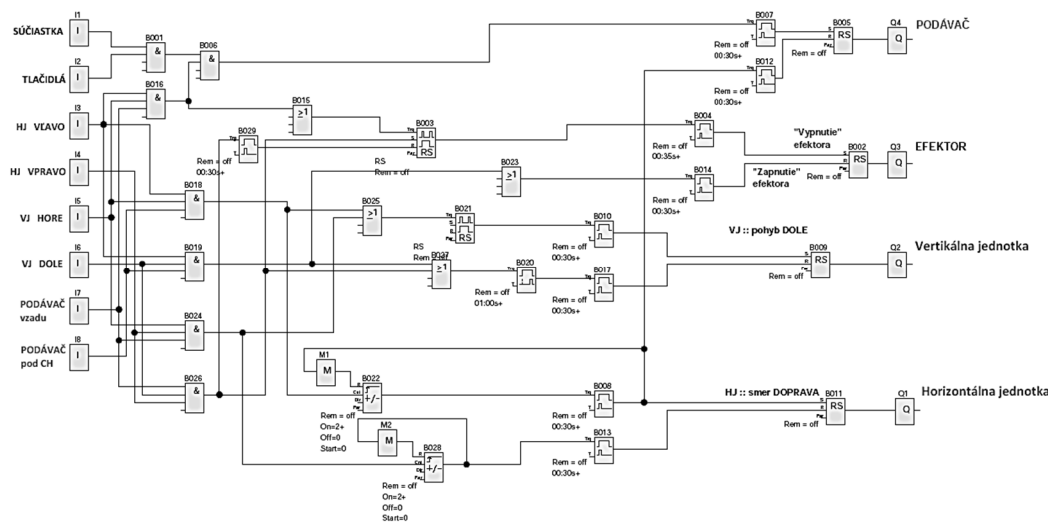


Fig. 8. Handling cycle program

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Since the withdrawal point of the handling mechanism is realized as an input with a human operator, one blank per one handling cycle is counted.

In order not to have to deal with special approach vectors of the manipulation device to establish sufficient contact of the effector with the O_M , the compensator was applied as a separate mechanical structure defining the removal height during handling (compensation in the $Z +$ direction), Fig. 9.

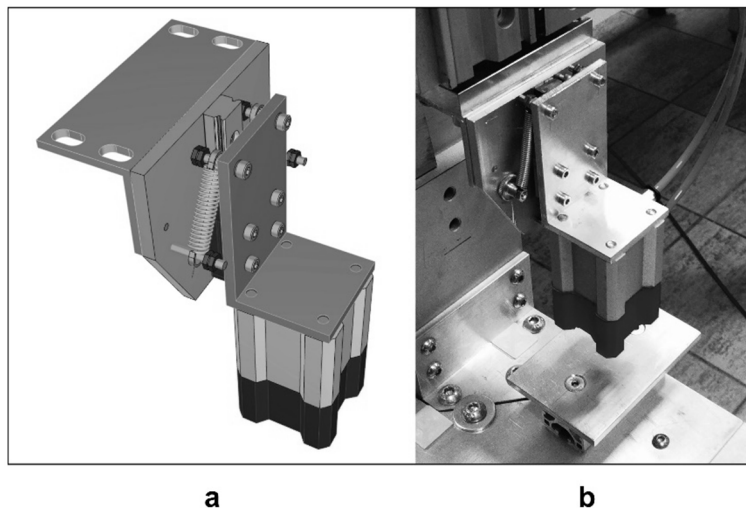


Fig. 9. 3D model of gripping effector assembly with compensator (a) and its real form (b)

Conclusions. The realization of the project from the assignment of the diploma thesis to the realization output in the form of an educational model (stend) took several years and went through several changes. Today, he is able to demonstrate in the process of teaching at the Department of Robotics in explaining the individual principles of gripping effectors working on the basis of one-sided gripping. There are other alternatives to unconventional one-sided gripping solutions (e.g. Bernoulli suction cup).

Acknowledgement. *This contribution is the result of the project implementation: Research modules for intelligent robotic systems (ITMS: 26220220141) supported by the Research & Development operational Program funded by the ERDF.*

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УДК 621.5

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ПРОЕКТУВАННЯ ТА РЕАЛІЗАЦІЯ ЗАХВАТІВ З ПОСТІЙНИМИ МАГНІТАМИ

Актуальність теми дослідження. Сучасне виробництво вимагає простих і недорогих компонентних рішень для захоплення великих деталей. Проектування захватних елементів з використанням постійного магніту в цьому аспекті є перспективним напрямком.

Постановка проблеми. Метою проекту було реалізувати захоплюючий компонент з наявного у продажу пневматичного приводу, доповненого неодимовим постійним магнітом, і застосувати для приводу захватного вузла пневматичний пристрій для маніпуляції порталом, призначений для навчальної діяльності на кафедрі.

Аналіз останніх досліджень і публікацій. Реалізація проекту вимагала детального дослідження ринку, орієнтованого на захвати аналогічної концепції та вивчення принципів та властивостей постійних магнітів. В результаті аналізу інформації була оптимізована мета проекту – проектування дешевого та надійного захватного елемента.

Виділення недосліджених частин загальної проблеми. Для одержуваного рішення були використані доступні компоненти, з акцентом на низькі витрати на їх придбання. Це було пов'язано з тим, що проект був призначений для лабораторного використання.

Постановка завдання. Метою дослідження було створення реально функціонуючого та надійно працюючого захватного пристрою, додатного як об'єкт для навчальної діяльності у навчанні наших студентів.

Виклад основного матеріалу. У роботі представлено проектування і практична реалізація захватів з постійними магнітами для захватування деталей. Активізація і управління захватами реалізується стисненим повітрям. Реалізація результатів підтвердила правильність міркувань, а також повторюваність результатів при додержанні основної вимоги щодо низьких витрат.

Проект ґрунтувався на принципах, запропонованих провідними компаніями, але результати впровадження демонструють більш високу силу захоплення при менших витратах. Крім того, забезпечується можливість розширення діапазону розмірів відповідно до вимог замовника.

Висновки відповідно до статті. Проект був успішним, його реалізація також сприяла вдосконаленню навчального процесу на кафедрі, що було однією із зазначених переваг. Він забезпечує наочну демонстрацію можливостей виконання завдань маніпулювання нестандартними об'єктами.

Ключові слова: завдання маніпуляції; автоматизація; однобічне затискання; постійний магніт; пневматичні компоненти.

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