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Peter Tuleja
Assistant Professor, Assistant Professor of the Department of production systems and robotics
Technical University of Kosice (Košice, Slovakia)
E-mail: peter.tuleja@tuke.sk. **ORCID:** https://orcid.org/0000-0001-6390-3109
Scopus Author ID: 55570858300

MANIPULATION OF SENSITIVE OBJECTS USING COMPRESSED AIR

The article deals with the issue of object manipulation, the nature of which requires specific properties of the environment in which the manipulation takes place. The handling of CD/DVD media was chosen as an example. For this purpose, as part of the preparation of educational stands at our department, a teaching workplace was designed and implemented, which will serve to train the frequenters of our faculty in the field of effective use of compressed air in manipulation tasks requiring the generation of negative pressure. The stand described in the article is available both to students as part of the educational process and to the technical public as part of demonstrating the benefits of the proposed application.

In addition to the general criteria for the manipulation task, the article also describes the solution of the stand, including the design of the pneumatic circuit and the designed control program for the used PLC.

The article has an educational and descriptive character.

Keywords: *compressed air; vacuum; manipulation; object of manipulation; parameter optimization.*
Fig.: 11. Table: 1. References: 10.

Relevance of the research. The manipulation task in an automated process is always associated with certain limitations, which force a designer and engineer to find the optimal solution while observing the established limitations. We can simply refer to these constraints as boundary conditions of manipulation.

In technical practice, there is often a need to handle "sensitive objects", e.g. objects requiring increased cleanliness (especially with regard to the presence of mechanical impurities - dust, etc.). These requirements are most often present in the electrical industry, but also in related areas, such as in the production of media for digital recording (CD and DVD media).

In the production of these carriers, in addition to the quality of the environment in which the handling takes place, it is necessary to observe the conditions for gripping them. The conditions change, as a rule, depending on the ongoing phase of the production process.

Problem statement. The CD/DVD carrier consists of a total of 4 layers, which are bonded to each other in a certain order during production (Fig. 1).

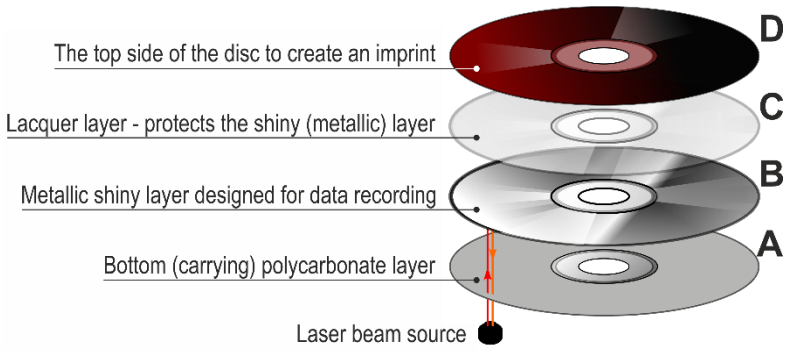

Fig. 1. The layers forming the CD carrier

Source: [1] – modified by the author.

During production, the basic component is a polycarbonate (polymethyl methacrylate) disk with an outer diameter of 120 mm, a central hole of 15 mm diameter and a thickness of 1.2 mm (Fig. 1, layer A).

During production, the most sensitive phase is when the metal layer B is installed on the polycarbonate plate A and then treated with the top lacquered layer C. Contact with the metal layer B is inadmissible, as a trace after the touch can be considered an error when reading the inscription. Likewise, layer D intended for printing (aesthetic point of view).

During manipulation operations, the central ring is considered to be the optimal surface for gripping, contact with which does not threaten the usability of the medium itself (Fig. 2). Its size is limited to a ring with an outer diameter of max. 34 mm and an inner diameter of 15 mm.

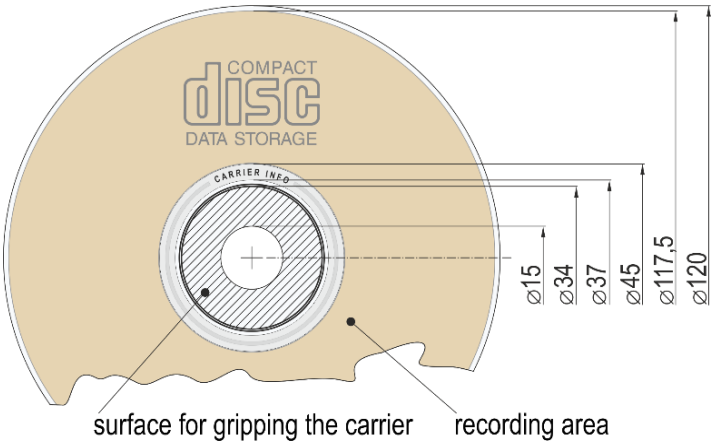

Fig. 2. Dimensions of the area usable for gripping the CD carrier

Source: created by the author.

In addition to the already mentioned area bounded by an inner diameter of 45 mm and an outer diameter of 117.5 mm (metallic layer B), the area carrying information about the disk (something like the FAT table on floppy disks) is also "forbidden". It consists of a ring with an inner diameter of 37 mm and an outer diameter of 45 mm.

Analysis of recent research and publications. Restrictions on gripping apply only during the initial stages of carrier production, when the recording layer is applied (in the case of R/RW carriers) or until the record of the work offered on the carrier is created (pressing of the metallic layer). For these stages of production (manipulation of the basic polycarbonate disc), specially adapted vacuum suction cups have proven themselves in technical practice as contact handling means (Fig. 3), possibly cyclone suction cups (Fig. 4).

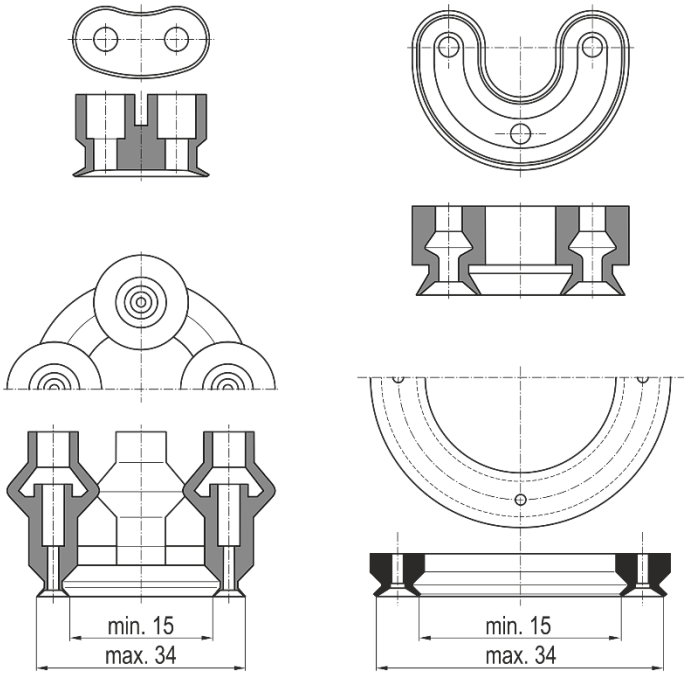

Fig. 3. Special shapes of vacuum suction cups

Source: catalog data [6].

Fig. 4. Cyclone (Bernoulli) suction cups of various manufacturers
Source: by editing the catalog data of [8; 5; 7; 1] – created by the author.

While vacuum suction cups in a special size adjustment can be used practically without limits, the use of cyclone suction cups requires solving the problem of gripping a single piece of CD carrier, since the vortex acting as the basis for the creation of a vacuum effect tends to take more than just one piece from the stacked carriers, which can happen when storing in the storage area for the next production step, a serious problem.

After the finalization of production, i.e. only when it is stored in the case, the carrier can be manipulated from any side, even safer manipulation is from the side from which the record is read.

Uninvestigated parts of a common problem. When dealing with the issue of handling CD carriers as part of the educational process, we therefore limited ourselves to handling the finished carrier, which is a pressed CD with a recording (music CD or CD with data created in a professional recording device). This limitation resulted from the need to purchase new suction cups and special carriers intended for them. We considered these increased costs to be disproportionate to such purposes of use. That's why we solved it by using 16mm diameter silicone suction cups, and we chose the side of the CD carrier on which the print is applied as the gripping surface.

Research objective. The goal of the post is:

1. approximation of the procedure for the design and implementation of the workplace, which would allow the handling of CD carriers;
2. description of the handling task and design of the pneumatic circuit;
3. proposal of the sequence of steps during manipulation;
4. design of the control program for the controller (PLC);
5. description of the methodology intended for the implementation of educational and practical training of students.

The statement of basic materials. As an educational aid for the purposes of the department and the institute, a training stand was built in an attempt to make the students aware of the dangers that the manipulation described above brings with it.

The stand was designed in accordance with the broader concept of practical teaching of pneumatic mechanisms at the institute [9] as in order 12 separate workplace (Fig. 5).

The handling device is installed on a perforated steel plate of dimensions 700x550mm placed on posts made of BOSCH aluminum profiles of dimensions 40×40mm.

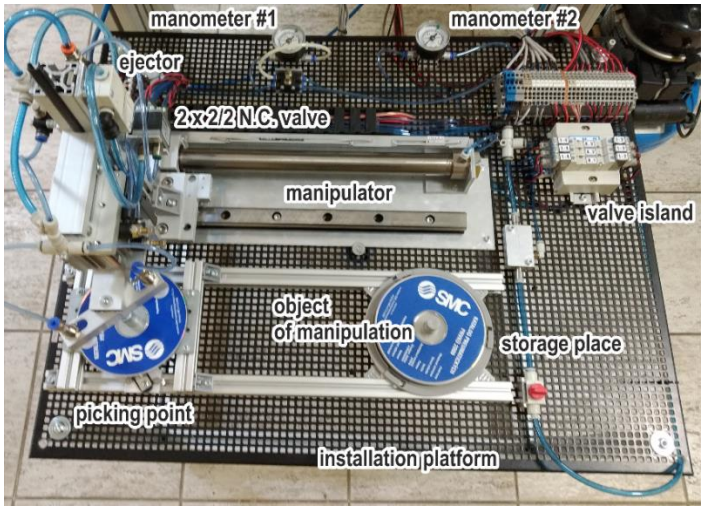

Fig. 5. Dispositional arrangement of the workplace

Source: photo created by the author.

The handling device itself consists of a pair of pneumatic drives produced by the SMC corporation (a world leader in the production of pneumatic components): a rodless linear pneumatic drive with magnetic coupling 12-A-1 (CY3B25TF-320) and a compact linear drive 12-A-2 (ECQ2B32- 30D) (Fig. 6).

Fig. 6. Drives used for the construction of the handling mechanism

Source: by editing the catalog data of [3, 4] - created by the author.

The rodless drive ensures the horizontal movement of the mechanism, the compact drive ensures the vertical component of the movement.

Movement control is ensured by the form of a valve island marked 8-V-3, which is made up of a trio of 5/2 bistable electropneumatic valves marked 8.1 ... 8.3 (Fig. 7). As can be seen from the wiring diagram, Fig. 8, valves 8.1 and 8.2 are adjusted to 3/2 N.O. This is so that it is possible to create the so-called positive control of the rodless drive (to ensure the possibility of stopping in a defined position - on the sensor marked in the wiring diagram 12A1-S-3). For this, it is necessary to apply pressure to both sides of the drive piston at the same time.

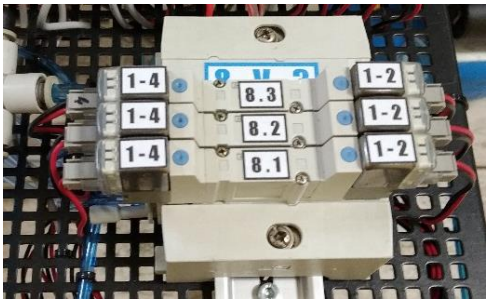

Fig. 7. Valve island

Source: photo created by the author.

The third of the valves of the valve island 8-V-3 ensures the operation of the vertical unit 12-A-2.

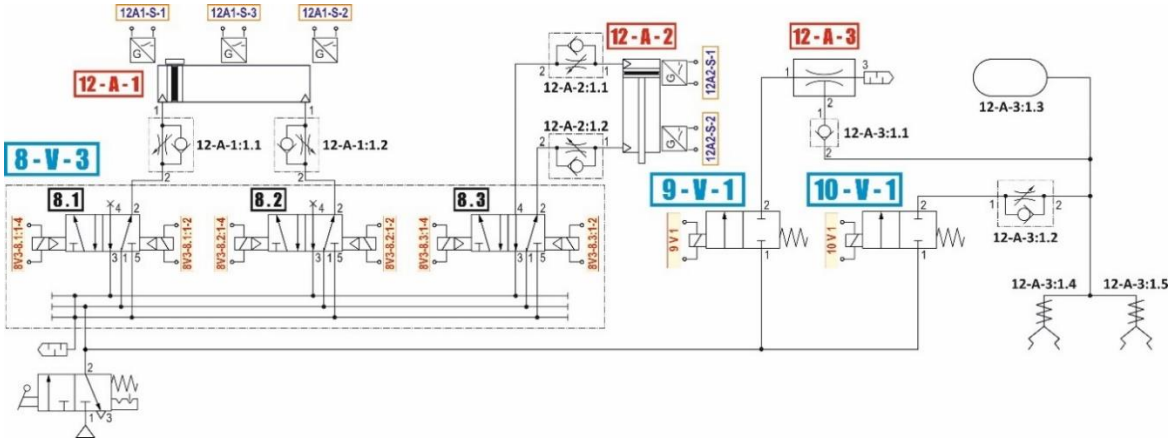

Fig. 8. Wiring diagram of the pneumatic circuit of the workplace

Source: compiled by the author.

This modification was required by the condition we set for the initialization of the mechanism and its alignment during the individual stages of the activity.

The manipulation task of the mechanism consists in transferring any number of CD carriers from the interval <1;11>. The maximum number of CD carriers is determined by the maximum stroke of the used suspension of the suction cup carrier (Fig. 9).

Fig. 9. Vacuum suction cup with spring-loaded carrier

Source: manufacturer's catalog [10].

The presence of a CD carrier in the tank is detected by a BALLUF diffusion sensor marked 12AX-S-X (see FBD diagram with control program, Fig. 11).

To initialize and align the mechanism, it is necessary to follow the instructions given in Table. Buttons, Fig. 10, listed in the table are available on the training table, where the controller controlling the sequence of workplace activities is also located.

Table – Meaning and use of initialization buttons

BUTTON	ACTIVITY	NOTE
TL1	Cycle START/cycle STOP	
TL2	Setting the suction head above the point of tank	with holding until the sensor 12-A-1-S1 is reached
TL3	Initialization (bringing pressure to both sides of the pistonless cylinder)	
TL4	Moving the suction head away from the point of tank	with holding until the sensor 12-A-1-S3 is reached

Source: created by the author.

Fig. 10. Control buttons

Source: photo created by the author.

The vacuum circuit ensuring the activation and deactivation of suction cups 12-A-3:1.4 and 12-A-3:1.5 is solved in the same way as we already described in the article published in issue 3(25) of this journal [9]. This ensures that the ejector is disabled during the transfer of the CD carrier from the storage location to the storage location. This significantly reduces the consumption of compressed air.

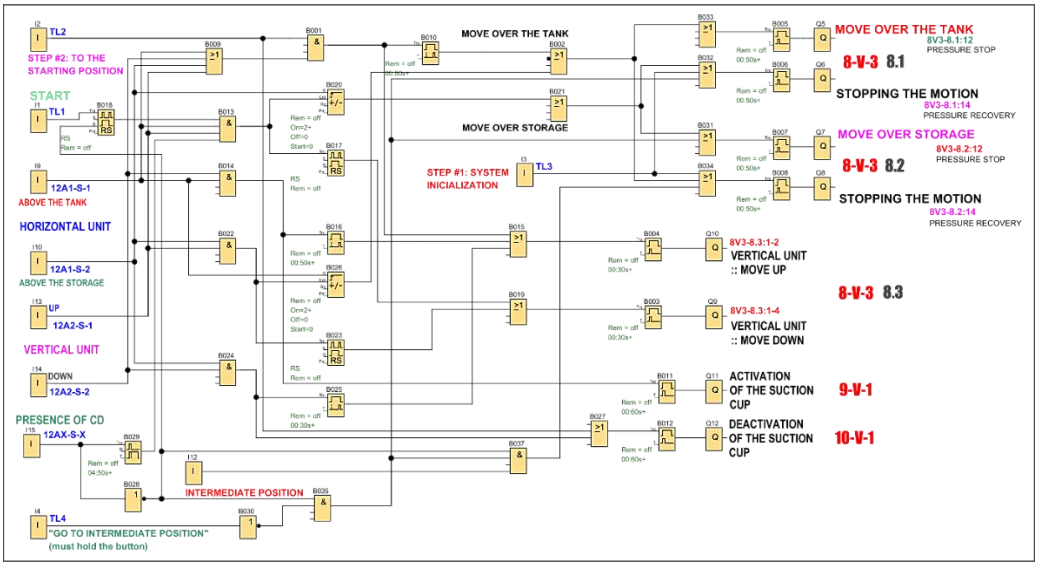

Fig. 11. FBD diagram of control program for PLC SIEMENS LOGO!

Source: created by the author.

Conclusions. The presented problem and the mechanism for its solution is a suitable addition to the concept of training workplaces for the practical preparation of our students, but they also expressed their desire to borrow it from cooperative secondary schools. It will thus contribute to the provision of better training for our students, to the provision of demonstration use for people from technical practice as well as primary and secondary school students as part of excursions at our institute.

The implementation of the described mechanism ensures the possibility, within the teaching process at the department and the institute, to provide our students with a slightly better preparation for their use in technical and practical positions after completing their university studies.

We believe that even in such partial steps, there is potential leading to the fulfillment of this effort of ours.

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References

1. 49_1.pdf : https://official.en.koganei.co.jp/product/NCT_ALL.
2. Author: Pbroks13 – Own work by uploader. Disc image taken from Image:Etiquette cd-rom 01.svg, CC BY-SA 3. 0, https://commons.wikimedia.org/w/index.php?curid=4862958.

3. CQ2B_EU.pdf : https://www.smc.eu/sk-sk/produkty-a-podpora/c-d-q2-kompaktny-valec-dvojcinny-jednostranna-piestnica~158338~cfg?partNumber=CQ2B32-30D.
4. CY3-C_EU.pdf: https://www.smc.eu/sk-sk/produkty-a-podpora/cy3b-bezpiestnicovy-valec-magneticky-prenos-sily-bez-vedenia-zakladne-prevedenie~41624~cfg?partNumber =CY3B25-320.
5. ES100-145-ZNC.pdf : https://www.smc.eu/sk-sk/produkty-a-podpora/znc-series-bernoulli-type-non-contact-gripper~168804~cfg.
6. FIPA-Gesamtkatalog-Vakuumsauger-S07_en_US.pdf: https://www.fipa.com/en-DE/product.
7. FIPA-S-CD-DVD_en_US.pdf: https://www.fipa.com/en-DE/product/bernoulli-vacuum-cups-sx-b-pk.
8. https://www.emerson.com/de-de/catalog/vacuum-technologies/aventics-sku-r412014869-de-de.
9. Tuleja, P., & Ščurka, M. (2021). RETROFIT OF PNEUMATIC MECHANISM MODEL USING VACUUM. Technical Sciences and Technology, (3(25)), 110–116. ISSN 2519-4569; https://doi.org/10.25140/2411-5363-2021-3(25)-110-116.
10. ZP_EU.pdf: https://www.smc.eu/sk-sk/produkty-a-podpora/zpt-b-j-k-prisavka-s-odpruzenym-nadstavcom-privod-vakua-v-osi~138576~cfg.

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Петро Тулея
доцент, доцент кафедри Виробничих систем і робототехніки
Кошицький технічний університет (Кошице, Словаччина)
E-mail: peter.tuleja@tuke.sk. **ORCID:** https://orcid.org/0000-0001-6390-3109
Scopus Author ID: 55570858300

МАНІПУЛЮВАННЯ ЧУТЛИВИМИ ОБ'ЄКТАМИ ЗА ДОПОМОГОЮ СТИСНЕНОГО ПОВІТРЯ

У статті розглянуто проблему маніпулювання об'єктами, природа яких вимагає специфічних властивостей середовища, у якому відбувається маніпулювання. Маніпулювання, описане у статті, вимагає підвищеної уваги при захопленні конкретного об'єкта. Як приклад було обрано дії з носіями CD/DVD.

Для цього в межах багаторічної підготовки навчальних стендів на нашій кафедрі розроблено та впроваджено чергове навчальне місце, яке буде служити для навчання студентів кафедри та інституту у сфері ефективного використання стисненого повітря при виконанні завдань, що вимагають використання негативного тиску.

Модель робочого місця, описана в статті, доступна для студентів як частина навчального процесу, а також для технічної громадськості, як частина демонстрації переваг запропонованого застосування. Модель дозволяє вирішувати не тільки загальну задачу маніпулювання, але й часткові завдання, пов'язані із сортуванням, ініціалізацією та програмуванням логічного контролера.

Крім загальних критеріїв такого маніпуляційного завдання, у статті також описано техніко-конструктивне рішення моделі. Його технічне рішення полягає в розробленому та фізично реалізованому механізмі, який дозволяє маніпулювати обраним об'єктом маніпулювання. Проєктована частина пневматичного контуру, у якій створюється негативний тиск, розроблена з урахуванням економії стисненого повітря під час маніпуляційного завдання.

Це було досягнуто за допомогою схеми з використанням одноступінчатого ежектора в поєднанні зі зворотним клапаном і вакуумним резервуаром, що створило умови для створення «вакуумного замку», подібного до того, який часто використовується в гідравліці.

Весь цей проєкт створених навчальних робочих місць також підтримується методичною підтримкою у вигляді навчального тексту (наразі готується), включаючи проєктування пневматичної схеми, опис і параметричне визначення використовуваних компонентів і складену програму керування для використовуваних контролерів. Також готується проєктування та впровадження модуля підтримки бази даних для відповідного відбору необхідної інформації.

Стаття має навчально-описовий характер.

Ключові слова: *стиснене повітря; вакуум; маніпулювання; об'єкт маніпуляції; оптимізація параметрів.*
Рис.: 11. Табл.: 1. Бібл.: 10.

Tuleja, P. (2022). Manipulation of sensitive objects using compressed air. *Technical Sciences and Technologies*, (3(29)), 45-51.