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RETROFIT OF PNEUMATIC MECHANISM MODEL USING VACUUM

The article describes a device for transferring manipulation objects using a vacuum suction cup. The suction cup is carried by the arm of the swing mechanism. The swing mechanism is realized by transforming the linear motion from a pneumatic pistonless drive to a rotary motion. The rack and pinion transformation block was used for this.

The article describes the retrofit procedure of the originally designed structure, which had unsatisfactory parameters.

In addition, the issue of saving the compressed air needed to generate the vacuum in the suction cup was addressed. Modification of the circuit can be performed by the manipulation cycle without the need for permanent activation of the ejector.

The solution in its current form is used for the educational purposes of the department in the training of skills in the deployment of pneumatic mechanisms and in their programming.

Keywords: training; electropneumatics; controller; retrofit; swing mechanism.

Fig.: 13. **References:** 4.

Urgency of the research. Several models of mechanisms are available in the conditions of the Laboratory of Pneumatic Mechanisms of our institute. These are designed for the training process to master the basic programming and other routines of our students.

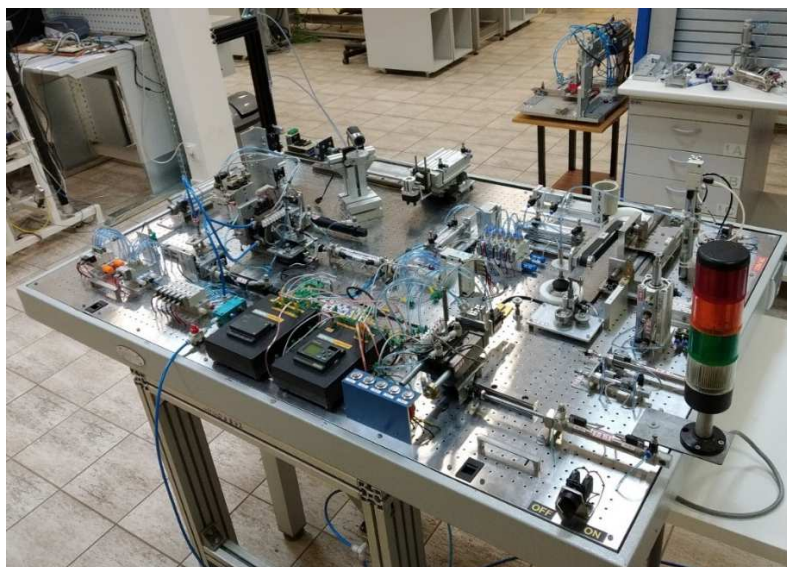


Fig. 1. Training table in its current form

The models we have placed on the so-called training table [2] (Fig. 1), originated gradually from its installation to the present day and is still a "living" process of continuous change. This process is strongly influenced by several factors, e. g. availability of the necessary components on the market.

As some models used the currently surviving types of building components at the time of their creation, there was a need for a retrofit of these models.

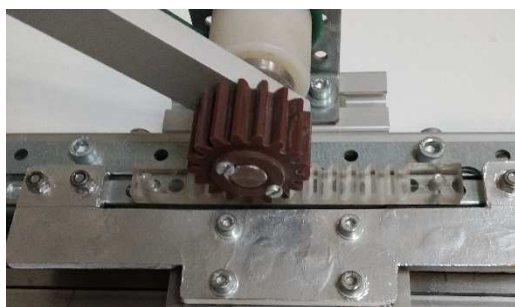
Target setting and actual researches and issues analysis. One of the retrofitted models is also the model of the mechanism, collectively referred to as Workplace 6: Mechanism with a suction cup [3].

It is a model of a mechanism based on a linear driving force from a pistonless pneumatic drive using a rack and pinion transformation block, thus achieving the resulting swinging motion with a range of 180° (Fig. 2).



Fig. 2. The original model of the solved mechanism

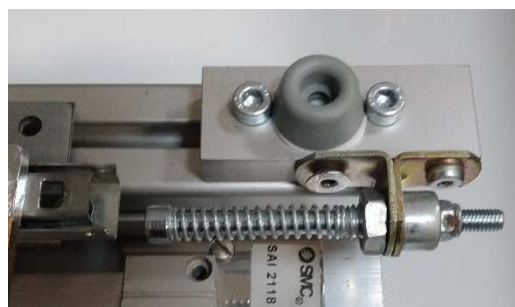
The original concept used usable components for this purpose, but technically and especially from the point of view of reliability (Fig. 3).



a



b



c



d

Fig. 3. The most problematic components of the original mechanism

A major problem was the use of plastic transformer block components. In addition to the material, the modulus of the tooth of the rack and pinion was also problematic (Fig. 3a). A "drawer" guide rail, used in the furniture industry, was used as a guide (Fig. 3b). The properties of these two components caused excessive frictional resistances, resulting in shock movements during the start-up of the mechanism. A simple spring bumper was used as a way to compensate for this phenomenon (Fig. 3c), which was able to transfer the accumulated energy during the reversal of the drive to the outer position during the reversal of the motion. This softened the sudden start of the mechanism, but was not completely removed. A synchronizing member used with the intention of maintaining the orientation of the suction cup throughout the movement of the arm (Fig. 3d), was stripped and shifted during cycling (a circular belt was used as a synchronization belt for roller conveyors).

All this together led to the described retrofit, which was realized in the form of a diploma thesis [1].

The statement of basic materials. The problems causing the components were thus known; it was necessary to find suitable substitutes that would eliminate the shortcomings of the original solution (Fig. 4).

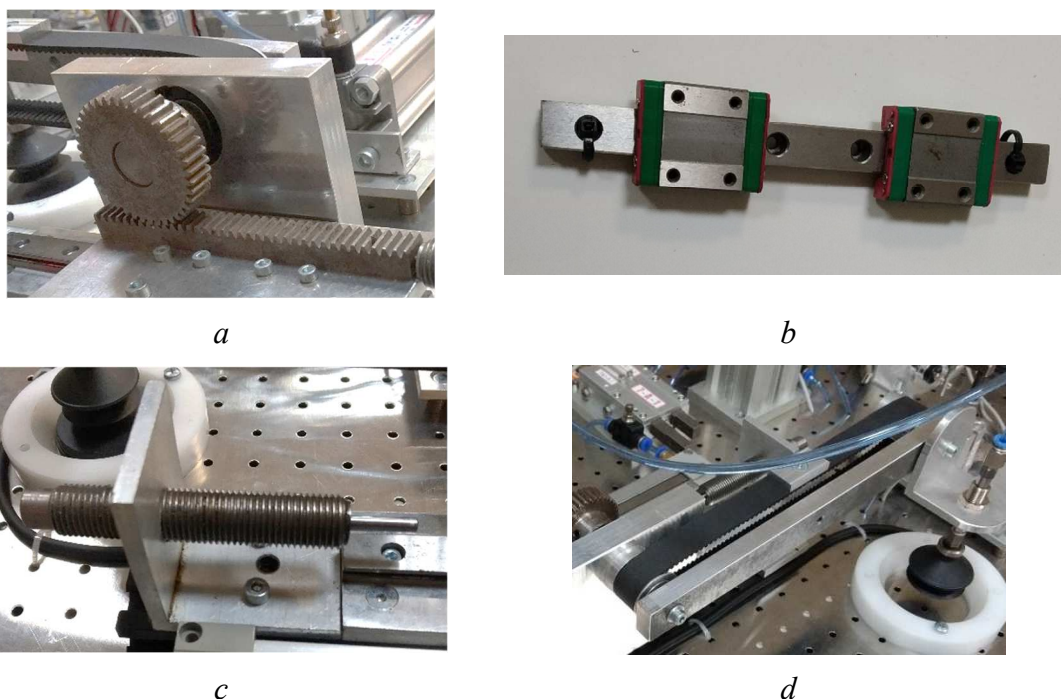


Fig. 4. Náhrady problematických komponentov mechanizmu

First of all, the plastic rack-pinion transformer was replaced by a metal one (Fig. 4a), the more preferred modulus of the tooth being used ($m = 1$). The ridge with the carrier was placed on a professional linear guide (replica HIWIN MGN12C) (Fig. 4b). By applying these two changes in the original equipment, a smoother operation of the mechanism was achieved. The originally designed spring bumper was replaced by a professional kinetic energy damper (SMC RJ1410) (Fig. 4c). This ensured a significantly better damping function in the end positions of movement. The ambiguity in the synchronization of the suction cup orientation during movement was removed using a toothed belt with pulleys (Fig. 4d).

These modifications created a new version of the mechanism (Fig. 5).



Fig. 5. Mechanism model after retrofit application

To increase the attractiveness of education, the model was supplemented with a gravity tank with a feeder (Fig. 6).



Fig. 6. Gravity tank of objects with feeder

The feeder is realized by a pneumatic linear drive with a guide (replica SMC CDQMB16 50D). Using the "blade", manipulation objects (O_M) are pushed out of the tank tube (Fig. 7), into a conically shaped space, which serves as a place for removing the O_M .



Fig. 7. Manipulated object

The O_M is gripped at the sampling point by a bag suction cup on a spring holder (SMC ZPT25DSK10-M5-A10) (Fig. 8). The suction cup is carried by a swing mechanism on an arm with a length of 220 mm (spacing between the axes is 187 mm).



Fig. 8. Bag suction cup with a spring holder

FEM analysis of mechanism arm at a load of 200 grams (considerably exaggerated total weight of the suction cup carrier, suction cup with spring holder and O_M) is shown in (Fig. 9).

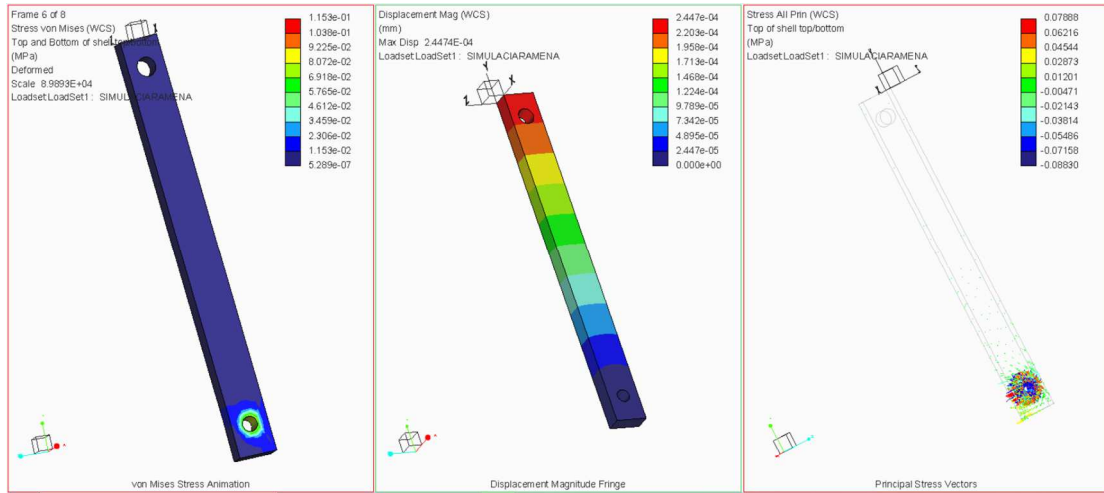


Fig. 9. FEM analysis of the mechanism arm [1]

When controlling the operation of the mechanism, the presence of O_M in the gravity tank is also monitored, which was realized using an optical sensor (KEYENCE CZ-11 with receiver CZ-K1P) (Fig. 10).

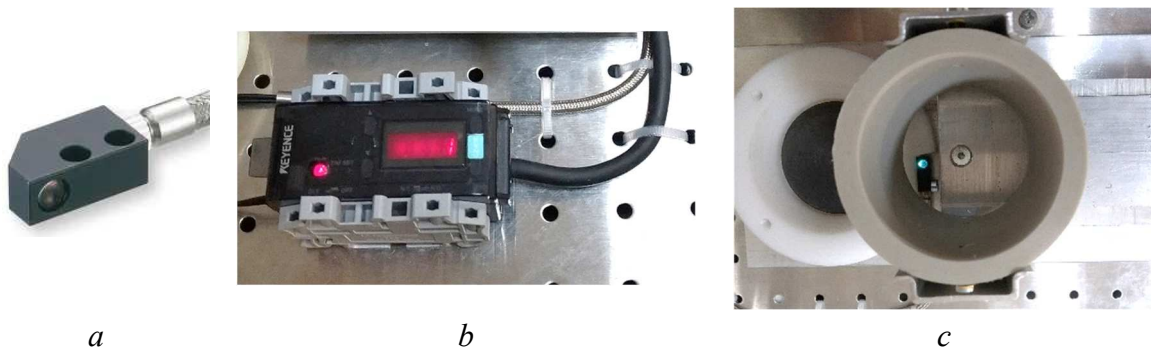


Fig. 10. Presence sensing O_M :

a) sensor [3], b) receiver, c) location of the sensor at the bottom of the gravity tank

When operating the mechanism, emphasis was also placed on saving compressed air. Therefore, to create a gripping force between the suction cup and the O_M , the air-saving circuit needed to generate the vacuum in the ejector was used (Fig. 11).

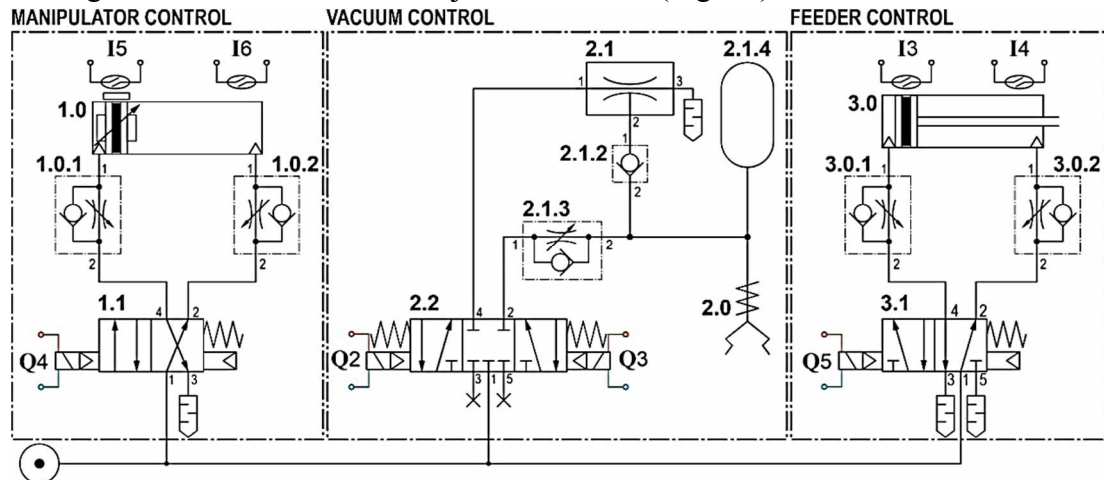


Fig. 11. Mechanism circuit diagram

The vacuum circuit then works as follows:

The signal from the PLC for a short time (0.5 s) held on connector **Q3** will ensure air flow through valve **2.2** in the direction of channels 1-4 which will activate the vacuum generation in ejector **2.1** on channel 2. The vacuum "fills" the circuit in the part bounded by ejector **2.1** (its channel 2) valve **2.2** (its channel 2), vacuum reservoir **2.1.4** and suction cups bell **2.0** closed by O_M . This vacuum remains closed in the described part of the circuit due to the presence of the non-return valve **2.1.2**. The arm movement can start (drive movement **1.0**). When the actuator reaches the position under sensor **I6**, the PLC sends a short signal (approx. 0.8 s) to the connector **Q2** of valve **2.2**. This causes the suction cup to separate from the manipulated body (since compressed air then flows through the throttle valve **2.1.3**) and the arm (actuator **1.0**) can return to its initial position (by canceling the signal at connector **Q4** of valve **1.1**). If another O_M is prepared at the collection site, the process can be repeated.

The manipulation process ends when the O_M presence sensor in the magazine sends a signal about the absence of the part. Then the red light on the connected traffic light comes on (Fig. 12), and after the last O_M is transferred to the storage location, the process is stopped and the manipulator arm remains above the storage location.



Fig. 12. Traffic light on after ejecting the last part from the hopper

The movements of the manipulator and the component feeder are evident from the wiring diagram (Fig. 11).

The FBD diagram of the program in the PLC is shown in (Fig. 13).

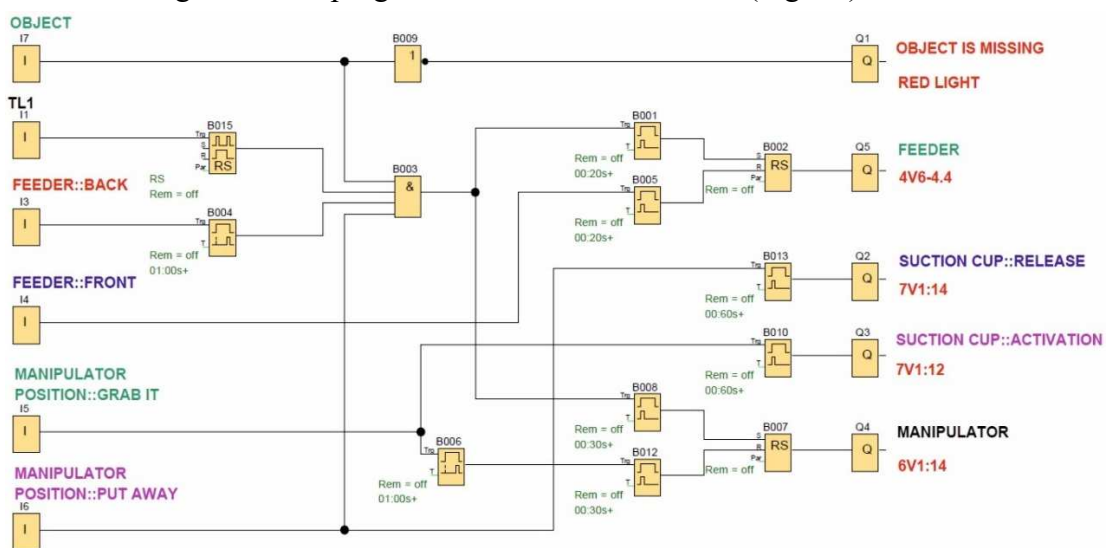


Fig. 13. FBD program diagram for controlling the activities of the mechanism

Conclusion. The retrofit procedure of the existing model for educational purposes in the form of a student's diploma thesis has proved very successful in this case. The material output of the student's work in solving the final thesis project was not only a benefit for the student in his good evaluation at the state exam, but also brought benefits in the form of a new model usable in a set of other models for practical preparation of our students for real technical practice.

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РЕТРОФІТ МОДЕЛІ ПНЕВМАТИЧНОГО МЕХАНІЗМУ ЗА ВИКОРИСТАННЯ ВАКУУМУ

У статті розглядається реальний процес структурних модифікацій моделі пневматичного механізму, призначеного для навчальних цілей, у процесі підготовки студентів кафедри до технічної практики.

Практичному навчанню останнім часом надається велике значення, але в педагогічній практиці досі бракує засобів навчання для їх впровадження.

У статті не йдеться про деталі, а про загальний підхід до вирішення проблеми модернізації незадовільної моделі механізму, про який йдеться.

У статті описано процес модернізації моделі пневматичного механізму для маніпулювання об'єктом за допомогою вакууму (присоски). Метою статті є підхід до процедури та впровадження вдосконалення практичного навчання з використанням реальних технічних засобів, реалізованих як результат випускних робіт студентів.

Технічне рішення модернізації, описане у статті, відповідає стандартним процедурам вирішення подібних завдань. Рішення базується на аналізі недоліків попереднього рішення та дає вказівки щодо рішення з практичною реалізацією з використанням наявних компонентів.

Представлений опис модернізації освітньої моделі реального механізму маніпуляцій з використанням вакууму з акцентом на економію споживання стисненого повітря разом із реальною продуктивністю відновленого та функціонуючого механізму є прикладом для інших подібних проєктів у рамках заключних дипломних робіт, результатом яких є фізична модель, придатна для використання в освітніх цілях.

Ключові слова: навчання; електропневматика; контролер; модернізація; механізм розгойдування.