Wroclaw University of Science and Technology

Faculty of Electronics, Photonics and Microsystems

Wrocław University of Science and Technology

Designing a construction that helps to increase the lifting capacity of Universal Robots

Author: Petrichenko Elizaveta

Course: Intermediate Project

Supervisor: Ph.D. Witold Paluszyński

Date: January 2022

Abstract

The project attempts to develop a method that allows the robot of the UR company to lift loads up to 50 kg while the maximum lifting capacity of the UR16e collaborative robot is 16 kg. The movement of the load along the surface is accomplished by the robot, and the lifting of heavy loads occurs due to the creation of a high vacuum in the hose, which is attached to the gripper of the robot. The vacuum hose is moved by a crane system firmly attached to the floor.

Introduction

Lifting capacity is one of the main important concepts in Robotics. Many leading companies compete in this indicator, offering better and better options, but at the same time they have to sacrifice other characteristics. There are already industrial robots capable of lifting even 200 kilograms in our world, but the uniqueness of this project is to develop such a system that will increase the carrying capacity of a collaborative robot. Because Cobots give manufacturers access to all the benefits of advanced robotic automation, without the extra costs associated with traditional robots: difficult programming, long set-up, and shielded work cells.

Fig1. Assembled construction

Initial conditions

The following task was received from the customer: there are open boxes with the product. It is necessary to put boxes from the conveyor on a pallet in three layers. Each layer should have four boxes that are close to each other. The weight of one box is 32 kilograms.

Description of the system

The main task of this project is to create a collaborative system with advantages from industrial robots. The idea behind this design is: the robot is only needed to navigate the gripper, the ascensional power will be generated by the vacuum in the hose due to suction force.

The initial model looked like this:

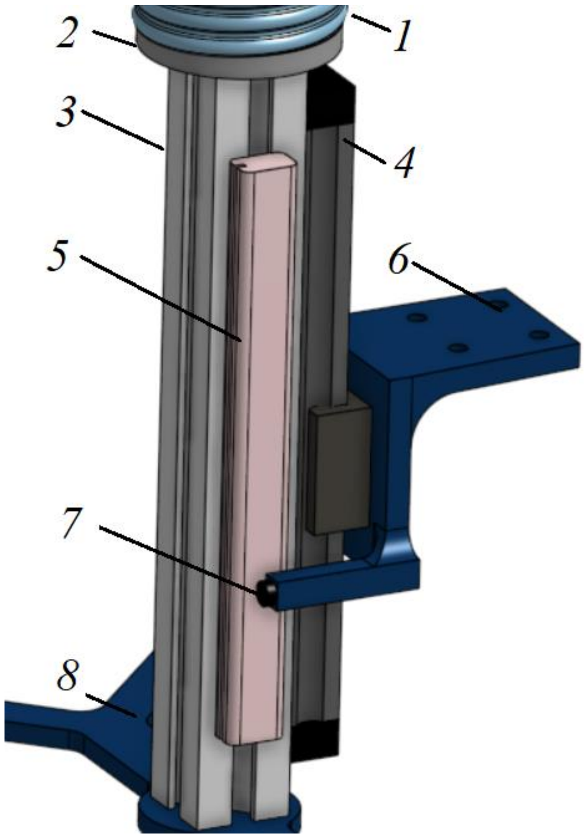

Fig.2 3D model of the gripper Fig.3 Enlarged view of the gripper

Where 1 — vacuum hose, 2 — part that allows to attach a vacuum hose to the gripper, 3 — aluminum profile for fixing all elements, 4 — linear guides, for moving the gripper along the z-axis, 5 — sensor for tracking the position, 6 — part that connects the construction to the robot, 7 — magnet, 8 — gripper.

Part 2 has a through hole for the tube. Supplying air into this tube, it becomes possible to regulate the amount of vacuum in the hose.

The dimensions of the box and the obligatory condition that the pneumatic cylinders should be applied perpendicular to the corners of the box were taken into account in the process of designing the part 8.

Since it is necessary to lift exactly open boxes, it is not possible to use vacuum suction cups and they must be replaced by pneumatic cylinders. In the future, the model will take on the following form:

Fig.4 Changed type of the gripper

Accordingly, the detail that allows you to grab the box looks like this. Its shape is justified by the fact that the box has ledges.

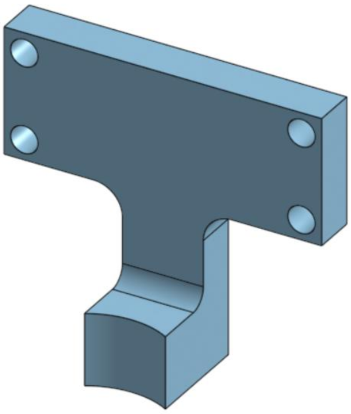

Fig.5 Detail for grabbing the box

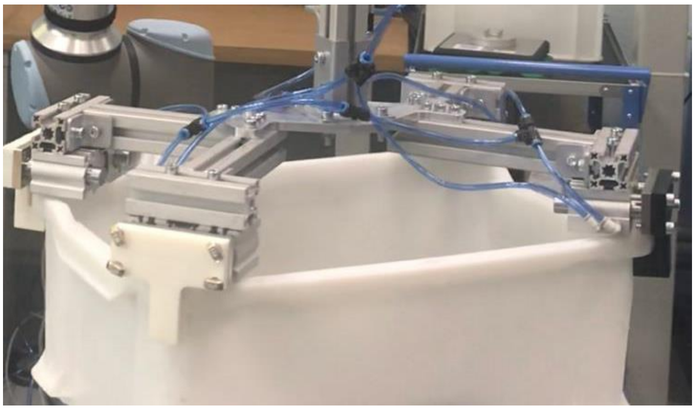

Fig.6 View of grabbing the box

For fixing a vacuum hose, it is possible to use Wall-Mounted Jib Crane. The jib crane is attached to an existing column or wall and has a pivoting angle of 180°. This enables the optimum use of existing hall dimensions. Special, newly developed, wall consoles for attachment of the wall-mounted jib crane permit easy installation.

Fig.7 Crane Fig.8 Detailed view

1 — Chain hoist

2 — Energy supply

- Trailing cable or conductor line

3 — Wall bracket painted steel

- For adaptation to fastening elements

4 — Aluminum pivot bearing

- Column mounted jib crane swivel angle: 270°
- Wall mounted jib crane swivel angle: 180°
- Can be limited

5 — Aluminum jib

- Length: 2,000 mm to 8,000 mm

The process of lifting the load is as follows:

When the robot lowers the gripper, part number 6 tends to the lowest position, a signal is transmitted from the magnetic sensor to the robot, and the robot is transmitting a signal to the electronic vacuum regulator. At the time the robot lowers the gripper, the vacuum is minimal. Then the robot gives a signal to grab the box with a cylinder and starts to rise. When the handle is raised, the signal from the magnetic sensor changes and a vacuum begins to be sufficient to lift the load. The gripper raised to the required height, the vacuum does not change and the robot only directs the load to the required position.

Selecting the necessary components

- pneumatic cylinders

The main characteristics are lateral load and piston stroke for selection of the appropriate cylinder. The choice of this equipment will be taken from the SMC catalog due to the huge number of alternatives. Since the distance between the boxes is very small (about 50 centimeters), the piston stroke should be minimal. In view of the fact that the weight of the box is 32 kilograms, one pneumatic cylinder must withstand at least 8 kg in the horizontal direction. It is clear from the table below that the minimum piston diameter is 32 mm.

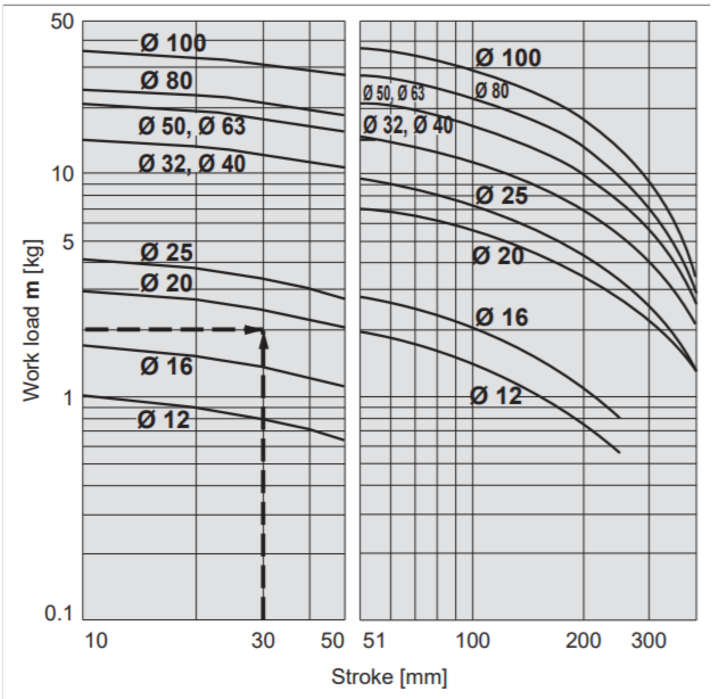

Fig.9 Dependence of work load on the stroke

Since the cylinder must withstand large loads with a small piston stroke, the choice of model should be in the group “Heavy duty”. Under these conditions, MGPM32TF-25Z model is suitable with a piston stroke of 25mm.

- sensor for tracking the position

Magnetic field sensors either utilize an internal magnet or directly detect a permanent or electromagnetic field. The internal magnet sensors detect ferrous steel and produce either an analog or digital output. Hall Switches, Reed Switches, and other external magnet sensors detect the magnetic field from a magnet or electro coil. Thus, Position sensors MPA- 323THTP0 is ideally suited for this task.

- vacuum regulator

When the input signal rises, the air supply solenoid valve turns ON, and the exhaust solenoid valve turns OFF. Therefore, supply pressure passes through the air supply solenoid valve q and is applied to the pilot chamber. The pressure in the pilot chamber e increases and operates on the upper surface of the diaphragm. As a result, the air supply valve linked to the diaphragm opens, and a portion of the supply pressure becomes output pressure. This output pressure feeds back to the control circuit via the pressure sensor. Thus, one of the options may be Electro-Pneumatic Regulator ITV3000.

Comparison with exciting options

	Collaborative robots	Industrial robots	Winch
Advantages	1. Allows an employee to work in close proximity to the robot 2. Takes up less space, compared to its counterpart 3. Safe 4. The gripper of the robot allows to lift any items 5. Application flexibility	1. It is possible to lift heavy loads by the robot itself 2. The gripper of the robot allows to lift any items	1. Cheap 2. The simple principle of the system
Disadvantages	1. Additional elements are required for lifting heavy loads 2. In high humidity, mold can form in the folds of the hose 3. A fairly complex design that will take up significant amount of space	1. Takes up an incredible amount of space 2. Partially unsafe	1. It is impossible to lift loads on which the hook cannot catch 2. Restricted application 3. It is difficult to control the winch mechanics by the robot electronics

Arising difficulties after the first attempt

- oscillations

Possible solution: for signal processing, it is possible to use PID control to improve the result, or to change the design of the construction and fix the guides on the crane.

- fragility of modeled parts

It is necessary to make all modeled parts metal and change the thickness in places with a load.

In general, the experiment was successful. The loaded box managed to be lifted and moved, but the positioning occurred with a large error due to oscillations and 3D printed detail was not strong enough. In further experiments, it is also necessary to limit the movement of the gripper in the x-y plane when lifting the load.

References:

- https://www.schmalz.com/en-us/vacuum-lifters-and-crane-systems/vacuum-tube-lifters-jumbo/
- https://cobotlift.com/lifting-type/others/
- https://www.cobottrends.com/new-ur10e-cobot-arm-25-more-payload-capacity/
- https://www.smc.eu/en-gb/products/mgp~88411~nav
- https://www.sick.com/ca/en/magnetic-cylinder-sensors/position-sensors/mpa/mpa-323thtp0/p/p305811
- https://www.smc.eu/en-gb/products/itv~43688~nav
- https://www.schmalz.com/en-gb/vacuum-lifters-and-crane-systems/crane-systems-and-jib-cranes/wall-mounted-jib-cranes/
- consultations from the leading robotics specialist of the «Promenergo Avtomatika» company Nikolay Romanov