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VIBRATIONS OF DEFORMABLE OBJECTS WITH DIFFERENT GRASPING METHODS

Abstract: The impact of object vibrations on the capabilities of robot grasping systems is very significant. The process of vibration generation from the method of grasping, even with the same gripping device, will be very different. Therefore, the need to analyze such processes in automated robotic cells creates a gap for further research to overcome vibration or use it for useful purposes.
Keywords: robotics, manipulation, grasping, deformable objects, vibration

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ВІБРАЦІЇ ДЕФОРМІВНИХ ОБЄКТІВ ПРИ РІЗНИХ МЕТОДАХ ЗАХОПЛЕННЯ

Анотація: Вплив вібрацій об'єкта на можливості захоплювальних систем роботів є дуже суттєвим. Процес утворення вібрацій залежно від методу захоплення навіть за того самого захоплювального пристрою буде дуже сильно відрізнятися. Тому необхідність в аналізі таких процесів в автоматизованих робототехнічних комірках створює зазор для подальших досліджень для подолання вібрації або її використання в корисних цілях.
Ключові слова: робототехніка, маніпулювання, захоплення, гнучкі обєкти, вібрації

The use of any gripping device causes vibrations, regardless of whether it is a mechanical gripper [1-2], magnetic [3], pneumatic [4] or any other [5]. When interacting with an object, we disrupt the stability of the system and carry out various types of force interactions, which, depending on the interaction method, can extinguish these vibrations. Of all the possible objects used in robotic cells, the most difficult to stabilize vibrations is for deformable objects. In addition, there are many local pneumatic grippers that, having grasped the object, continue to cause additional vibrations of deformable objects (Fig. 1a) [6-7]. If we add the use of local pneumatic grippers to the difficult-to-control deformable objects, we get a complex task that will lead to uncertainty and minimize the success of the pick and place operation in a robotic cell.

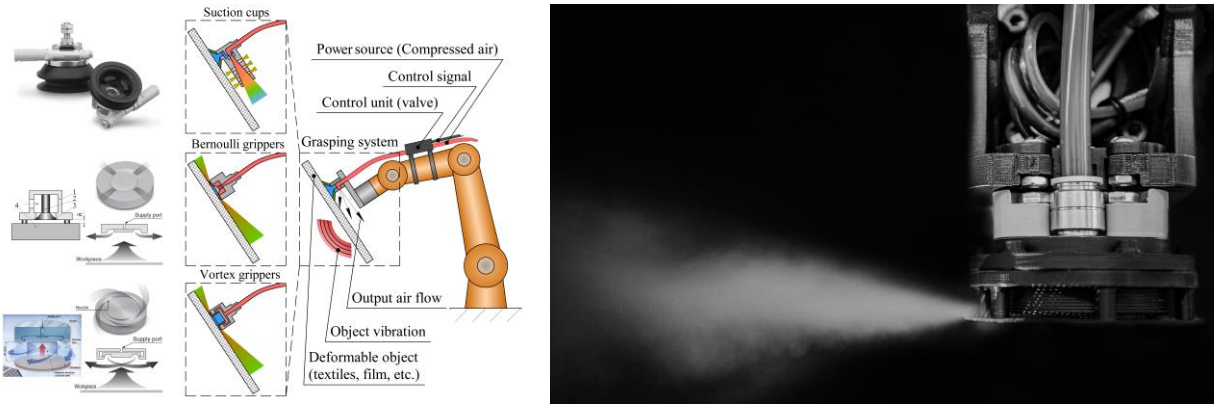

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Fig. 1. Causes of local vibrations due to gripping devices: (a) diagram of the connection of local pneumatic grippers to the robot and the direction of the air causing the vibrations [6]; (b) experimental demonstration of air flow with smoke generated by a Bernoulli gripper [7].

One of the most suitable examples for demonstrating the problem of vibration of deformable objects is jet grippers [8-10] in which, unlike classical vacuum grippers, air is released to the outside [11-19], which leads to vibration of deformable objects. We have demonstrated the flow of air with smoke that forms an improved Bernoulli gripper for textile material grasping (Fig. 1b) [7].

Thanks to the successful work on the methods of numerical modeling of a pneumatic gripper for textile materials [20], and the implementation of the methodology for automated research of gripping devices with textile materials [21], it was possible to conduct a study of the influence of the parameters of the gripping system on the force characteristics. This allows us to state the need to minimize vibrations to ensure maximum gripping force. However, in addition to increasing the gripping force, the method of manipulation after grasping remained an important factor [22], which causes the interaction of air flows with deformable objects. By optimizing the trajectory parameters, we achieved a significant reduction in the required holding force for robotic pick and place operations [23]. Therefore, the task of studying the influence of air flows during gripping is in the future. For this purpose, two gripping schemes have been developed (Fig. 2), with a deformable object hanging from one side, and with a uniform object hanging from two.

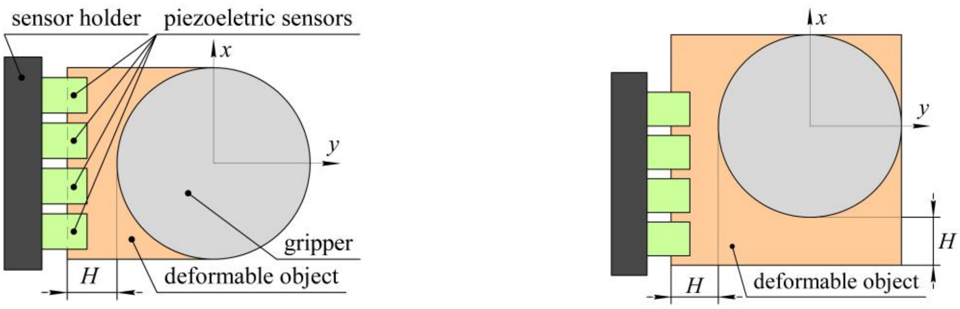

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Fig. 2. Scheme of measuring vibrations of a deformable object when grasping by various methods: (a) when a deformable object hangs from one side; (b) when a deformable object hangs from both sides evenly.

By measuring the average vibration rate with four piezoelectric sensors, we found the vibrations of the deformable object for different lengths of the object hanging outside the gripper (Fig. 3).

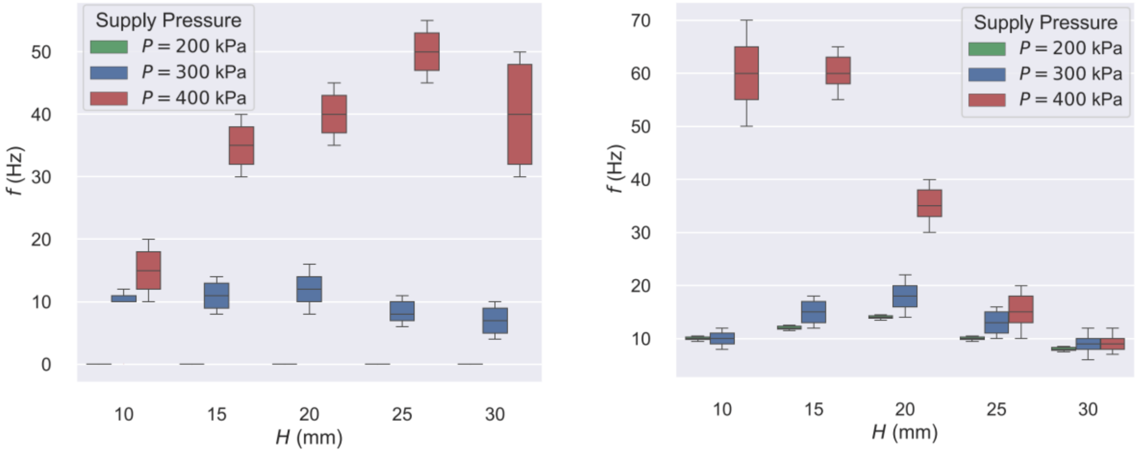

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Fig. 3. Results of vibration measurements when grasping deformable objects while changing the length of the hanging material for: (a) one side; (b) both sides evenly.

The obtained vibration data demonstrate the dependence of the supply pressure, the area of interaction with the object and the mass of the hanging deformable object. At low supply pressure parameters (200 kPa) for the conventional one-end variant, there are no vibrations, and for hanging from two ends, there is a small vibration. This is due to the fact that when grasping a deformable object from two sides, the area of interaction of the air flow with the object doubles and allows the object to oscillate. It is obvious that for the conventional one-side, the area was not enough to start oscillations. In addition, the expected vibration trend is visible for a supply pressure of 300 kPa, that with an increase in the length of the conventional H, the object first increases oscillations and after reaching the critical mass and area (at H = 20 mm) it decreases vabrations. On the other hand, at a supply pressure of 400 kPa and a deformable object from one side, we see a consistent increase in object vibrations with a peak of H = 25 mm. And for hanging from two sides (400 kPa) vibrations are gradually reduced due to a significant increase in the mass of the deformable object that oscillates. Thanks to the reengineering of the previously proposed gripper for textile objects [6], it was possible to completely remove the vibration and provide an increase in the lifting and holding force.

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