

OPTIMIZATION BY EXPERIMENTAL TESTING OF A RANGE OF UNCONVENTIONAL VACUUM GRABBING DEVICES

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Abstract: The scientific paper describes a scientific method of quick identification of the optimal grabbing surfaces, for a injecting Sigma oven grip component. In the following it have been realized experimental tests, using for this purpose a flexible vacuum prehensile device. For the experimental tests, we used three methods of grabbing the object surfaces, and the best result being that when we used the information offered by the applied expert system. As a result of the experiments the authors would recommend the use on a large scale of the conceived and experimented system.

Keywords: Optimization, vacuum prehensile device, expert system, Sigma oven grip, experimental tests, suckers, injecting system.

1. INTRODUCTION

The paper present a vacuum prehensile device, equipped on a robot, robot realized by assembling different modular elements. The extraction of the components injected in the mold, was realized with the help of four suckers, their position of surface grabbing being adjusted by an controller.

The configuration and the number of suckers from the structure of the vacuum prehensile device is established accordingly to the form of the injected object.

The bent shape of the grabbing surfaces of the two grips, injected in a mold with two nests determines on the suckers contact with the bent surfaces, the suckers deformation.

The suckers deformation on contact with the bent surfaces of the two injected components, creates irregular tensions which can finally bring to the sucker detachment while handling, generating the free fall of the handled objects, their degradation in the fall, followed by the interruption of the production process.

2. EXPERIMENTAL TESTS USING THE ORIGINAL TYPE OF THE GRABBING DEVICE

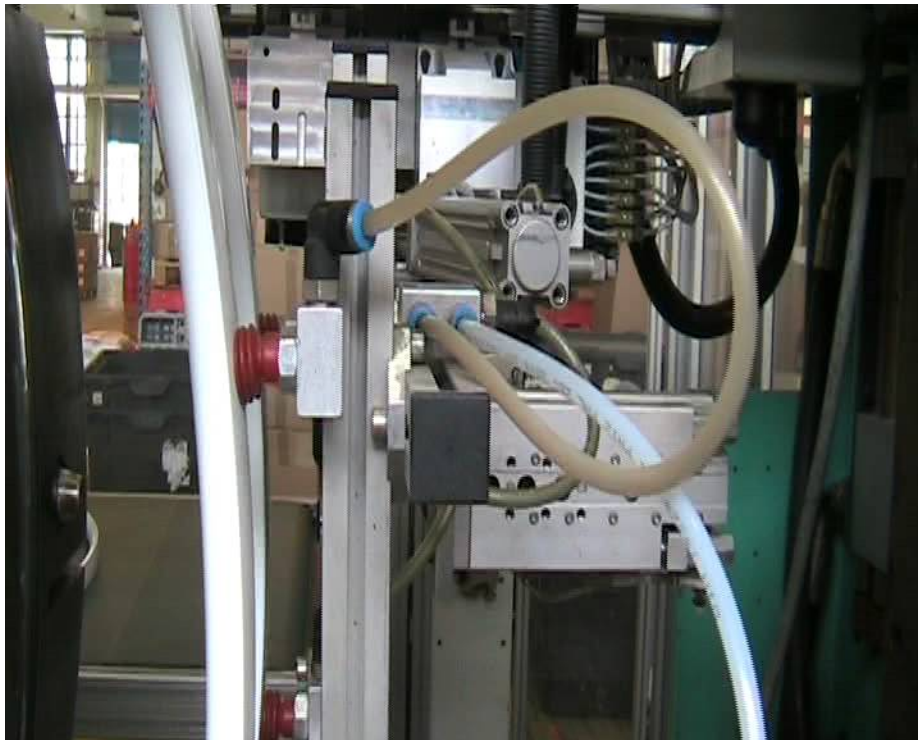
In picture 1 is presented the present grabbing system from the structure of the

vacuum grabbing device, with the rigid cup holders, which has been conceived, executed and delivered by the company which developed the MULTILIFT.H robot and was mounted on a ARBURG injecting system..

It can be observed from this picture, an irregular deformation of the contact suckers in contact with the pieces surfaces, and to better highlight this phenomenon, we choose for the first test a set of red colored suckers.

The experiments, using this constructive type of a vacuum prehensile device with rigid cup holders have pointed the extraction handling operations of the injected components, the counting and registering the detachment umber at different handling speeds on the G and Z axis in the conditions of vacuum production in the installation, on the Venturi principle. So at a constant pressure of 6 [bar] in the robots pneumatic installation, in the vacuum prehensile device is realized a under pressure of - 0,75 [bar].

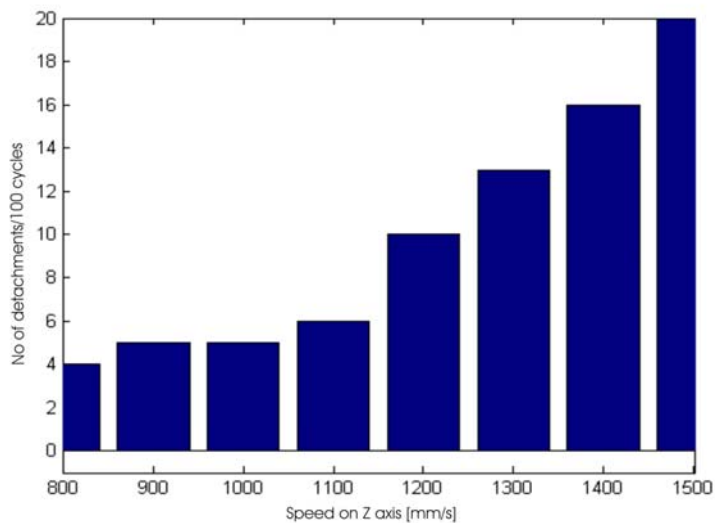
As a result of the experiments realized on the flexible cell for injection, according to the experimented value of the parameters and presented in table 1, it have been obtained a number from 4 to 20 detachment in 100 cycles of extraction-handling, for different working speeds realized by the robot on G and Z axis, according to table 1, and being represented graphically in picture 2.



Picture 1. Grabbing the Sigma oven grip components

Table 1.

Crt. No.	Speed on G axis. [mm/s]	Speed on Z axis. [mm/s]	No. Of simultaneous grabbed pieces	No. of extraction-handling cycles	No. of Detachments
1	400	800	2	100	4
2	450	900	2	100	5
3	500	1000	2	100	5
4	550	1100	2	100	6
5	600	1200	2	100	10
6	650	1300	2	100	13
7	700	1400	2	100	16
8	750	1500	2	100	20

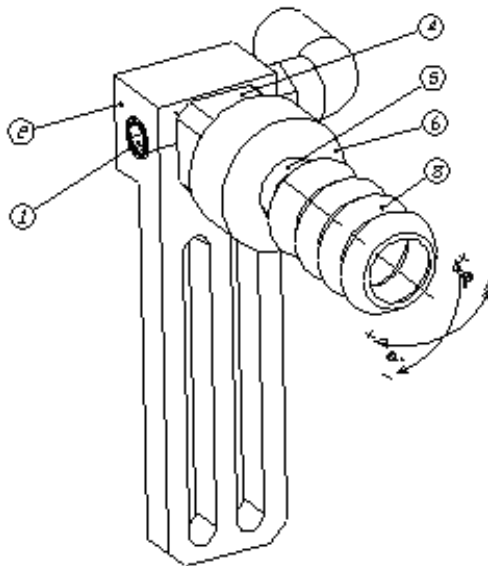


Picture 2. Graph for the number of detachments for the corresponding handling speeds according to the values in table 1

3. EXPERIMENTAL TESTS USING THE FLEXIBLE VACUUM GRABBING DEVICE

For resolving these necessities the authors have conceived, realized and experienced a vacuum prehensile device with suckers that can be positioned and orientated angularly, to obtain a grabbing on a perpendicular direction to the surface of the handled component.

The conceived and realized cup holder module can be adjusted with three rotations,



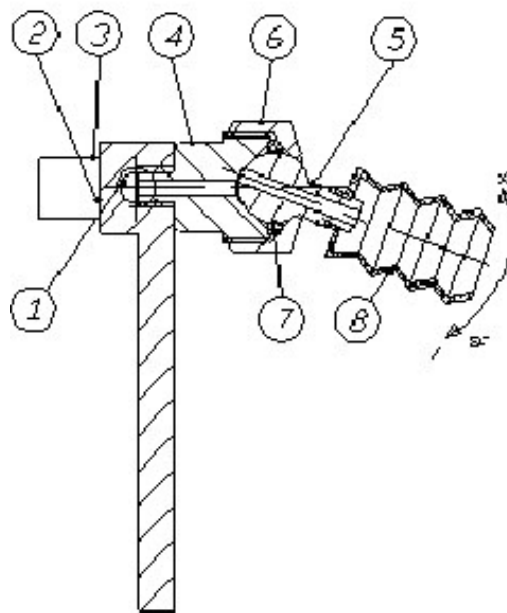
Picture 3. 3D cup holder module

introducing a spherical cinematic couple (third class), with the possibility of manual blocking in the wished position.

In picture 3 is presented the 3D model of a cup holder.

The 2D model of cup holder is presented in picture 4, having in composition the following constructive elements:

1 – Screw cap; 2 – Translation bride; 3 – Vacuum connection; 4 – spherical support; 5 – spherical joint; 6 – sleeve lock 7 – sealing ring; 8 – sucker.



Picture 4. 2D cup holder module

With these modules can be realized different varieties of flexible prehensile devices, with the possibilities of linear adjustment after two directions in a area and a 3R angular adjustment, having a certain number of suckers, according to the complexity of the handled component.

By assembling different constructive modular elements specific for the production of these devices, to which we supplementary mounted the four cup holder modules, we realized a constructive type of flexible vacuum grabbing device whose 3D assembly is presented in picture 5. The 3D model of the vacuum grabbing device assembly conceived by the authors is presented in picture 5, and it's component elements are the next:

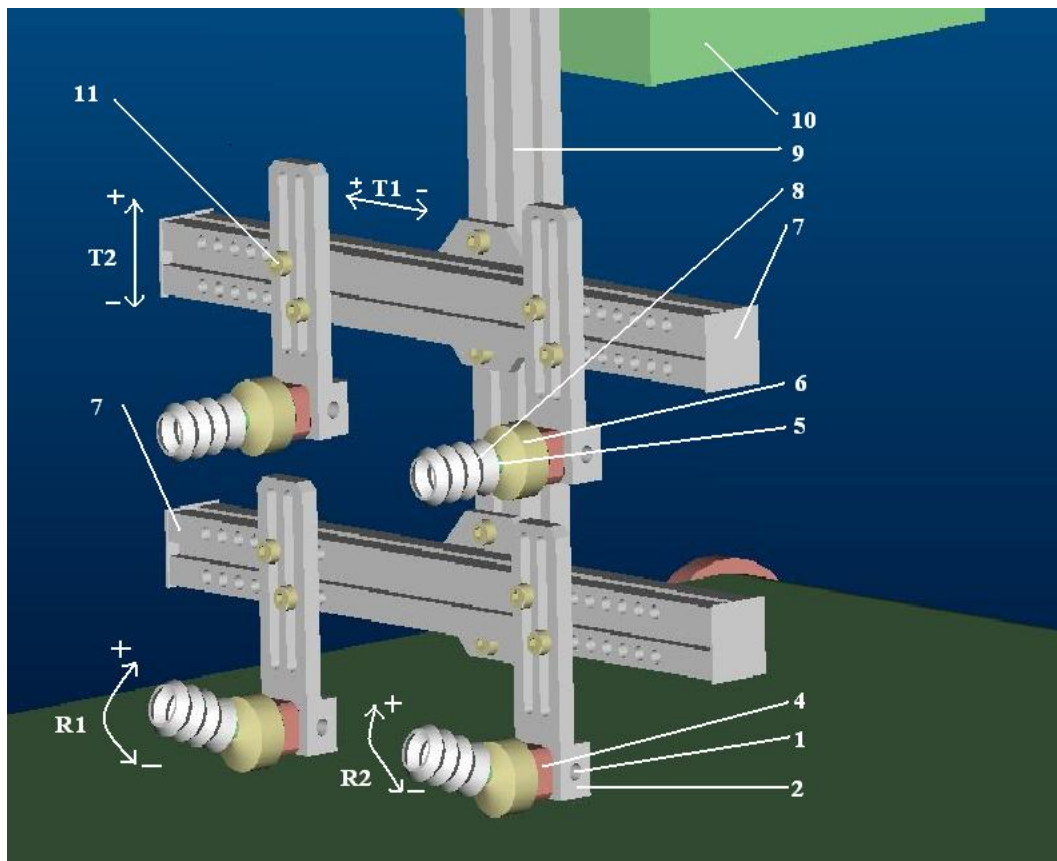
1 – Screw cap; 2 – Translation bride; 3 – Vacuum connection; 4 – Spherical joint; 5 - Suction cup mounting ring; 6 - sleeve lock; 7 - support; 8 - cups; 9 - central support; 10 – Couplings; 11 - fixing screws.

The vacuum prehensile device from picture 6 has been realized practically and experienced at S.C. Plator S.A Oradea, and the results obtained consisted in the significantly reduction of the stationing time of the ARBURG injecting machine, by reducing to minimum the number of accidental detachment of the objects while handling.

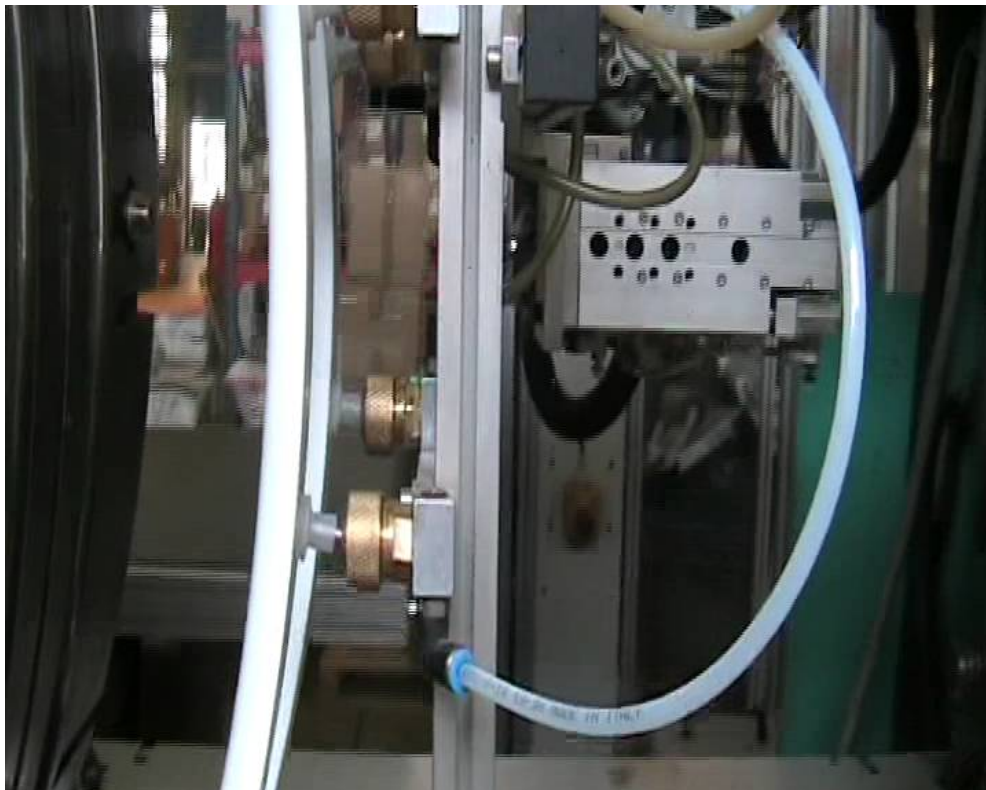
As a result of the adjustments and blocking of the spherical joints of the cup holders in the correct position, the cups in contact with the grabbed surface aren't no longer deformed unevenly, so eliminating, the probability of accidental detachments of the handled pieces.

In compliance with the speed domains of the handling robot, presented in the previous type, the experiments have been realized over a number of 100 work cycles.

As a result of the experiments we obtained the following results, values that are presented in table 2.



Picture 5. The 3D model of the vacuum grabbing device assembly



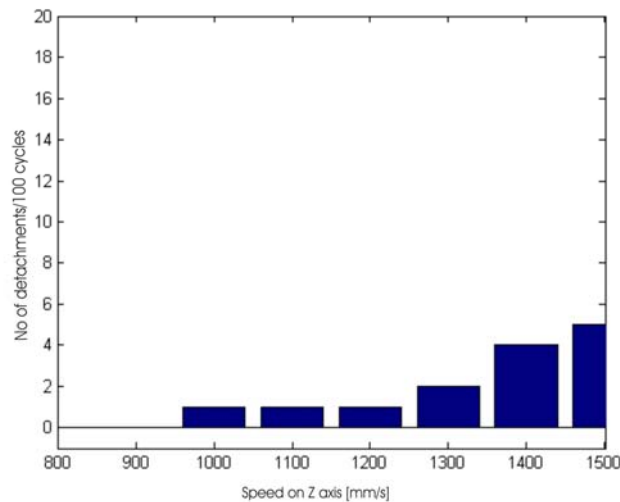
Picture 6. Vacuum grabbing device, adjustment and blocking of the cup holders followed by grabbing tests of the SIGMA oven grip components

According to the values of the experimental tests, presented in table 2, the maximum number of detachments has fallen from 20 to 5 pieces. Practically the number of process interruptions of the injection process

has dropped, also reducing the number of deteriorated objects as a result of the free fall, fact that can be observed from the graph presented in picture 7.

Table 2.

Crt. No.	Speed on G axis. [mm/s]	Speed on Z axis. [mm/s]	No. Of simultaneous grabbed pieces	No. of extraction-handling cycles	No. of Detachments
1	400	800	2	100	0
2	450	900	2	100	0
3	500	1000	2	100	1
4	550	1100	2	100	1
5	600	1200	2	100	1
6	650	1300	2	100	2
7	700	1400	2	100	4
8	750	1500	2	100	5



Picture 7. Graph of the detachment number variation for different handling speeds according to the values from table 1

4. EXPERIMENTAL TESTS USING THE FLEXIBLE VACUUM GRABBING DEVICE TYPE, USING THE CUPS POSITIONED WITH THE HELP OF THE EXPERT SYSTEM

For the experiments the position of the cups has been chosen between the two centers at the extremities of the component (centers 1 and 4).

Using the position of the calculated cups and presented before we will calculate for the vacuum grabbing device, by reverse cinematic analysis, the location parameters of the cups, namely: $d_1 \pm \frac{a_1}{2}, d_2, \theta_1, \theta_2, \theta_3$ for each of the four cups, taking account that the grabbing device handles two components at a time. In table 3 are presented the values obtained for the location parameters of the four cups.

Table 3

Location Parameter Cup No.	$d_1 \pm \frac{a_1}{2}$	d_2	θ_1	θ_2	θ_3
1	0.208	0.05	-19.25	0	0
2	0.552	0.05	19.25	0	0
3	0.552	-0.05	19.25	0	0
4	0.208	-0.05	-19.25	0	0

In the next stage of the experiments, the flexible vacuum prehensile device was adjusted so that the contact between the cups and the surface to be realized in the extremities area 1 – 4, indicated by the program as the optimum grabbing area.

The experiments were realized maintaining the same speed parameters for handling, on G and Z axis, maintaining constant the same depression used in the first experimental tests.

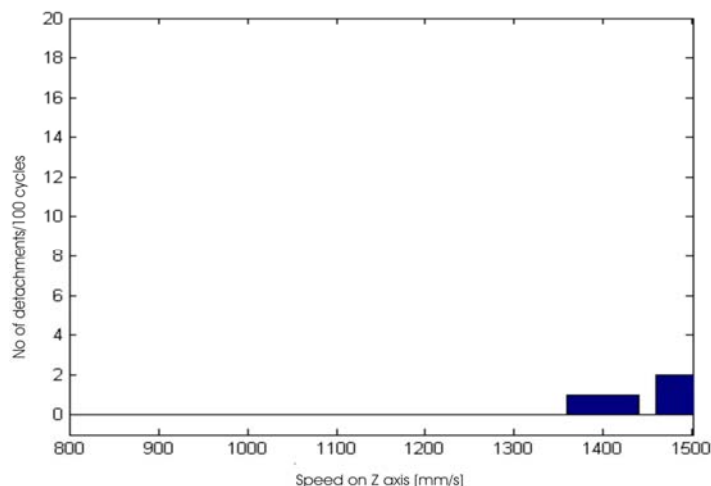
As a result of the experimental test developed in identical conditions, but

determining the exact values and the grabbing areas of the cups, in 100 handling cycles, the number of detachments of the handled objects was reduced substantially, the values of the tests being presented in table 4.

According to the values presented in table 4 represented, and graphically presented in picture 8, it results that the number of object detachments from the vacuum prehensile devices cups has fallen considerably.

Table 4.

Crt. No.	Speed on G axis. [mm/s]	Speed on Z axis. [mm/s]	No. Of simultaneous grabbed pieces	No. of extraction-handling cycles	No. of Detachments.
1	400	800	2	100	0
2	450	900	2	100	0
3	500	1000	2	100	0
4	550	1100	2	100	0
5	600	1200	2	100	0
6	650	1300	2	100	0
7	700	1400	2	100	1
8	750	1500	2	100	2



Picture 8. Variation graph of the number of detachments for different speeds according to the values from table 4.

According to table 4 and the graph shown below it can be observed that at handling speeds on G and Z axis of 400 mm/s; 800 mm/s; 650 mm/s; 1300 mm/s, we have no detachment of the object. The optimum speed areas is modified in a positive way so that the in at the speed of 700 mm/s an G axis was registered one detachment, and at 750 mm/s were registered two detachments.

5. GENERAL CONCLUSIONS REGARDING THE FIRST EXPERIMENTAL TESTS

At the end of the experimental tests, realized at Plastor SA, where were tested the types of vacuum grabbing devices, classic and flexible ones, presented in detail in this paper, we reached the following conclusions:

According to the tests results, with the results presented in graphs, it clearly results that at the last experimental type, based on the data furnished by the conceived expert system the cups being positioned perpendicularly on the surfaces with a maximum grabbing, the number of detachments of the handled component were minimum.

As a result of this method application the number of detachments during the manipulations was highly reduced at a minimum number and at the experimental test where the cups have been positioned on the optimum areas determined with the help of the expert system, the detachments have been completely eliminated. In conclusion the realized experiments clearly confirm the advantages given by the flexible vacuum grabbing systems conceived and experimented by the authors.

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