18th International Conference
ENGINEERING MECHANICS 2012
Svratka, Czech Republic, May 14 – 17, 2012

pp. 108–109
Paper #224

THE STUDY OF MECHANICS OF DEFORMATION BEHAVIOUR OF SERVICE ROBOTS GRIPPING SYSTEMS

M. Horák*, F. Novotný**

Abstract: *This paper presents an analysis of the gripping system and contact links with a vertical plane of contact. It focuses on comparing the classic gripping elements and elements which combined methods of gripping force deducing with the using of different physical principles (vacuum, friction and adhesion). The first part of the paper describes the behavior of suction cups used as standard during radial loading using a computer simulation depending on rigidity of an elastomer sealing rim of the suction cup. The second part illustrates structural modifications of the suction cup by means of a bearing supporting plate having a material with an adhesion layer on the contact boundary and allowing the down-pressure to be regulated depending on mechanical properties of the object kept.*

Keywords: ***Gripping element, suction cup, vacuum, adhesion, contact.***

1. Introduction

In most cases it concerns applications combining the latest smart vacuum technology with high-tech systems of multi-angle industrial robots having six degrees of freedom that replace standard single-purpose manipulators step by step. When handling of jumbo formats of sheets having boundary dimensions ca. 3 x 6 m, nowadays a cooperation of two robots placed on a common travelling device is used. It is obvious that a handling task like this makes high demands for providing the parallel motion of both robots. Possible inaccuracies in positioning (Horák, 2008) find distinct expression in an undesirable loading of the sheet gripped, excessive loading of the robot wrist and vacuum gripping elements.

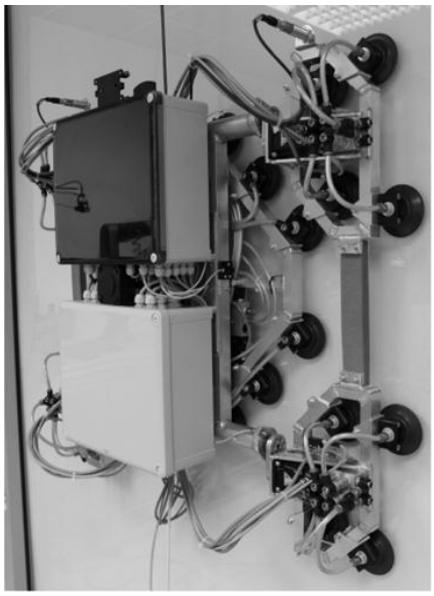

Fig. 1: Developed service robot

The use of suction cups in the field of holding-down systems, such as locomotion devices (chassis) of service robots allowing the autonomous motion on vertically oriented walls, is a reciprocal task (Fig. 1). As for the systems based on the stepping principle of the robot motion (Novotný & Horák & Plavec, 2011), changes in the center of gravity distance occur, which has a negative impact on the loading pattern of particular suction cups subjected to radial and axial forces as well as to tilting moments depending on the geometry of the chassis kinematics (climbing robot).

It is necessary to specify such safety level so that the gripping or holding-down system satisfied the requirements for the stable keeping in the all regimes of loading. Thus, authors put the accent on an analysis of deformation behavior of suction cups with a rigid body and flexible sealing rim. The basic aim is focused to modify the contact areas of the suction cup in order to increase their load capacity in radial direction when a preservation of the vacuum level, because during the robot motion on the vertical walls the suction cups are overtaxed in the radial direction.

* Ing. Marcel Horák, Ph.D.: Technical University of Liberec, Faculty of Mechanical Engineering, Department of Glass Producing Machines and Robotics; Studentská 1402/2; 461 17, Liberec; CZ, e-mail: marcel.horak@tul.cz

** doc. Ing. František Novotný, CSc.: Technical University of Liberec, Faculty of Mechanical Engineering, Department of Glass Producing Machines and Robotics; Studentská 1402/2; 461 17, Liberec; CZ, e-mail: frantisek.novotny@tul.cz

2. Combined vacuum adhesive gripping element

The proposed design solution combining the vacuum gripping element (GE) with a rigid flange, a flexible sealing rim, and a withdrawable positionable plate treated by an adhesive layer is a one possibility to increase the radial load capacity (Horák & Novotný, 2011).

Fig. 2 shows the solution enabling to adjust automatically the adhesive layer or the bearing plate orientation depending on an orientation of the object contact surface (the plate and the piston are connected through a ball joint) in position when the adhesive insert is out of the contact with the object handled.

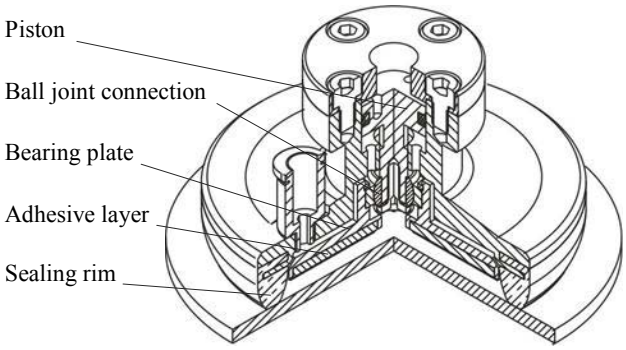

Fig. 2: GE with flatness compensation

2.1. Results of laboratory tests

From the diagrams given it results that the adhesive layer together with the bearing plate affects evidently the gripping (contact) stability and finds expression in a marked increase of the load capacity (Fig. 3) which is dependent on the observed level of the contact profile shift and vacuum, and ranges from 31% to 94%. As for a pure stabile character of the contact defined by the determined maximum shift 0.5 mm, the load capacity increase as high as **60 %** at average.

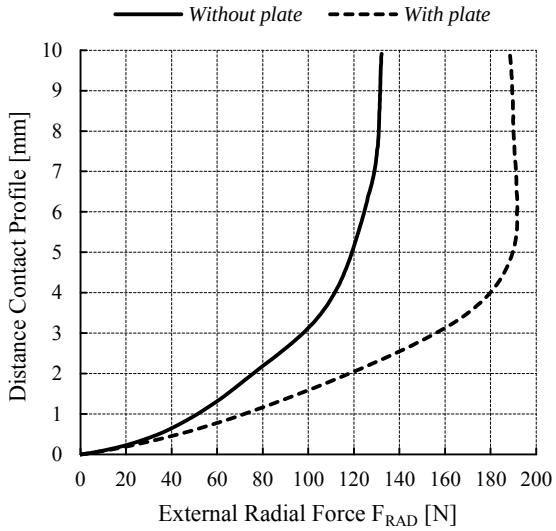

Fig. 3: Rad. distance of profile (vacuum -80 kPa)

3. Conclusions

The main part was focused on problems related to increasing the load capacity of elements in radial direction by reason of unprecedented demands on vacuum gripping heads in connection with the new production technologies and methods. A vacuum-adhesive gripping element was designed and tested in laboratory. Provided clean operation, it was shown during tests that the use of adhesive layers leads to increasing of the radial load capacity at tens of per cents in comparison with standard solutions whereas the vacuum level is kept.

Acknowledgement

This work was supported by the Research plan No. MSM 4674788501 and OP Research and Development for Innovation: Centre for Nanomaterials, Advanced Technologies and Innovation, CZ.1.05/2.1.00/01.0005.

References

Horák, M. (2008). Dynamická manipulace s plochým sklem. Liberec: TU v Liberci. 2008. 165 s., ISBN 978-80-7372-425-2

Novotný, F. & Horák, M. & Plavec, M. (2011) Mobilní plošina pro pohyb po vertikální stěně. *Utility model No. 22900*, http://spisy.upv.cz/UtilityModels/FullDocuments/FDUM0022/uv022900.pdf

Horák, M. & Novotný, F. (2011) Podtlakový úchopný prvek. *Patent No. 302959*, http://spisy.upv.cz/Patents/FullDocuments/302/302959.pdf

Horák, M. & Novotný, F. (2011) Increases in the Radial Capacity of Vacuum Gripping Elements. *MM Science Journal, October 2011*, Special Edition - 20th International Workshop on Robotics in Alpe-Adria-Danube Region (RAAD), October 5-7 2011, MKČR E 7645, www.mmscience.eu, p. 122-127. ISSN 1803-1269 (Print), ISSN 1805-0476 (On-line)