International Conference on Smart Electronic Systems - 2016
KLE Society's Dr M S Sheshgiri College of Engineering & Technology, Belagavi

International Journal of Technology and Science, ISSN (Online) 2350-1111, (Print) 2350-1103 Volume 3, Issue 4, 2016 pp. 32-33

# Implementation of Electro adhesion system for pick and place application

Gauri Shivdas Gaunekar
[1] Goa College Of Engineering/Department Of Electronics & Telecommunication, Ponda, India
Email: gaunekargauri@gmail.com

***Abstract*— This paper describes a novel technique for pick and place robot using electroadhesion. It involves picking and placing a polywoven packaging sack in a constrained environment while strictly maintaining working parameters of the existing system. The scientific methods to perform this task are studied under the concept of Astrictive Prehension. This is mainly achieved using into three distinct methods – namely, vacuum suction, magnetoadhesion an electr adhesion. A prototype of electroadhesive pad is demonstrated using polyimide as a dielectric material. The electrode geometry used is comb type or also called interdigital electrodes.**

*Index Terms*— **Atrictive Prehension, Electroadhesion, Pick and place, Retention force.**

## I. Introduction

Human development has always been adopting new technologies to make the work and its environment easier and more effective. The work which was handled by human hands has led to the need for more effective handling equipment, especially prehension system (grippers).These systems perform different tasks such as assembling, packaging, etc. One of these tasks is Pick and Place. Numerous methods have been employed to implement this technology. These include Vaccuum Suction, Magnetoadhesion and Electroadhesion. Among these, Electroadhesion is shown to be one of the more robust attachment mechanisms.

## II. Electroadhesion – operating principle

Electroadhesion is the electrostatic effect of astriction between two surfaces subjected to an electrical field. An electroadhesive pad consists of conductive electrodes placed upon a polymer substrate. When alternate positive and negative voltages are applied to adjacent electrodes, the resulting electric field sets up opposite charges on the surface that the pad touches, and thus causes electrostatic adhesion between the electrodes and the induced charges in the touched surface material.

Electroadhesion can be divided into two basic forms: that which concerns the prehension of electrically conducting materials where the general laws of capacitance hold true (D = E Є) and that used with electrically insulating materials where the more advanced theory of electrostatics (D = E Є + P) applies. Fig.1 shows a typical example and its equivalent electrical circuit. The applied potential is normally high voltage[1].

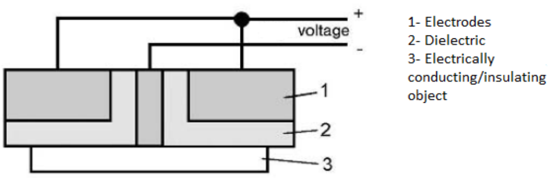


Fig. 1 Equivalent circuit for electroadhesion pad

From [1], [2], [3], the basic equation for retention force, F is directly proportional to dielectric constant Є i.e. $Є_0Є_r$ where $Є_0$ is the absolute dielectric constant($8.854*10^{-12}$ F/m), $Є_r$ is the relative dielectric constant of the material, *A* is the area of the electroadhesive pad , *V* is the voltage applied and inversely proportional to the square of the distance *d* between the pad and the substrate and is given as

$$F = Є_0Є_rAV/2d^2 \quad (1)$$

Considering the prehension of insulating materials there are four major types of electrical polarization, namely electronic, atomic, dipole and interfacial. For electroadhesive prehension purpose, only the last two are of interest and their contribution is better described as follows:

- Permanent polarization as a result of molecular permanent dipole moment.
- Induced polarization due to an applied electric field.

The former is weaker and is subject to the effects of temperature. The later is much stronger and is used in the electroadhesion of insulating materials.

Any crystal structures present in the dielectric will tend to have their own, separate dipole moments. Considering that most polymers are at least partially crystalline, these structural polarizabilities are often responsible for the overall electroadhesive effect. From the electrostatic theory we have equation for retention force as in (1). Previously, the polarization component Pm was simply considered as a scalar. However, at the molecular level, where highly polarizable materials are concerned, this is rarely the case.

In an electrically conducting medium, such as metal, any charge applied will disperse through the conductor in the form of a current. In an insulator this is not the case. So a charge build up occurs on the surface. This takes the form of electrons, or holes (positive charges), being attached to the molecules from which the material is made. These electrons cannot flow from one atom to the next as in a conductor. So, the only way an atom can shed its spare electrons is by turning the molecule to which it is attached so that the negative end of one molecule makes contact with the positive end of another molecule thus allowing the charges to be neutralized. This phenomena is called Induced polarization.

In a solid, the molecules are usually so rigidly bound as to make such large rotations and displacements impossible. However, as these molecules try to rotate due to the effects of these applied charges, a torque is experienced. Because the molecules are firmly attached to one another, the combination of such forces produces a net force on the surface of the object which causes it to adhere to the dielectric gripper. This effect is known as polarisation Pm and is related to the molecular structure and electric field *E* can be given by (2).

$$Pm = \alpha_0 E \quad (2)$$

$\alpha_0$ - molecular polarisability of dipole
E - applied electric field strength [V/m]

International Journal of Technology and Science, ISSN (Online) 2350-1111, (Print) 2350-1103 Volume 3, Issue 4, 2016 pp. 32-33

Electroadhesive forces do not permeate through the object material deeply. Being the result of charge generation at an interface between two dissimilar dielectric materials, they tend to provide a interfacial force. This can be very useful when applying this technique to the removal of single sheets of material from a stack of the same and is used in this respect for paper handling, destacking of textile fabric etc.

## III. ELECTROADHESIVE PAD

The electroadhesive pad comprises a first electrode, a second electrode, and an insulation material as shown in "fig.(1)". The first electrode is configured to apply a first voltage at a first location of the electroadhesive pad. The second electrode is configured to apply a second voltage at a second location of the electroadhesive pad. The difference in voltage between the first voltage and second voltage includes an electrostatic adhesion voltage that produces an electrostatic force between the pad and the substrate that is suitable to maintain a current position of the pad relative to the substrate. The insulation material is disposed between the first electrode and a surface of the substrate, and/or disposed between the second electrode and the substrate surface. The insulation material includes a thickness less than about 2 millimeters between the first electrode and a surface of the substrate and between the second electrode and a surface of the substrate[4].

Another important factor in electroadhesion is the dielectric material used for the pad. The electrode panel comprises of a dielectric over which the electrodes are mounted and another layer of dilectric is placed over it for electric insulation. The compliant force of the pad depends upon the dielectric material chosen as in [1] and [4]-[5]. The material to be selected for electroadhesion depends mainly upon the substrate material you want to adhere to.

From [6] it can be seen that the dielectrics such as Polyimide, Silicone Rubber, shows a good clamping characteristics with the surface materials such as paper, wood, glass and wall.

Insulation material may include mylar, polyimide, silicone, silicone rubbers, polyurethanes, polypropelene, latex, fiberglass, ceramic. PVC films are very useful due to its good elasticity, elastic modulus, and dielectric breakdown strength. Another material is mylar due to its excellent breakdown strength and low leakage and also low power consumption[7]-[8].

The substrate material is polywoven sack. Therefore the area of our concern is Astrictive prehension of insulating materials.

## IV. DESIGN

The design is as shown in the figure 3.2. It consists of a Polyimide film of thickness 25 micron as a dielectric material with dielectric constant 3.4 .The electrode pattern is a comb type. The electrodes placed are of copper foil adhesive tape. The width and the gap between the two electrodes is approximately 5 mm.

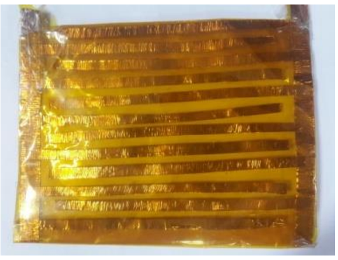

Fig. 2. Prototype of electroadhesive pad using polyimide film.

## V. EXPERIMENTAL RESULTS

The mechanism could pick up polywoven material of very small dimensions. As the size of elecroadhesion pad was increased, the dimensions of substrate material also increased. The size of the substrate picked up depends on the geometry of the electrodes. Interdigited structure proves to be the best in the test cases.

## VI. DISCUSSIONS

- From the literature survey it can be concluded that Electroadhesion is suitable method that can be used for performing Astrictive Prehension.
- The adhesive force depends upon the dielectric material used.
- There is a need of doing a research on properties of the material which ease greater amount of electroadhesion.

## VII. CONCLUSIONS

We have successfully demonstrated pick and place application of electroadhesion. The size of object picked is however very small and can be used for restricted applications. We intend to carry out more research on electrode geometry, material properties and control mechanisms to improve the adhesive force for broadening the application area.

## REFERENCES

[1] Gareth J. Monkman, Stefan Hesse, Ralf Steinmann, Henrik Schunk-Robot Grippers(2007),Wiley-VCH Verlag GmbH and Co. KGaA.

[2] J¨urg Germann, Bryan Schubert and Dario Floreano, "Stretchable Electroadhesion for Soft Robots", 2014 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2014) September 14-18, 2014, Chicago, IL, USA.

[3] Keng Huat Koh, Kuppan Chetty RM, *Member IEEE,* and S. G. Ponnambalam, *Senior Member IEEE,"* Modeling and Simulation of Electrostatic Adhesion for Wall Climbing Robot*",* Proceedings of the 2011 IEEE International Conference on Robotics and Biomimetics December 7-11, 2011, Phuket, Thailand.

[4] Ronald E. Pelrine, Harsha Prahlad, Joseph S. Eckerle, Roy D. Kornbluh, Scott Stanford, "Electroadhesion", US 2008/0089002 A1, Apr. 17, 2008.

[5] Donald Ruffatto ill, Jainam Shah, Matthew Spenko, "Optimization and Experimental Validation of Electrostatic Adhesive Geometry", 978-1-4673-1813-6/13/31.00c 2013 IEEE. 1 IEEEAC Paper 2266, Version 2, Updated 4/1/2013.

[6] Rui Chen, Rong Liu, Member, IEEE and Hua Shen, "Design of a Double-tracked Wall Climbing Robot Based on Electrostatic Adhesion Mechanism", IEEE Workshop on Advanced Robotics and its Social Impacts (ARSO) Shibaura Institute of Technology, Tokyo, JAPAN,November 7-9, 2013.

[7] Jurg Germann, Bryan Schubert and Dario Floreano,"Stretchable Electroadhesion for Soft Robots", IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2014) September 14-18, 2014, Chicago, IL, USA.

[8] Harsha E. Prahlad, Ronald E. Pelrine, Pablo E. Garcia, Richard Mahoney, Los Altos, Joseph S. Eckerle," Electroadhesive Gripping" US patent 8,325,458 B2, Dec. 4, 2012.