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IMPLEMENTATION OF ELECTROADHESION BASED ASTRICTIVE PREHENSION SYSTEM

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Abstract— **This paper describes a novel technique for astriction using electroadhesion principle. It involves picking and placing a polywoven packaging sack in a constrained environment. The scientific methods involved 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 electroadhesion. A prototype of electroadhesive pad is demonstrated using Polyimide and Mylar as dielectric materials. The electrode geometry used is comb type or also called interdigital electrodes. The substrtae materials taking into consideration are BOPP film, packaging paper, GSM-75 paper and polywoven material.**

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

I. INTRODUCTION

Industrial environment requires different tasks to be performed such as assembling, packaging, etc. One of these tasks is Pick and Place. Pick and place has always been an important task to perform in an industrial environment. Earlier it was handled by human hands. But today's scenario in an industry needs novel techniques to perform this task as per the current rate of production. 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 dielectric material. When alternate positive and negative charges are applied to adjacent electrodes, the resulting electric field sets up opposite charges on the surface of the pad, and thus causes electrostatic astriction between the pad and the substrate material.

Electroadhesion can be divided into two basic forms:

- Prehension of electrically conducting materials where the general laws of capacitance hold true ($D = E \epsilon$)
- Prehension of electrically insulating material where the more advanced theory of electrostatics ($D = E \epsilon + P$) applies.

Fig.1 shows a typical example and its equivalent electrical circuit. The applied potential is normally high voltage[1].

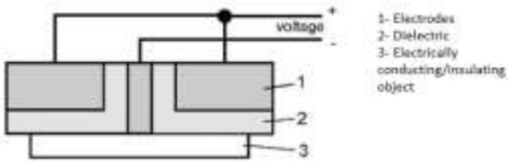

Fig. 1 Equivalent circuit for electroadhesion pad

From [1], [2], [3], the basic equation for retention force, F is directly proportional to dielectric constant ϵ i.e. $\epsilon_0 \epsilon_r$ where ϵ_0 is the absolute dielectric constant($8.854*10^{-12}$ F/m), ϵ_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 given as

$$F = \epsilon_0 \epsilon_r AV/2d^2 \qquad (1)$$

Considering the prehension of insulating materials there are four major types of electrical polarization, namely electronic, atomic, dipole and interfacial. For electroadhesive prehension purposes, 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.

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 applied with a first voltage at a first location of the electroadhesive pad. The second electrode is applied with a second voltage at a second location of the electroadhesive pad. The difference in voltage between these alternating electrodes include an electrostatic adhesion voltage that produces an electrostatic force between the pad and 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.[4].

Important factor in electroadhesion is the dielectric/insulation 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 dielectric 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 include a dielectric pad taking into account two dielectric materials Polyimide and Mylar as shown in the fig. 2 and fig. 3.

Fig. 2 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.

Fig. 3 shows an Electroadhesive pad with Comb geometry. It consists of a dielectric material, Mylar with electrode pattern placed on it. The dielectric constant of the material is 3.1 and thickness 100 micron. The electrode pattern implemented is a Comb type, the width of each electrode is 1 mm and the gap between the two electrodes is 1 mm.

Fig. 3. Prototype of electroadhesive pad using mylar film.

V. EXPERIMENTAL RESULTS

Mylar dielectric with comb type electrode geometry with minimum electrode width and minimum electrode separation was found to give the best result.

VI. CONCLUSIONS

- An Electroadhesion system was successfully implemented for performing Astrictive Prehension of packaging material.
- The adhesion system was implemented using two dielectric materials and the performance was evaluated.
- The electroadhesive pad was designed using several geometries and the performance was also evaluated.

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