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Study of End Effectors – A Review

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Abstract: Robots play a vital role in automation of machines. The performance of robotic manipulator is completed by the end effectors. The choice of end effectors is depended on the type of task to be performed. For holding the component and pick & place activities to the specified location gripper is selected and for different types of workshop operations various tools are fixed on the manipulator e.g. welding electrode holder, painting spray gun etc.

Keywords: *Robot, Grippers, End Effectors, Manipulator, Workshop Operations*

I. INTRODUCTION

End effector is a device that is attached to the wrist of robot arm so as to enable the robot to perform a specific task. It is some time referred as the hand of the robot.

In robotics, an end effector is the device at the end of a robotic arm, designed to interact with the environment. The exact nature of this device depends on the application of the robot.

In the strict definition, which originates from serial robotic manipulators, the end effector means the last link (or end) of the robot. At this endpoint the tools are attached. In a wider sense, an end effectors' can be seen as the part of a robot that interacts with the work environment. This does not refer to the wheels of a mobile robot or the feet of a humanoid robot which are also not end effectors—they are part of the robot's mobility.[1]

II. METHODOLGY

An effector is a device that attaches to the wrist of the robot arm enables robot to perform a specific task. The End effector is the part of special – purpose tooling for a robot. Usually, end effectors must be custom engineered for the particular task which is to be performed.

The two major categories of end effectors are:

1. Grippers
2. Tools

Grippers are end effectors used to graph and hold objects. The objects are generally work parts that are to be moved by robot, Grippers can be classified as single grippers or double grippers. This classification applies best to mechanical grippers. Single grippers is distinguished by the fact that only one grasping device is mounted on robot's wrist. A double gripper has two gripping devices attached to the wrist and is used to handle two separate objects. The two gripping devices can be actuated is especially useful in machine loading and unloading applications. The term multiple grippers is applied in the case where two or more grasping mechanisms are fastened to the wrist. Another way of classifying grippers depends on whether the past is grasped on its exterior surface as its internal surface, e.g. a ring shaped part. The first type is called an external gripper and second type is called internal grippers.

III. MECHANICAL GRIPPERS

We can think of a mechanical gripper as a robot hand. A basic robot hand will have only two or three fingers

A mechanical hand that wraps around an object will rely on friction in order to secure the object it is holding.

Friction between the gripper and the object will depend on two things, First is the type of surface whether it be metal on metal, rubber on metal, smooth surfaces or rough surfaces and the second is the force which is pressing the surfaces together. Mechanical grippers are often fitted with some

type of pad usually made from polyurethane as this provides greater friction. Pads are less likely to damage the work piece. Pads are also used so to have a better grip as the polyurethane will make contact with all parts of the surface when the gripper is closed. Mechanical grippers can be designed and made for specific purposes and adjusted according to the size of the object. They can also have dual grippers. We are all familiar with the saying 'two hands are better than one" and robots benefit from having dual grippers as they can increase productivity, be used with machines that have two work stations where one robot can load two parts in a single operation, operations in which the size of objects or part change due to the machining processes and where the cycle time of the robot is too slow to keep up with the production of other machines.[2]

$$W= \mu nFg$$

Where
μ= coefficient of friction of finger contact surface against
the part surface.
N= number of contacting fingers
Fg= gripper force
W= weight of the part or object being gripped.

IV. GRIPPER FORCE ANALYSIS

Though there are numerous forces acting over the body that has been lifted by the robotic arm, the main force acting there is the frictional force. The gripping surface can be made of a soft material with high coefficient of friction so that the surface of the object is not damaged. The robotic gripper must withstand not only the weight of the object but also acceleration and the motion that is caused due to frequent movement of the object. To find out the force required to grip the object, the following formula is used

$$F = \mu Wn$$

where:

F= is the force required to grip the object,

μ= is the coefficient of friction,

n= is the number of fingers in the gripper and

W= is the weight of the object

But the above equation is incomplete. The direction of the movement also plays an important role over the gripping of the object. For example, when the body is moved upwards, against the gravitational force, the force required will be more than towards the gravitational force. Hence, another term is introduced and the formula becomes:

$$F = \mu Wng$$

Here, the value of g should not be taken as the acceleration due to gravity. In fact, here g stands for multiplication factor. The value of g ranges from 1 to 3. When the body is moved in the horizontal direction then the value is taken to be 2, when moved against the gravitational force then 3 and along the gravitational force, i.e.,downwards, 1.

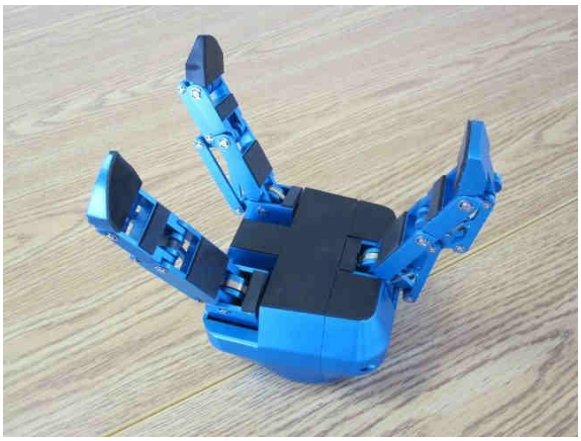

Figure 1: 3 Finger Gripper

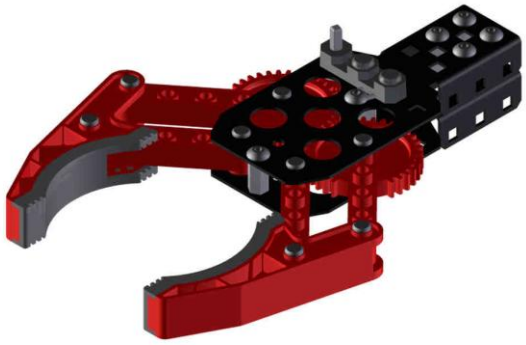

Figure 2: 2 Finger Gripper

V. OTHER TYPES OF GRIPPERS

A. Vaccum Cups

They are also called suction cups. The usual requirements on the objects to be handled are that they be flat, smooth and clean conditions necessary to form a satisfactory vacuum between object and suction cup. Suction pads some in a wide range of material to meet specific application requirements. E.g. nitrile, silicone natural rubbers, fluoroelastomers and polyurethanes. The co – efficient of friction between work piece and suction pad is very important.[4]

Oily surfaces : $\mu = 0.1$
Moist or wet surfaces : $\mu = 0.2$ to 0.4
Glass, stone, plastic (dry) : $\mu = 0.5$
Wood and metal : $\mu = 0.5$
Rough surface : $\mu = 0.6$
Sandpaper (dry) : μ =01.1

B. Magnetic Gippers

Magnetic grippers obviously only work on magnetic objects and therefore are limited in working with certain metals.
For maximum effect the magnet needs to have complete contact with the surface of the metal to be gripped. Any air gaps will reduce the strength of the magnetic force, therefore flat sheets of metal are best suited to magnetic grippers. If the magnet is strong enough, a magnetic gripper can pick up an irregular shaped object. In some cases the shape of the magnet matches the shape of the object
A disadvantage of using magnetic grippers is the temperature. Permanent magnets tend to become demagnetized when heated and so there is the danger that prolonged contact with a hot work piece will weaken them to the point where they can no longer be used. The effect of heat will depend on the time the magnet spends in contact with the hot part. Most magnetic materials are relatively unaffected by temperatures up to around 100 degrees. Electromagnets can be used instead and are operated by a DC electric current and lose nearly all of their magnetism when the power is turned off. Permanent magnets are also used in situations where there is an explosive atmosphere and sparks from electrical equipment would cause a hazard.

C. Adhesive Grippers

Gripper designs in which an adhesive substance performs the grasping action can be used to handle fabrics and other light weight materials, Adhesive material is loaded in the form a continuous ribbon into a feeding mechanism that isattached to the robot wrist.

D. Hooks, Scoops

Hooks and scoops are the simplest type of end effectors that can be classes as grippers.
A scoop or ladle is commonly used to scoop up molten metal and transfer it to the mould

Tools as End Effector
1. Welding
2. Painting
3. Drilling, Flaming, Tapping
4. Riveting

Welding

Welding gun is used as end effectors. Welding process in which robot is used is of two types.
1. Spot Welding
2. Continuous Arc Welding

Spot welding – The process of welding in which two similar metal pieces are localized heated by passing a large current through the parts are to be welded. This current results sufficient heat the contact area to fuse the two metals and produces the weld. A end effector to robot's wrist and the robot is programmed to perform a sequence of welds on the product as it arrives at the workstation. Some robot spot welding lines operate with several dozen robots allprogrammed to perform different welding cycles on the product. The product quality is improved and production rate is quite high.

Continuous Arc welding : Continuous arc welding is used to made long welded joints in which an air tight seal is often required between the two pieces are being joined. Here welding electrode gun is used for making long continuous welding joints in an in herent protective gates atmosphere topreserve the quality of weld. A sequences of steps to be performed are fed in the control unit of robot and its works in the same

manners. To guide the welding gun and check the quality of welding done by robot a vision based system is used. A high vision camera is mounted on the robot near the welding gun to view the path and compare the quality of welt made as programmed. Robovision II from Automatic Inc. and west vision from General Electric are examples of commercial vision system in a single pass category. In the automatic system the camera is focused about 4 cm in front of weld. The observed image is analyzed to extract the location of the entire of seam etc.

E. Painting

The commercial industrial painting method are categorized as follows : -

1. Immersion and flow coating method
2. Spray – Coating method.

Immersion and flow coating method – The object is completely dipped in primmer solution. The primmer solution bath is a electrically charged positive and it gets stick to the object. After keeping it for some time the object is removed and died in a furnace for about 2-4 hrs at temp from 200c to 100 c. After the baking of object it comes into atmosphere. All these activities are tone by one or more than one robotic manipulator arm as per the size of object. Then, object is again dipped in liquid paint for some time. As the paint is electrically charged positive it gets tick on the object. After keeping it for some time object gets removed from the bath of paint and again kept in furnace for 1-2 hrs at a temp. 100C to 200 C. So that paint may get tried up. The body / object is quietly inspected for any left over marks and after satisfying all requirements buffing and polishing of the object take place. Besides visual inspectionrobotic inspection is also performed and results gets verified with each other.

CONCLUSION

The correct choice of end effector is very important and necessary considering the robot manipulator work space limit and type of operations to be performed on the type of works piece. In this study a co-relation and co-ordination of different types of end effectors is shown for completing the desired task completely and satisfactorily.

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