International Journal on Applications in Engineering and Technology
Volume 1: Issue 5: May 2015, pp 7-.12 www.aetsjournal.com *ISSN (Online) : 2455-0523*

DESIGN OF RECONFIGURABLE END-EFFECTOR

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Abstract

The existing end-effector is used for so many operations like grasping, pinching, drilling, welding etc. Each end-effector can perform only one operation. There are two conditions for performing more than one operation. They are1. An end-effector can be changed as per the application 2. The robot has more than one arm. The above conditions increase the weight and cost of the robot. The objectives of this project are to designing a reconfigurable end-effector that can perform more than one operation and also reduce the cost of end-effector. Finally our reconfigurable end-effector can perform grasp and drill operation.

Keywords: *End-effector, Reconfigurable end-effector.*

1.0 INTRODUCTION

End effector is a device that is attached to the end of the wrist arm. It can perform so many operations like grasping, drilling, welding and grinding etc. Reconfigurable end-effector is an end-effector in which the shape can be modified based on the application. Two basic functions of the end-effector is

1. Hold the part while work is being performed.
2. Hold tool which is performing work on the part.

1.1 GRIPPERS

Grippers are used to grasp and manipulatethe objects.It is just like a human hand it enables holding, tightening, handling and releasing of an object.They are classified into 3 types. They are

1. Mechanical Grippers
2. Vacuum Grippers
3. Magnetic Grippers

1.2 MECHANICAL GRIPPERS

It is the standard gripper that uses fingers to physically grasp and manipulate objects. A mechanical gripper is used as an end-effector in a robot for grasping the objects with its mechanically operated fingers. In industries, two fingers are enough for holding purposes. More than three fingers can also be used based on the application.

1.3 VACUUM GRIPPERSS

The vacuum Cups are made of elastic material and round in shape. The vacuum gripper has two components. They are vacuum gripper cups and vacuum system. The vacuum is created between cup and the object. The vacuum can be generated by a vacuum pump or a venture system. After lifting and placing the part at the desired place the vacuum is released. Number of grippers determines the size and weight of object to be grasped. Vacuum gripper is used for handling of fragile parts.

1.4 MAGNETIC GRIPPERS

Grippers in which a magnetic substance performs the grasping action for handling ferrous material are called magnetic grippers. The types of magnetic grippers are

1. Electromagnetic grippers
2. Permanent magnet grippers.

1.5 TYPES OF GRIPPER MECHANISMS

There are various ways of classifying mechanical grippers and their actuating mechanism. One method is according to the type of finger movement used by the gripper. In this classification, the grippers can actuate the opening and closing of the fingers by one of the following motions are pivoting movement and linear or translational movement. Mechanical grippers can also be classified according to the type of kinematics device used to actuate the finger movement. Classification of the gripper mechanism is

1. Linkage actuation
2. Gear and rack actuation
3. Cam actuation
4. Screw actuation
5. Rope and pulley actuation
6. Miscellaneous.

1.6 GRIPPER ACTUATION TYPE

Manual type actuator: Actuated by hand crank, wheel, levers, or other manual or mechanical means.

Electric type actuator: Grippers fingers or jaws actuated by electric motor, solenoid, etc.

Pneumatic type actuator: Gripper is actuated by compressed air acting on a cylinder or vanes.

Hydraulic type actuator: Gripper is actuated by hydraulic fluid acting on a cylinder or vanes.

2.0 LITERATURE REVIEW

Guowu and co [1] tells about the dexterous hands robot only can manipulate the objects of different shapes, size and stiffness as human being. In traditional design the lengthy tendons are used for transmission and multi motor actuators are used. A human hand has over 25 DOF and each finger has 4 DOF. Three human fingers have 12 DOF, but they reduced the DOF 12 to 7. When middle joints rotates the tip joint will follow its movement naturally and vice versus. The middle and tip phalanx pulley ratio is 2:1, which is similar to the human finger. In this way 3 DOF are omitted. The main function of the yaw movement is to adjust the distance between the index and middle finger and to help to rotate the object more conveniently. For compact purpose, the yaw joints of both middle and index fingers are given up but that of the thumb is kept. Then the design of the 3 fingers in 7 DOF is achieved by this way.Norsinnirazainul and all [2] modified the existing seven bar linkage mechanism by adding a guiding slot in the upper middle phalange link. This link length is can be adjusted to achieve human finger's configuration during pinching and grasping. If the distal phalanx touches the object first, the finger will be in pinching mode, whereas if the proximal phalanx makes the first contact with the object, the finger will be in grasping operation. Since the upper link of the middle phalange need to be short in pinching operation and relatively long to realize grasping constructing, the upper link of this bar is modified by constructing it with a guiding slot. This is shortens the middle phalanx length. R.Rizk and co [3] presents the study of the grasp stability of an isotropic underactuated finger, which is made by two phalanxes and uses cams and tendon for actuation. Most industrial applications require grasping. A good gripper must be able to adapt itself on the grasped object whatever its shape. A better shape adaptation increases the number of contact points between the gripper and the object. Existing gripper dexterous hands is having more than six actuators. They reduce the number of actuators. In existing the phalanxes are joined with pulley. There the Pulleys are replaced by cams providing a variable transmission ratio. Michele Guarnieri and all [4] It consists of four fingers actuated by one actuator and they can adapt to the grasped object surface. They develop the mobile platform that can help rescuers in carrying out easier and safer rescue operation on stricken areas. They introduce a special docking mechanism utilized for the connection of the vehicle with auxiliary crawler units. The arm can be utilized also as a lever for the main body, so that the vehicle can crawl over high obstacles. Each phalanx is not individually actuated instead all the segments are actuated by the traction of a special "tuna flashing" wire. It can resist up to 120kg in tension and it offers very low friction, which is an important feature when it is rolled around the finger pulleys. To control the stretching of the wire, springs were introduced.

Roma La Sapienz [5] tells about in this paper an atlas of 64 linkage-type grippers is presented. For each mechanism one of the possible functional schematic is provided for a better understanding of its kinematic properties. Some of the linkages herein depicted are believed to be novel. The atlas should be helpful to designers in the field of robotics.Ching-weichuang and all [6] investigate the conceptual design for the underactuated passively adaptive finger mechanisms. This mechanism can be used for prosthetic hand application. They observed the finger mechanism from the kinematic viewpoints. Based on these they develop the finger mechanism with three DOF and eight links are generated.Thierry Lalibert and others [7] are developed their existing underactuated finger mechanism.Theexisting mechanism is a three-degree-of-freedom (DOF) underactuated finger, used in all the hands, is first introduced. A first hand, which has 12DOF and 6 motors, is then presented. Subsequently, by including underactuationamong the fingers and coupling their orientation, a second hand with 10DOF and 2 motors is obtained.Jinn-BiauSheu and all [8] investigatedinthispaper, thekinematicsynthesisofa four-bar mechanismwithrollingcontacts. Thismechanismcomprisesatwo-fingeredgripperandagraspedobject.Thesynthesisequationsusedformotiongenerationand function generationareestablished. Thenumberoffreechoicesindesignvariablesforthekinematicsynthesisisalsodiscussed. Furthermore, theoptimization-basednumericaltechniquesappliedtosolvethedesignequations.Ashish Singh and all [9] tell about design and fabrication of a multi-fingered gripper. The research is motivated by the requirement for grasping of objects of arbitrary shape and size. Kinematic and dynamic analysis of gripper is made to support this novel design. Puran Singh and co [10] designs the end effector to grasp any physical thing that may be a human hand or any instrument. To achieve this goal they intend to incorporate a simple linkage actuation mechanism. An AC motor is used along with spur gears and a threaded shaft arrangement. This gripper can perform the basic function of picking, holding and grasping of objects by means of a DC motor and it forms the mechanism for the spot welding.

Fu Zhuang and all [11] designed the robot end-effectorGrabbing Mechanism Based on a Bionic snake Mouth.The grabbing movement is realized by the ‘bite’ function of the bionic snake mouth actuator, and the swallowing function insures a continuous grip on the object. The upper jaw consists of a double four-bar linkage mechanism and the lower jaw mechanism implementing a lateral expansion function are the two elements of the robot end-effector. Robin aman [12] try to solve a problem concerning drilling, a project was started at the universities in Linkoping and Lund. As a part of the project this thesis aims to help solve the drilling problem. The goal of this thesis is to design an end effector that will help avoid slipping when drilling.L.Birglen [13] using amethodtoobtaindesignsofthesefingerscapableofvariousbehaviorsduringtheirclosingmotionsispresented.Themethodisbasedonusingtriggeredpassiveelements incarefullyselectedjointsofthefingerandtheselectionor optimizationofgeometricparameterstoobtain particularkinematicrelationshipsbetweenthemotionsof thephalanges.Thismethodisverygeneraland canbeappliedtoanyself-adaptiveroboticfingerinordertoobtainmanydifferenttypesofclosingmotions.Chiara Lanni and Marco Ceccarelli [14] they analysis of mechanisms in two-finger grippers has discussed to formulate anoptimum design procedure. The design problem has been approached and formulated as an optimizationproblem by using the basiccharacteristics of grasping mechanisms.Mohammed Khadeeruddin and all [15] the designed robotic gripper in a two jaw actuated gripper which is different from the conventional cam and follower gripper in the way that controlled movement of the jaws is done with the help of pneumatic cylinders using air pressure. The force developed in the cylinder is very gentle and is directly delivered to the jaws in a compact way.Burakdogan[16] in this thesis study, a two-fingered gripper and a four-fingered multipurpose gripper are developed and manufactured. In addition to development of robotic hands, computer control hardware and software are also developed for computer control of both hands.CheSoh and others [17]design a robust gripper that can perform easier and faster picking and placing operation for multiple shapes and sizes objects. This adjustable gripper for robotic system can to improve the picking and placing operation in manufacturing field.Lael U. Odhner and all [18] introduces the i-HY Hand, an underactuated hand driven by 5 actuators that is capable ofperforming a wide range of grasping and in-hand manipulation tasks. They focus on the development of underactuated fingers that are capable of both firm power grasps and low stiffness fingertip grasps using only the passive mechanics of the finger mechanism.

3.0 CONCEPTUAL DESIGN:

- It should be able to perform more the one operation.
- It should be able to grasp objects of different shape and size.
- It should be able to take different loads (within upper limit).
- There should be stability during manipulations.
- Synchronization in finger motion.
- Use minimum number of actuator.
- It should not slip.

In conceptual design so many attempts are taken to create a new type of end effector. The Fig A represents the Fig A: conceptual design of reconfigurable end effector.

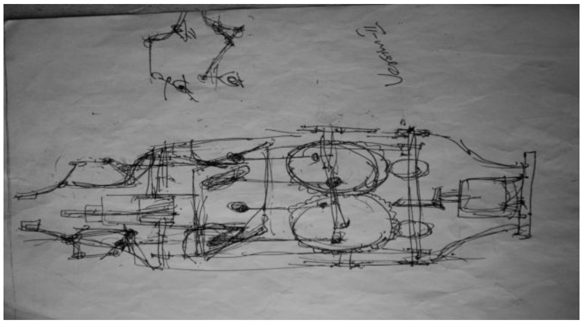

Fig A: conceptual design of reconfigurable end effector.

4.0 MECHANICALDESIGN

The new invention of the reconfigurable end-effector is consists of three modules as like gripper, drilling arrangements and actuator and gear system. The three modules are arranged one by one in a single frame. Gripper is located in front of the frame. Drilling arrangements are located in middle of the frame. Actuator and gear systems are located in bottom of the frame.

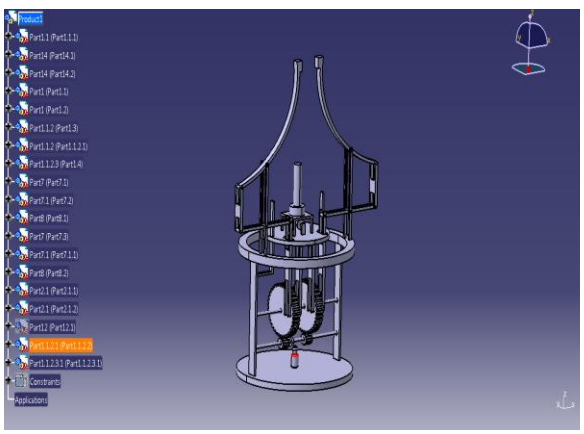

Fig B: Isometric view of the reconfigurable end effector.

4.1 ACTUATOR AND GEAR SYSTEM

The electrical actuator is used for power transmission. It's mounted on the base plate of the frame and located on the center axis. The actuator shaft is connected with bevel gear so the power is transmitted by the bevel gear in 90 degree. The frame has two shafts, one for driver gear and another for driven gear. These shafts are located perpendicular to the center axis. The pair of driver and driven gear ratio is 1:3. The driven gears are rotates some degree angle. The driven gears are the single input for the both grasp and drill operation. Each driven gear has a pair of links. They are gives the movement to gripper and drill arrangements.

4.2 DRILLING ARRANGEMENT

The total drill arrangement is mounted on the plate and it slides in the frame. This plate has a two pair of slots; one slots for gripper links another one for guide rods. The drill plate bottom is connected with driven gears by the use of links. When driven gears rotate the drill plate moves upward. Then the drilling operation will be done.

4.3 GRIPPER

The gripper is designed simple 4bar linkage mechanism. Gripper is placed the top of the end-effector. It's used for grasp and manipulates the objects.

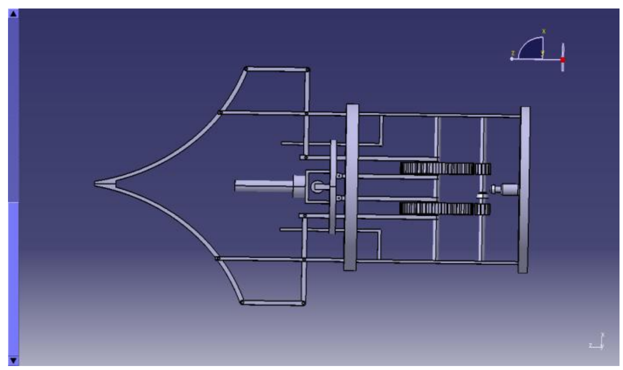

Fig C: Side view of the reconfigurable end effector.

4.3.1 SYNTHESIS OF LINKAGE

Considering the dimensional aspects of the conceptual design, here it is assumed that the finger mechanism is required to generate the function y=2x in the range of 1 to 2. We Use this function and limits in chebychev spacing or precision positions, according to Freudenstein's equations. First we use the chebychev spacing method to find the three accuracy points and corresponding value of y. after that we find out the three accuracy point angles by the use of range and input &output angle. These values are substituted in Freudenstein's equation and then get the four link lengths. The determined link lengths are 52.049mm, 23.932mm, 109.58mm and 80mm.

4.3.2DOUBLE-ROCKER MECHANISM

There the sum of the length of the largest and shorted links is more than the sum of the lengths of the other two links.According to this Grashof's law (S+L ≤ P+Q)our linkage is class-II 4-bar linkage mechanism. So in this case fixing of any of the links always results in a rocker-rocker mechanism or double rocker mechanism.The link1 is connected with frame and it extended some length behind of the frame. This extension of the link is connected with the input link. This input link is actuated by the driven gear and it comes inside the drill plate but it has good clearance for the drill plate movements. One end of the 1st link is connected with the 2nd link. The 2nd link is connected with 3rd link and the 3rd link is connected frame.

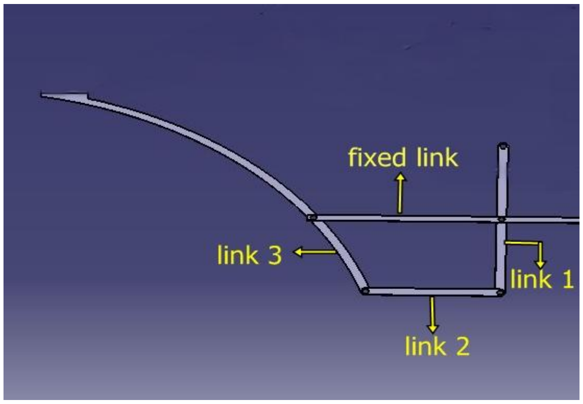

Fig D: 4bar double rocker mechanism.

The 3rd link is also extended to the mid axis of the end-effector. The total gripper mechanism is fully placed outside of the frame. The 4thlink is fixed one and it is placed between the two hinged joints of the 1st and 3rd links. If a driven gear rotates certain degree the input link moves upward. The 1st link is oscillate some angle the 3rdlink is oscillates. By using this oscillating motion the gripper open and closed movements are to be done.

4.3.3DEGREE OF FREEDOM

Degree of freedom is nothing but the number of independent movement in the system.We can identify the number of degrees of freedom by the number of actuators or inputs on the systems. Now this is very important when fabricating a robotic arm and forming the linkage mechanisms. The table: 1 is used to identify the number of degree of freedom. Our four-bar mechanism is having one loop and four joints so the degree of freedom is 1. From that the only one input in enough to actuate the four-bar mechanism. There two fingers are used for grasping each fingers are one degree of freedom.

Loops	DOF	Joints
1	N-3	N
2	N-5	N+1
3	N-7	N+2
4	N-9	N+3
5	N-11	N+4
and so on		

Table: 1

5.0 CONCLUSION

Thus the existing mechanisms of the grippers are revived and different types of grippers are studied. By using these existing mechanisms and literature review some conceptual design are created. Theconceptual design is developed and created the good and better reconfigurable end-effector. Finally we achieved the grasp and drill operations in a single end-effector.

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