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Nickel based alloy Design of an impactive type robotic gripper to handle irregular shaped objects

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Abstract: Gripper is a device that grasps, retains and eventually releases the work piece. It can hold, tighten, handle and release an object as does a human hand. It can be attached to a robot or be part of a fixed automation system because this component handles the work piece. The increasing demand for robotic applications in dynamic unstructured environments is motivating the need for dexterous end-effectors, which can cope with a wide variety of tasks and objects encountered in these environments. In robotics, end effector is a device at the end of a robotic arm, designed to interact with the environment. The type of gripper designed is impactive type which uses jaws or claws to physically grasp by direct impact upon the object.

In this paper our aim is to design a simple mechanism for grasping irregularly shaped object by using a four fingered robotic gripper.

Keyword: Gripper, design, forces etc.

Introduction

In 1750, Gripper is a device that grasps, retains and eventually releases a work piece. It can hold, tighten, handle and release an object just like a human hand. The type of Gripper designed is Impactive type which uses jaws or claws to physically grasp by direct impact upon the object. A multi-fingered robotic gripper has potentiality to achieve dexterous manipulation. It has the functions of:

1) Stably grasping an object of any shape.
2) Manipulating the grasped object from the initial pose to the desired pose.

Gripper Types

There are three primary types of standard grippers:

1) Parallel
2) Angular
3) Concentric

The types vary according to the motion of the gripper jaws in relation to the gripper body. With a parallel gripper, the gripper jaws move parallel to the gripper body. The jaws come together at the same point when closed, and have external and internal gripping applications. Parallel grippers can pick up numerous part sizes with one set of jaws. However, parts to the gripped must be located accurately at the same place each time. These grippers are typically more accurate than angular or concentric grippers and are the most commonly used grippers.
When part location varies, an asynchronous parallel gripper is a better choice for the use. The jaws on this gripper move independent of each other, making it suitable for applications where parts shift position, such as on conveyor. These grippers do not shift parts to center, as do synchronous parallel grippers. Instead, the fingers conform to the part's diameter. Parts picked up off center would be released off center.
Parallel grippers come into basic technologies-direct acting piston and piston wedge-and offer external and internal gripping actions. The jaws of an angular gripper open and close around a central pivot point. They move in a sweeping or arcing motion and have external gripping capabilities. Angular grippers are often used when space is limited or when the jaws need to move out of the way. They are usually dedicated to picking up only one part type.

Therefore, angular grippers are not normally used for positioning or placement of many different parts. As the most simple of the gripper designs, angular grippers are usually the least expensive.The angular grippers come in two basic technologies-single acting spring return and double acting spring assist, and offer external gripping actions.

Concentric grippers are best suited for round parts. This gripper has external and internal gripping actions, and the force remains constant throughout the stroke. It has a high grip force to size ratio and a higher moment capacity compared with other designs. A center bore can be added to increase the flexibility of the gripper. The basic technology for this type is piston-wedge and direct-acting piston.

Classification of gripper on the basis of number of jaws

Grippers can also be classified on the basis of the number of jaws that they can use to hold a work piece.

1. The two-jaw gripper is the most popular style. This gripper-either angular or parallel-provides two mounting locations for the fingers to contact the part. The jaws move in a synchronous motion, opening and closing towards the central axis of the gripper body.
2. The three-jaw gripper is a more specialized style. These include parallel and concentric grippers and provide three mounting locations for the fingers that contact the part.The jaws move in a synchronous motion, opening and closing towards the central axis of the gripper body. Three jaws provide more contact and accurate centering with the part than two-jaw grippers do.

Grasp Mechanics

Grasp Mechanics becomes increasingly important when a robot needs to perform human-like grasping operations or employ tools designed to be used by humans as well as robots. Two separate issues are involved with the creation of an effective robotic hand.

Firstly, the duplication of human dexterity in a compact and reliable package is extremely difficult. Second, while the job of grasping an object is usually accomplished with very little thought by most people, for a robot, grasping an object and maintaining that grasp requires a significant amount of knowledge about the local grasp environment and the current interface between the hand and the object.

Gripper Design Types

1) **IMPACTIVE** – Uses Jaws or claws, which physically grasp by direct impact upon the object.

Used for manipulating objects with hard surface and surfaces which offer a high friction value.

2) **INGRESSIVE** – Pins, needles or hackles are used, which physically penetrate the surface of the object (used in textile, carbon and glass fiber handling) to grasp the object.

Used for manipulating the object by physically penetrating (textile, carbon and glass fibre handling).

3) **ASTRICTIVE** – Suction forces are applied to the objects surface (whether by vacuum, magneto – or electro-adhesion) to grasp it.

Used for gripping smooth and plane surface (whether by vacuum, magneto– or electro adhesion).

4) **CONTIGUTIVE** – Requires direct contact for adhesion to take place (such as glue, surface tension or freezing) in order to grasp the object.

Lifts and transports the object using adhesive gripper (such as glue, surface tension or freezing).

The advantages and limitations of the design of impactive type as compared to others are,

- ADVANTAGES
- ➢ Economical.
- ➢ Suitable for lifting heavy loads.
- ➢ Low maintenance.

- DISADVANTAGES
- ➢ Unsuitable for fragile objects.
- ➢ May distort the surface.

Force and Torque Considerations

Much attention has been focused on the forces generated by the digits in grasping and lifting the objects. Most of the studies on grip forces have dealt with the pinch grasp in which only two digits exert force on the objects. In such a grasp, the force can be decomposed into two components:

- The grip force, which is horizontal and
- The load force, which is vertical.

The criteria for a stable pinch grasp are simple: the sum of the load forces should equal the object's weight and the ratio of the grip force to the load force must exceed a specific value determined by the coefficient of friction between the object and the digits.

In multi-fingered grasp, the directions of the contact forces as well as the distribution of the load across fingers are only loosely constrained. For equilibrium, the sum of the forces in the horizontal plane must be zero, and these horizontal forces must intersect at a common point (the force focus).

Furthermore, friction constrains the direction of the force exerted by the each digit to lie within a cone. Thus neither the direction nor the magnitude of the contact forces is specified uniquely by the task. Several studies have investigated the distribution of the grip force across fingers in multi-fingered grasps; the analysis of the contact forces was limited to the normal forces. Hence little is known about how the direction of contact force is controlled in a multi-fingered grasp. The style of the jaw plays a major role in determining the force required in a gripper application and the weight of the work piece that the gripper experiences from gravity. Acceleration also plays a role in determining the gripper force. Thus, both weights must be considered when determining the gripper force.

While force is a major consideration, the torque that is experienced by the gripper is equally important. There are two sources of torque. The gripper can generate torque on itself, or it can be generated by the parts' acceleration and weight. This means that long jaws are often required. Either the part is bulky, or it must be held at a distance to fit in a machine. In either of the cases, the longer the jaw, the greater the torque that gripper imposes on itself. The next task is to determine the torque that gripper would experience from the work piece.

The total torque that the work piece will see is the addition of the jaw torque and the work piece torque.

To successfully handle long work pieces gripper must have superior bearing support to accommodate larger movements end cantilevers. Basically, the contact surface of each jaw is extended to stabilize the work piece in motion and balance the long jaws.

Reduction of jaw weight is an important objective in gripper design, particularly for high-speed applications. One way to minimize jaw weight without sacrificing strength is by using a lightweight material, such as aluminum. Another option is to narrow the gripper jaws. This reduces weight and helps avoid interference each time the jaws open to release a part.

For multiple work piece handling and applications that require specific grip forces, the jaws that adjust to a gripper's stroke provide the most flexibility. The jaw alignment is critical. If they do not meet accurately, the part position and gripper holding power are greatly compromised. To help ensure proper alignment, dowel holes and/or a surface to key on are a must.

Design

POWER TRANSMISSION

The motor used is an electric 12 V .D.C. motor and producing direct current of 35 A.

Power transmitted is

$P = V.I$

$= 35 \times 12$

$= 420$ W

Power = 420 W

Gripper Design

DESIGN OF GRIPPER LINKS

The object to be lifted is a cricket ball.
Object diameter = 8 cm
Object weight = 156 g
The link1 has two parts, Part1 and Part2.

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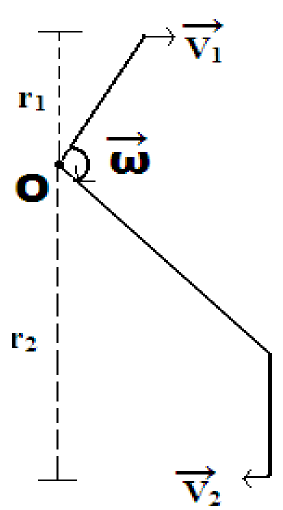
The lengths are as follows:

Part1 = 10 cm
Part2 = 5 cm
The link2 is having a length of 5 cm.
Therefore, the ratio of the length of the two links is
Link1 : Link2 :: 3 : 1
The link can move a distance of 15 cm.
Therefore, the distance moved by both the links is 30 cm.
The minimum distance between the links = 5 cm
The maximum distance between the links = 35 cm
Hence, the range of the links is 30 cm.

Calculations

Velocity Reduction
Since $\omega = V_1/r_1 = V_2/r_2$
$r_2 / r_1 = 3$(due to geometry)
Assuming the velocity of approach of the gripper link as 6 mm/s
(Velocity of link2)
$V_1 = V_2/r_2 \times r_1$



Therefore, velocity of link1 = 8 mm/s
(Because of link ratio as 3:1)
Now taking standard ISO Metric thread M16X2
Where, the diameter of shaft is 16 mm, then the pitch of shaft (threaded) is 2mm.
Therefore,
$N_s \times$ Pitch = Velocity of link1
N_s = rotations per second (r.p.s)
Pitch in mm
Velocity in mm/s
Therefore, $N_s \times 2 = 8$
N_s = 4 r.p.s or 240 r.p.m.
Speed of motor is 900 rpm.
Velocity reduction = 900/ 240= 3.75
Thus we use spur gear of module, m = 01
Number of teeth on pinion, T_P = 18
Therefore number of teeth on gear, T_G = 68
Diameter of Pinion, $D_P = T_P \times m = 18 \times 1$

Thus we use spur gear of module = 1
D_P = 18 mm
Therefore, the diameter of gear is $D_g = 68 \times 1 = 68$ mm
Therefore, the torque is
$T = P/\acute{\omega} = (420 \times 60)/(2 \times \pi \times 240)$
Therefore, torque = 16.75 N-m

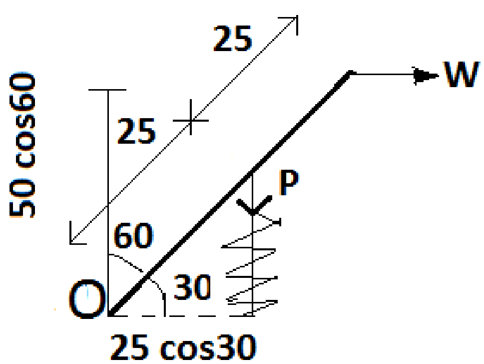
Design of Threaded Shaft

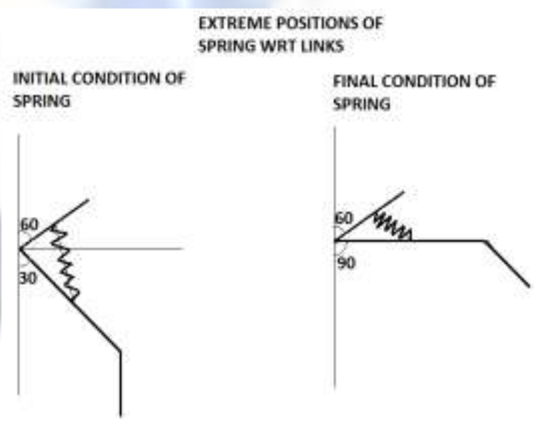
Pitch = 2 mm
Diameter = 16 mm
The length of the threaded portion is 50 mm.
Torque at each threaded shaft = (Torque at secondary shaft)/4
Torque at single threaded shaft = 4.1875 N-m

According to principle of power screw:
Torque = $\{(W.d_m)(f.\pi.d_m + L.\cos\alpha_n)\}/\{2(\pi.d_m.\cos\alpha_n - f.L)\}$
W = Maximum force at the nut
F = Coefficient of friction between shaft and nut.
L = lead = Pitch = 2 mm
α_n= Angle of helix =14.5°
d_m =Nominal diameter of thread
$W = \{2 \times 4.1875 \times (\pi \times 0.016 \times \cos 14.5 - 0.16 \times 0.002)\} / \{0.016(0.16 \times 0.016 \times \pi + 0.002 \times \cos 14.5\}$
W = 2.53 KN

Design of Spring

Spring is the member between link1 and link2 which is transmitting force between them.
The angle between the casing and link1 is fixed to be 60^0 and the angle between link1 and link 2 is 90^0 at Free State of spring (at no load).
The force available at the nut W = 2.53 kN
Taking moment about the hinge O





$P \times 25\cos(30) = W \times 50\cos(60)$
P =2.92 KN

From the link configuration analysis compressed length or solid length is calculated as

L_s = 8 mm And the free length of spring is
L_f = 18 mm Now deflection in the spring
$\partial = (8.P.C^3.N)/(d.G)$
Where, P = Force on the spring
C = spring index = D/d
N = Number of active coils

G = Modulus of rigidity
Assuming C = 4,
Material is mild steel, G = 75 GPa
$\partial = L_f - L_s = 10$ mm
Another empirical relation in spring is as follows:
Assuming N=5,
$L_S = (N+1) \times d$
We obtain, d = 10 mm
Corresponding standard wire gauge no. lies between 3/0 and 4/0.

References

[1]. Coe, S. and Waldron, K.J., "Mechanical Design of the DIGITS System," 1st National Applied Mechanisms and Robotics Conference, paper no. 89AMR-8C-5, Nov. 1989.
[2]. Jacobsen, S. C., Iverson, E. K., Knutti, D. F., Johnson, R. T., Biggers K. B., "Design of the Utah/M.I.T. Dextrous Hand", IEEE Transactions of Robotics and Automation", April 1986.
[3]. Mason. M.P, Salisbury, J.K., "Robot Hands and the Mechanics of Manipulation". MIT Press, Cambridge, Massachusetts, 1985.
[4]. Suhaib Md., Mukherjee S., Khan R.A., "Dexterous Rotation of Cube By Multifingered robotic hand", Proc. National Conference on TIME-2003,KITS Warangal, India, Aug 2003.
[5]. Juvinall Robert C.,Marshek Kurt M.,"Fundamentals of machine component design",Wiley student edition, 2007.
[6]. Monkman Gareth J., Hesse Stefan,Steinmann Ralf, Schunk Henrik,"Robot grippers", Wiley-VCH Verlag GmbH and Co. KGaA, 2007.