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A survey paper on a factors affecting on selection of mechanical gripper

[1]Vinayak D. Latake, [2]Dr. V.M.Phalle
[1]PG Scholar, [2]AssociateProfessor
Department ofMechanical Engineering, Veermata Jijabai Technological Institute, Mumbai, Maharashtra, India-400019
[1]vinayaklatake89@gmail.com, [2]vmphalle@vjti.org.in

***Abstract*—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. As most of the fingers are of replaceabletype, it can be easily removed and replaced. The force that a robotic gripper applies to a part is typically used by engineers to select grippers but in actual practice it is not enough to select gripper. There are so many factors are to be considered while designing the gripper like mechanism for gripping, trajectories, parameters that influencing gripping task etc. So in this paper those factors are discussedin brief.**

***IndexTerms*— Mechanical gripper, gripping force,mechanisms,trajectory.**

I. Introduction

A mechanical gripper is an end effector that uses mechanical fingers actuated by a mechanism to grasp an object. Fingers are the one which makes an actual contact with object. The fingers are either attached to the mechanism or are an integral part of the mechanism. The function of gripper mechanism is to translate some form of power input into grasping action of fingers against the part. The power input supplied from the robot and can be mechanical, pneumatic, hydraulic or electrical. The mechanism must be able to open and close the finger and to exert the sufficient force against the part when closed to hold it securely.

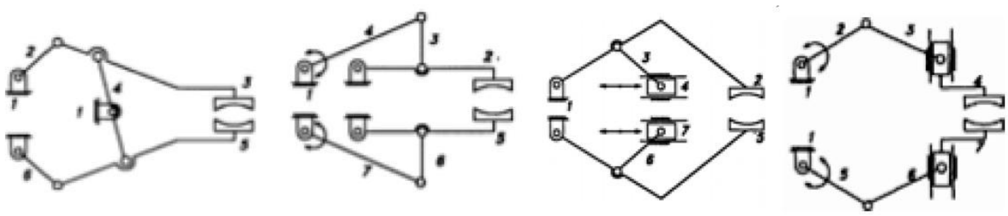
The process of handling component parts or workpieces in production is often underrated as technically simple or even trivial. From the production point of view it is obvious that the workpiece itself does not increase in value during the handling process. Since a gripper gives a great contribution to practical success of using an automated and/or robotized solution, a proper design may be of fundamental importance. The design of a gripper must take into account several aspects of the system design together with the peculiarities of a given application or a multi-task purpose. Strong constraints for the gripping system can be considered for lightness, small dimensions, rigidity, multi-task capability, simplicity and lack of maintenance. These design characteristics can be achieved by considering specific end-effectors or grippers. In the last case a two-finger gripper corresponds to the minimum number of fingers and the minimum complexity of a hand.

II. MECHANICAL GRIPPER CLASSIFICATION

Mechanical gripper classification according to the type of kinematic device used to actuate the finger movement [8] is as follows-

A. Linkage Actuation-

The design of linkage actuation helps in finding out the conversion of gripper's input force into the gripping force, the time taken to actuate the gripper, and the maximum capability to open the finger. It has plenty of designs for opening and closing the finger, and some of its types are shown below. Many different types of kinematic chains can be used.Special attention requires the motion of the fingers.This motion can be linear, rotary or a combination of both.Needs of limited encumbrance, stiff design, light mechanical design and easy operation may limit the number of the mechanism links. In fact, most of industrial gripper mechanisms show kinematic chains that are composed by four-bar, slider-crank linkages [2].



a) b)

Fig.2.1 Examples of Linkage actuation mechanisms based on: a) four bar linkage b) slider crank linkage

B. Gear and Rack Actuation-

For this actuation, the gear and rack are connected with a piston, which provides linear-type movement. The two partial pinion gears are driven when the rack is moved. As it is linked with gripper, the opening and closing of fingers are accomplished.

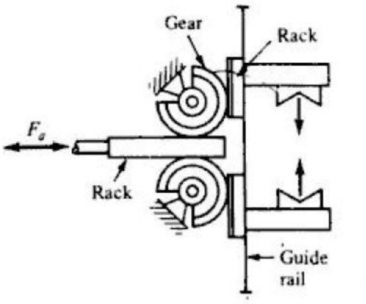


Fig 2.2 Gear and rack actuation mechanism

C. Cam Actuation-

A cam actuated gripper with spring loaded follower can be used to provide open and close actions of fingers. The spring is incorporated for forcing the gripper to close if the cam is moved in one direction, while the movement of cam on the other direction causes the gripper to open. This type can be useful for holding various sizes of work parts.

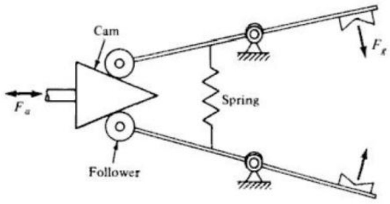


Fig 2.3 Cam actuation mechanism

D. Screw Actuation-

The screw-type actuated gripper consists of a screw connected with a threaded block. To rotate the screw, a motor is used along with a speed reduction device. If the screw is turned in one direction, the threaded block is moved in one direction. Similarly, the threaded block moves in the opposite direction if the screw is turned on the other direction. As the threaded block is attached with gripper, it makes the fingers to open and close.

Fig 2.4 Screw actuation mechanism

E. Rope and Pulley Actuation-

In this actuation, a tension device is required to go up against the rope movement in the pulley. Suppose, if the pulley is activated in one direction for opening the gripper, the tension device will provide slack in the rope. Similarly, the gripper is closed by activating the pulley on the other direction.

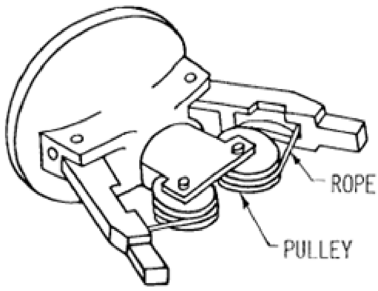


Fig 2.5 Rope and pulley actuation mechanism

III. PARAMETERS INFLUENCING GRIPPING TASK

Every gripping task is influenced by the following criteria [1]-

A. Ambient conditions of the gripping task-

Ambient conditions may include potential risks for handling process. Cold or damp environments as well asclean room operations call for customized automation technology. Ambient conditions of production such as periodical cleaning in accordance with hygiene requirements will also determine either gripper construction or appropriate provisions such as frequent maintenance intervals. More challenging are ambient conditions which are hard to detect, such as fluctuations in workpiece quality.

B. Workpiece features-

Based on workpiece features, which include geometrical as well as physical properties, type or operating principle of gripper needs to be selected.

C. Workpiece status at pick and place

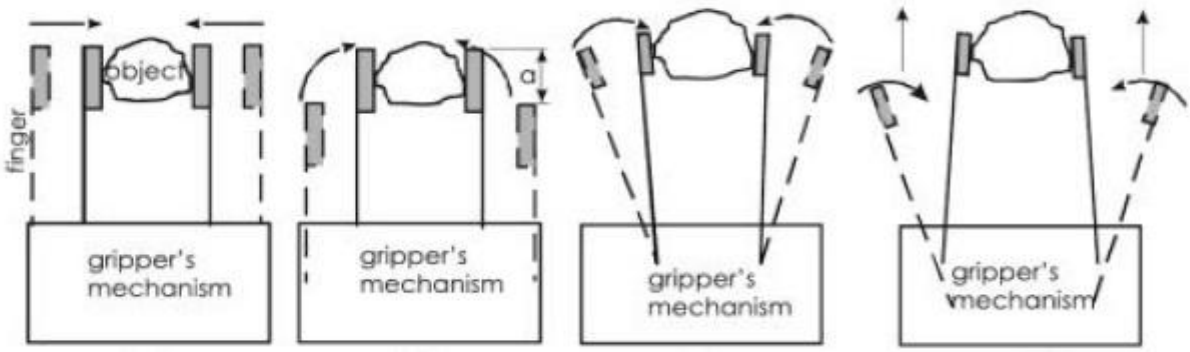
Additional information on workpiece status, especially the position and orientation of the workpiece within the workspace, are essential for safe gripping.

TABLE- PARAMETERS INFLUENCING GRIPPING TASK

Ambient conditions of the gripping task	Workpiece features	Workpiece status at pick and place
Temperature	Geometry	Set up tolerance
Energy supply	Dimension	Operation at rest
Clean room	Tolerance	Operation in motion
Hygiene	Mass	Accessibility
Safety provisions	Centre of gravity	
Maintenance free	Material	

IV. TRAJECTORY

While considering two finger grasp, the finger moved in definite path to grasp the object and it is known as trajectory. Each kind of approximation has specific grasp characteristics, which must be taken into account at the moment the gripper grasps the object. These trajectories [4] are of four types as follows-



(a) (b) (c) (d)

Fig- 4.1 Finger approximation movement: a) Rectilinear translation b) curvilinear translation c) rotation d) roto-translation

A. Rectilinear Translation Trajectory-

The fingers are always parallel to original position, without varying its distance to the gripper's frame as shown in figure 4.1 a. The parallel approximation provides the possibility of grasping by its outer or interior surface parallelepiped, cylindrical objects, or those with parallel faces to both fingers, producing parallel or opposed grasp forces. If the directions of these forces do not coincide, a moment will be produced in the object on the plane defined by the forces. Once a gripper's position has been reached with respect of the object, a finger's point does not vary its distance to the frame, maintaining the relative position finger-object of the line by the points of each finger when they come near the object.

B. Curvilinear Trajectory-

The trajectory is curvilinear. Here, the finger although it is always parallel to the original position, there displacement of the finger in the direction indicated in the figure 4.1b. The approximation by curvilinear translation has similar grasp characteristics to the previous one, with the sole difference that one point of each finger varies the position of the line which they define with respect of the predicted grasp line of the object. This makes the grasp location not precise, depending on the gripper's initial location.

C. Rotation Trajectory-

Figure 4.1c shows an approximate movement towards the object, where the finger describes a circular trajectory around a fixed point of the mechanism. The approximation by rotation also produces variation in distance between a point and the theoretical object's line of contact. The grasp forces produce a non null component of them.

D. Roto-translation Trajectory-

Figure 4.1d shows an approximation of the finger to the object in two movements. The approximation by roto-translation produces similar effects to those of the approximation by rotation.

V. GRIPPING FORCE

Forces are transmitted by gripper fingers, the so called operating elements of the gripper. The amount of force which needs to be applied depends on the body mass, surface friction, and geometry of the workpiece. If gripping force just needs to be transmitted via surface friction, pressure must be put on workpiece surface. For workpieces which react to pressure, e.g. the surface of which easily deformed or damaged, a maximumpressure must be determined. The upper limit for prehension force [3] is dictated by the allowable surface pressure, depending in terms on the contact force which is different than gripping force and the coefficient of elasticity of the gripper jaw and object material. The following relationship is valid for point and line shaped contact.

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$$P = 0.418\sqrt{\left(\frac{\mathrm{Fk} * Et}{L}\left(\frac{2}{d} \pm \frac{1}{r}\right)\right)}$$

Where,
P= Surface pressure (N/mm^2)
F_k= contact force (N)
E_t=average coefficient of elasticity (N/mm^2)
d=diameter of gripped object (mm)
$\pm$ = (+ convex gripper jaw shape; - concave gripper jaw shape)
r = radius of curvature of gripper jaw (mm)
L = contact line length (mm)

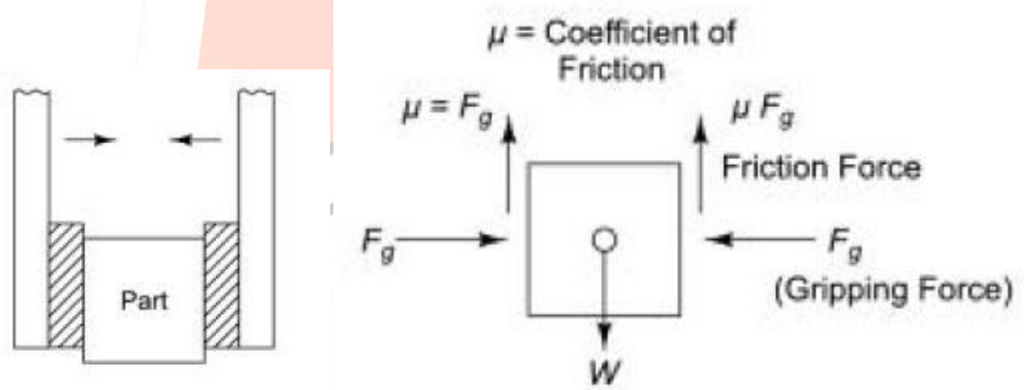
The average elasticity coefficient E_t may be derived from the different gripper jaw and workpiece material.

$$Et = \frac{2 * Eo * Ej}{Eo + Ej}$$

Where,
E_o = Young's modulus of object
E_j = Young's modulus of gripper jaw.

In principle, low surface pressure causes little abrasion which is important for the employment of grippers in clean room application.

Gripping forces vary according to form and number of active surfaces between workpiece and gripper fingers. For understanding purposes consider an example [10] in which a square block is to be grasped.



(a) (b)

Fig- 5.1 Gripping mechanism working with mechanical friction: a) Friction in mechanical gripping b) Free body diagram

Figure 5.1a shows the actual component as well the fingers, while 5.1 b is the free body diagram of whole system so that force calculations can be done.

By applying Newton's laws of motion,

$$Fg = \frac{m * g}{\mu * n}$$

Where,
F_g = gripping force (N)
m = mass of part/workpiece (Kg)
g = acceleration of gravity (m/sec2)
μ= coefficient of friction
n = number of pairs of contact surfaces.
From this equation gripping force is calculated and by using this force gripper is to be designed.

VI. CONCLUSION

Selection of mechanical gripper is not an easy task. Since a gripper gives a great contribution to practical success of using an automated and/or robotized solution, a proper design may be of fundamental importance.The design of a gripper must take into account several aspects of the system design together with the peculiarities of a given application or a multi-task purpose. Hence while proper designing some factors are to be considered e.g. gripper mechanism, trajectory, gripping force etc. These factors play very vital role. Hence the selection of proper factors while designing the mechanical gripper reduces a lot of iterations and more important time.

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