GRIPPING IN ROBOTIZED WORKPLACES
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Abstract: The industrial robots are characterized as electro-mechanical system by higher level of integrated electronic. They realize a predefined actions by flexible acting and information exchanging with environment. Its connection to manufacturing devices are used for workpiece loading and unloading to these devices.

Key words: griper, effector, clamping, clamping force, positioning

1. INTRODUCTION

The industrial robots are able to take, move, machine and assemble workpiece. They are universal automated devices realizing movements similar as a human arm. The industrial robots has a follow base characteristics and differ from other industrial devices by these characteristic:
- target oriented,
- flexibility,
- programmability,
- automated working,
- information exchange between a robot and its environment,
- acting to environment.

On base of today trends at field of robotics was added a new characteristics too:
- possibility to robot working in case of environment changing to unknowable state,
- structure of robot have some intelligence and is possible use this intelligence to activities planing and realizing.

The industrial robots as a complex systems are contain tree cooperating subsystems. These subsystems are follow:
- sensing subsystem,
- control subsystem,
- acting subsystem.

All of these subsystems we can analyze by its lower level subsystems, what realize the partial operations.

2. END EFFECTORS FOR INDUSTRIAL ROBOTS

The end effectors of industrial robots as an interactive part of robots design realize some very important functions derived from base of robots using at concrete case. One of end effectors function is manipulation tasks realizing in technological process. In this case the end effectors realize not only workpiece moving, but often realize the workpiece positioning and orientation at technological device workspace.

The other different function of end effectors may be technological process realization in workpiece (milling, drilling, screwing...). End effectors can be design to realize the measurement and quality control too.

Robotic technologies becomes to huge range of applications so we can find spread spectrum of special end effectors design. These special end effectors can use in medicine, space applications, army and so much other fields.

End effectors can divide by its function to:
- gripping end effectors – grippers,
- technological end effectors,
- measuring end effectors,
- control end effectors,
- combined end effectors,
- special end effectors.

3. CLASSIFICATION OF GRIPPING END EFFECTORS

The gripping end effectors are designed for operations when the workpiece must be gripped, must be realized some manipulation by workpiece, or must be realized some technological operation by this workpiece in time of gripping (workpiece is clamped by robot gripper). The shorter name for this type of end effectors is grippers.

Base of griper classification are the specific characteristics for gripper types. On base of gripping force realization we can classify the grippers to following groups:
- mechanical,
- magnetic,
- vacuum,
- press,
- android,

On base of griper control we can classify the grippers to following groups:
- without controlling,
- binary controlled,
- nonflexible,
- adaptive.

On base of control:
- without control,
- binary controlled,
From construction point of view the “M” class gripper structure contain two or more clamping jigs. Shape of these jigs are defined as a base shapes: cone, cylinder, sphere, planar or its combinations. These shapes are used in depending of manipulated part shapes. Principally all of these gripper jig shapes can be use to gripping all manipulated part shapes, but we must qualify these cases by other points of view too. Difference between gripping by individual cases of gripping jig shape will be in level of other criteria achievement. In base of these qualification will be find the best solution of gripping jigs shape for concrete manipulation and for concrete objects. The goal is design the simples construction of gripper with accent to small mas of end effector and certain functions. Very important criteria is achieving to high accuracy of gripping. By adjustable range of gripping dimension we can achieve most flexible gripper. At case of adaptive grippers is very necessary take mind to sensors mounting in design time of grippers. The grippers acts to manipulated objects by clamping forces $F_{ju}$ which has crucial role for they dimensioning in design time. In general hold the follow equation (1) [1]:

$$
\sum_{j=1}^{n} F_{ju} = k \sum_{m=1}^{n} F_{m},
$$

where:

- $F_{ju}$ – clamping forces,
- $F_{m}$ – outer forces,
- $k$ – safety constant,

Cumulative safety constant $k$ are calculated by multiplication of partial safety coefficients. These partial coefficients takes head to concrete factors of operation. The cumulative safety constant are calculated by equation (2):

$$
k = k_1k_2k_3k_4k_5k_6,
$$

where:

- $k_1$ – coefficient of manipulated objects
- $k_2$ – coefficient of clamping type
- $k_3$ – coefficient of manipulated object surface
- $k_4$ – coefficient of clamping forces drifting
- $k_5$ – coefficient of working cycle dynamics
- $k_6$ – coefficient of running cases.

The methods of clamping forces calculation are based on critical stability in contact layer in cases of adverse conditions of running. This calculation we can realize by follow equations (3):

$$
\sum_{j=1}^{n} F_{ju} = \sum_{n=1}^{N} F_{mv} \eta_{mv} j_{m} \eta_{in}
$$

where:

- $F_{mv}$ – forces from actuators,
- $\eta_{mv}$ – actuators effectivity
- $\eta_{in}$ – gearings effectivity

The next clamping jigs design criteria is a material of manipulated objects. Quality of surface (roughness, hardness, ...) are affect to clamping jigs surface type. By modification of clamping jigs active surface we can modify friction between clamping jigs and manipulated...
objects. This modification are realized by various value of friction coefficient $\mu$.

Clamping force value to cylindrical object centered gripping by planar clamping jigs (fig 1.) is possible calculate by follow equation (3):

$$F_a = k_m \left[ a_1 + a_2 \left( \frac{1}{2\mu} \right) + a_3 \left( \frac{1}{\mu} \right) \right]$$  \hspace{1cm} (3)

where:

$\mu$ – friction coefficient

$a_i$ – partial gravity and instants accelerations in X, Y, Z axis

Fig.1. Cylindrical object centered gripping by planar clamping jigs

Clamping force value to cylindrical object eccentrically gripping by planar clamping jigs (fig 2.) is possible calculate by follow equation (4):

$$F_a = k_m \left[ a_1 \left( \frac{3l}{b} + \frac{1}{2} \right) + a_2 \left( \frac{1}{2\mu} \right) + a_3 \left( \frac{3l}{\mu b} \right) \right],$$  \hspace{1cm} (4)

where:

$l$ – length of gravity center excentricity,

$b$ – length of contact line between a jigs and object.

Fig.2. Cylindrical object eccentrically gripping by planar clamping jigs

The working temperature of manipulated objects at give part of technological process define material type to design of clamping jigs and whole gripper.

5. CONCLUSION – DESIGN TRENDS

Robotized workplaces are used at several industrial branches. Request to competitive and effective manufacturing generate pressure to robotics design centers. The end effector design must take head to lot of special requests apart a common mechanical engineering parts. Trends in this area is a continuous accuracy increasing and develop a new methods to gripper design.

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