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CUTTING METHODS AND CARTESIAN ROBOTS

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Abstract

The main principal of cutting any material with a cartesian robot is trajectory following. The cutting method must be compatible with a cartesian robot. Generally 4 different ways of cutting methods are preferred with cartesian robots. These ways are oxigen cutting, plasma cutting, laser cutting and waterjet cutting. Waterjet cutting is the most populer because it provides cold cutting and it doesn't cause any deformation on especially metals and on the other hand it can cut all material. In this study, designing of a cartesian robot compatible waterjet cutting is explained.

KESME YÖNTEMLERİ VE KARTEZYEN ROBOTLAR

Özetçe

Herhangi bir malzemeyi kartezyen robot ile kesmenin ana prensibi yörünge takibidir. Kesme yöntemi kartezyen robot ile çalışabilecek uyumda olmalıdır. Genellikle kartezyen robotlar ile 4 farklı kesme yöntemi kullanılır. Bunlar, oksijen kesme, plazma kesme, lazer kesme ve sujeti kesme yöntemleridir. Sujeti kesme yöntemi soğuk kesme sağladığından, metallerde ısı girdisi oluşturmadığı ve deformasyona neden olmadığı ve tüm malzemelere uygulanabildiği için en kullanışlı olanıdır. Bu çalışmada sujeti kesme yöntemi ile uyumlu kartezyen robot dizaynı anlatılmıştır.

Keywords : *cartesian, robot , cutting*
Anahtar Kelimeler : *kartezyen, robot, kesme*

1. OPERATION PRINCIPLE OF CARTESIAN CUTTING ROBOT

Cartesian robots follow two dimensional trajectory shapes drawn by using any 2D software are transferred to DXF codes and DXF codes are the initial conditions for the main software. The main software includes all of the mechanical and dynamical specifications which belongs to system. The main software provides driving the AC servomotors and uses PD control algorithm to control velocity and position of the cutting head.

Cartesian robot dimensions can be any according to request of plant . The cutting speed varies depending on the thickness and material . Mechanical components like lineer guides, ball bearing, rack and pinion, electrical motors and reduction gears according to requested velocity of machine.

Any closed shapes can be drawn by using LINE and ARC commands only. Therefore two separate following trajectory software were prepared for LINE and ARC cutting. DXF file of the geometry is decoded and written in a file. In this file, LINES and ARCS are represented by different codes. By using these codes, the main software decides to call either LINE or ARC trajectory following software.

Some simple basic geometric shapes, such as circles, squares and rectangles, can be cut without drawing them. The parameters defining these shapes can be input to the software in numerical format directly.

The movement of the cutting head is realised through ball screw, reduction gear, rack-pinion system and AC servomotors. The trajectory following is the main problem in the system design. Position and velocity control of the cutting head should be in maximum accuracy.

In order to increase the position accuracy ball screws and ball rail system was selected in this system. The advantages of the ball screw over the acme screw drive are :

a. The mechanical efficiency of an acme screw drive is a maximum of %50, whereas a ball screw can reach a mechanical efficiency of up to %98

b. Higher life expectancy due to negligible wear during operation

c. Less drive power required

d. No stick - slip effect

e. More precise positioning

f. Higher travel speed

g. Less heat up

The ball rail system with self aligning feature automatically compensates for errors in alignment up to 10" of arc with no reduction in load carrying capacity.

The positioning of the cutting head is an important step on the way to fully automatic cutting. For the running of automatic production processes a number of parameters are stored in the numerical control as machine constants. The machine's zero point and the machine's fixed point are normally identical. Relative X and Y coordinates will be given for that reference point and together with the defined working area. The zero point defined to the software is usually the point at which all automatic processes start. All cutting processes will be automatically controlled, and monitored within the programmed working area.

2. CUTTING METHODS

Generally four cutting methods Plasma, Laser, Oxigen and Waterjet are preferred in Industry and used with Cartesian cutting robots. First three hot cutting methods burn material and cause some distorsions and deflections on material but waterjet cutting technology provides a cold cutting. Waterjet cutting is the newest technology and it provides completely cold processing. In added , all material can be cut with this technology. In this study waterjet cutting is considered on cutting head of cartesian robots.

3. TRAJECTORY FOLLOWING CONTROL ALGORITHM

System : The Loads driven with AC servomotor.

(1) : $J_e.\omega_m + B_e.\omega_m + M_{dm} = M_d = k_m .u$

State space equation:

$$x_1 = \theta_m \quad (2)$$

$$x_2 = \omega_m \quad (3)$$

$$x_1 = x_2 \quad (4)$$

$$x_2 = \frac{-B_e}{J_e}.x_2 + \frac{-1}{J_e}.M_{dm} + \frac{k_m}{J_e}.u \quad (5)$$

$x_1(0) = 0;$ $x_2(0) = 0$

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & \frac{-B_e}{j_e} \end{bmatrix} . \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{k_m}{J_e} \end{bmatrix} . \ u + \begin{bmatrix} 0 \\ \frac{-1}{J_e} \end{bmatrix} . \ M_{dm} \qquad (6)$$

$$\mathbf{X} = A.\mathbf{X} + B.\mathbf{U} + C.\mathbf{W} \qquad (7)$$

Transfer function of the system:

Control type : PD; $u = K_p\ (\theta_{mref} - x1) - K_v\ (\omega_{mref} - x2)$; (8)

$$\frac{\theta_m}{\theta_{mref}} = \frac{K_{p.}.k_m}{J_e.s^2 + B_e.s + k_m.K_v.s + K_p.k_m} \qquad (9)$$

$$K_p = \frac{\omega_0{}^2.J_e}{k_m} \qquad (10)$$

$$K_v = \frac{2.\varsigma.\omega_0.J_e - B_e}{k_m} \qquad (11)$$

X axis motor:

Fnx_1: $x_1 = x_2$;

Fnx_2: $$x_2 = \frac{-B_e}{J_e}.x_2 + u_x.\frac{k_m}{J_e} \qquad (12)$$

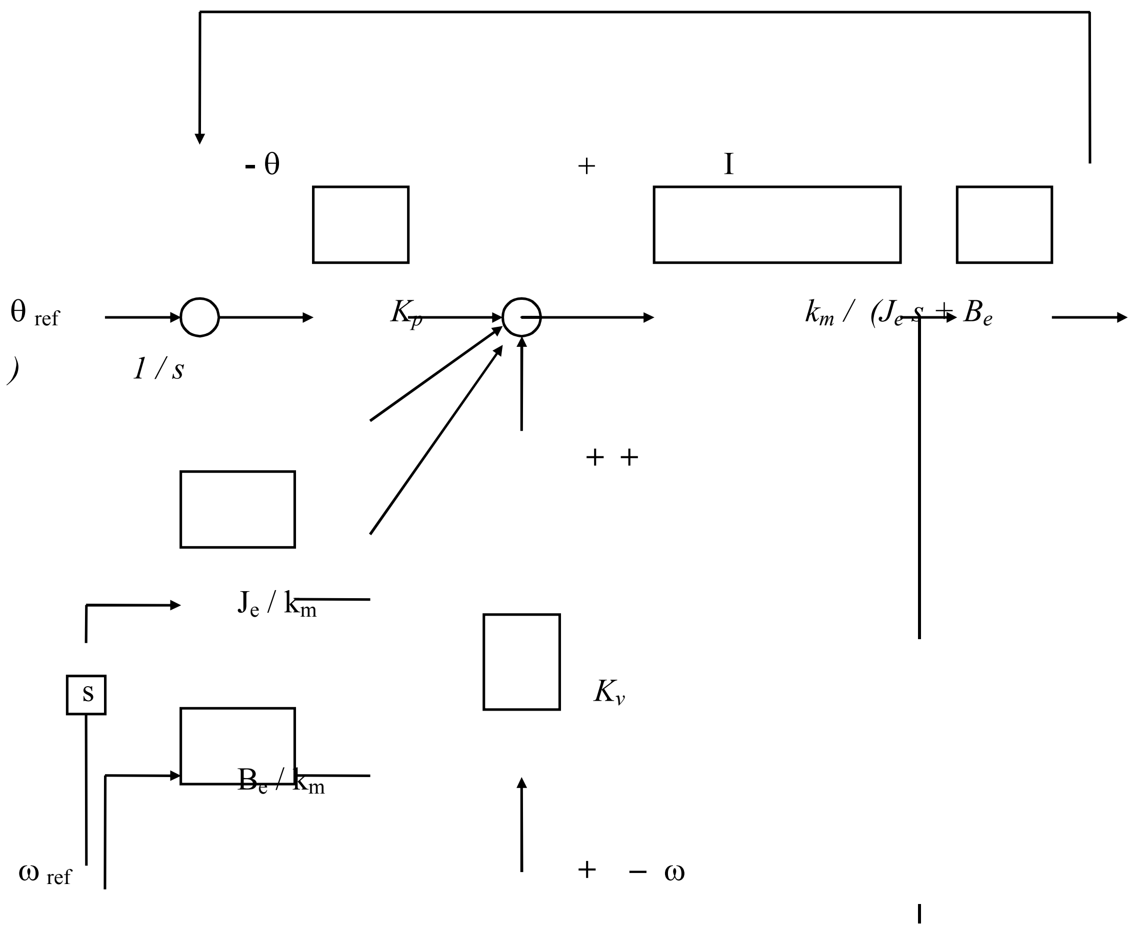
Y axis motor:

Fny_1: $y_1 = y_2$;

Fny_2: $$y_2 = \frac{-B_e}{J_e}.y_2 + u_y.\frac{k_m}{J_e} \qquad (13)$$

4. BLOCK DIAGRAM OF THE SYSTEM

4.1. Arc block diagram



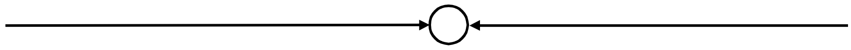


Figure 1: Arc Block diagram

4.2. Line Block Diagram

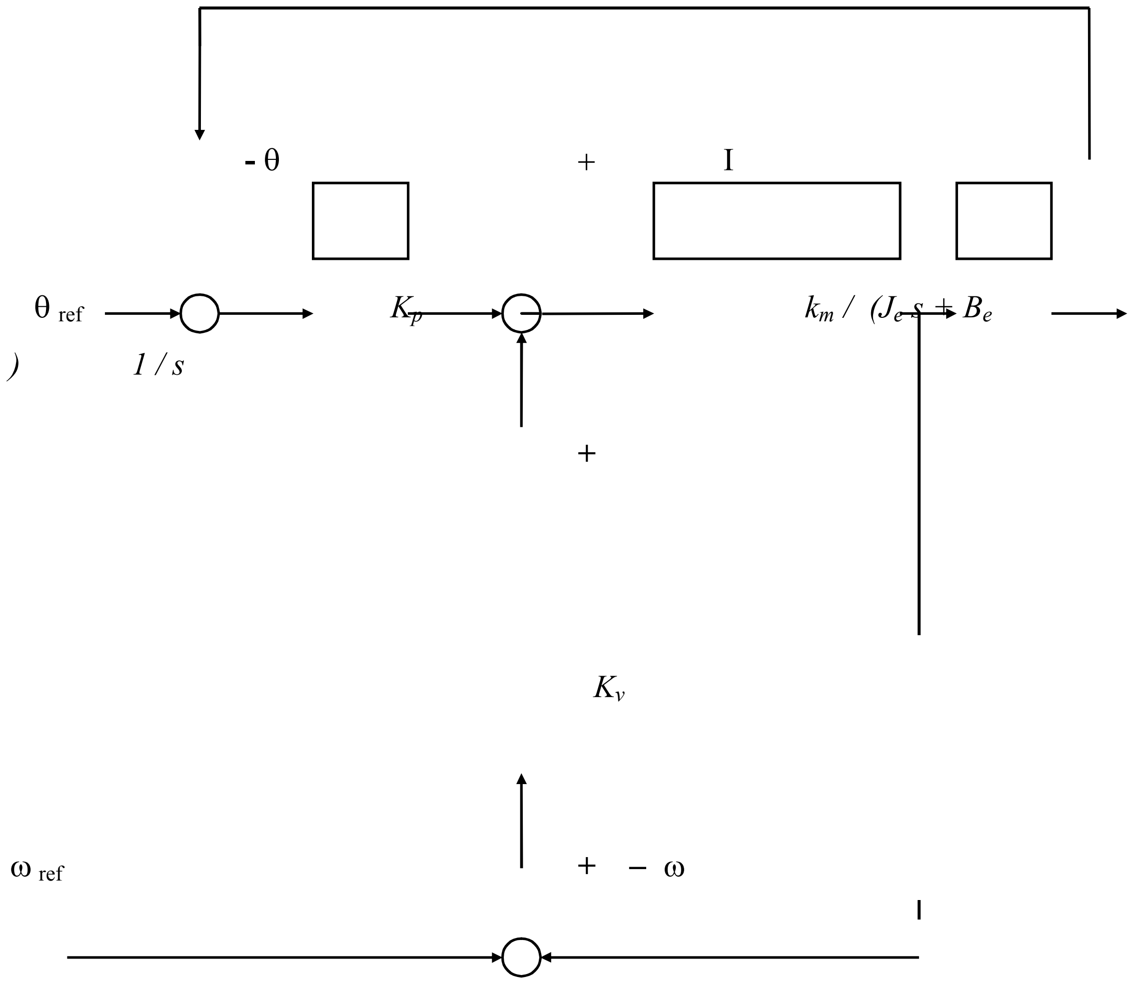


Figure 2: Line block diagram

5. CONCLUSION

Waterjet cutting method is preferred and applied with cartesian robots due to its many advantages. The main advantage of waterjet cutting method is applying to all material. In added, the method is proper for trajectory following with cartesian robots, easy cutting head application on bridge and easy operation. And the other advantages of waterjet cutting method, it doesn't cause any thermal effect and deformation on metallic material.

Waterjet cutting machines substitute rapidly other thermal cutting methods like oxygen, plasma and laser cutting methods for especially metallic material.

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