The Dynamics & Torque and Force-Angle Relation on Velocity of Hammer with Lagrange Equation in Robotic Arm I

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Abstract: The dynamic equation of three freedoms is established hammer in robotic arm by Lagrange equation. In the simulation occasion the dynamic equation will be computed in three freedoms according to this study. The force decreases a little with increasing angle from 0 to 2N with 0.05m/s while the torque decreases from 0 to 40Nm with the angle. Meantime torque decreases from 0 to 30Nm with the v of 0.2m/s. With increasing speed to the one M2 can reduce from 180Nm to 20Nm with the 0.5m/s meantime it is 240Nm with 0.3m/s. The highest torque M2 has 330Nm at the angle θ equals 0. The angel torque decreases when θ1 increases from 0 to 0.1 from 150Nm to 1400Nm with the speed of 0.1m/s.

Keywords: Dynamic Equation, hammering, three freedoms; torque; force; angel; velocity; Robotic Arm, Lagrange Equation

1. Introduction

The robotic arm shall be studied detail that dynamic equation is established to grasp each parameters to wield its virtual use value. Because it has main two freedoms one is rotation and the other is punch it’s this equation will be established according to these features. The each dynamic equation is plotted then substitute into Lagrange equation to search for the dynamic equation to be established. [1–4] Because it has three parts to move and hammering below equation is to be solved according to each parts movement. After establishing this equation it can be analyzed by related parameters to optimum and cost decreasing. The length and mass of components and position will be control parameters. So in this paper these parameters will be further discussed to look for cost decreasing. [5, 6] It is hopeful to assist designer and related teacher in studying further at factory and university. In this paper the dynamic equation in the three freedoms of mechanical arms is established to satisfy the college research even industrial demand and further study in detail. In mechanical arm what the freedoms is chosen is Most important to robot behavior because the three freedoms is more advanced and complicated than two freedoms. The amount of equation is important so it will be found that it is much or little to its complication to calculation course. Simplification and rapid and efficient computation is our aim.

In modern industry the activity of robotic arm is high as an automatic device. It is an important branch for the Robot. Its feature has been completing anticipated working task by program. It is an automatic device for robot technological field to be gained the most practical applications that is in industry manufacture, medical healing, military, semi-conductive manufacture and space exploring. Its structure and property have an advantage of human and robot respectively especial in exhibiting human intelligence and adaption. Its precision and capability in all kinds of environment is excellent so that it has wide prospects in each field of economy. The punching destruction is often used in destruction applications.
2. Torque and Force Curves

As seen in Table 1 the parameter in robot arm is listed. [6]

Table 1 Parameters of robot arms

<table>
<thead>
<tr>
<th>items</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>l1 /m</td>
<td>0.55</td>
</tr>
<tr>
<td>l2 /m</td>
<td>0.5</td>
</tr>
<tr>
<td>l3 /m</td>
<td>0.3</td>
</tr>
<tr>
<td>m1/N</td>
<td>7.7</td>
</tr>
<tr>
<td>m2/N</td>
<td>6.6</td>
</tr>
<tr>
<td>m3/N</td>
<td>4.0</td>
</tr>
<tr>
<td>l4 /m</td>
<td>0.35</td>
</tr>
<tr>
<td>l5 /m</td>
<td>0.3</td>
</tr>
<tr>
<td>q1 /°/s</td>
<td>4</td>
</tr>
<tr>
<td>q2 /°/s</td>
<td>4</td>
</tr>
<tr>
<td>q3 /°/s</td>
<td>4</td>
</tr>
<tr>
<td>q1 /°/s2</td>
<td>3</td>
</tr>
<tr>
<td>q2 /°/s2</td>
<td>3</td>
</tr>
<tr>
<td>q3 /°/s2</td>
<td>3</td>
</tr>
</tbody>
</table>

Lagrange equation is

\[
\frac{d}{dt} \left( \frac{\partial E}{\partial \dot{q}_i} \right) - \frac{\partial E}{\partial q_i} + \frac{\partial E}{\partial \dot{q}_i} = F_i, \quad (i=1, 2... n)
\]  

(1)

Here \( E_k \) is kinetic of system;

\( E_v \) is potential energy of system?

\( q \) is generalized coordinate, it is a group of independent parameters that can define mechanical system movement;

\( F \) is generalized force, when \( q \) is an angular displacement it a torque, when \( q \) is linear displacement it a force;

N is system generalized coordinate.

System generalized force is supposed that \( F_k(k=1,2...,m) \) and \( M_j(j=1,2...,n) \) is force and torque acting on system. Its power is

\[
P = \sum_{i=1}^{m} (F_i v_i \cos \alpha_i) + \sum_{j=1}^{n} (\pm M_j \omega_j)
\]

(2)

Here \( \omega_j \): angular velocity acting on component with \( M_j \);

\( v_k \): the velocity in force \( F_k \) point of action; (the syntropy +, reverse direction -)

\( \alpha_k \): angle between \( F_k \) and \( v_k \)

When generalized coordinates is \( \varphi \) angular displacement generalized force=equivalent torque \( M_c \).
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\[ \delta W_i = \sum_{j=1}^{n} (F_i \delta s_j \cos \alpha_j) + \sum_{j=1}^{n} (\pm M_j \delta \phi_i) \]  
(3)

Here \( a_x \) is zero; \( F_j = 0; \ v_j = 0; \ \omega_j = 0; \ M_j = \partial \phi / \partial \phi \), is virtual angular displacement; \( \delta s_j \) is virtual displacement.

Supposing that

\[ \delta s_j = \frac{\partial s_j}{\partial q_i} \delta q_i + \frac{\partial s_j}{\partial q_1} \delta q_1 \]  
(4)

\[ \delta \phi_j = \frac{\partial \phi_j}{\partial q_i} \delta q_i + \frac{\partial \phi_j}{\partial q_1} \delta q_1 \]  
(5)

Replace equation below with above two equations

\[
\begin{align*}
F_1 &= \sum_{i=1}^{n} \left[ F_i \frac{\partial s_x}{\partial q_1} \cos \alpha_i \right] + \sum_{j=1}^{n} \left[ M_j \frac{\partial \phi_j}{\partial q_1} \right] \\
F_2 &= \sum_{i=1}^{n} \left[ F_i \frac{\partial s_x}{\partial q_1} \cos \alpha_i \right] + \sum_{j=1}^{n} \left[ M_j \frac{\partial \phi_j}{\partial q_1} \right]
\end{align*}
\]  
(6)

This is generalized force equation.

3. Results and Discussion

In terms of dynamic equations it is calculated that the drawing between two parameters. Here \( v \) is the hammer velocity in part 3, it is supposed to be 0.02~0.5m/s. Force \( F_j \) and torque \( M_j \) could be computed in terms of angle \( \theta \) and acceleration \( a \). \( M_j \) is based on \( v \). \( F_j \) is based on equation above. Detailed analysis and drawing between them is as below:

3.1 Results

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\[ F_j = \sum_{i=1}^{n} \left[ F_i \frac{\partial s_x}{\partial q_1} \cos \alpha_i \right] + \sum_{j=1}^{n} \left[ M_j \frac{\partial \phi_j}{\partial q_1} \right] \]

And as seen in Figure 1 the force decreases with the increasing angle \( \theta \) from 12N to 88N. The \( M_j \) torque decreases when \( \theta \) increases from 0 to \( \frac{\pi}{2} \) from 150Nm to 1400Nm with the speed of 0.1m/s. As Figure 2 with increasing speed to 0.5m/s the torque will reduce to -800Nm with the one of 0.5m/s. It is 1100Nm with 0.3m/s. The biggest \( M_j \) is at 0.02m/s which has the one about 1600Nm.
Figure 3 the relations of $F_2$ and $M_2$ & $\theta_2$ in robot arm.

As seen in Figure 3 $F_2$ reduces when angle changes from above value. The $M_2$ decreases from 180Nm to 20Nm with the same speed above as Figure 4. With increasing speed to the one $M_2$ can reduce from 180Nm to 20Nm with the 0.5m/s meantime it is 240Nm with 0.3m/s. The highest torque $M_2$ has 330Nm at the angle $\theta_2$ equals 0.

Figure 4 the relations of $M_2$ & $\theta_2$ with the speed $v$ in robot arm.

As Figure 5 the force decreases a little with increasing angle3 from 0 to 2N with 0.05m/s while the torque decreases from 0 to 40Nm with the angle. Meantime in Figure 6 torque decreases from 0 to 30Nm with the $v$ of 0.2m/s. The torque raises in terms of speed decreases. The biggest one is at 0.05m/s which has been 38Nm.

4 Conclusions

In the modeling of three freedoms in hammer of robotic arm the kinetic equation is established according to Lagrange equation based on two freedoms robotic arm. It compensates the blank in three freedoms for robotic hammer arm. It is found that the first and second item is complicated and long besides others is concise. In the simulation occasion the dynamic equation will be computed on three freedoms according to this study. The force decreases a little with increasing angle3 from 0 to 2N with 0.05m/s while the torque decreases from 0 to 40Nm with the angle. Meantime torque decreases from 0 to 30Nm with the $v$ of 0.2m/s. With increasing speed to the one angle2 can reduce from 180Nm to 20Nm with the 0.5m/s meantime it is 240Nm with 0.3m/s. The highest torque $M_2$ has 330Nm at the angle $\theta_2$ equals 0. The $M_1$ torque decreases when $\theta_1$ increases from 0 to $\pi$ from 150Nm to 1400Nm with the speed of 0.1m/s.

Figure 5 the relations of $F_3$ and $M_3$ & $\theta_3$ in robot arm.

Figure 6 the relations of $M_3$ & $\theta_3$ with the speed $v$ in robot arm.

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References