Department of Robotics and Mechatronics Engineering

University of Dhaka

# Lab Report

**Course Name: Advance Robotics Lab**

**Course Code:** RME 4111

**Experiment no :** 03

**Experiment Name :** Robotic Gripper Analysis.

**Group No :** 2

**Group Members :**

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**Objectives of the experiments :**

1. Determine the force requirements
2. Evaluate gripper performance
3. Optimize grip design and parameters
4. Investigate safety considerations

**Theory :**

Robot grippers are fundamental components that play a vital role in a wide range of industrial and robotic applications. They serve as the "hands" of robots, enabling them to manipulate and handle objects with precision and efficiency. Without robot grippers, many tasks would be challenging, time-consuming, or even dangerous for humans to perform. As such, analyzing the forces exerted by robot grippers is of utmost importance. By understanding these forces, we can evaluate the grippers' performance, refine their design, and ensure safe and efficient operations. In this section, we will delve into the theoretical foundations and concepts that underpin the force analysis of robot grippers, shedding light on the key considerations involved.


Fig : A robot gripper [1]

**Role of Robot Grippers:**

Robot grippers are pivotal in industrial and robotic applications, where they facilitate the grasping, lifting, carrying, and manipulation of objects. Their versatility allows them to perform a broad spectrum of tasks, such as assembly, packaging, material handling, and even surgical procedures. The ability of robot grippers to precisely and reliably interact with objects enhances productivity, accuracy, and overall system performance.

**Importance of Force Analysis:**

Analyzing the forces exerted by robot grippers is critical for several reasons. Firstly, it provides insights into the grippers' performance, allowing us to assess their effectiveness in achieving a secure and stable grip on objects. By understanding the forces involved, we can optimize the grippers' capabilities and improve their overall efficiency. Secondly, force analysis helps in refining the design of robot grippers, enabling the development of more effective and adaptable gripper systems. By understanding the forces at play, we can optimize factors such as gripper geometry, materials, actuation mechanisms, and control algorithms to enhance gripping capabilities. Lastly, force analysis is essential for ensuring safe operations. By determining force limits, we can prevent excessive forces that could potentially damage the gripper, the objects being handled, or compromise the safety of human-robot interactions.

Apparatus used :

1. A robot gripper
2. Protactor
3. Calculator

Working procedure :

1. To begin, it was necessary to calculate the force exerted by the torque. This force (referred to as F) should be perpendicular to the radius of rotation. The torque can be expressed as follows:

$$T = F \times r$$

$$F = T / r$$

Having obtained relevant information about the servomotor (specific model used), we were aware that the torque equated to 78 N·mm, which is equivalent to 78 N·mm. Additionally, the radius was measured to be 51.742 mm.

So, $$F = 0.078\text{N.mm} / 51.742 \text{ mm}$$

$$= 1.5075 \text{ N}$$

2. Then, we proceeded by acquiring the robot gripper, which was set to the minimum aperture position. Our initial step in measuring the force involved determining the desired angle for the minimum aperture.

Here for Minimum Aperture ,


Fig : Measuring for minimum aperture.

$\alpha$= 70 degree

$\beta$ = 5 degree

$\varphi$= 85 degree

$F_1 = F\cos\alpha = 0.516$ N

$F_2 = F_1\sin(\alpha + \beta)/\sin\varphi = 0.50$ N

$F_{gripper} = F_1\cos(\alpha + \beta)+F2\cos\varphi = 0.177$ N

So, gripper force for minimum aperture is 0.177 N.

3. Then, we expanded the gripper for measurement of the medium aperture. And then took the meausrment of the angle with the help of a protactor.


Fig : Measuring for medium aperture.

$\alpha$= 25 degree

$\beta$ = 47 degree

$\varphi$= 75 degree

$F_1 = F\cos\alpha = 1.365$ N

$F_2 = F_1\sin(\alpha + \beta)/\sin\varphi = 1.345$ N

$F_{gripper} = F_1\cos(\alpha + \beta) + F2\cos\varphi = 0.77$ N

So, gripper force for medimum aperture is 0.77 N.

4. And , for the last measurement we expanded the two side of gripper as far as we could. Then, we got the state of maximum aperture of the gripper.

For maximum aperture,

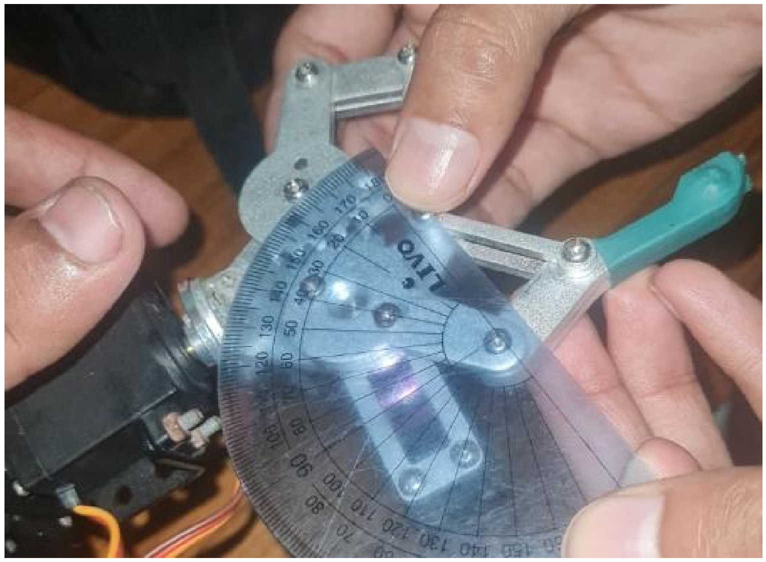

Fig : Measuring for maximum aperture.

For maximum aperture, value of $\alpha = 0$.

So,

$\beta = 78$ degree

$\varphi = 20$ degree

$F_1 = F\cos\alpha = 1.5075$ N

$F_2 = F_1\sin(\alpha + \beta)/\sin\varphi = 4.311$ N

$F_{gripper} = F_1\cos(\alpha + \beta) + F2\cos\varphi = 4.364$ N

So, gripper force for maximum aperture is 4.364 N.

**Result :** As we saw from the working procedure part, we got,

gripper force for minimum aperture is 0.177 N.

gripper force for medium aperture is 0.77 N.

gripper force for maximum aperture is 4.364 N.

**Conclusion :** From the experiment on Robot gripper's force analysis, we can say that, the force of the gripper varies in specific condition. It was greater in maximum aperture. This is because a larger aperture allows the gripper to encompass a larger object or exert force over a wider area.

**Reference :**

[1] https://www.jsumo.com/aluminum-gripper-robotic-kit

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$T = Fr$

$\Rightarrow F = \frac{T}{r} = \frac{78 Nmm}{51.742 mm} = 1.5075 N$

Minimum aperture

$\alpha = 70^\circ$

$\beta = 5^\circ$

$\phi = 85^\circ$

$F_1 = F \cos \alpha$

$= 1.5075 \times \cos 70^\circ$

$= 0.516 N$

$\Sigma F_x = 0$

$\Rightarrow \cancel{F_2} - F_1 \cos(\alpha + \beta) - F_2 \cos\varphi + F_{gripper} = 0$

$\Rightarrow F_{gripper} = 0.516 \cos 75^\circ + F_2 \cos 85^\circ$

$\Rightarrow F_{gripper} = 0.177 N$

$\Sigma F_y = 0$

$\Rightarrow F_1 \sin(\alpha + \beta) - F_2 \sin\varphi = 0$

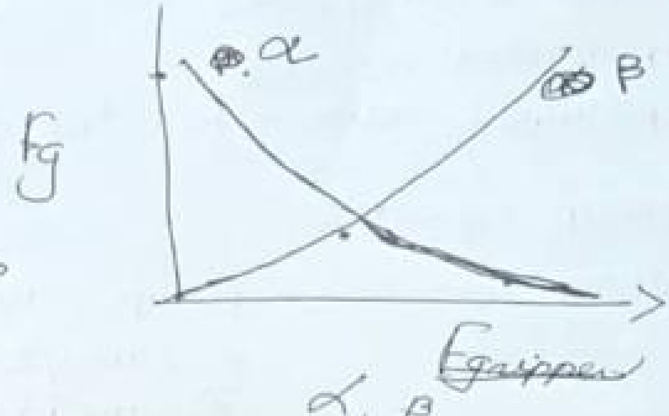
$\Rightarrow F_2 = F_1 \sin(\alpha + \beta) / \sin\varphi = 0.516 \sin(75^\circ) / \sin 85^\circ$

$= 0.50 \quad N$

Medium aperture

$\alpha = 25^\circ$
$\beta = 47^\circ$
$\phi = \cancel{6}\ 75^\circ$

$F_1 = F\cos\alpha$
$= 1.5075 \cos 25^\circ$
$= 1.366\ N$




$\Sigma F_x = 0$
$\Rightarrow -F_1\cos(\alpha+\beta) - F_2\cos\phi + F_{gripper} = 0$
$\Rightarrow F_{gripper} = F_1\cos(72^\circ) + F_2\cos(75^\circ)$

$\Sigma F_y = 0$
$\Rightarrow F_1\sin(\alpha+\beta) - F_2\sin\phi = 0$
$\Rightarrow F_2 = \dfrac{F_1\sin(\alpha+\beta)}{\sin\phi} = \dfrac{1.366\sin 72^\circ}{\sin 75^\circ} = 1.345\ N$

$F_{gripper} = 0.77\ N$

Maximum aperture

$\beta = 78^\circ$
$\varphi = 20^\circ$

$F_1 = F$
$= 1.5075\ N$

$\Sigma F_y = 0$
$\Rightarrow F_1\sin\beta - F_2\sin\varphi = 0$
$\Rightarrow F_2 = \dfrac{F_1\sin\beta}{\sin\varphi}$
$\Rightarrow F_2 = 4.311\ N$

$\Sigma F_x = 0$
$\Rightarrow -F_1\cos\beta - F_2\cos\varphi + F_{gripper} = 0$
$\Rightarrow F_{gripper} = F_1\cos\beta + F_2\cos\varphi$
$\Rightarrow F_{gripper} = 4.364\ N$