Parallel and Angular Grippers

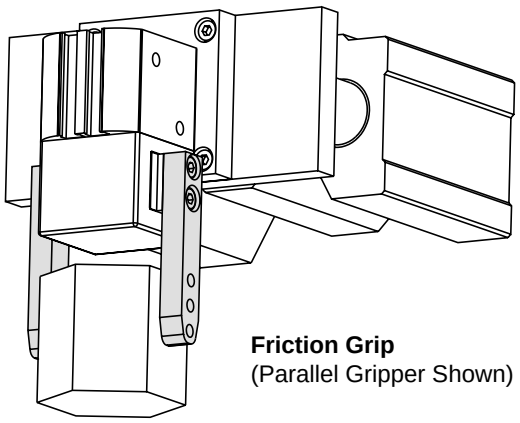
Parker Hannifin Corporation
Automation Actuator Division
Wadsworth, OH 44281

FORCE REQUIREMENTS

When determining gripper force requirements, the gripper fingers must be able to control the workpiece under worst-case conditions. The specific workpiece needs to maintain a steady, constant position within the grasp of the fingers, and at the same time, care must be taken to ensure the workpiece will not deform.

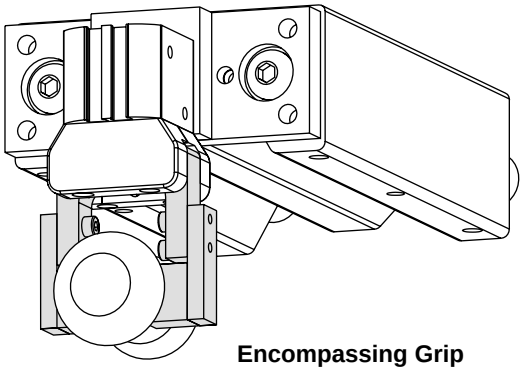
There are two types of grips that determine the force required from a gripper: (1) friction grip and (2) encompassing grip.

Friction grip depends on the frictional force of the gripper to maintain the position of the workpiece. Generally, this corresponds to tight tolerances and increased positional accuracy. Typical coefficient of friction for a friction grip is 0.2 to 0.4. This will vary depending on specific applications. A typical friction grip requires as much as four times the force to perform the same function as an encompassing grip.



Friction Grip
(Parallel Gripper Shown)

Encompassing grip uses the fingers to cradle the workpiece. This provides for more stability and safety because the fingers must be forced open to move the workpiece.



Encompassing Grip
(Angular Gripper Shown)

GRIP FORCES

Forces are additive when figuring out the total gripper holding force. The weight of the workpiece governs the required holding force. Forces can be broken down into:

- Weight – weight due to part plus tooling
- Acceleration – starting and stopping forces

Both forces are additive.

A factor of safety is needed for a precision machine. The factor of safety can vary depending on specific application. In general, the following factor of safety is suggested:

Friction grip	4
Encompassing grip	1.25

Example 1 uses gravitational force (G = 32.26 ft/s^2) to solve for gripper holding force.

Example 1:

A workpiece weighing 20 pounds is subject to an acceleration of .5G (16.1 ft/s^2). The grip force needed is

Weight of Workpiece + Acceleration Force = Grip Force

20 lbf + (20 lbf x .5) = 30 lbf

From the example, solve for grip force.

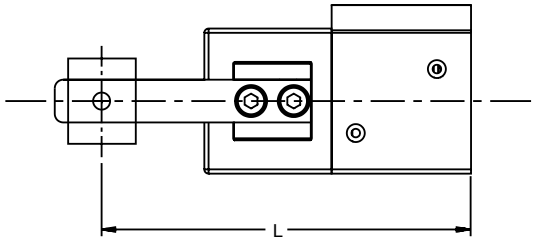
Friction grip = 4 x 30 lbf = 120 lbf

Encompassing grip = 1.25 x 30 lbf = 37.5 lbf

Use Gripping Force Relations on pages 8-9 to determine the correct gripper size.

TORQUE

The forces acting on the center of gravity of the workpiece at a distance (L) from the bottom of the gripper creates a moment arm.



The sum of the force components acting on the center of gravity can be broken down into:

- Force created by static load
- Force created from acceleration

Both forces are additive so that:

Sum of Force Components x Distance (L) = Total Torque

When solving for torque, be aware that forces will change depending on the orientation of the workpiece. To minimize torque, the workpiece should be gripped as close to the top of the gripper as possible.

SYSTEM DESIGN GUIDELINES

The two main considerations are (1) throughput and productivity design and (2) reliability design. By overlapping each criteria, a design may concentrate on both production and reliability. Also, in multiple steps or functions, both design concentrations can be utililzed to achieve a desired result. Each function in the system is unique and must be analyzed according to a specific design criteria.

THROUGHPUT AND PRODUCTIVITY CRITERIA

1) Minimize dead space between gripper fingers and workpiece. This is the clearance between a fully open/ closed gripper and the workpiece. Use encompassing gripper fingers and minimal jaw travel.
2) Minimize weight of gripper to decrease acceleration forces.
3) Clamp workpiece securely. Use an encompassing grip to increase machine speeds.
4) Avoid time consuming tool changes. Use one gripper for various workpieces.
5) Use one gripper to perform multiple functions.

RELIABILITY CRITERIA

1) Clamp workpiece securely. Minimize the possiblity of a dropped or misaligned workpiece.
2) Use encompassing type grip. Ensure precision and accuracy.
3) Regulate clamping force. Protect against deforming the workpiece.
4) Minimize finger length. The longer the tooling, the more the finger will deflect and lose grip force.
5) Provide sufficient deadspace to ensure clearance between the part and the fingers. Minimize the chance of the fingers crashing into a misaligned part.
6) Gripper fingers should properly align the workpiece on critical operations.
7) Surface materials of both gripper and workpiece should clamp at low friction to ensure precise and accurate placement of the workpiece.
8) Do not use parts in an assembled workpiece to maintain proper part alignment in the gripper – any tolerance in the assembled workpiece can affect the alignment.
9) Use a gripper dedicated to one function to perform multiple functions – minimizes the chance of being mishandled since the workpiece never leaves the gripper.

CONVERSION CHART

Metric to English
(Multiply ___ by_____ to obtain)

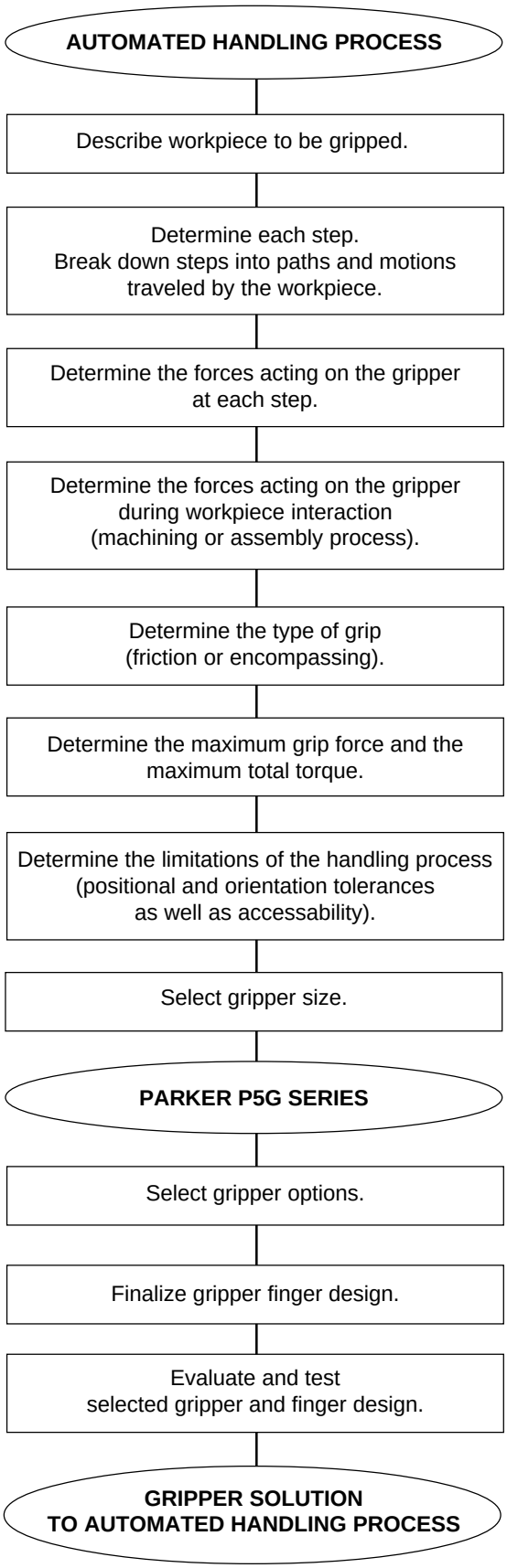
Length		
mm	0.0394	in
Area		
mm^2	0.0016	in^2
cm^2	0.155	in^2
Volume		
mm^3	$6.10x10^{-5}$	in^3
cm^3 (cc)	0.061	in^3
L	0.0353	ft^3
Weight		
g	0.0353	oz.
kg	2.204	lb.
Force		
kgf	2.204	lbf
N	0.224	lbf
Torque		
Nm	0.737	ft-lb
Pressure		
kPa	0.145	psi
bar	14.50	psi
Energy		
Nm	0.737	ft-lb
Power		
W	0.737	ft-lb/s
kW	1.341	hp

Temperature
°F = (1.8 x °C) + 32

Flow rate
l/min x 0.035 = SCFM

Key
mm = millimeter
cm = centimeter
cc = cubic centimeter
L = liter
g = gram
kg = kilogram
kgf = kilogram force
N = Newton
Nm = Newton meter
in = inch
ft = foot
oz = ounce
lb = pound
lbf = pound force
ft-lb = foot pound

Parker Hannifin Corporation
Automation Actuator Division
Wadsworth, OH 44281


AUTOMATED HANDLING PROCESS
Describe workpiece to be gripped.
Determine each step.
Break down steps into paths and motions
traveled by the workpiece.
Determine the forces acting on the gripper
at each step.
Determine the forces acting on the gripper
during workpiece interaction
(machining or assembly process).
Determine the type of grip
(friction or encompassing).
Determine the maximum grip force and the
maximum total torque.
Determine the limitations of the handling process
(positional and orientation tolerances
as well as accessability).
Select gripper size.
PARKER P5G SERIES
Select gripper options.
Finalize gripper finger design.
Evaluate and test
selected gripper and finger design.
GRIPPER SOLUTION
TO AUTOMATED HANDLING PROCESS

Contact Information:

Name: _____ **Phone Number:** _____

Company: _____ **Fax Number:** _____

E-Mail: _____

Please tell us about your application and we will respond promptly with recommendations. Please provide the following application details and ***fax to (330) 334-3335***.

Weight of workpiece: _____

Workpiece hardness: _____

Workpiece temperature: _____

Workpiece shape: _____

Number of orientations per cycle: _____

Type of actuator: _____

Maximum acceleration: _____

Cycles per minute: _____

Distance Travel per Step: _____

Type of Fingers: Friction _____ **Encompassing** _____

Workpiece positioning tolerance: _____

Supply air pressure: _____

Control method: _____

Electrical supply: _____

Operating conditions: _____

Type of position sensor: _____

Number of sensors: _____

Flow controls*: _____

*Flow controls are recommended on all grippers.

Sketch of applications

P5G Series

- True parallel, 30° angular, 180° angular
- 16mm, 25mm, 32mm and 40mm bore sizes
- Switch grooves standard in all bodies
- Gripping force up to 144 lbf

P5G Series grippers are precise, reliable and provide a very high grip force to weight ratio at low cost.

Two jaw designs, standard and maximum force open or maximum force closed, are available on parallel grippers for custom solutions. Options include double acting, extended travel, spring assist, spring return, and stroke adjust. Angular grippers are available with spring return and stroke adjust. All styles are offered with flow controls, proximity sensors and flush mounted position switches. Operating pressure to 100 PSIG.

GP/GA Series

- 3 styles
- Parallel, 30° and 180° motion
- Up to 54 lb gripping force on parallel, up to 27 lb gripping force on angular

GP Series are true parallel grippers. **GA Series** angular grippers provide 30° and 180° gripping motion for pick and place applications. Gripper fingers are machined steel and have multiple holes for mounting end effect tooling.

Non-lube service for pressures to 150 PSI. Options include proximity sensors, flow controls and high-temperature seals.

H2 Series

- 3 styles
- 30° motion
- Pressures to 145 PSI

H2 Series grippers provide extremely high force output with a unique linkage design that multiplies the force to the fingers. Standard movement is 30°. Protective boot keeps out contamination.