Parallel and Angular Grippers
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.

Grizzlies
Introduction

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/s²) to solve for gripper holding force.

Example 1:
A workpiece weighing 20 pounds is subject to an acceleration of .5G (16.1 ft/s²). The grip force needed is

\[
\text{Weight of Workpiece} + \text{Acceleration Force} = \text{Grip Force}
\]

\[
20 \text{ lbf} + (20 \text{ lbf} \times .5) = 30 \text{ lbf}
\]

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.

\[
\text{Torque} = \text{Sum of Force Components} \times \text{Distance (L)}
\]

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:

\[
\text{Sum of Force Components} \times \text{Distance (L)} = \text{Total Torque}
\]

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 criterion, a design may concentrate on both production and reliability. Also, in multiple steps or functions, both design concentrations can be utilized 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 possibility 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)

<table>
<thead>
<tr>
<th>Key</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>in</td>
</tr>
<tr>
<td>cm²</td>
<td>in²</td>
</tr>
<tr>
<td>cm³ (cc)</td>
<td>in³</td>
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<tr>
<td>L</td>
<td>ft³</td>
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<tr>
<td>g</td>
<td>oz.</td>
</tr>
<tr>
<td>kg</td>
<td>lb.</td>
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<tr>
<td>kgf</td>
<td>lbf</td>
</tr>
<tr>
<td>N</td>
<td>lbf</td>
</tr>
<tr>
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<td>Nm</td>
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<tr>
<td>Pressure</td>
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<tr>
<td>bar</td>
<td>psi</td>
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<tr>
<td>Energy</td>
<td>Nm</td>
</tr>
<tr>
<td>Power</td>
<td>W</td>
</tr>
<tr>
<td>kW</td>
<td>hp</td>
</tr>
<tr>
<td>Temperature</td>
<td>°F = (1.8 x °C) + 32</td>
</tr>
<tr>
<td>Flow rate</td>
<td>l/min x 0.035 = SCFM</td>
</tr>
</tbody>
</table>
Gripper Selection Flowchart

**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 accessibility).
- 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**
Application Fax

Contact Information:

Name: ____________________________
Company: __________________________

Phone Number: _____________________
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: ____________________________

*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.