

Chapter IV. Hand Tool Design, Evaluation, and Selection – Selected Excerpts from Chapter

IV B2. Handle Grip Forces

Guidelines

Tool Weight

How heavy should a tool be if it is to be manually handled?

- User Preference. 2 – 3.85 lb hand tools were rated “just right” by users (Armstrong, et al., 1989). Grip forces required to use tools weighing 2 – 4.4 lb were rated “comfortable” by users (Armstrong, et al., 1989). Perceived exertion when using tool weighing 2.2 lb was significantly less than when using tools weighing 4.4 or 6.6 lb (Ulin, et al., 1992). Note that the above ratings were obtained by workers in automotive plants using tools representative of that industry.
- Note that there is a tradeoff between light-weight tools and increased tool weight benefiting performance of task (e.g., grinder).
- Use heavy tools (e.g., grinders) on horizontal surfaces.

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Guidelines Use of Gloves

Table IV.3. The Effects of Gloves on Human Performance (↑ = Increase, ↓ = Decrease, — = No Significant Effect. Percentages shown in some cells indicate magnitude of effect due to glove type)

| Parameter | Glove Type | | | | | | | | |
|------------------------|---------------------|--------------------|-------------------------|------------|------------------|----------|------------------|-------------|-------------------------|
| | Leather | Cotton | Nylon / Stainless Steel | Steel Mesh | Latex | Chemical | Rubber | Pressurized | 1 vs. Multiple Layers * |
| Maximum Power Grip | ↓ 10-20% (1, 6, 12) | ↓ 7-26% (10,12,14) | ↓ 12% (10,12) | ↓ 16% (12) | | | ↓ 10-20% (6, 14) | | ↓ 10-15% (6) |
| Maximum Pinch Grip | | — (10) | — (10) | | | | | | — (10) |
| Submaximal Grip | | | | | ↓ (4)** | | | ↓ (15) | ↓ (4)** |
| Perceived Grip Force | ↑ (17) *** | | | | | | | | |
| Torque | ↑ (3,8,11) | | ↑ (8) | | — (8) | ↑ (11) | ↑ (8) | | ↓ (3) |
| Push/Pull | ↑ (3) | | | | | | | | |
| Sensory Discrimination | | | | | ↓ (4,5) — (9) | | | | ↓ (4,5,16) |
| Dexterity | | | | | ↓ (5) — (9) | ↓ (13) | | | ↓ (5,13) |
| Vibration Tolerance | ↑ (7) *** | | | | | | | | |

* Includes glove liners

** Forces exerted in performance of task increased over bare hand condition

*** Glove type not specified

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IV C1. Resting Hand

Introduction

When the hand is at rest, the fingers are slightly spread and somewhat flexed. The thumb tends to fall over the index finger, forming a convex surface along the thumb and palm, and a concave surface along the fingers (refer to Figure IV.3). By designing to fit the shape of the resting hand, the tool can be operated comfortably and with minimal stress on the soft tissues of the fingers and palm of the hand.

Figure IV.3. Resting Hand Position (adapted from Pheasant, 1988) and Tool Designed for Resting Hand



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F. Ergonomic Tool Design – Examples

Examples

Spray Guns

Table IV.15 provides ergonomic design features for spray guns (adapted primarily from Lee, et al., 1997; and Bjoring and Hagg, 2000).

Table IV.15 (Cont.). Recommended design features of spray guns.

| | |
|-----------------------|---|
| Trigger | <ul style="list-style-type: none"> • Providing an extra trigger on top of the spray gun recommended by Lee, et al. (1997). Ergonomic benefits of this design feature were field-validated by Mirka, et al. (2002). • Triggering Forces: <ul style="list-style-type: none"> ○ Maximum 2 lb for 1-finger triggering ○ Maximum 4.5 lb for 2-finger triggering ○ Maximum 6.7 lb for 4-finger (full-hand) triggering). • It should be possible to control the fluid flow without changing the trigger force. |
| Weight / Force | <ul style="list-style-type: none"> • Minimize the weight of the tool (e.g., consider plastics versus aluminum) • Hoses: <ul style="list-style-type: none"> ○ Attachment points should be flexible (swivel). ○ Hoses should be highly compliant (flexible). ○ Hoses should be paint repellant and easily cleaned to maintain compliance. ○ Hoses should be attached to the gun as close to each other as possible. |
| Handle / Gun Features | <ul style="list-style-type: none"> • Minimize gun length to improve center of gravity and reduce shoulder abduction. • Handle and trigger should have ellipsoidal cross-section when activated. • Recommended handle grip span 2-2.4" • Recommended handle length approximately 5" • Handle Material: <ul style="list-style-type: none"> ○ Low thermal conductivity to minimize cold ○ High friction to minimize grip forces ○ Slight compressibility. • All edges radiused. • 90-100° angle between handle and upper part of gun. |