AGRABILITY PROJECT

What to look for when selecting or modifying hand tools to provide a better fit with the user

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The process of selecting and or modifying tools, especially hand tools, to provide a better fit for the user is something everyone at one time or another has attempted to do in daily life. Whether that tool is a computer keyboard used at work or a small Phillips screwdriver used for a woodworking hobby in the garage, no one tool works for all jobs and no one tool fits all users in the most efficient or comfortable fashion. Fit, in terms of comfort and efficiency of use, is particularly important for tools used for long-term projects or for occupational activities.

It is easy to find research that documents the association of hand tools and the problems that result if the wrong tool is used for a task, or if the correct tool is used improperly. Much of the desire to create a better hand tool has always been driven by the parallel desire to create a more efficient work process and an improved product at a lower cost. In the mid-1800s, **Wojciech Jastrzebowski** coined the word *ergonomics*, which means the study or science of work. Many pioneers in the ergonomics field have since refined this study of the science of work, especially after World War II. Today, the science of ergonomics is now more often referred to as "fitting the task to the person" **(Chaffin & Andersson, 1984)**. Please note: *task* is not limited to work only, but may refer to work, recreational, sports, etc. Ergonomics, also known as *human factors*, also attempts to look at the cognitive or decision making performance of humans.

In the last decade, tremendous strides have been made in design and development of hand tools in an attempt to reduce the problems, including potential injuries to the worker, while also increasing tool efficiency. These improved hand tools are often sold or labeled as "ergonomic" hand tools. Although everyone—including farmers and ranchers coping with effects of arthritis, strokes, finger or hand amputations, the aging process, or repetitive strain injuries (RSI)—can benefit from improved hand tools, it is important to remember that no one hand tool is perfect for every job, and no one hand tool is perfect for every user.

Developing a "single standard" for ergonomic hand tool design is difficult because of the variation in human anthropometry (i.e., branch of human science that deals with body measurements, human performance, work environments, and tasks). Therefore, investigation of appropriate tool design and of using hand tools while utilizing proper ergonomic principles continues to evolve. There are guidelines and methods, however, by which tools can be tested to effectively evaluate specific ergonomic features. In general, ergonomic hand tool features can be classified by the following design goals:

- Decrease the force or grip strength required to use the tool.
- Decrease repetitive motion associated with using the tool.
- Decrease awkward body postures or wrist positions when using the tool.
- Decrease vibration transmitted to the hand and wrist.

To help you select hand tools with ergonomic features, the remainder of this article focuses on these four design goals. The end of this article provides a list of "ergonomic" tools (e.g., wrenches, screwdrivers, hammers, pliers, scissors, pruners, gardening tools, cutters, files, and knives) that have been located on the Internet, as well as a list of common materials you can purchase to modify tools, especially the tool handle area, to improve hand grip and possibly reduce vibration. Some hand tools listed are also designed for ease of one-

handed use.

Features That Decrease Force or Grip Strength

Changing the tool handle, a seemingly simple solution, often goes a long way towards reducing the force or grip strength required to use a tool. While not true for every user, in general tools with longer or thicker handles require less force. A hand tool with a longer handle allows the user to generate more leverage by applying a smaller force at a greater distance whereas a thicker tool handle allows more surface for grasping, or in the case of a standard screw driver, increase the torque thereby reducing the overall required force. In some situations, a hand tool designed with a pistol grip may require less gripping force than an in-line tool handle being used for the same job, but other factors such as task orientation may have to be taken into account.

Conventional hand tools, such as pliers and wrenches, are designed with slightly wider handles that allow the grip force (and resultant contact stress) to be distributed over a larger surface and thus decrease the grip strength. Hand tools that open and close such as pliers should consider the optimum opening span to permit use by small and large hands, gloves, and left or right hand operation. Obviously, hand tools should be properly maintained; for example, a worn drill bit will require more force to use. Saw blades that are Teflon coated or coated with other non-stick materials may improve tool efficiency thereby reducing applied forces.

Hand tools with cushion grips may also provide improved tool comfort, and depending upon the texture or cushion material used, may provide some slip resistance and reduced grip force. Be cautious of hand tools marketed as “tools with a non-slip handle.” Many times the tool handles are simply coated in a slip resistant material, and that material may not stand up to the various environments required of the tool. Often a simple handle flange or handle taper is just as effective in reducing the grip strength needed to use a particular tool as a handle cushion or coating material. Tool handles should also be free of sharp edges. Finger grips can be molded into a handle to provide improved slip resistance; however, that tool should then **only** be used by the individual for whom it was customized.

As previously mentioned, no one hand tool is perfect for every job, and no one hand tool is perfect for every user. For example, choosing a hand tool with a larger diameter handle to allow for decreased grip strength may in fact cause a problem when a person with a small hand uses the tool. Each person has his or her optimum-gripping diameter; typically, the diameter of a cylindrical handle should be approximately 1.5 inches, the average person’s optimum grip diameter **(Radwin & Haney, 1996).** To determine an individual’s optimum grip diameter, use the “OK” method. Ask the person to make the okay sign using the thumb and index finger and then measure the inside diameter of the “O” formed by the thumb and index finger. This measurement indicates the optimum grip diameter of a hand tool for that individual. If a hand tool does not meet that individual’s optimum grip diameter, customization might be necessary.

A variety of materials can be used to customize or modify the handle of most hand tools and Internet sites for many of these are listed later in this report. These materials include Magic Wrap, Plastic Dip, My Grip, Thermoplastic, Heat Shrink Tubing, Tool Wrap, Plastazote, and pipe insulation. Gloves with slip resistant material on the palm and fingers can also be purchased. In addition to making tool handles thicker, materials such My Grip, Thermoplastic, or epoxy putty can be applied to create custom molded finger grips.

Features That Decrease Repetitive Motion

Repetitive strain injuries (RSI) are a family of injuries affecting the muscles, tendons, nerves, and joints and typically occur in the hand, arm, shoulder, neck, and even the back of the tool operator. In the past, RSI was associated with sports injuries such as “tennis elbow.” Today however, RSIs are becoming increasingly common among workers who perform repetitive tasks (e.g., typists, meat cutters, assembly line workers, etc.) as part of their daily job or occupation. While research continues into the exact cause of RSI, ergonomists tend to agree that a combination of applied force, poor posture, and the repetitive nature of some tasks combine to increase a person’s chances of RSI.

Many steps can be taken to avoid repetitive motions when using hand tools over a prolonged period of time. For example, if a repetitive assembly task has sufficient clearance, changing to tools with a ratcheting mechanism or gears can help to reduce repetition. Keeping hand tools properly maintained (e.g., sharpen saw blades, drill

bits, etc.) and using proper operating methods (e.g., making pilot holes for drilling, etc.) can reduce the required grip force and repetition. If the work environment allows, changing to a power tool might also reduce repetitive motions. (Note: Using power tools may just exchange repetitive motion for tool vibration, and other power tool related issues, keep reading for specifics.) If possible, switching to hand tools (e.g., pliers and scissors that open and close) that have adjustable spring-loaded returns can reduce repetition. Finally, some innovative hand tools can also reduce repetitive motions. For example, the Stanley® SharpTooth™ Tool Box Saw has a blade that cuts 50% faster due to a unique tooth design that cuts in both directions.

If it is not possible to reduce the repetitive motions using hand tools due to the nature of your job/task, it may be beneficial to take some time to plan or redesign the work task itself. Sometimes a few hours of employee brainstorming and problem solving might not only increase morale, the time and resulting solutions may save some costly medical bills later.

Features That Decrease Awkward Body Postures and Wrist Positions

Even with the proper tool for the job, sometimes the task at hand may require an awkward body position or poor wrist positioning to complete the task. A user's ability to apply force to a hand tool may change based on the limb or limb position (e.g., extending arms versus keeping arms close to the body, or using the nonpreferred hand instead of the preferred hand) and on body position (e.g., using the tool while lying down rather than using the tool while standing). As noted previously, the ability to apply grip strength to a tool depends upon the tool handle type, size, and length. Equally important, however, may be the user's gender, overall body size, age, training for proper tool use, posture, and direction of tool travel (i.e., pull versus push).

Poor wrist positioning can diminish grip strength. One study found that grip strength is decreased by 27% when a wrist is held in flexion, 23% in extension, 17% in radial deviation, and 14% in ulnar deviation **(Terrel & Purswell, 1976**). Poor wrist positioning can also lead to repetitive strain injuries; therefore, using hand tools that minimize flexion, extension, and deviation is preferred.

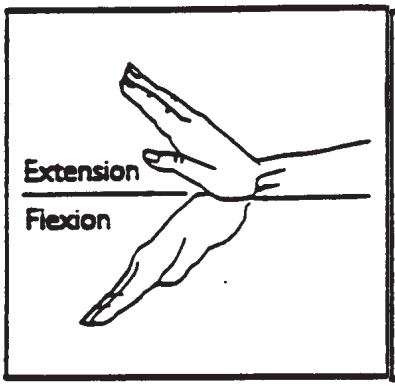

Figure B-2. Wrist flexion and extension.

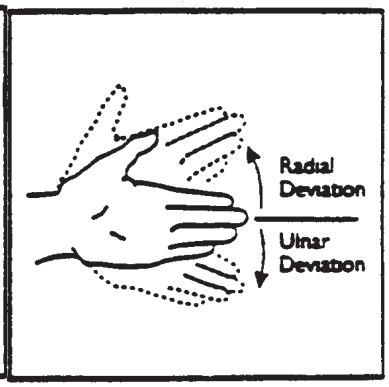

Figure B-3. Radial and ulnar deviations.

Several hammers and pliers are designed with a bent or curved handle to maintain a more natural wrist position. Some tools, such as gardening tools or paintbrushes, can be modified with an add-on pistol grip that allows a more natural wrist posture or position.

Features That Decrease Vibration

Vibration in tools is generally associated with power hand tools. To operate the tools, there are different sources of power such as air, electric, and gas. Typically power hand tools are used when the advantages of a greater force are required, repetitive tasks are being performed, or a time savings might be achieved. With the advantages of power tools also come some disadvantages including possible vibration, different types of

repetitive strain (e.g., trigger finger), and increased operator demands and requirements to handle and react to the forces generated by the power tool.

Among these disadvantages, vibration may be the largest concern. Exposure to large amounts of vibration in a localized area, such as the user's hand, over a prolonged period of time might increase the risk of chronic disorders of the muscles, nerves, and tendons. Other studies have shown vibration to cause temporary sensory impairments **(Streeter, 1970, Radwin et. al., 1990).**

Although vibration is sometimes a desired effect (e.g., sanders, grinders), most often vibration is an undesirable by-product of using a power tool. Hand tool guidelines that exist tend to focus in areas where the effect on humans are measurable (e.g., amount of vibration transmitted) **(ISO 5349, 1986, ANSI S3.34, 1986).** The amount of vibration transmitted by a power tool can be influenced by a tool's weight, design, and various attachments (e.g., power line). Proper maintenance of power tools is a top priority, to prevent any added vibration due to a failing bearing, or worn, out-of-balance parts.

Power tools designed with anti-vibration materials or anti-vibration mounts/handles have had limited success in reducing the amount of transmitted vibration. If your job or work environment requires you to use power tools for prolonged periods of time, you may wish to consider redesigning the process, redistributing the work, or using some kind of external support to handle the power tool. You can purchase gloves with material that dampens vibration being transmitted to the hands, wrists and upper extremities, but their effectiveness may vary.

References:

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ISO 5349 (1986), *Guide for the Measurement and the Assessment of Human Exposure to Hand Transmitted Vibration*.

ANSI S3.34 (1986). *Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand.*

Radwin & Haney. (1996). *"An Ergonomics Guide to Hand Tools*," AIHA Ergonomics Committee, Fairfax, VA. 22031 ISBN 0-932627-75-7.

Terrel, R. & . Purswell J.(1976). *The Influence of Forearm and Wrist Orientation on Static Grip Strength as a Design Criterion for Hand Tools.* Proc. Hum Factors Soc., 20:28-32.

Streeter, H. (1970). *Effects of Localized Vibration on the Human Tactile Sense.* Am. Ind. Hyg. Assoc. J. 31:87-91.

Radwin, R.G., Armstrong, T.J., Chaffin, D.B., Langolf, G.D., and Albers, J.W.(1990) *Hand-Arm Frequency-Weighted Vibration Effects on Tactility*. Inter J. Indust. Ergon. 6:75-82.

Resources:

Hammers:

- Bio Curve Hammer http://www.contractorstools.com/barco.html
- Vaughan's Steel Eagle hammers http://www.hammernet.com
- Stanley AntiVibe™ III Hammer http://www.stanleytools.com

- Barco® BioCurve Carpenter Hammer http://www.barcotools.com/product_info.htm
- Stiletto Titanium Hammers http://www.duluthtrading.com/
- Lee Valley Tools Nailing Hammer* (w/ nail starter) http://www.leevalley.com/wood/page.asp?page=32056&category=1%2C43412&SID=&ccurrency=2
- OXO GOOD GRIPS 16 oz. Hammer http://www.toolstoolstoolstools.com

Pliers:

- Pliers, STORK, Needle Nose, Pistol Grip 912EP http://www.snapon.com/
- Pliers, STORK , Gripping, Pistol Grip, 9 3/4" 612EP http://www.snapon.com/
- Stanley MaxGrip™ Self-Adjusting Pliers http://www.stanleytools.com
- Stanley MaxGrip™Locking Adjustable Wrench http://www.stanleytools.com

7-1/2" Needle Nose Pliers w/Fatigue Reducing Handles D366-6C Klein design minimizes bending of wrist, reduces strain and fatigue. Knurled jaws with rounded edges, coil spring, comfortable foam plastic-covered handles http://store.yahoo.com/gicky/712neednospl.html

- Straight Jaw Auto Lock Pliers* (Adjusts automatically with no sizing) http://www.sears.com
- Robo Grip*(Self-adjusting pliers with ergonomic design) http://www.sears.com

Screwdrivers:

- Stanley multibit ratcheting screwdriver (68-010) http://www.stanleytools.com
- Stanley Super Proto screwdriver http://www.stanleytools.com
- OXO GOOD GRIPS 1/4" x 4" Flathead Screwdriver and 1/4" x 4" Phillips Screwdriver http://www.bindependent.com/ Look under B able, Household tools and gadgets
- Craftsman(r) Professional 12-pc. Grip Driver Set*(Angled handle for better grip) http://www.craftsman.com/

Wrenches:

- Craftsman 16 Inch Speed Wrench* (Wrench for confined spaces) http://www.sears.com
- Craftsman(r) 8-in. Clench Wrench *1/4 (Self-adjusting, ratcheting wrench) http://www.sears.com
- Smart Wrench™ http://store.yahoo.com/wonderfulbuys/squeezewrench.html

Knives, Scissors, Cutters:

- Cutters, STORK, Diagonal, Light Duty, Pistol Grip, 9 812EP http://www.snapon.com/
- Cutters, STORK, Diagonal, Medium Duty, Pistol Grip, 11" 311CP http://www.snapon.com/
- Cutters, Electronic, Oval Head, Ergonomic Handles, 4 1/4" (AWG #17 max.) E746CG http://www.snapon.com/
- Cutters, Electronic, Oval Head, Ergonomic Handles, 4 1/4" (AWG #16 max.) E747CG http://www.snapon.com/
- North Coast Medical, Inc. cutting utensils http://www.ncmedical.com/
- Excelta Cutters, http://www.alimed.com/product_detail.cfm?VMID=2&CategoryID=234&FamilySKU=75384 reduce hand stress and fatigue
- Linstrom Cutters, http://www.alimed.com/product_detail.cfm?VMID=2&CategoryID=234&FamilySKU=73592 adjustable spring, reduces required force
- Fiskars PowerGrip Utility Knife LWE-7845-6984 http://www.lifewithease.com/powergrip.html
- Fist Grip Tools http://www.fistgrip.com/
- Ratchet Action Anvil Pruner http://www.lifewithease.com/ratchetpruner.html
- Earth Bud-Eze tools http://www.earthbudeze.com/ leverage enhanced gardening tools
- OXO Swivel Scissors http://www.bindependent.com/ Look under B able, Household tools and gadgets
- Stanley SharpTooth™ Tool Box Saw http://www.stanleytools.com/default.asp?TYPE=PRODUCT&PARTNUMBER=15-086 – tooth design that cuts in both directions making cutting faster and reducing fatigue

One Handed Tools:

- Clic - Change System by Bosch Power Tools - for Rapid one-handed bit changes http://www.oldhouseweb.com/stories/Detailed/888.shtml
- Craftsman Speed Lok System* (Interchangeable bit system and screw holder) http://www.sears.com

One Handed Grippers and Clamps:

- American Tool's Quick-Grip One Handed Gripper and Clamp http://www.quick-gripclamp.com/pi/toolsrch.asp
- Quick-Grip Quick-Change - One Handed Gripper and Clamp/Spreader http://www.quick-gripclamp.com/pi/toolSrch.asp?contentID=65
- Quick-Grip Advantage - One Handed Gripper and Clamp – http://www.quick-gripclamp.com/pi/toolSrch.asp?contentID=95
- Jorgensen's EZHold II - One Handed Gripper and Clamp http://www.adjustableclamp.com/barscroll.htm
- Wolfcraft's Quick Jaw clamps - One Handed Gripper and Clamp – http://www.wolfcraft.com/product_detail.cfm?id=66
- One Handed Swiss Army Knife – http://www.swissarmyexpress.com Select Lockblades, page down to "one handed"
- Rothenberger One Handed Tube Bender – Sets, 24114, One Handed Bender

http://www.rothenberger-usa.com/44.html
Precision tube bending up to 90° of soft copper and aluminum tubing

One Handed Nail Starters:

- Dead On Titanium Death Stick, via the Tool Crib (w/ nail starter) http://www.deadontools.com/ds_deathstick.html
- Stilletto Framing Hammer*, via the Tool Crib (w/ nail starter) http://www.duluthtrading.com
- Auto Hammer* http://www.infomercialindex.com/products/100/autohammer/auto_hammer.html

Other:

- Walton Ergonomic File Handle's http://www.waltontools.com/products/filehndl.htm
- Ali Med http://www.alimed.com Search on hand tool, and Plastazote
- CEMENTEX Products Inc.: double insulated hand tools http://www.cementexusa.com

Antivibration Materials:

- Sorbothane http://www.sorbothane.com
- Viscolas http://www.viscolas.com
- OrthexTM Grip Kit http://www.viscolas.com
- Grip Master http://www.viscolas.com
- Anti-Vibration Gloves http://www.viscolas.com
- Hatch Gloves and Accessories http://www.hatch-gloves.com

**** Indicates Tools from South Dakota AgrAbility***