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Features of Hand Tools – A Review

P. Rajya Lakshmi[1], Dr. D. Ratna Kumari[2]

[1]H.No-10-8, P & T Colony, Dil;sukhnagar, Hyderabad, Telangana, India.

[2]Department of Resource Management and Consumer Science, College of Home Science
Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana, India

Abstract: ***People spend most of their time in using hand tools. Hand tools aid to perform any job safely, efficiently and comfortably even in adverse working conditions reinforcing strength and effectiveness of hands. If the hand tools are not well designed people may face drudgery. Although in recent years the use of modern gadgets and appliances have apparently simplified the methods of performing many activities but on the other hand it has brought in several ergonomic issues towards health and safe working performance of the user. While doing any work, different undesirable and un-ergonomic tools to which people become adaptable that effect user health and psychology. To avoid such hazards features of hand tools is necessary to be considered. The review was collected accordingly and the designed tools which consider features of hand tools in the aspect of ergonomics - should be of good quality, lightweight and the heavy weight tools should be suspended or counterbalanced. Tools with straight handles are for tasks where the force is exerted perpendicular to the straightened forearm and wrist, for instance, when the force must be applied vertically. Larger handles allow fingers to wrap comfortably around the tool in a power grip, which prevents slippage and reduces stress and impact on hands, fingers and wrists. The thicker the handle the lesser is the load on the hand muscles can also be noted.***

Keywords: Ergonomics, Pinch grip, Power grip, Dorsiflexion and Planar flexion.

1. Introduction

A hand tool can be defined a metal instrument held in hand and used for preparing and repairing (Oxford dictionary, 2004); or a device used to perform or facilitate manual or mechanical work and an aid necessary for carrying out one's occupation or profession (Lifco dictionary, 2004). Major population use the hand tools in their daily life very frequently (Frievalds, 1997). Although in recent years the use of modern gadgets and appliances have apparently simplified the methods of performing many activities but on the other hand it has brought in several ergonomic issues towards health and safe working performance of the user. While doing any work, different undesirable and un-ergonomic tools to which people become adaptable that effect their health and psychology. To avoid such hazards ergonomic evaluation of hand tools is necessary. Ergonomic evaluation of tools which is the study of anatomical, physiological and psychological aspects of man and tools with the object of performing a task safely, comfortably and efficiently to enhance productivity (Greenberg & Chaffin, 1997). It is needed for all the tools used to reduce the effort in all the ways considering both physical and mental aspects. So, there is a need to consider the features of hand tools and accordingly the review was collected.

2. Features of Hand Tools

Tools are as old as the human race, originating as the extensions of arms and hands. By increasing the performance of basic tools, the human could progress to more effective food production and eventually to highly skilled industrial operations. A hand tool is a tool which mainly consists of a head and a handle, with sometimes a shaft or a body in the case of a power tool, and in some cases the hand tool comprises of a body and base. There are several types of hand tools which consist of different body parts according to their function. The handle can be considered as the most important part of a hand tool on which the human input force is applied to the system as a motive force, or guiding and stabilizing force. Some design considerations have to be given due importance while designing a hand tool (Schoenmarklin *et al.* 1994).

It may be difficult to determine where the junctions of head, shaft and handle actually occur (Morris,1989). In every case, there is some form of handle, body and it is at the handle that the greater portion of the human interface of any tool is found.

The physical features of hand tools are those in which the external factors like length, width, size, thickness etc are considered (Morris, 2009). They include –

2.1 Handle Grip

The hand is an amazing human instrument, and can be used to grip objects in several ways. A well-balanced hand tool having the right grip on the handle feels very comfortable in the hand. If a tool is not properly designed, the grip also becomes bad and then it has to be held more firmly, at an awkward angle. A proper grip helps in the reduction of pain and fatigue while using the tool. Tools that can be used by both the hands allow workers to alternate hands while working (Hand tools buying guide, 2011 of Canadian Center for Occupational Tool Design).

The prehensile movements of the hand in terms of a power grip and precision grip, each of these grips have different functional characteristics. In a 'power grip' the object is held in a clamp formed by the partly flexed fingers and the palm, with counter pressure being applied by the thumb lying more or less in the plane of the palm. Such a grip is found for example in holding a heavy hammer (Figure 1). In a 'precision grip' the object is pinched between the flexor aspects of the fingers and the opposing thumb, as for example in tapping with a light hammer (Napier, 1956).

Kroemer and Grandjean (1997) in their study on the effects of posture, duration and force on pinching frequency, revealed that the design of handgrips had a high priority in skilled work. They found that the maximum grasping force can be quadrupled by changing over from holding with the fingertips to clasping with the whole hand. The power of the fingers was greatest when the hand was slightly moved upwards (dorsal flexion). On contrast, grasping power, and consequently level of skilled operation is reduced if the hand is bent downwards (planar flexion) or turned to either side (Figure 2).

McCormick and Sanders (1982) have noted that in general, the grip strength is reduced with any flexion or deviation of the wrist, particularly for palmar flexion. A reduction in grip strength can impede the intended performance and/or its speed and can increase the likelihood of the user losing control of the tool and dropping it. They also added that reduced grip strength would certainly result in increased fatigue. While using hand tools, pressure exerted on the palm area due to the awkward posture or deviation of hand, reduces the grip strength which tends towards the increase in workload and fatigue.

Sen (1998) in his study, 'Ergonomic design of some railway tools for maintenance of railway tracks in India' modified the wooden handle of the beater by covering it with perforated and corrugated thick rubber sleeve on the areas of the hand grip to minimize transmission of impact shocks and vibrations as well as to prevent slippage of the tool especially when they were wet due to sweating. But the rubber was unable to stop the sweating and produced the heat from the contact of hands and rubber while working.

Bobjer (1999) in his study, 'Effect of grip on garden scissors' indicated that a contoured grip can sometimes help to increase grip strength. At other times a contoured grip can interfere with the ability to grip the item. He studied scissors and found that they are often have a heavily contoured grip that may fit an adult's right hand but which may cause difficulties for smaller or larger hands or for left handlers. The grip on a pair of scissors can be reshaped to provide universal operation.

Tools with "bent" or angled handles or tools with pistol-grips are beneficial where the force is exerted in a straight line in the same direction as the straightened forearm and wrist, especially when the force must be applied horizontally. Tools with straight handles are for tasks where the force is exerted perpendicular to the straightened forearm and wrist, for instance, when the force must be applied vertically. Whereas for the rolling pins, the horizontal handles make the work easier as the force is exerted perpendicular to the straightened forearm and wrist, for instance, when the force must be applied vertically. Shaped tools such as bent-handle tools are effective where most of the tasks are done in the same plane and height as the arm and hand, and when only one or two other tools are used. The crucial ergonomic principle in tool use and design - bend the tool, not the wrists - however correct and valuable does not always prevent discomfort and injuries when bent-handle tools are used indiscriminately, regardless of the layout of the work situation (Canadian Centre for Occupational Tool Design, 2005).

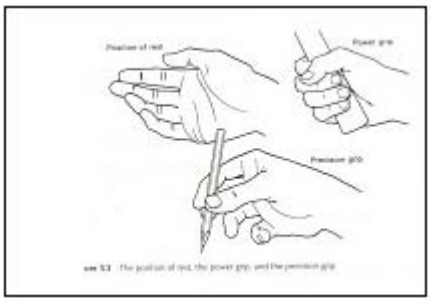

Figure 1: The Position of Rest, the Power Grip and Precision Grip

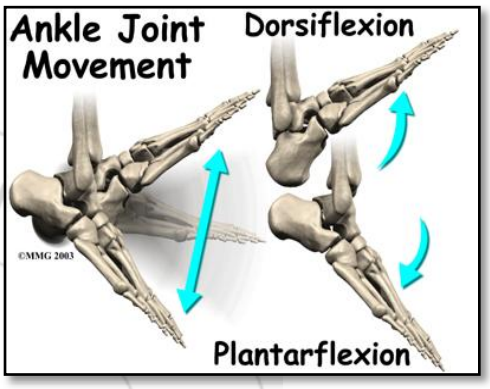

Figure 2: The flexions of elbow

Hand Tools Buying guide (2011) of Canadian Centre for Occupational Tool Design, stated that the handle size plays an important consideration while purchasing hand tools. The handle of a hand tool is considered to be of the right-size if it lets the hand to go more than halfway around the handle without the fingers and the thumb meeting. The recommended grip diameter usually falls between 1"-2". To provide good control as also to prevent pain and pressure hot spots in the palm, handles should be at least 4" long. Handles for precision hand tools should be 1/4th"-1/2" in diameter and at least 3" long.

From the above review it can be concluded that a well-balanced tool having the right grip on the handle feels very comfortable in the hand. Researchers opined that any rolling pin body should be of minimum diameter of having about 11/2" and the maximum diameter of 21/2", the handles of the rolling pin diameter can be between 1" to 2". Tools with straight handles are for tasks where the force is exerted perpendicular to the straightened forearm and wrist, for instance, when the force must be applied vertically. It was also known that the countered grip can sometimes help to increase in grip strength.

2.2. Shape and size of handle

The shape of the tool handle will affect the holding posture of the tool, the shape of the handle is a primary factor in reducing or eliminating user fatigue (Winston and Narayan, 1993).

The shape should confirm the natural holding position of the hand. In the resting stage, the right hand of a right handed

person holding in such a manner as to meet the requirements of both the precision and power will be held more than half-supinated, with the wrist abducted about 15 degrees and slightly dorsiflexed, the little finger in almost full flexion, the others less so, the first finger less than the half flexed, and the thumb abducted and slightly flexed. The combination of the abduction and dorsiflexion (Figure 3.) at the wrist with varying flexion of the fingers and thumb generates an angle of about 78 degrees between the long axis of the arm and a line passing through the central point of the loop is created by the thumb and the first finger, that is, the transverse axis of the fist (Graffin, 1996).

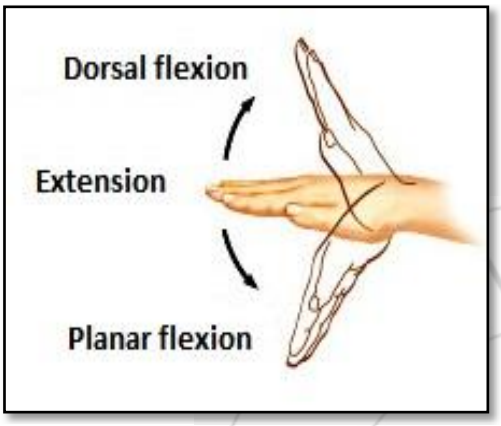

Figure 3: The flexions of hand

Patkin (1997) outlines the aspects with respect to shape of the handle as follows-

- Uniform diameter and smooth surface along the length, to allow sliding, for e.g.: on the back of an axe handle.
- Thickened centrally, if there is a need to secure against sliding.
- Flattening for the thumb to straighten, and press on and guide, as a precision variant of the power grip, e.g.: a fine mallet.
- Flattening for the thumb and fingers, to prevent unwanted twisting, for e.g. a saucepan handle.
- No sharp edges or high spots in the area of grip. These decrease comfort, strength, and security of grip to an extent, which can be measured.

Chang and Wang (2000) in his study on screwdrivers on 250 industrial workers found that applied pressure can be minimized by enlarging and flattening handles and by avoiding pressure producing ridges. Thus indentation of the handles for the fingers is undesirable. Encasing the basic metal handles in a rubber or plastic sheath provides insulation and improves the tactile feel.

Bobjer (1999) conducted a study on 250 industrial workers. He evaluated examined maximum torque from a power grip on a screwdriver handle. The best shape was cylindrical with a rounded end. Within the range of diameters used in the size of 1"-21/2", an increase in diameter allowed for a greater force production.

Various studies have shown that the size of an object taken in conjunction with its weight has a multiplicative effect over and above that of either size or weight alone. The size of a hand tool, however, is only of significance when it is relatively uncommon.

Cochran and Riley (1996) in a his study, 'The effects of handle shape and size on exerted forces' indicated that no one shape may be perfect and the shape may be more dependent on the type of task and motions involved. He evaluated the handles of screw drivers and found that a rectangular shape of width: height ratios from 1:1.25 to 1:1.50 appeared to be a good compromise. One unique advantage of a rectangular cross section is that the tool does not roll when placed on a table.

From the above review it can be concluded that the shape of the handle is a primary factor in reducing or eliminating user fatigue. Researches opinioned that the shape of the hand tool having a cylindrical body, over the centuries were more helpful in performing any activity in an even and balanced manner.

2.3 Thickness of handle

With respect to the thickness, it is desirable for the handle to conform to anthropometric requirements.

Cochran and Riley (1996) in their study, 'The effect of handle shape and size on exerted forces' using various handles of non-circular cross section, found largest thrust forces in handles of 1" circumference for both males and females. For manipulation, however the smallest handles were found ¾" to be the best.

Woodson and Conovoer (1996) studied handle diameter in relation to type of grip. They also studied the gender difference in relation to the handle design and recommended a diameter of 20 mm (3/4 in) for a hook grip. The actual width for the individual will vary with its function and size. Thus where the tool is large and where a power grip is required, for e.g.: in a heavy hammer or the handle of a power drill, the width will be found at the upper limit of the range.

Frievalds (1997) in his study, 'The ergonomics of tools' evaluated shovels taking a sample of 120 gardeners and concluded that in general, the thicker the handle the lesser is the load on the hand muscles. However, because of the shapes of the space enclosed by the grip, the caliber of the handle should not be normally same throughout its length. It will of course normally be wider at the thumb end narrower at the little finger.

Stanton (1998) in his study, 'Evaluation of powered screw driver design characteristics' studied grip in relation to handle diameter and emphasized that the size of the handle must fit the hands of those who may use the tool. Since a handle is meant to be grasped with a power grip, the handle diameter should be in the range of 3-4".

Elizabeth (2000) developed a chakla which is used in conjunction with Belan to roll out dough to form breads. The edge was beveled. The top work surface is raised by about quarter inch and polished smooth. It was about 8" to 9" in diameter and about 1" thick. It is a heavy stoneware. At the

bottom there may be 3 or 4 four feet, each quarter inch thick carved out.

Canadian Centre for Occupational Tool Design, 2005 in the study "Hand Tool Ergonomics", stated that handles should be cylindrical or oval in cross section, with a diameter of between 1"-2". For precision work the recommended diameter for handles is between 1/3rd- 1/6th". For a greater torque large screwdrivers should have a handle diameter up to 1"-21/2".

In a similar study by the above centre in the year 2008, stated that when single-handled tools like hammers, screwdrivers, chisels, wrenches, and nut drivers, handle diameter can make a big difference in level of comfort and efficiency. For tasks that require more force (such as torquing screws and nuts, hammering, and heavy chiseling), Tools with handle diameters that range from 1 1/4" - 2" should be chosen. Larger handles allow fingers to wrap comfortably around the tool in a power grip, which prevents slippage and reduces stress and impact on hands, fingers and wrists. For tasks that call for more precision and delicacy (like fine chiseling and driving miniature screws), single-handle tools whose grips fall within the 1/4" - 1/2" range are ideal. The smaller diameter handles make it easy to comfortably grip tools between the fingertips without overexerting fingers, knuckle joints, or hand muscles.

Researches opined that the handle diameter has a major influence in level of comfort and efficiency. The width of the rolling board was between ¾"-1". The thickness of the rolling pin handles range between 1"-2". The diameter of the rolling boards range between 8"-11". Larger handles allow fingers to wrap comfortably around the tool in a power grip, which prevents slippage and reduces stress and impact on hands, fingers and wrists. The thicker the handle the lesser is the load on the hand muscles can also be noted.

3. Conclusion

In conclusion, ergonomically designed tools should be of high quality, lightweight and the heavy weight tools should be suspended or counterbalanced. The handles should be of the correct size to allow control and comfort: the tool should be bent, not the wrist, and the tools should be of firm grip so as to use less energy and be less likely to slip. Tools with straight handles are for tasks where the force is exerted perpendicular to the straightened forearm and wrist, for instance, when the force must be applied vertically. It was also known that the countered grip can sometimes help to increase in grip strength. The shape and size of the hand tool having a cylindrical body, over the centuries were more helpful in performing any activity in an even and balanced manner. Larger handles allow fingers to wrap comfortably around the tool in a power grip, which prevents slippage and reduces stress and impact on hands, fingers and wrists. The thicker the handle the lesser is the load on the hand muscles can also be noted. All of these factors should be considered when choosing or recommending the best adaptive tools.

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Author Profile

Mrs. P. Rajya Lakshmi, PG Student of Department of Resource Management and Consumer Science, College of Home Science, Professor Jayashankar Telangana State Agricultural University, Hyderabad.

Dr. D. Ratna Kumari, Professor, Department of Resource Management and Consumer Science, College of Home Science, Professor Jayashankar Telangana State Agricultural University, Hyderabad.

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