

AN ERGONOMIC EVALUATION OF CLECO PLIERS

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Repetitive use of a hand tool requiring large forces along with unnatural postures can cause musculoskeletal disorders in the upper extremity. Cleco pliers are used to install fasteners to sheet metals in aircraft manufacturing. The present study compares two types of mechanical Cleco pliers in terms of repetition, grip force, posture, and discomfort and identifies their major design features which affect the ergonomic interface between the hand and the tool.

INTRODUCTION

Repetitive use of hand tools requiring forceful grip exertions in bent wrist posture over a long period of time can cause musculoskeletal disorders in the upper extremity such as tendinitis, trigger finger, and carpal tunnel syndrome (CTS). For medical treatment, these disorders cost about \$7,000 for shoulder tendinitis and \$6,000 for CTS per case; the total cost increases if other expenses such as lost production and rehabilitation expense are included. To prevent workers from developing musculoskeletal disorders at the workplace and reduce the consequent cost such as workers' compensation and loss in productivity, ergonomists have been concerned with the proper design, selection, evaluation, and use of hand tools.

Cleco pliers are used in the aircraft manufacturing industry to install fasteners to sheet metal such as skins, frames, and stringers so that the components can be held together securely while operations are being performed. The pliers are made from forged steel and nickel plated to resist wear and abuse.

The objective of the present study is to evaluate Cleco pliers through ergonomic methods so that workers can maintain a more natural posture of the upper extremity, use less force, and have greater comfort when installing fasteners. Ergonomic evaluation of the pliers will contribute to reducing the risk of musculoskeletal disorders at work.

MATERIALS AND METHODS

Detailed ergonomic analysis techniques to evaluate the pliers in this study include: (1) analysis

of design parameters, (2) motion and time study, (3) analysis of grip force, (4) analysis of hand-wrist posture, and (5) analysis of upper-extremity discomfort. First, in the design parameter analysis, the pliers were divided into several components such as head (upper/lower), fulcrum, handle (upper/lower), and grip pad; and, then, their physical attributes such as length, width, diameter, thickness, curvature, angle, clearance, movement range, and material were defined.

Second, a motion and time study is conducted at the work site for selected workers to identify motion elements and corresponding motion times for installing fasteners to sheet metal. This motion and time analysis is to examine (1) motion elements which can be improved or eliminated by redesign of the pliers, (2) hand-wrist motions repeated with a relatively high frequency, and (3) fastener installation time.

Third, in the grip force analysis, grip forces applied by the fingers to the handle of Cleco pliers during installing fasteners are measured by using force sensitive resistors (FSRs). The FSR sensor is a thin film device which changes its resistance as normal force applied to the sensor surface varies. Five FSR sensors are attached along the handle surface for measurement of the finger forces and interfaced with an analog-to-digital converter.

Fourth, postures of the hand-wrist while using the pliers to install fasteners are analyzed by the whole-hand input device CyberGlove[®] model CG2202-R. The glove instrument has 20 sensors to measure finger flexion and finger abduction and 2 sensors to measure wrist flexion and wrist abduction. The sensors are long, thin strips sewn

into the glove fabric and measure the change in resistance as they are bent.

Last, to evaluate the level of musculoskeletal problems of workers using the pliers, a discomfort survey for the upper-extremity including the shoulder, upper-arm, forearm, and hand is conducted by using a body discomfort map. The level of discomfort for various parts of the upper-extremity are rated by participants in this study using a scale of 0 (nothing at all) to 10 (almost maximum)--the Borg categorical scale (CR-10) with verbal anchors. The hand-wrist area is further divided into several sub-areas to identify specific regions where the users are experiencing discomfort due to use of the pliers.