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# Ergonomic evaluation of a fixture used for power driven wire-tying hand tools

Kai Way Li\*

*Department of Industrial Management, Chung-Hua University, Hsin-Chu 300, Taiwan*

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## Abstract

Using metal wire to tie components together is common on construction sites. The wire-tying task, accomplished using pliers, involves repetitive forceful exertion and awkward wrist postures. In this research, the use of a powered screwdriver with a specially designed fixture for clamping and twisting metal wires was introduced. The powered driver-fixture combination was proposed as an alternative to the traditionally used pliers for wire-tying tasks. A laboratory experiment to simulate the wire-tying task using two power screwdriver-fixture combinations was performed. The experimental results showed that the normalized EMG of the flexor digitorum superficialis muscle and flexor carpi ulnaris muscle of the right arm were significantly ( $p < 0.001$ ) reduced when using the powered driver-fixture combinations compared to using pliers. Using the powered driver-fixture combinations requires only 28% of the time to complete each wire tying compared to using pliers. The numbers of awkward wrist postures, including extension and ulnar deviation were also significantly decreased when using the powered driver-fixture combinations. The subjective response of the subjects, including muscular exertion level, muscular discomfort, ease of use, and total satisfaction all favored the powered driver-fixture combinations, compared to pliers in performing the wire-tying task.

## Relevance to industry

Non-power hand tools such as pliers are commonly used in metal wire wrapping and tying tasks. In this paper, tools that combine a fixture and powered screwdrivers for wire-tying task are introduced and evaluated. The powered screwdriver-fixture combinations enable wire-tying tasks being performed more efficiently, with less force and wrist motion, and with a better subjective rating.

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## 1. Introduction

Upper extremity cumulative trauma disorders (CTDs) have been associated with work activity in a variety of tasks. In a survey conducted by the

Institute for Occupational Safety & Health of the ROC (IOSH, 1997), 531 construction workers in northern Taiwan were interviewed concerning their experience with musculoskeletal symptoms. Aches in the upper extremity, after low back pain, were reported as the second most common problems. Aches in the upper extremity were found to be associated with the extensive use of

\*Tel.: +886-353-74281; fax: +886-4-2422-6527.

*E-mail address:* kai@chu.edu.tw (K.W. Li).

hand tools and/or awkward working postures. Seventy four percent of the interviewees reported that they used hand tools to accomplish their tasks. Among them, 57% reported that they had experienced aches in the upper extremity in the past 12 months. Awkward postures, excessive muscular force and high rates of manual repetition are recognized as key ergonomic CTDs risk factors in the literature (Armstrong et al., 1986; Putz-Anderson, 1988; Muggleton et al., 1999; Silverstein et al., 1986; Moore and Garg, 1994). The design/redesign of hand tools is an essential issue in the reduction of hand/wrist discomfort and injuries (Myers and Trent, 1988; Putz-Anderson, 1988; Cobb et al., 1996; Killough and Crumpton, 1996; Muggleton et al., 1999; Lee and Jiang, 1999).

Pliers are the most commonly used non-powered hand tools by construction workers (IOSH, 1997). They are normally used in cutting wires and tying components together. Pliers are cheap and easy to use but are not specifically designed for repetitive use in the wire-tying task. When tying wire, the wire must be clamped and twisted. Twisting wires cannot be completed without the repetition of awkward hand/wrist postures, such as wrist extension and ulnar deviation together with the supination and pronation of the forearm.

In another study (Li, 2002), the author designed a wire-tying hand tool for the wire-tying task. This tool consisted of a fixture, a rotational mechanism with a hand crank, and a handle. In fact, the fixture may also be attached to a powered

screwdriver to twist the metal wires. The aim of this study was to evaluate the use of the fixture, designed in the former study (Li, 2002), on power driven screwdrivers for tying wire. The purpose was to reduce the muscular effort of the forearm when tying metal wire. Reduction of repetitive awkward hand/wrist motions such as ulnar deviation, flexion, extension, pronation and supination of the hand/arm when using a hand tool in tying the wire were also desired.

## 2. Fixture design

Twisting wire is simply a rotation of two strips of the wire around each other. Such a motion may easily be generated using a powered screwdriver. The wire twisting operation requires securing the wires in a fixture. Fig. 1 shows the fixture design for the wire-tying task. The fixture consists of two pieces of steel connected by three pins. Two small springs were inserted in the two side-pins so that the two pieces could be separated automatically. One outer spring was used to press one steel piece against the other to generate the clamp function. Wires that were inserted into the opening between the two pieces are clamped when the two pieces are pressed together. The forceful grasp required when using pliers was, therefore, unnecessary when twisting the wires. The steel piece was pushed when the whistle-shaped switch was activated to compress the outer spring. Unclamping the wires

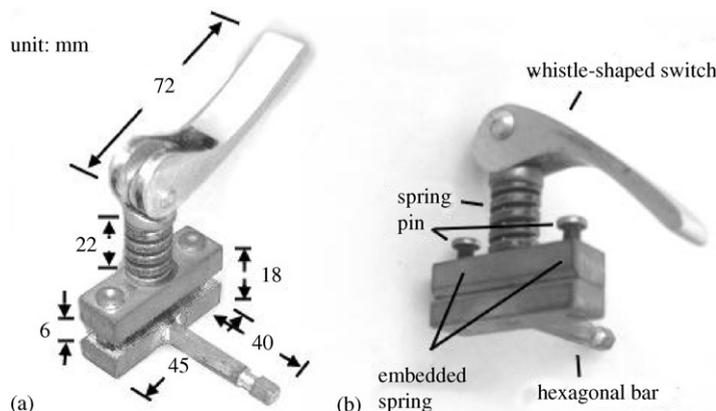


Fig. 1. Fixture to clamp metal wire: (a) release, (b) clamp.

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