

Research Article

Effects of Handle Size and Operation Height on Performance of Screwdriver

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Abstract: This study investigated the effects of handle size (length and diameter) and operation height on operation performance of screwdriver. Results showed that the operation height and handle diameter were significantly affect the operation performance. The operation performance was better at 1200 mm operation height than at 450 mm. The operation performance was better at 38 mm handle diameter than at 50 and 25 mm. Further, operation height 1200 mm, handle diameter 38 mm, and handle length 100 mm are the best combination.

Keywords: Handle diameter; Handle length; Operation height; Performance; Screwdriver

INTRODUCTION

Screwdriver is the one of the most important hand tools for many industrial fields, especially in construction industrial. There are many factors that might affect the performance of screwdriver, such as handle diameter, hand length, hand contour, operation height, operation direction... etc.

Lee and Cheng [1] investigated the maximal finger flexion force of electric screwdriver, and indicated that the 50 mm grip diameter with maximal finger flexion force than 40 mm and 60 mm. Chang et al. [2] evaluating the effects of wearing gloves and wrist support on hand-arm response while operating an in-line pneumatic screwdriver, and reported that wearing nylon glove and without wrist support is the best combination. Björing et al. [3] investigated the handle characteristics for pistol grip power tools, and indicated that the handle with 50 × 30 mm cross-sectional area with best performance.

However, in general, the workers usually used manual screwdriver when appliance repair work. Grant et al. [4] evaluated the effects of handle diameter on manual effort during a simulated industrial task, and indicated that handles 1.0 cm smaller than the users' inside grip diameter may reduce effort and the potential for injury. Hall [5] investigated the hand strength while grasping cylinders (diameter 10-100 mm) of handling tools. The gripping action was dependent on cylinder diameter, and the subjects strongly preferred cylinders with 30-40 mm diameter. Habes and Grant [6] studied the electromyography of maximum torques and upper extremity muscle activity in simulated screw driving

tasks, and indicated that 37 mm handle diameter is better than 29 mm. Adams and Peterson [7] investigated the maximum voluntary hand grip torque for circular (diameter: 0.9, 1.5, and 2.0 inches) electrical connectors and indicated that 2.0 inches diameter with best maximum voluntary hand grip torque. Lin and Leu [8] investigated the static simulation of nonclutch motorcycle handle design, the brake grip span between 55-65 mm, and the handle diameter about 40 mm is the best combination.

Unfortunately, studies concerned about handle length and operation height is rare. Therefore, the present study investigated the effects of handle length, handle diameter, and operation height on operation performance of screwdriver.

METHODOLOGY

Experimental design

Three levels of handle diameter were tested: 25, 38, and 50 mm. The present experiment employed three levels of handle length: 100, 150, and 200 mm. Two levels of operation height were tested: 450 and 1200 mm. There two height levels is the general height of power supply outlet in Taiwan houses. All subjects completed 18 within-subjects experimental treatment combinations (3 handle diameters × 3 handle lengths × 2 operation heights).

Subjects

Eighteen male college students were enrolled as subjects (age range = 19-25 years) in order to avoid gender effect.

Task and procedure

Subjects were instructed to perform a screw driving task and have to fix ten base box of power supply outlet on a horizontal wood strip (200 cm × 20 cm).

Dependent measures and data analysis

Operation performance was defined as the number of fixed screws per minute of the subjects. Analysis of variance was conducted using Statistical Analysis System (SAS 9.0).

RESULTS

The performance for each level of independent variable is shown in Table 1. The results of ANOVA

for the reading performance of independent variables (Table 2) indicated that handle diameter ($F_{2,289} = 8.10$) and operation height ($F_{1,289} = 10.97$) had significant impact on the operation performance. The handle was not significantly affect the operation performance. However, 100 mm resulted in slightly better operation performance than 150 and 200 mm.

Duncan multiple paired-comparisons (Table 1) indicated out that the operation performance for operation height 1200 mm (13.3) was significantly better than that for operation height 450 mm (12.4). For handle diameter, 38 mm (13.5) resulted in the best operation performance, followed by 50 mm (12.7), and 25 mm (12.3).

Table-1: Operation performance for each level of independent variables and Duncan grouping

Variables	n	Performance	Group
Height			
1200 mm	162	13.3	A
450 mm	162	12.4	B
Length			
100 mm	108	13.2	A
150 mm	108	12.6	A
200 mm	108	12.7	A
Diameter			
38 mm	108	13.5	A
50 mm	108	12.7	B
25 mm	108	12.3	B

Table-2: ANOVA for operation performance of independent variables.

Sources	df	SSE	MSE	F-value
Subject	17	517.44	30.44	6.21**
Height (H)	1	53.78	53.78	10.97**
Length(L)	2	23.91	11.95	2.44
H*L	2	3.17	1.58	0.32
Diameter (D)	2	79.41	39.70	8.10**
H*D	2	2.00	1.00	0.20
L*D	4	24.74	6.19	1.26
H*L*D	4	5.44	1.36	0.89
Error	289	1417.00	4.90	

** : $p < 0.01$

DISCUSSION

Handle diameter

ANOVA result shows that handle diameter did significantly affect operation performance. Handle diameter 38 mm resulted in the best operation performance. This result is consistence with Grant *et al.* [4], Hall [5], Habes and Grant [6], and Lin and Leu [8].

Handle length

Handle length did not significantly affect operation performance. This result is out of our expected. One reason might offer to explain the result. The subjects will keep the screwdriver position assist by another hand. Therefore, increasing the stability of the screwdriver when perform the screw driving task.

Operation height

ANOVA result shows that operation height did significantly affect operation performance. Operation performance operation was significantly better for operation height 1200 mm than that for operation height 450 mm. This might due to the operation height 1200 mm was about same as the subjects' elbow height. Therefore, the subjects can work in stand posture. When at operation height 450 mm, the subjects must work using squat or high kneeling posture. Therefore, reduce the operation performance.

In summary, operation height 1200 mm, handle diameter 38 mm, and handle length 100 mm are the best combination for manual screwdriver.

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REFERENCES

1. Lee YH, Cheng CL; Triggering force and measurement of maximal finger flexion force, *International Journal of Industrial Ergonomics*, 1995; 15:167-177.
2. Chang CH, Wang MJ, Lin SC; Evaluating the effects of wearing gloves and wrist support on hand-arm response while operating an in-line pneumatic screwdriver, *International Journal of Industrial Ergonomics*, 1999; 24:473-481.
3. Björing G, Johansson L, Hägg GM; Choice of handle characteristics for pistol grip power tools, *International Journal of Industrial Ergonomics*, 1999; 24: 647-656.
4. Grant KA, Habes DJ, Steward LL; An analysis of handle designs for reducing manual effort: The Influence of grip diameter, *International Journal of Industrial Ergonomics*, 1992; 10:199-206.
5. Hall C; External pressure at the hand during object handling and work with tools, *International Journal of Industrial Ergonomics*, 1997; 20:191-206.
6. Habes DJ, Grant KA; An electromyography study of maximum torques and upper extremity muscle activity in simulated screwdriving tasks, *International Journal of Industrial Ergonomics*, 1997; 20:339-346.
7. Adams SK, Peterson PJ; Maximum voluntary hand grip torque for circular electrical connectors, *Human Factors*, 1998; 30(6):733-745.
8. Lin CC, Leu DT; Static simulation of nonclutsh motorcycle handle design, *Journal of Technology*, 1997; 12(3):1-6.