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Development of The Tunnel Type Locating Drill Jig by Practical and Adaptive Tooling

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Abstract

In order to prevent the production defects the optimum design of product, jig and fixture putting in the field is very significant manufacturing method. Drilling Jig is the device according to industrial demand for multi manufacturing products on the growing at alarming rate. In the field of design and making for machine tool working, welding, assembling with jig and fixture for mass production is a specific division. They require analysis of many kinds of important factors, theory and practice of machine tool operating process and jig & fixture structure, machining condition for tool making, tool materials, heat treatment of jig & fixture components, know-how and so on. In this study we designed and constructed a drilling jig of mass production and performed tryout under the Auto CAD, Auto Lisp database, that we made by database, and window environment. Especially this study is reveals with the analysis of part drawing, jig planning, jig design etc, and then the result of drill jig's making try out.

Key Words : Locating, Supporting, Clamping, Bushing, Process, Tunnel Type Locator

1. Introduction

The jig and fixture perform machine tool working for mass production. Among them, the jig is a special device that supporting, locating, and clamping are placed on a part to be machined. It is a product tool that is made not only locates and holds the workpiece but it also guides the drill, reamer, tap, boring tool, etc. as the operation can be performed. Jigs are usually fitted with hardened steel bushings for guiding drills or other cutting tools.

If the holes of 13mm above are to be drilled, it is usually necessary to nest or to securely fasten the jig on the drilling machine table. Due to small jigs are usually necessary to product manufacturing industrial. In this paper, We designed one of a small jigs production planning. So, the goal of this paper is the accomplishment of optimization of small size drill jig design and making the practical and adaptive drilling jig with theoretical background, database, experiences, Auto Cad, Auto Lisp and Window environment.

2. Part Drawing and Its Production Plan

Fig. 1 shows the experimental production part drawing. According to this part drawing, we made production plan as the Table 1 showing. In the Table 1, the drilling jig operation is performed at the operation number 5.

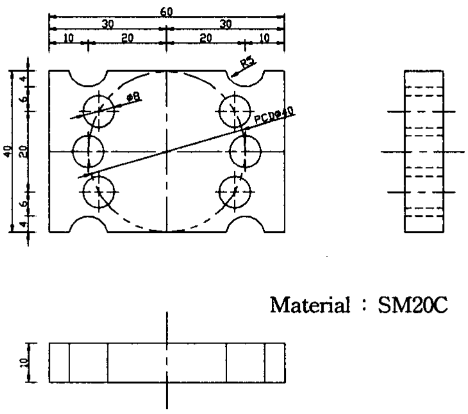


Fig. 1 Production part drawing

3. Location System

Fig. 2 shows an object which unrestricted movement occur. This object is free to move in any of twelve possible directions. To visualize this, the lanes have been made X-X, Y-Y, and Z-Z. The directions of movement are numbered from one to twelve.[1)]

Tabe 1 Production Plan

PRODUCTION PLAN			
Part No.		Part name : Precision bracket	
Operation No.	Description	Department	Machine tool
1.	Cut off-ⓣ×ⓦ stock to Ⓛlength with cutting allowance	#○○ cut off room	Abrasive cut off saw #○○-○○
2.	Drill-ØD hole thru	#○○ Drilling	Drill press #○○-○○
3.	Mill- t×w×L Two side of length direction.	#○○ Milling	Horiz. Mill #○○-○○
4.		#○○ Drilling	Drill press #○○-○○
5.	Drill-ØD	#○○ Finishing	Tumbler #○○-○○
6.	De burr inspect-visual and dimensional		None
Operation No.	Tool description	Size	Spec. Tool
1.	Cutt off wheel	○×○×○mm	None
2.	Drill	ØD1 mm	#J-○○○-1 Jig
3.	Milling cutter(2)	w×t×d	#F-○○○-1 Fixture
4.	Drill	ØD2 mm	#J-○○○-2 Jig
5.	Plug gage(2)	ØD1, ØD2	#G-○○○-2 #G-○○○-1

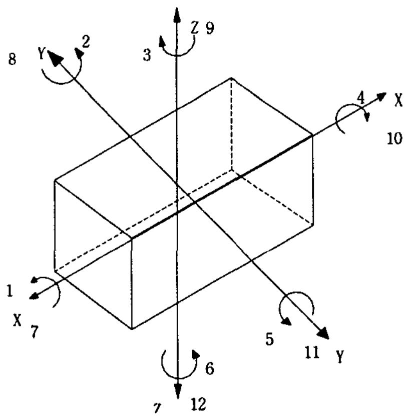


Fig. 2 planes of movement

Fig, 3 illustrates the principle of restricting movement. By placing the part on a three pin-locator base, five direction of movement(#2, #5, #1, #4, #12) are restricted. Flat bases may also be used, but these should be installed rather than machined into the base. To restrict the movement of the part around the Z-Z axis and in direction #8, two more pin-type locators are positioned. To restrict direction #7, a single, a single-pin locator is used. The remaining directions, #9, #10, #11 are restricted by using a clamping device. This 3-2-1, or 6-point locating method is the most common external locator for square or rectangular part.[1)~3)]

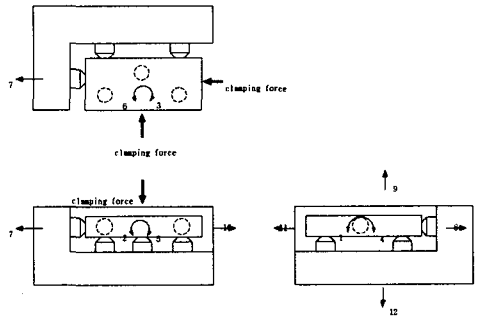


Fig. 3 Six-pin locators base restricts nine directions of movement with three kinds of clamping force.

4. Jig Bushing for Drill Jig Design

The jig bushing for drill jig design requires the following for preliminary consideration.

- Size of hole or holes to be drilled
- The type or types of bushings required for drilled holes (head or headless press fit; stationary renewable, or slip renewable, with liner bushings) and reamed, counter sunk, counter bored, or tapped holes(slip removable with liner bushings).
- The outside diameter must be confirmed for ground to press fit size, oversize for fitting and ground for slip fit in liner bushings, the length of drill bushings must be considered among short, medium, long or special size, also special type bushings too with standard bushings altered by grinding or bushings made to specifications. We must decide the for special purposes such as index pin holes or pilot bushings for reamers and boring bars. When installing bushing, another important factor to consider is burr clearance. In any drilling operation two kinds of burrs are produced, primary and secondary. The primary

burr is made on the side opposite the drill bushings. The secondary burr is produced at the point where the drill enters the work. These burrs must be considered and sufficient clearance provided. Fig. 4 and Table 2 shows the data base of fixed bushing and renewable bushings and Table 3 shows the fitting tolerance of representatives.

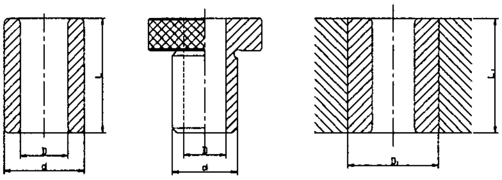


Fig. 4 Profile of fixed and renewable bushing[1~4)]

Table 2 Tolerance of bushings

unit : 0.001mm

Purpose	Fixed bushing			Renewable bushing		Jig body	
	d	D	L	d	D	D_1	L_1
Drilling bushing	p6	G6	0	m5	G6	H7	+500 0
H7 hole reaming bushing	p6		0 -500	m5		H7	+500 0
Bushing for renewable bushing	p6		0 -500			H7	+500 0

Table 3 Fitting tolerance of representatives.

unit : 0.001mm

Kind-ness \ Size	Grade	1 to 3	3 to 6	6 to 10	10 to 18	18 to 30	30 to 50	50 to 80
Shaft	p6	+16 +9	+20 +12	+24 +15	+29 +18	+35 +22	+42 +26	+51 +32
	m5	+7 +2	+9 +4	+12 +6	+15 +7	+17 +8	+20 +9	+24 +11
Hole	G6	+10 +3	+12 +4	+14 +5	+17 +6	+20 +7	+25 +9	+29 +10
	H7	+9 +0	+12 +0	+15 +0	+18 +0	+21 +0	+25 +0	+30 +0

5. Decision of locator diameter and bushing diameter and hole to hole distance

Fig. 5 shows the illustration of locator diameter, bushing diameter, and hole distance etc.

When the production part drilled diameter is $D_1 \pm 0.1$mm. At this time, the machining tolerances is been $\pm$ 0.1mm. The bushing size must be let down +0.1mm therefore it should be decided precision tolerance in D_4 G6($\emptyset 6$ G6 : $\emptyset 6 ^{+0.012}_{+0.004}$)

At this time, the drilling diameter is not come out over size $\emptyset$6.012.

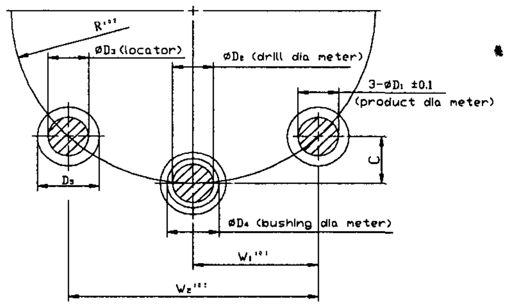


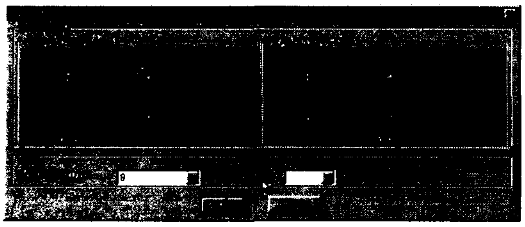
Fig. 5 Decision of locator diameter, bushing diameter and holes distance

Also, the locator size D_3 must be lower than lowest tolerance -0.1mm, hence we decided 0.1-0.02=0.08, at this time the machining tolerance $\pm$ 0.01mm os decided.

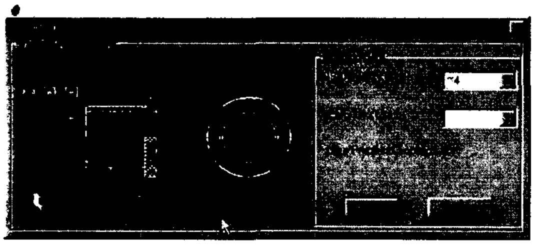
According to these calculations we can decide the locator diameter D_3($\emptyset$5.88$\pm$0.01). By the Hoffman's theory, the jig hole distance tolerance must be followed in 20~25% of production part tolerance. So, in this paper' production part distance can come out $W_1 \pm 0.02$(20% of $\pm$0.1) $W_2 \pm 0.04$(20% of $\pm$0.2) to applicate in jig as a minimized percentage. It can be shown in Fig. 8 jig drawing of design result.[4)~7)]

6. Auto-Lisp Programming and Application for Jig Design

Upper principle sound instructions and whole of the data base was foundation of the Auto-Lisp programming Fig. 6 shows the one of a results of Auto-Lisp programming. We used this programming to the several kinds of jig components for the jig rapid design. Fig. 7 shows the one of a part from Auto-Lisp programming procedures of the jig bushing among the whole of components.



(a) Liner bushing



(b) Renewable bushing

Fig. 6 Result of Auto-Lisp Programming

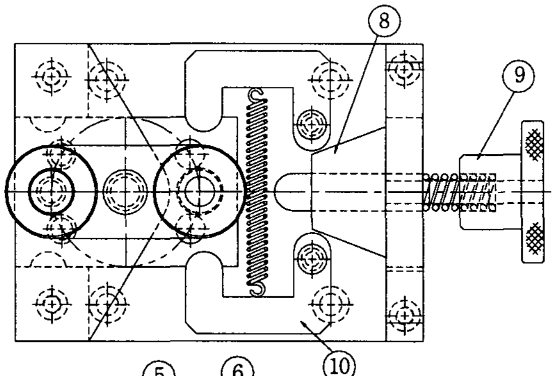
```
defun lbush ()
        (setvar "aunits" 1)
        (setvar "osmode" 0)
        (setvar "cmdecho" 0)
        (setq data_file "/JF/data/liner.dat")
        (load "/JF/dlistl")
        (graphscr)
        (lbush_dcl)
        (cond ((= lhbush "1") (Lhbush_draw))
        (cond ((= lpbush "1") (Lpbush_draw))
```

Fig. 7 Procedures of Auto-Lisp programming for jig bushing

7. Try out

Fig. 8 shows the assembling drawing of drill jig design result.

Fig. 9 shows the result tryout for experimental production part. Also we checked every dimension of production part with tolerance control. We could find the jig assembling function was minimized problems about the loading and unloading. This problem was improved into the passing zone by trouble shooting of jig component's repair and out own experience. Furthermore, the production part from tryout was so fine into the production part tolerance.



NO	DESCRIPTION	SIZE	MAT'L	Q'TY	REMARK
12	JIG FRAME	ø10x12	STC7	4	
11	SIDE PLATE	80x25x10	SM35C	1	
10	CLAMP	39x27x10	STC7	2	
9	EJECTOR BUSH	ø38x23	STC7	1	
8	EJECTOR	35x68x20	SM35C	1	
7	CLAMP HINGE PIN	ø8x22	STC5	1	
6	DRILL BUSH	ø25x13.25	STC7	1	
5	ROTATE PIN	ø12x19	STC5	1	
4	LOCATING BUSH	ø25x16.25	STC7	1	
3	DRILL GUIDE PLATE	65x25x10	SM35C	1	
2	UPPER PLATE	80x42x22	SM35C	1	
1	BASE PLATE	110x80x12	SM35C	1	

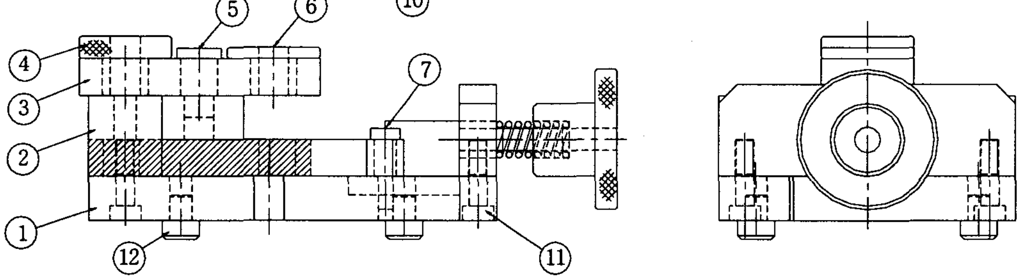
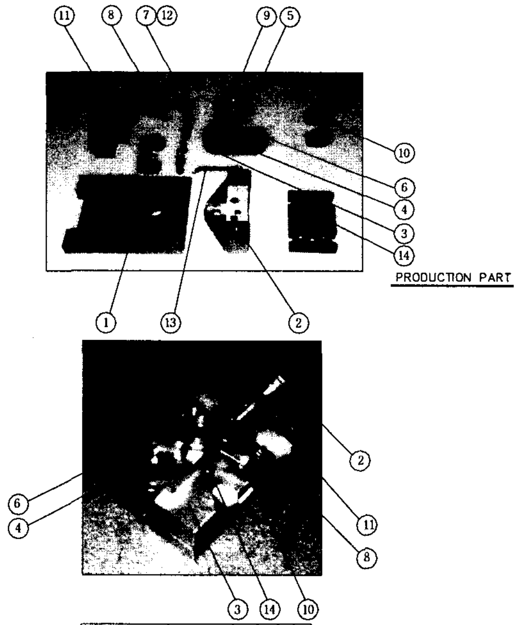


Fig. 8 Assembling drawing of drill jig design result



14	PRODUCTION PART	80x40x10t		1	
13	SPRRING			1	
12	JIG FRAME	φ10x12	STC7	4	
11	SIDE PLATE	80x25x10	SM35C	1	
10	CLAMP	39x27x10	STC7	2	
9	EJECTOR BUSH	φ38x23	STC7	1	
8	EJECTOR	35x68x20	SM35C	1	
7	CLAMP HINGE PIN	φ8x22	STC5	1	
6	DRILL BUSH	φ25x13.25	STC7	1	
5	ROTATE PIN	φ12x19	STC5	1	
4	LOCATING BUSH	φ25x16.25	STC7	1	
3	DRILL GUIDE PLATE	65x25x10	SM35C	1	
2	UPPER PLATE	80x42x22	SM35C	1	
1	BASE PLATE	110x80x12	SM35C	1	
NO	DESCRIPTION	SIZE	MAT'L	Q'TY	REMARK

Fig. 9 Actual assembling of jig and its component by jig making

8. Conclusion

In order to prevent the defect of jig design and making, this study developed the practical and adaptive drill jig design, then its analyzing. This study could be carried out by the theoretical back ground, data base and our own field experiences.

The conclusion of this study is as follows

(1) The data base and practical experiences were available for drill jig design.

(2) The drill bushings and locators should be accurate in those necessary making tolerances.

(3) Jig components accuracy in data base was effective for jig design.

(4) 3-2-1 locating system could be transferred to pin point or plane surface suppose.

(5) Our own making Auto-Lisp programming was effective for rapid jig design.

Acknowledgement

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References

1. Edward G. Hoffman, Jig and Fixture Design, Van Nostrand Reinold Co.1980.
2. Ewald L. Witzel, Jig and Fixture Design, Delmar Publishers.
3. Erik K. Heriksen, M.Sc., Jig and Fixture Design Mannal, Industrial Press Inc., 1973.
4. Herman W.Pollack, Tool Design, Reston Publishing Co., Inc., 1976.
5. D.F.Eary, G.E.Johnson, Process Engineering for Manufacturing, Prentice -Hall, Inc., 1962.
6. Frank W. wilson, Handbook of Fixture Design, ASTME, 1962.
7. Oliver R. Wade, Tolerance Control in Design and Manufacturing, Industrial Press Inc., 1967.