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Development of Drilling Jig by Practical and Adaptive Tooling System(Part 1)

── System Analysis of Part Drawing and Jig Design ──

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Key Words : Locating, Supporting, Clamping, Bush, Process, Clearance, Tolerance

Abstract : *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. In order to prevent the production defects the optimum design of product, jig and fixture putting in the field is very significant manufacturing method. They require analysis of many kinds of important factors, theory and practice of machine tool operating process and its phenomena, 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, database, and window environment. Especially Part1 of this study is reveals with the analysis of part drawing, jig planning, jig design etc.*

1. Introduction

The jig and fixture perform a series of fundamental machine tool working for mass production mostly of whole, of their using. Among them, the jig is a special device that supports, locating, and clamping are placed on a part to be machined. It is a product tool so made that it not only locates and holds the workpiece but it also guides the drill, reamer, tap, boring tool, etc. as the operation is performed. Jigs are usually fitted with hardened steel bushings for guiding drills or other cutting tools. As a rule small jigs are not fastened to the drill press table.

If, however, holes above 13mm are to be drilled, it is usually necessary to nest or to securely fasten the jig to drilling machine table. Due to small jigs are usually necessary to product manufacturing industrial. In this paper, part1 we designed one of a small jigs also production planning. So, this paper's goal is the accomplishment to optimization of small size drill jig design and making the practical and adaptive drilling jig with theoretical background, database, experiences, Auto Cad and window environment.

2. Locating System

Fig. 1 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]

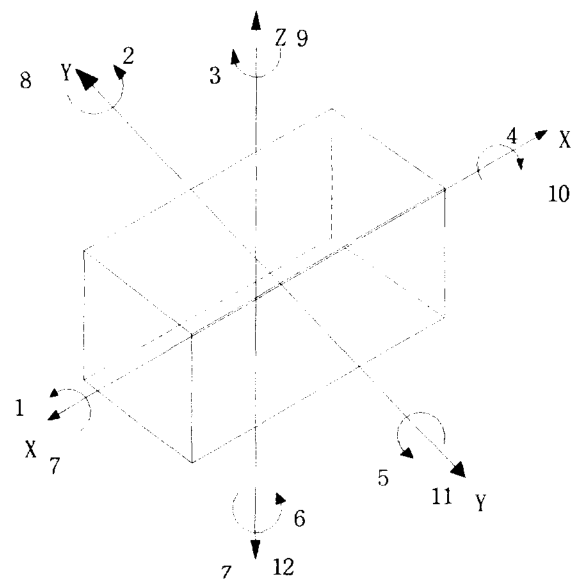


Fig. 1 planes of movement

Fig, 2 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]

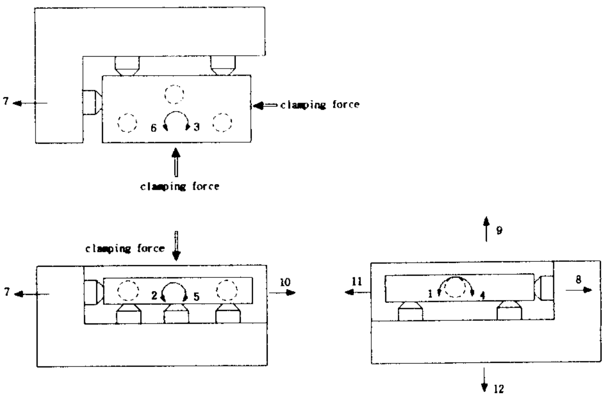


Fig. 2 Six-pin locators base restricts nine directions of movement with three kinds of clamping force.

3. Jig Bushing for Drill Jig Design

The jig bushing for drill jig design require 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 most be considered and sufficient clearance provided. Fig. 3 and Table 1 show the data base of fixed bushing and renewable bushings.

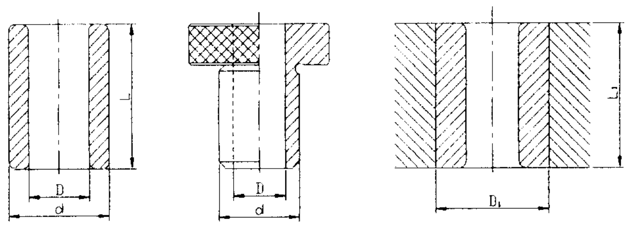


Fig. 3 profile of fixed and renewable bushing[1~4]

Table 1 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 2 Fitting tolerance of representatives.

unit : 0.001mm

Kind -ness	Grade \ Size	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

4. Decision of locator diameter bushing diameter and holes distance

When the production part drilled diameter is $D_1 \pm 0.1$mm, the bushing size must be let down +0.1mm therefore it should be decided precision tolerance in D_4 G6(Ø6 G6 : $Ø6 ^{+0.012}_{+0.004}$)

At this time, the drilling diameter is not come out over size Ø6.012. 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 ± 0.01mm os decided. According to these calculations we can decide the locator diameter D_3(Ø5.88±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 ±0.02(20% of ±0.1) W_2±0.04(20% of ±0.2) as a minimized percentage hence it can be shown in Fig. 11 jig drawing of design result.

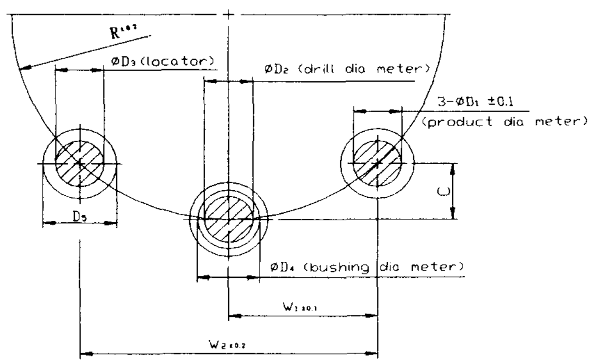
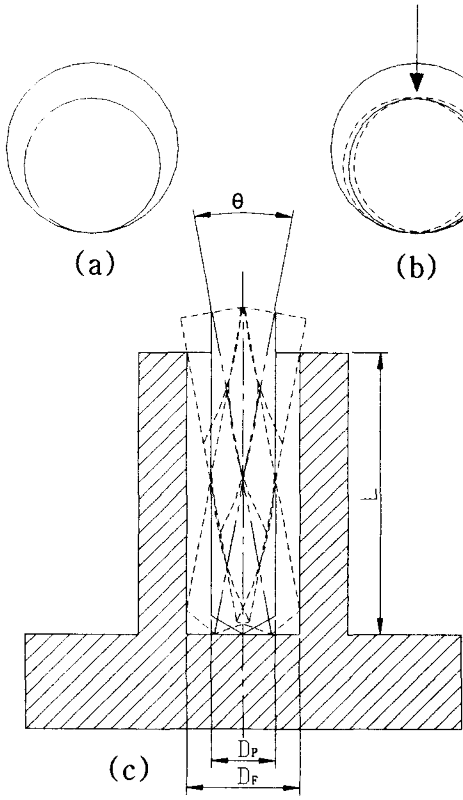


Fig. 4 Decision of locator diameter, bushing diameter and holes distance

Using the cylindrical locators involves nesting, therefore requires clearance in Fig. 5(a) the position of the center of the part may vary as much as the clearance and may be offset from its nominal position as much as one-half of the clearance. The application of a clamping pressure(see(b)) forces the offset to one side, but does not eliminate it, and the poor nesting at the contact point opposite the clamping pressure permits the part to shift slightly to one side or the other. If the part does not have a good locating base surface, but, for example, in a point(as shown in Fig. (c)), it is also subject to misalignment resulting in a maximum angular variation θ of the axis direction determined as following formula:

$$\theta = \frac{2(D_F - D_P)}{L}\ radian = \frac{360}{\pi} \cdot \frac{D_F - D_P}{L}\ degrees \text{------(1)}$$

once again confirming the fundamental rule that locating points should be as far as possible. It is strongly recommended, that the locating points be placed in mutually perpendicular planes.



Where, D_P : Actual drilled diameter

D_F : Drill diameter

θ : Angle of maximum variation

Fig. 5 Effect of clearance in cylindrical locating

5. Production System and Jig Planning of Process.

Fig. 6 Shows the departmental organization in product manufacturing field. In the figure we can find the importance of tool manufacturing department.

Fig. 7 Shows the out line of considerations in jig and fixture design. In this figure we can consider the

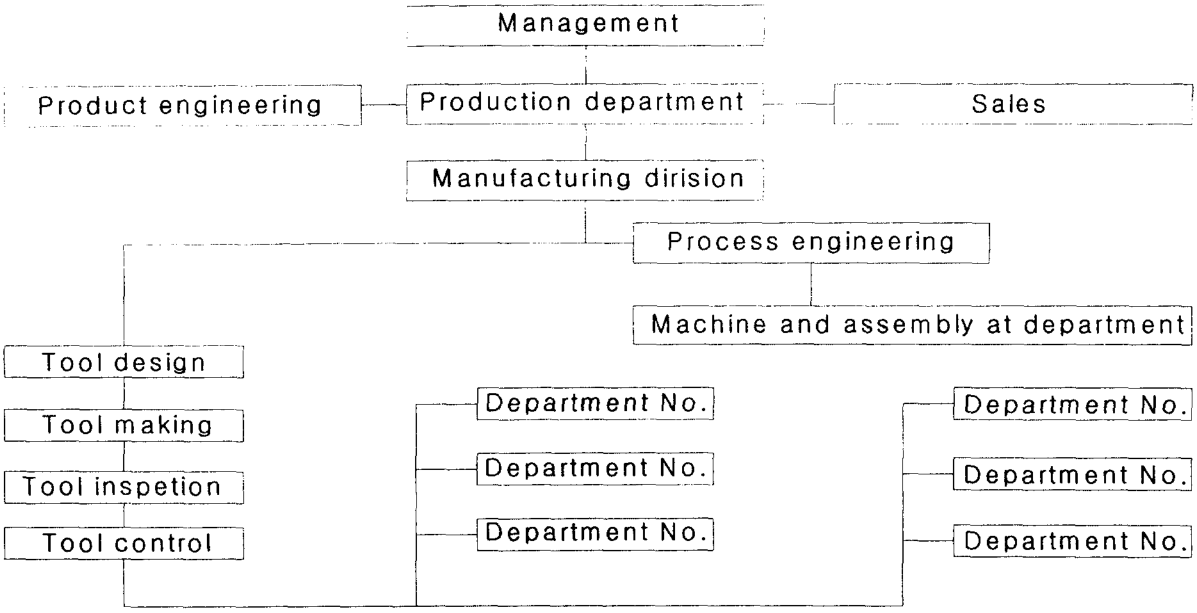


Fig. 6 Departmental organization in product manufacturing field.

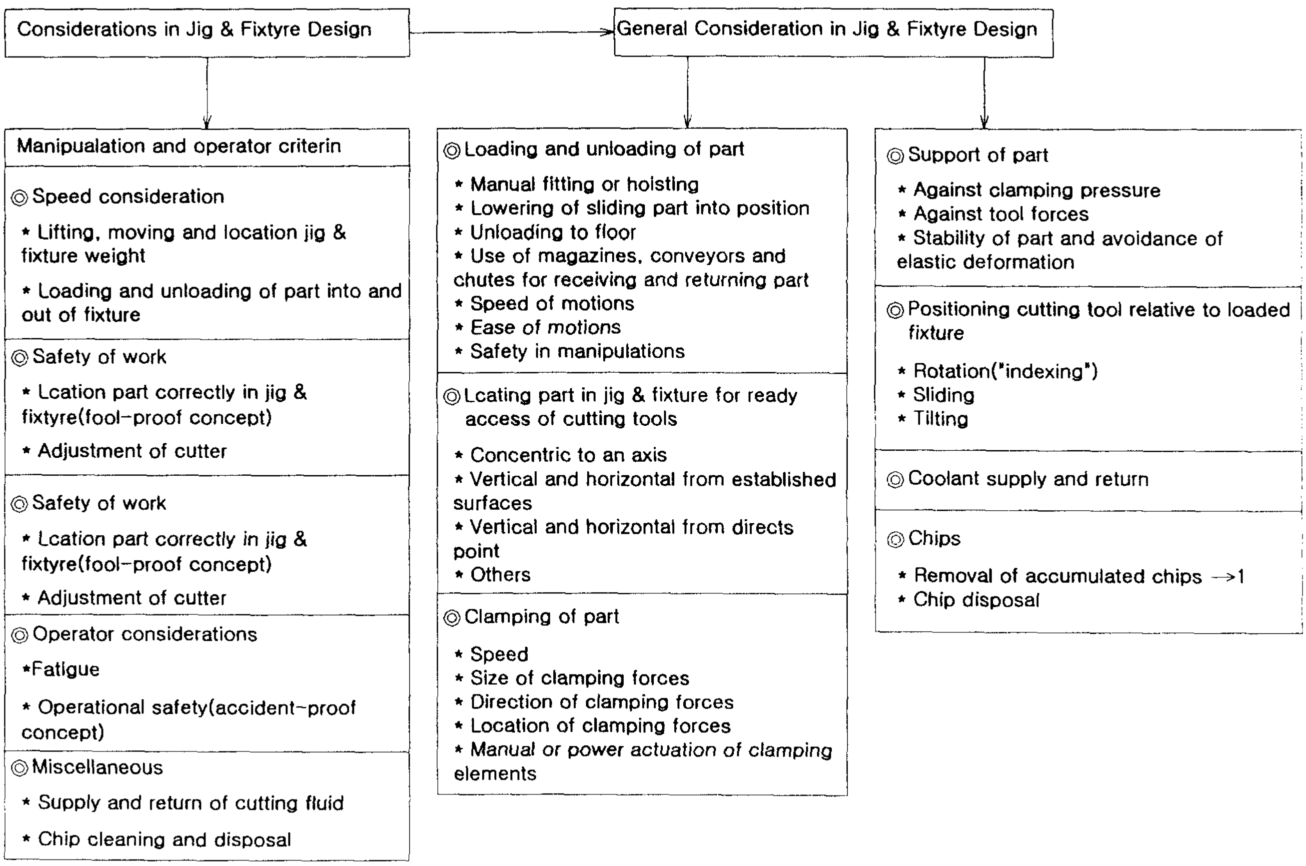
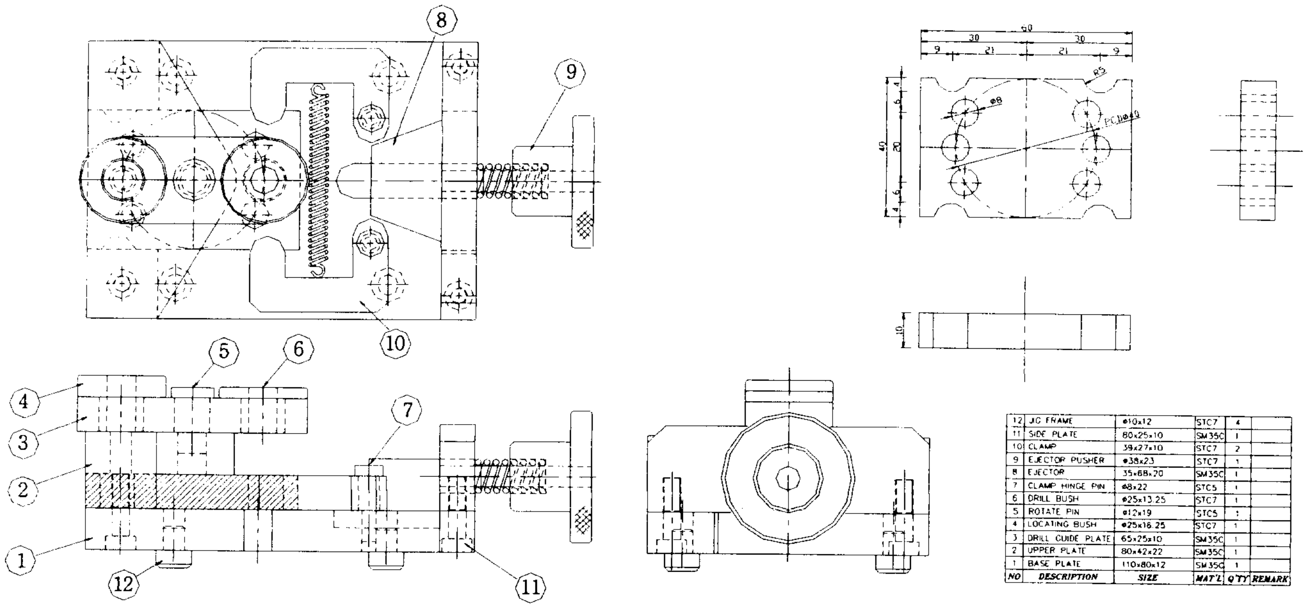


Fig. 7 Outline of considerations in jig and fixture design



NO	DESCRIPTION	SIZE	MAT'L	Q'TY	REMARK
12	JIG FRAME	φ10x12	STC7	4	
11	SIDE PLATE	80x25x10	SM35C	1	
10	CLAMP	39x27x10	STC7	2	
9	EJECTOR PUSHER	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	

Fig. 8 Assembling drawing of drilling fig design result

important point of loading and unloading, locating, clamping, safety of work and operator, cutting tool, coolant, and chip removement etc.[5~7] Fig. 8 shows the assembling drawing of the result of drilling jig design.

6. 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 shoal 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) Also 3-2-1 location system was effective loading and unloading as well as accurate location for production part.

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