

Design of Drilling Jig for Side Plate Component

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ABSTRACT

Manufacture industry competition requires every company to increase productivity and product quality. To increase productivity can be done by decreasing production time, one of them by decreasing setup time. This condition is a problem for small scale manufacturing that generally have conventional machines and have financial limitations for high-tech machinery investment. One that can be done to increase productivity and reduce the number of products reject is by applying the jig and fixture. This paper will discuss the design of drilling jig and fixtures for drilling process side plate component at small scale manufacturing. The results of implementation drilling jig and fixture showed increased productivity by reducing set up time and decreasing the number of products reject.

Keywords: Jig, Fixture, Quality, setup time, manufacture

1 INTRODUCTION

At present, the manufacturing industry is experiencing rapid technological developments. The demand for manufactured products is increasing every day. The main goal of each company is to produce high quality products that match consumer demand with a shortest processing time. High-tech machines that can produce fast processing times and good product accuracy are often used by the manufacturing industry. The procurement of machines with high technology is certainly not a problem for manufacturing companies with good financial ability rather than to small-scale manufacturing industry with limited investment. The common way to achieve produce high quality products with minimum manufacturing cost within shortest time for small-scale manufacturing industries that do not have high technology, is achieved economically by using jig and fixtures. One way that can be done to reduce the number of defects is to redesign the production tools Jig and fixture [5]. The use of a jig and fixture serves to support and lock the workpiece during the machining process so as to produce accurate parts duplication, where the jig serves to direct the cutting tool and fixture serves to grip the workpiece [3]. The use of jigs and fixtures is able to optimize the machining process because the use of jigs and fixtures minimizes setup time with elimination of individual making, positioning and increases product precision. The use of inappropriate aids may inhibit the process of product machining. This paper will discuss the design of jig and fixture to produce side plate components, which can reduce product defects, reduce setup time, increase productivity and ease of use.

2 RESEARCH METHOD

Jig and fixture are production tools used in the manufacturing process resulting in accurate part duplication [3]. Appropriate and parallel relationship between the cutter, or other tools, and workpiece shall be maintained. Jigs and fixtures are the production tools used in the manufacturing process, resulting in accurate duplication of parts [3]. Reference [4], Jigs are imparted with tool guiding elements such as drill bushes, which regulate the tool to the right position in the workpiece. The jig is a special equipment to position the workpiece, hold it firmly in place, and guide the motion of the power tool during machining process. The fixture is a device that serves to hold and locating the workpieces in the correct relationship to the cutter while machining operations. The design of jigs and fixtures is customized and specified to hold and withstand specific workpieces because jigs and fixtures fall into dedicated fixture or in other words that jigs and fixtures are designed for specific workpieces.

2.1 Principles of clamping (Workholding)

In general, clamping is part of production equipment that serves to hold workpiece. Viewed from the clamping is part of the jig and fixture that serves to grip the workpiece so that the position of the workpiece does not change during the machining process.

2.2 Determination of Large Stressing Force

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2.1 Principles of clamping (Workholding)

In general, clamping is part of production equipment that serves to hold workpiece. Viewed from the clamping is part of the jig and fixture that serves to grip the workpiece so that the position of the workpiece does not change during the machining process.

2.2 Determination of Large Stressing Force

The clamping force that should be applied to the object needs to be determined. An approach in determining the magnitude of the clamping force to be assigned to the workpiece can be determined by the magnitude of the largest machining force that will occur during the clamping. The calculation equation of the Drilling force and clamping force can be seen in Equation (1) and (2).[1]

Drilling Force =
$$1.16 \times k \times d \times (100 \times s)^{0.85}$$
 (1)

Where,

k = material factor

s = feed in mm/rev

d = the diameter of the drill in millimeter (mm)

Where,

F = force on Handle M = coefficient of Friction

Clamping Force = F x L +

A,B,R,L = dimensions of Toggle clamp

The relationship between the clamping force, the reaction force at the locator, and the machining force can be expressed by (3), [2].

$$\sum_{i \in P} f_i \cdot w_i + \sum_{j \in A} f_j \cdot w_j + f_k \cdot w_k = 0$$
(3)

For all *k*

where:

 w_i = Direction force (Colom wrench) acting on the *i*- locator

 w_i = Directions forces acting on the clamp to-*j*

 w_k = Direction of cutting force k

 f_i = Magnitude of the force (Colom wrench) working on the column-*i*

 f_i = Magnitude of the force acting on the clamp to-*j*

 f_k = The amount of cutting force k

P = Set all locators

A = Set entire clamp

K = Subscribe force cut

Equation (3) can be written in the following form:

(2)

$$W_p \cdot F_p + W_a F_a + f_k w_k = 0$$
 for all k

where:

 W_p = Matrix vector of acting force on the locator

- W_a = Matrix vector of acting force on the clamp
- w_k = Matrix vector of cutting force
- F_p = Matrix of acting forces on the locator
- F_a = Matrix of acting force on clamp
- f_k = Matrix of Cutting force
- p = Passive
- *a* = Aktive

Matrix W_p , W_a , and W_k prepared based on the direction of force and torque of a certain force and consists of a three-way force on the axes X, Y, and Y (n_x , n_y , n_z) and the three moments of the axes X, Y, and Y (m_x , m_y , m_z). By eliminating the matrix W_p on the left row of equation (4) then the reaction force in the locator (F_p) can be calculated as follows:

$$F_p = -W_p^{-1}.W_a F_a - W_p^{-1} w_k f_k$$

This equation (5) must produce a non-negative solution for F_p , which means each locator has contact with the workpiece.

At the locating stage, the workpiece is driven by an outer force, the placement force f_l , in the opposite direction to the direction of the locator force (w_l). At this stage the workpiece has not been gripped so there is no force of clamping. Equation (5) can be written as:

$$W_{p}F_{p} = -w_{l}f_{l} \quad \text{or} \quad F_{p} = -W_{p}^{-1}w_{l}f_{l}$$
where:

$$w_{l} = \text{The direction of placement force}$$

$$f_{l} = \text{Placement force}$$
(6)

Equation (6) must produce a non-negative solution for F_p , which means each locator has contact with the workpiece.

At the stage of clamping, outer force (f_l) is no longer working while the machining force has not worked, so the prevailing equation is

$$F_p = -W_p^{-1} W_a F_a \tag{7}$$

Equation (7) must produce a non-negative solution for F_p , indicating that there is contact between the workpiece, locator and clamping during the working of the clamping force.

At the machining stage, cutting forces and clamping forces work on the workpiece, so the applicable equations are:

$$F_p = -W_p^{-1}.W_kF_k + (-W_p^{-1}W_aF_a)$$

Equation (8) must produce a non-negative solution for F_p , indicating that there is contact between the workpiece, locator and clamping during the working of the machining force.

3 RESULTS AND ANALYSIS

The product to be design of jig and fixture is side plate component that can be seen in Fig.1.

(4)

(5)

(8)

240





Figure 1. Side Plate Components

3.1 Design of Jig and Fixture

The tools used today it is still not optimal as operators still feel inconvenience in the use of tools. Design of jig and fixture made to drilling process at the side plate component. There are several stages in doing the design, one of them is by choosing and designing the components needed in the design of jig and fixture such as baseplate, locator, support and clamping.

A. Baseplate

Baseplate is a component that serves as a base of jig and fixture support such as set block, support, stopper, clamping, and other required components in jig and fixture design. The baseplate is equipped with a rail to be driven because the characteristics of the drill press machine table cannot be moved according to the desired axis (X and Y). The drawing of baseplate can be seen in Fig. 2.

B. Set block design

Set block is a component part of the fixture that serves to hold and position the workpiece. Design of Set block can be seen in Fig 3.



Figure 2. Placements of Rail, Support, Gear and Platform



Figure 3. Set block design

C. Clamping Design

Clamping is a component of the jig and fixture that serves as a tap to keep the workpiece in position (Rigid). The basic placement of the clamp on a design is not allowed to interfere with the machining process, so the design must be precise and appropriate. The type of clamping used is adapted to the ease of loading and unloading process and can resist the magnitude of machining force. The cutting force that occurs is 186.50 N and the clamping needed is 997.86 N. Based on these results push action clamp is used because it has a function and usability that fits on this workpiece where the lever is pulled from the side so it makes it easier for operators in jig and fixture operation. Image of push action clamp and placement of workpiece against clamping can be seen in Fig 4.



Figure 4. Push Action Clamp and placement of workpiece against clamping

D. Design of Jig

The jig is a component that serves to direct the cutting tool for accuracy and precision. There are several components that are used in jig design, namely component bushing and fastening device. Bushing on the jig serves to avoid the sculpting so as not to touch directly against the jig. Design of jig can be seen in Fig 5.



Figure 5. Jig Design

3. 2 Placement, Clamping and Machining Matrix

Matrix calculation is done to find out whether the design is done well or not, seen from the calculation of matrix placement, clamping and machining is not negative value.

A. Placement Stage

The matrix calculation for the placement stage as follows:

 $F_p = -W_p^{-1}.W_l F_l$

$W_{p}^{-1} =$	mx my mz nx ny	0.081 0.042 -0.123 0.000 0.000	0.093 - 0.118 0.025 0.000 0.000	0.000 0.000 0.000 - 0.084 0.084	- 0.113 - 0.001 0.114 0.494 - 0.494	0.028 0.015 -0.043 0.000 -1.000	-0.244 -1.416 0.600 ; 0.000 0.000	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$).002).880).119).000 L.000
	nz	0.000	0.000	0.000	-1.000	0.000	0.000	$nz \mid 0 -1 1 \mid 1$.000

Conclusion:

 F_p is non-negative, it indicates that there is contact between the workpiece and the locator when the workpiece is in place. The workpiece in a balanced state or the force received by the locator can withstand the gravity of the workpiece.

B. Clamping Stage

.....1

The matrix calculation for the clamping stage as follows:

$F_p = -$	$-W_p$	$^{1}W_{a}F_{a}$								
$-W_{p}^{-1} =$	mx my mz nz nx ny nz	0.081 0.042 - 0.123 0.000 0.000 0.000	0.093 - 0.118 0.025 0.000 0.000 0.000	0.000 0.000 0.000 - 0.084 0.084 0.000	-0.113 -0.001 0.114 0.494 -0.494 -1.000	0.028 0.015 - 0.043 0.000 - 1.000 0.000	- 0.244 -1.416 0.600 0.000 0.000 0.000	$\begin{array}{c cccc} mx & 0.35 & -6.85 \\ my & 0 & 2.12 \\ W_a &= mz - 11.84 & 0 \\ nx & 0 & 0 \\ ny & -1 & 0 \\ nz & 0 & -1 \end{array} $	$T_a = \begin{vmatrix} 997.866 \\ 1.6 \end{vmatrix}; P$	$S_{P} = \begin{vmatrix} 0.009 \\ 1.503 \\ 0.088 \\ 997.866 \\ 0.000 \\ 0.000 \end{vmatrix}$

Conclusion:

 F_p is non-negative, indicating that there is contact between the workpiece, locator and clamping during the working of the clamping force.

C. Machinery Stage

The matrix calculation for the machinery stage as follows:

 $F_p = -W_p^{-1}.W_aF_a + (-W_p^{-1}.W_kF_k)$

								mx	- 6.85			186.5
$W_{p}^{-1} =$	тx	0.081	0.093	0.000	-0.113	0.028	-0.244	my	2.12	$F_k = 186.5 ,$		1.000
	тy	0.042	-0.118	0.000	-0.001	0.015	-1.416	<i>m</i> 7	0			175 25
	mz,	-0.123	0.025	0.000	0.114	-0.043	0.600;	$W_k = \sum_{mx}^{mx}$	Õ		$F_P =$	10.24
	nx	0.000	0.000	-0.084	0.494	0.000	0.000	пл	0			10.24
	ny	0.000	0.000	0.084	-0.494	-1.000	0.000	ny	0			0.000
	nz	0.000	0.000	0.000	-1.000	0.000	0.000	nz	-1			0.000

Conclusion:

 F_p is non-negative, indicating that there is contact between the workpiece, locator and clamping during the working of the machining force.

From the test results shows mathematically that the design of jig and fixture can give the position of the rigid workpiece during machining process, so the proposed jig and fixture can be used. The design of the jig and fixture can be seen in Fig 6.



Figure 6. Jig and fixture

3.3 Jig and Fixture Usage Analysis

The design of the jig and fixture is capable of generating a smaller setup time compared to the previous setup time of the tool which will indirectly affect the working time of a component to be faster. Comparison of time for the two tools and productivity can be seen in Table 1.

Table 1. Setup times and Productivity										
	Setup Time Total Production / hour Total Production / day									
	(minutes)	(unit)	(unit)	Products Reject						
Company Tool	0.97	3	31	20%						
Jig and Fixture	0.30	4	33	-						

4 CONCLUSION

The new jig and fixture designed can be used as a production tool manufacture side plate components that can simplify the setup process and ensure workpieces and cutting tools in the right conditions that meet the tolerance specifications. The design of jigs and fixtures is dependent on the shape of the workpiece, the type of machine and the type of machining operation used. There are numerous advantages with the use of jigs and fixtures, such as: increased productivity, consistent quality of manufactured products, and reduction of manufacturing cost. After implementation of this jig a fixture, number of parts rejected were reduced from 20% to zero parts per day. The new jig and fixture reduce total setup time from 0.97 minute to 0.30 minute.

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