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Making Holing Machine for AC Connecting Tube Product K25G

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Holing Machine, Tube AC Connecting K25G, Manufacturing Efficiency.

Abstract: Holing Machine is an after pressing tool that functions to make holes in the product. This Holing Machine is specifically used to make holes in the Tube AC Connecting K25G product that has finished the pressing process. The after pressing process of making holes in the Tube AC Connecting K25G product was previously done manually with the help of marking and Air Grinder. This method takes quite a long time, which is about 8 minutes to make holes in 4 Tube AC Connecting K25G products, resulting in wasted production time. This led to the creation of a Holing Machine to help the process of making holes in the Tube AC Connecting K25G product so that it can be done automatically. The Holing Machine is made with several stages of the manufacturing process starting with the process of making machine construction drawings, the process of selecting and preparing materials by the company, the machining process for making parts, the part assembly process and the trial process. From these stages, an estimate of the processing time and cost of the Holing Machine manufacturing process can be obtained. With the creation of this Holing Machine, it is expected to reduce the waste of time in the hole making process on the Tube AC Connecting K25G product by up to 22.59% from the previous hole making process time of 49.31% so that the waste of time in the production process of the Tube AC Connecting K25G product can be reduced. That way, the productivity of making the Tube AC Connecting K25G product can be increased.

INTRODUCTION

PT. Indokarlo perkasa is one of the companies engaged in the manufacturing sector under the auspices of PT. Astra Otopart, Tbk group. PT. Indokarlo Perkasa is engaged in the manufacture of rubber spare parts for the automotive sector of two-wheeled and four-wheeled vehicles.

Tube AC Connecting K25G is one of the rubber parts for two-wheeled vehicles produced by PT. Indokarlo Perkasa. Tube AC Connecting K25G functions as a connector between the air

filter and the engine for the air exhaust channel from the engine on two-wheeled vehicles. In the construction of Tube AC Connecting K25G, there is a hole made to eliminate noise from the air flowing in it.

The process of making holes in the Tube AC Connecting K25G product which cannot be done by modifying the product tooling, this results in an additional after pressing process having to be carried out to make holes in the product.

Previously, the after pressing process to make holes in the product was done manually with the help of marking on the product and an air grinder, but this still experienced problems both in terms of the process and the results of the holes in the product. The problem can be seen from the process of making holes in the product still takes quite a long time and the results of the holes in the product are not uniform both in terms of hole diameter and hole position. Therefore, to overcome this, a special Holing Machine was made to make holes in the Tube AC Connecting K25G product.

Considering that one of the objectives of the Industrial Practice Program (PPI) is as a means of obtaining study materials for the final project, the author as a student of the Bandung State Manufacturing Polytechnic took and raised the topic of the Holing Machine which is a special machine for making holes in the Tube AC Connecting K25G product, as material for compiling the final project.

MAKING PROCESS

Flowchart of Holing Machine manufacturing process

The manufacture of Holing Machine consists of several stages. These stages can be described in general in the following flowchart:

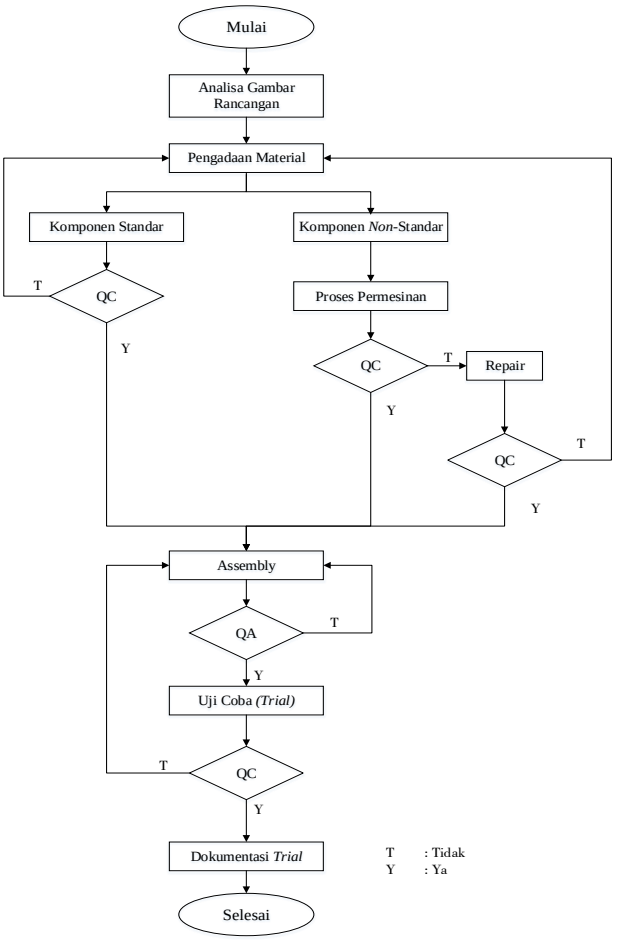
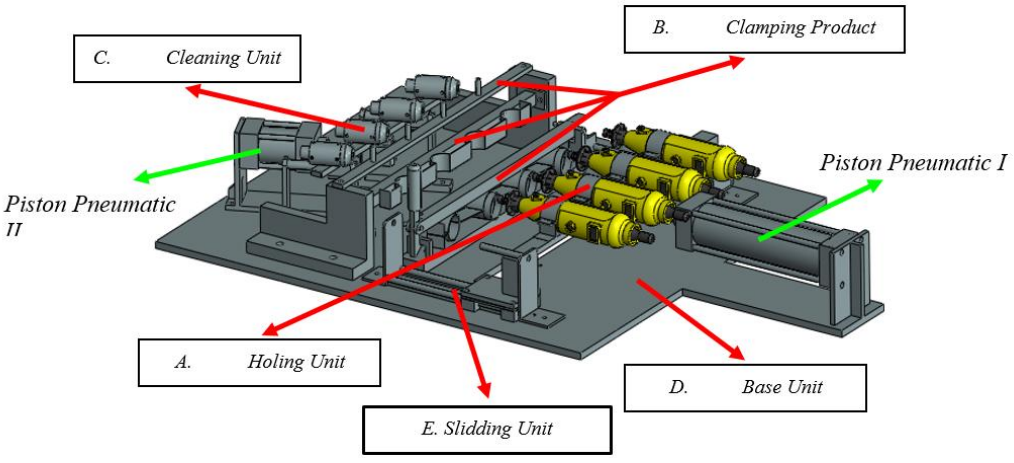


Diagram 1. Flowchart of the Holing Machine manufacturing process

Holing Machine Construction



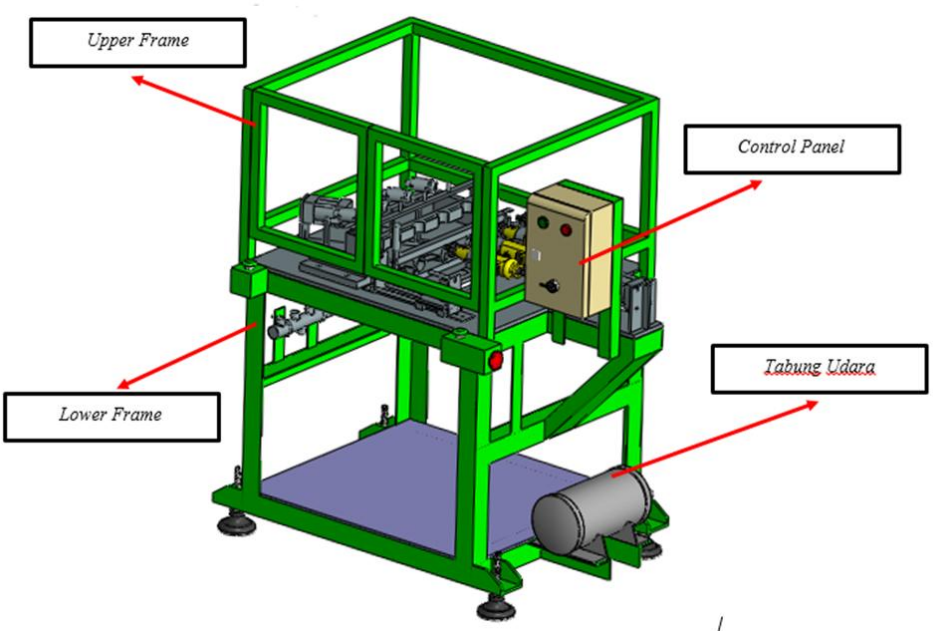


Figure 2. Holing Machine Construction

Table 1. List of Holing Machine Parts

List Assembly			
No.	**Code**	**Unit Name**	**Number of Components**
1	A	Holing Unit	13
2	B	Clamping Product Unit	13
3	C	Cleanning Unit	16
4	D	Base Unit	3
5	E	Slidding Unit	4

For a complete list of Holing Machine components, see Appendix G (1-2). As for the working drawings of each Non-standard Component, see Appendix A.

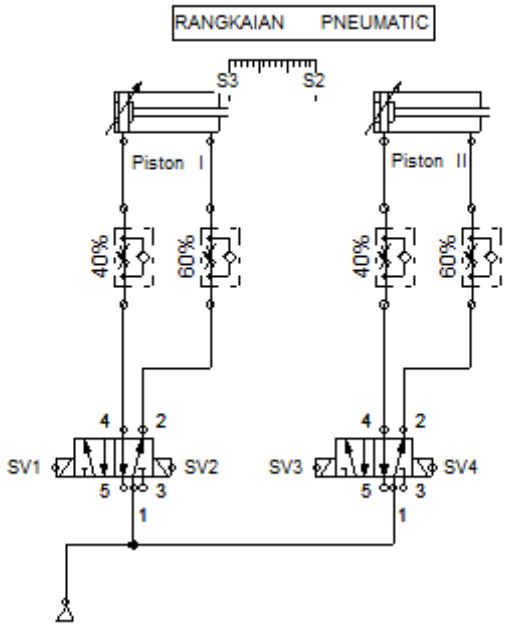
This Holing Machine functions to make holes in the Tube AC Connecting K25G product by utilizing the working principle of the electrical die grinder to rotate the cutting tool and assisted by the working principle of the pneumatic piston to push the electrical die grinder to make holes in the product that has been clamped in the clamping product unit. This Holing Machine consists of several parts, the functions of the parts of this Holing Machine are:

1. Holing Unit (A) functions as a hole-making unit in the Tube AC Connecting K25G product that utilizes the working principle of the electrical die grinder and the pneumatic piston that pushes the Holing Unit to make holes in the product.
2. Clamping Product Unit (B) functions as a clamping unit for the Tube AC Connecting K25G product which minimizes product shifting during the punching process.

3. Cleaning Unit (C) functions as a cleaning unit for residual cutting powder that sticks to the inside of the Tube AC Connecting K25G product after the punching process is complete. This Cleaning Unit utilizes the working principle of a pneumatic piston to push the Cleaning Unit towards the product.
4. Base Unit (D) functions as a stand for attaching the Holing Unit, Clamping Product Unit and Cleaning Unit.
5. Slidding unit (E) functions as a base for the movement of the holing unit which is pushed by the pneumatic piston.

Working Principle of Holing Machine

The working principle of Holing Machine utilizes the working principle of pneumatic piston and electrical die to make holes in Tube AC Connecting K25G products.



Information :

SV : *Selenoid Valve*
K : *Relay*
T : *Timer*
PB : *Push Button*
S : *Sensor*
SE : *Emergency Stop*

Figure 3. Electropneumatic Holing Machine circuit

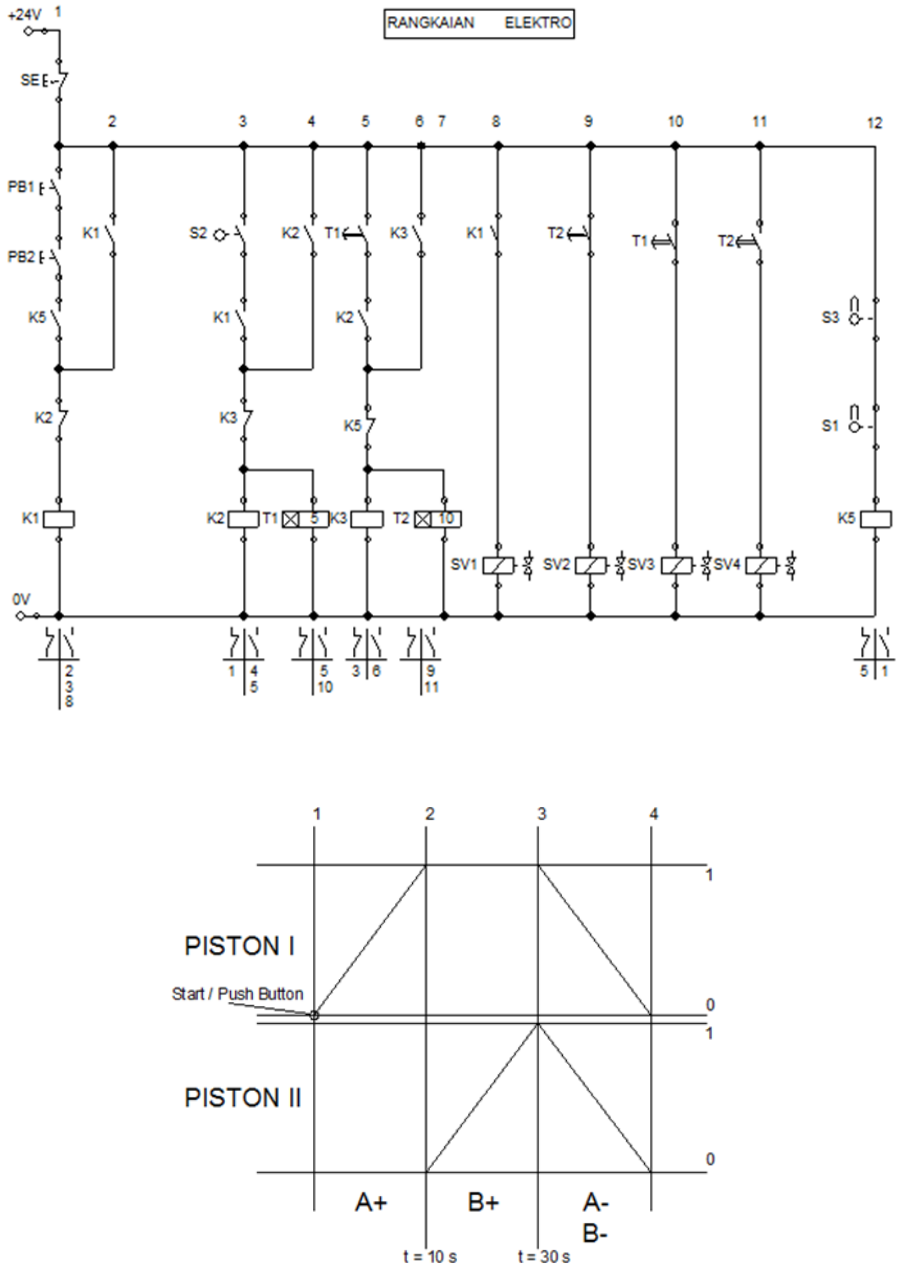
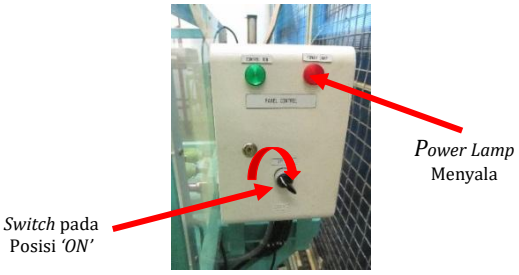
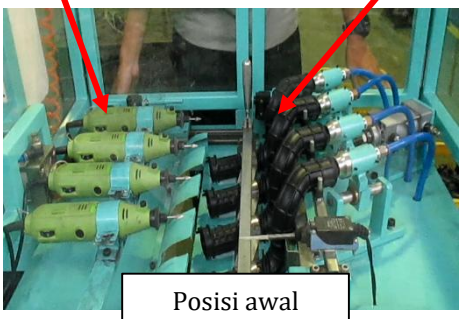


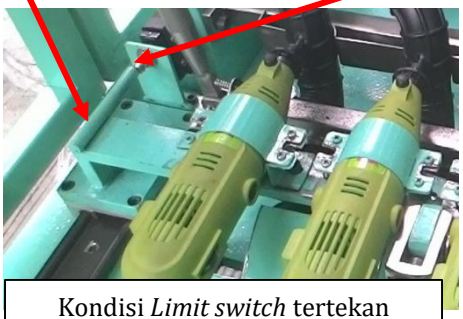
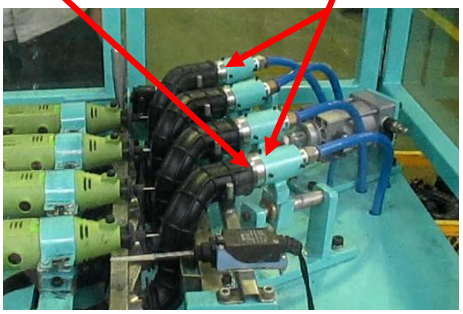
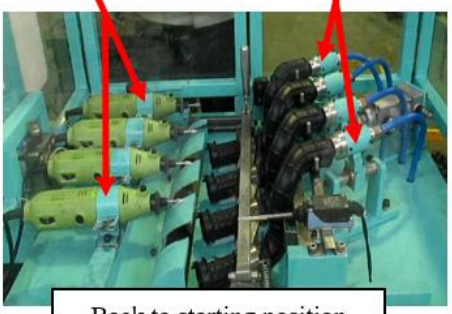
Figure 4. Piston working diagram on Holing Machine

The following is an explanation of the working principle of the Holing Machine, namely:

Table 2. Working Principle of Holing Machine

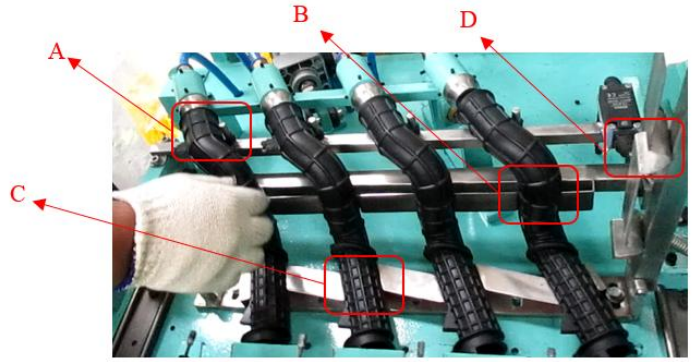
No	Explanation	Visual

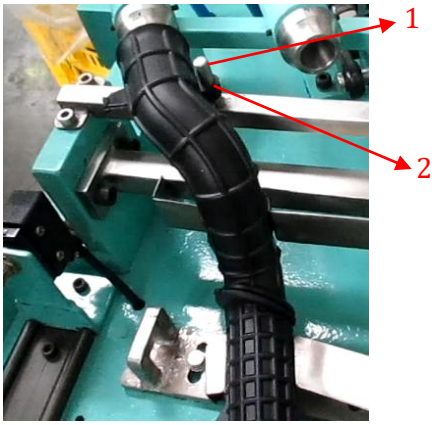
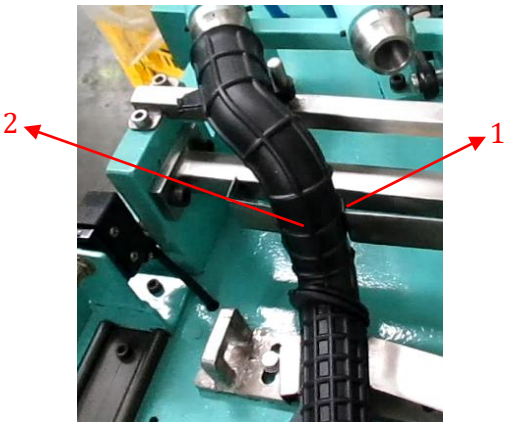
1	When the switch on the Control Panel is turned on (ON), the electrical system will be on, indicated by the Power Lamp indicator light on the Box Panel.	
2	Cekam produk pada *Clamping product Unit,* Ketika 2 *Push Button* ditekan, maka *Electrical Die Grinder* pada *holing unit* akan menyala dan *Piston pneumatic I* akan bekerja untuk mendorong *Holing Unit* menuju produk yang dicekam.	 
No	**Explanation**	**Visual**
3	The Holing Unit is pushed by the pneumatic Piston I towards the gripped product and the hollowing process occurs on the Tube AC Connecting K25G product.	

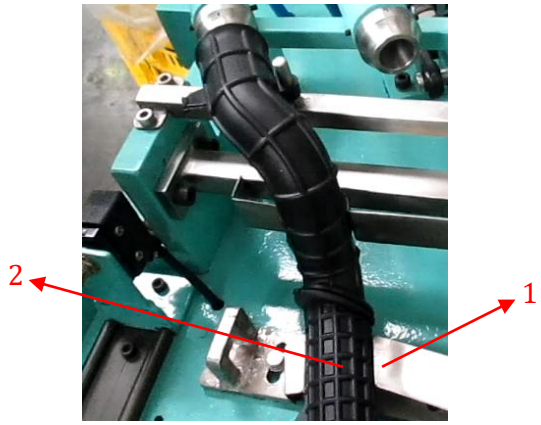
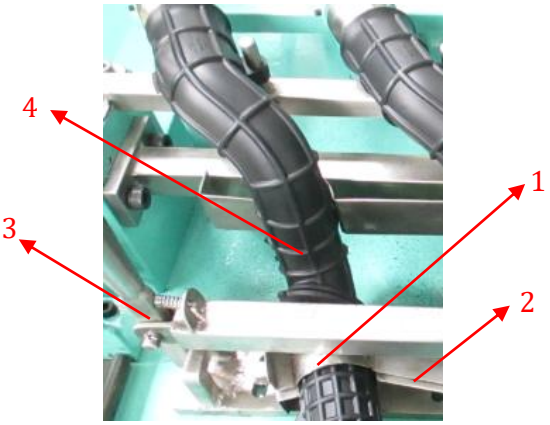
		
4	When the Tube AC Connecting K25G product has been perforated, the stopper axis will press the Limit Switch.	Poros *Stopper* *Limit Switch*  Kondisi *Limit switch* tertekan Poros *Stopper*
5	The Limit Switch activates the Pneumatic Piston II to push the Cleaning Unit towards the product and activates the compressed air that is fired through the air nozzle to clean the cutting dust on the inside of the product.	*Nozzle* Udara *Cleaning Unit* Maju 
6	The Cleaning Unit and Holing Unit will return to their initial position according to the time set in the control system, the air fired through the nozzle will stop and the electric current to the Electrical Die Grinder will also be cut off.	*Holing Unit Backwards* *Cleaning Unit Back*  Back to starting position

For SOP (Standard Operational Process) Holing Machine can be seen in attachment G-4. The flow of the hole making process on the Tube AC Connecting K25G product using Holing Machine is as follows:

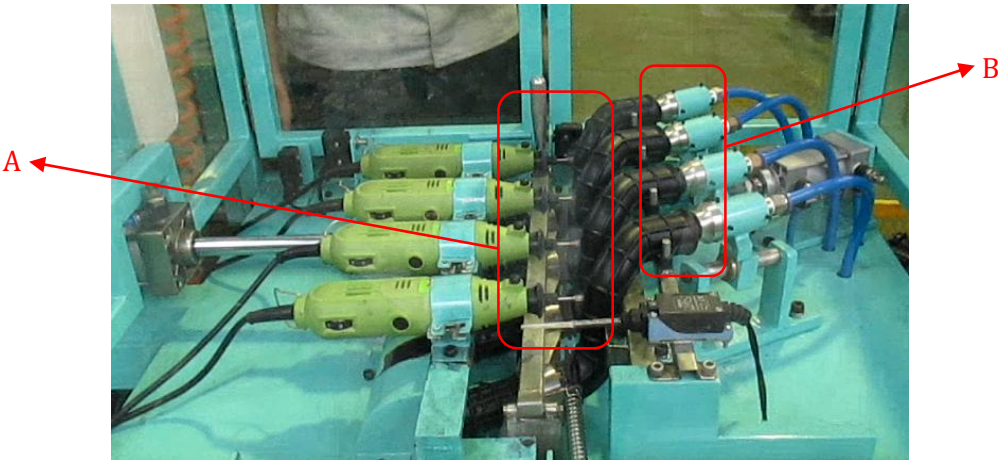
Table 3. Stages of manufacturing the Tube AC Connecting K25G product using a Holing Machine

<table>
<tr><th colspan="3">1. Product Clamping Process</th></tr>
<tr><td colspan="3"> 

Install the Tube AC Connecting K25G product to the Clamping Product Unit and make sure the product is properly installed on the Clamping Product Unit.</td></tr>
<tr><th>No</th><th>Explanation</th><th>Visual</th></tr>
<tr><td>A</td><td>Make sure the mounting hole on the Tube AC Connecting K25G product fits into the product retaining pin until it reaches the end of the product retaining pin.
1: Product retaining pin
2: Mounting hole on the Tube AC Connecting K25G product</td><td> 
</td></tr>
<tr><td>B</td><td>Position the contour of the Tube AC Connecting K25G product on the upper product holder. Press the product on the holder and make sure the product position does not shift on the upper product holder
1: Upper product holder
2: Contour of the Tube AC Connecting K25G product</td><td> 
</td></tr>
</table>

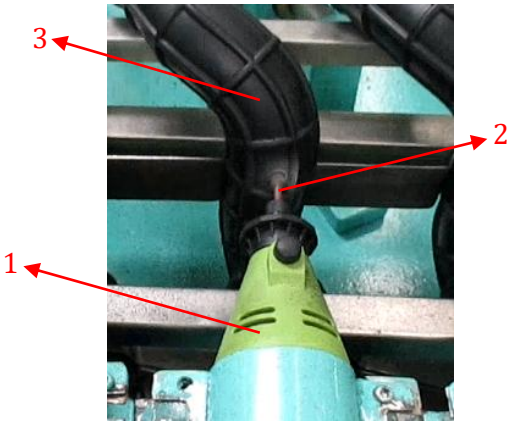
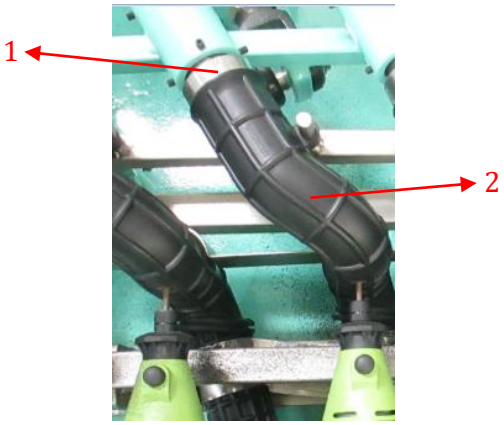
C	Position the contour of the Tube AC Connecting K25G product on the clamp plate holder (lower product clamp). Press the product on the holder and make sure the product position does not shift on the clamp plate holder (lower product clamp). 1: Clamp plate (lower product clamp) 2: Contour of the Tube AC Connecting K25G product	
D	Close the upper product clamp to strengthen the clamping of the Tube AC Connecting K25G product on the Clamping Product Unit. Lock the clamping of the upper product clamp by engaging the locking lever. 1: Upper product clamp 2: Lower product clamp 3: Locking Lever 4: Tube AC Connecting K25G product	

2. Product Punching Process



Turn on the control system on the Holing Machine and it will activate the pneumatic piston I to push the holing unit to perforate the Tube AC Connecting K25G product that has been clamped in the Clamping Product Unit which is continued with the product cleaning process by the Cleaning Unit which is pushed by the pneumatic piston II.

No	Explanation	Visual

A	Electrical Die Grinder on Holing Unit rotates the cutting tool (tungsten carbide burrs) to make holes in Tube AC Connecting K25G product that has been clamped on Clamping Product Unit. 1: Electrical Die Grinder 2: Tungsten carbide burrs 3: Tube AC Connecting K25G product	
B	The air nozzle on the Cleaning Unit shoots air that will clean the cutting dust left inside the Tube AC Connecting K25G product. 1: Air nozzle 2: Tube AC Connecting K25G product	

The processing time for making holes in the Tube AC Connecting K25G product outside the product setting and cleaning process can be calculated in the following way:

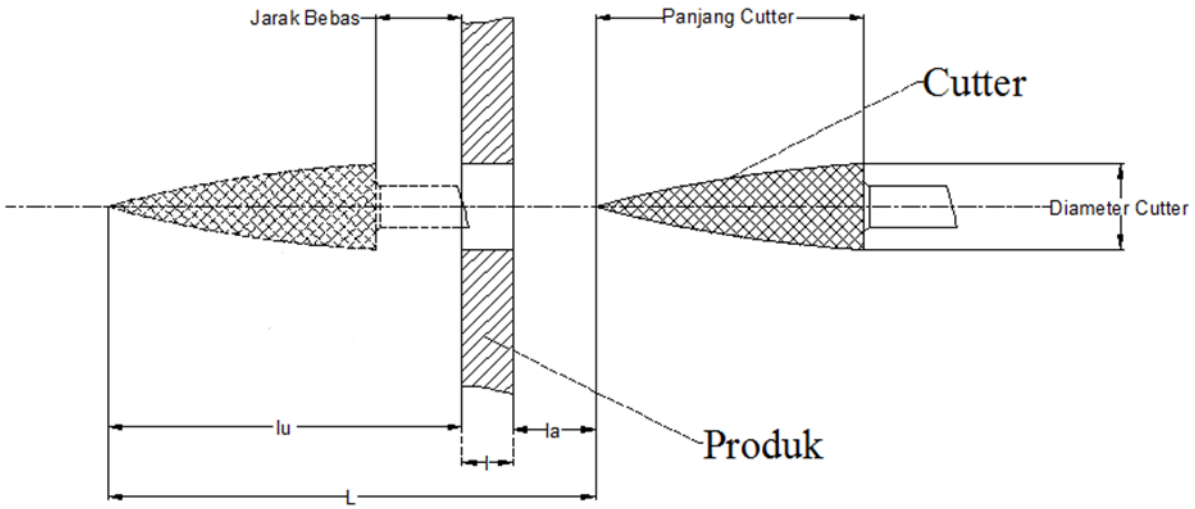


Figure 5. K25G AC Connecting Tube Product Punching Process

It is known:

Cutter : *Tungsten carbide burrs*
Material *Cutter* : *Carbide*
Diameter *Cutter* (d) : 6 mm
Cutter Length : 19 mm
Feeding (f) : 0,01 mm
Product Materials : *Natural Rubber*
Product Thickness (l) : 3,6 mm
Electrical Die Grinder (n) : 30000 rpm
Lots of food : 1 time

Rumus Panjang Pengerjaan :

$$\boldsymbol{L = l + la + lu}$$

L : Total Working Length (mm)
la : Initial Free Length (mm)
lu : Final Free Length (mm)

$$\boldsymbol{lu = Cutter\ Length + Free\ Length}$$

Process Time Formula:

$$\boldsymbol{Th = \frac{L\ x\ i}{f\ x\ n} = \frac{L\ x\ i}{Vf}}$$

Th : Processing Time (minutes)
L : Total Length of Processing Process (mm)
i : Lots of Food
f : Feeding (mm)
n : Cutter Rotation Speed (rpm)
Vf : Feeding Speed ($^{mm}/_{Menit}$)

Calculation:

Final Free Length :

$lu = Cutter\ Length + Free\ Length$

$lu = 19\ mm + 6\ mm$

$\boldsymbol{lu = 25\ mm}$

Length of Work:

$L = l + la + lu$

$L = 3{,}6\ mm + 6\ mm + 25mm$

$\boldsymbol{L = 34{,}6\ mm}$

Processing Time :

$$Th = \frac{L\ x\ i}{f\ x\ n}$$

$$Th = \frac{34{,}6\ mm\ x\ 1}{0{,}01\ mm\ x\ 30000\ rpm}$$

$Th = 0{,}115\ menit \approx 0{,}12\ menit$

$\boldsymbol{Th = 7{,}2\ second}$

So for the process of punching 1 Tube AC Connecting K25G product outside the product setting and cleaning process, it takes a process time of 0.12 minutes or 7.2 seconds.

Material Procurement

Procurement of materials for Holing Machine parts is divided into 2, namely Standard Components and Non-standard Components, here is the explanation:

1. Standard Components

   These Standard Components are obtained by purchasing Components that are already standard sold in the market, these Standard Components do not require another machining process. For the next process, these Standard Components are used directly in the assembly process.

   For a list of Standard Components, see Appendix G-2.

2. Non-Standard Components

   These Non-Standard Components are obtained by purchasing raw materials, then

machining is carried out to obtain the desired shape and function according to the working drawings.

For a list of Non-Standard Components, see Appendix G-1.

Machining Process

This process discusses non-standard components, this machining process includes, stages of the machining process, Operational Plan (OP) and Quality Control (QC) process. The following is an explanation of each stage of the machining process.

1. Stages of the Machining Process

The following is an example of the stages of the machining process used in the manufacture of Holing Machine components, namely the Product Retaining Pin.

Table 4. Scheme of stages in the process of making Product Retaining Pins

NO	NO PART	NAMA PART	TAHAPAN PROSES PENGERJAAN					
			1	2	3	4	5	6
7	PART 06	Pin Penahan Produk	BU	CW	KB1	BO	LS	QC

Description of Process Stages:

BU: Lathe

CW: Cutting Wheels

KB: Bench Work (Deburred)

BO: Drill

LS: Welding

QC: Quality Control

For the scheme of the process stages of each part, see attachment G-3.

2. Operational plan (OP)

Operation plan (OP) is a machining process planning operation that is useful for facilitating the material processing system to become components regularly and precisely, Operational Plan (OP) is made to minimize errors that can occur in material processing.

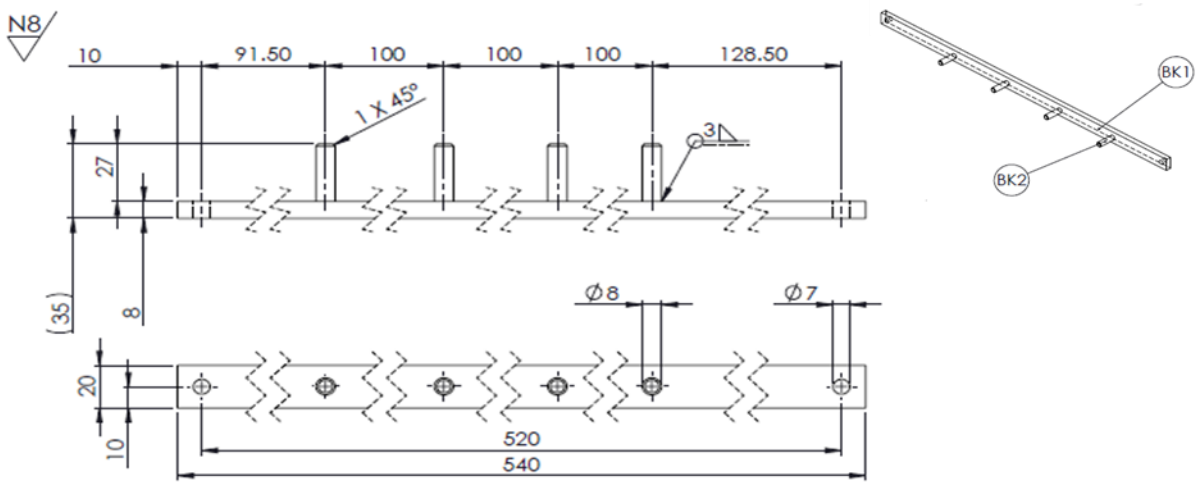
The following is an example of an Operation Plan (OP) for a Holing Machine component, namely the Product Retaining Pin.

Table 5. Operational Plan (OP) Product Retaining Pin

OPERATIONAL PLAN

Nama part	: Pin Penahan Produk	Material	: S50C
No. Part	: Part 06	Dimensi Material	:
Jumlah	: 1 pcs		
Gambar Kerja	:		

IKP



No		Proses	TC	TNC
101		Pelajari gambar kerja dan periksa material.		2.00
102		Setting mesin bubut		15.00
104		Cekam BK2 dengan chuck		2.00
105	N8	Bubut facing asal rata	0.38	
110	N8	Bubut memanjang hingga Ø8 mm	1.28	
204		Cekam balik BK2		2.00
205	N8	Bubut memanjang hingga Ø8 mm	1.28	
210	N8	Bubut Facing hingga panjang 27mm	0.76	
215	N8	Chamfer BK2 1x45°	0.29	
301		Periksa BK2		3.00
Total waktu pemesinan			4.00	24.00
Waktu total pembuatan 1 komponen BK2 (Th BK2 = Tc + Tnc)			28.00	
Waktu total pembuatan 4 komponen BK2 (Th BK2 = Tc + Tnc) x 4			112.00	
302		Setting Cutting Wheels		5.00
303		Marking plat 540x20x8 mm untuk proses pemotongan (BK1)		3.00
305	N8	Potong plat sesuai marking 540x20x8 mm	2.00	
402		Siapkan gerinda tangan		1.00
405	N8	Finishing hasil pemotongan dengan gerinda tangan	10.00	
501		Periksa BK1		3.00
502		Setting mesin bor		15.00
503		Marking BK1 untuk proses bor		2.00
504		Cekam BK1 untuk proses bor		2.00
505	N8	Centre drill BK1 sesuai marking	0.42	
510	N8	Bor tembus 2 lubang Ø7 mm	1.81	
601		Periksa BK1		3.00
602		Setting mesin las		10.00
603		Marking BK1 untuk proses las		3.00
605		Las 4 BK2 ke BK1 sesuai dengan posisi marking	1.00	
701		Periksa benda kerja		5.00
Total waktu pemesinan			15.24	52.00
Waktu total pembuatan komponen BK1 (Th BK1 = Tc + Tnc)			67.24	
Waktu total pembuatan komponen (Th = Th BK1 + Th BK2)			179.24	

For the complete component Operation Plan (OP) can be seen in Appendix B

3. Quality Control (QC)

Quality control (QC) is carried out after the machining process or component processing is complete. Quality Control (QC) is carried out to re-check the components to ensure they are in accordance with the specifications of the predetermined working drawings.

The following is an example of a checksheet for checking the Product Retaining Pin component on the Holing Machine:

Table 6. Product Retaining Pin Quality Control (QC) Form

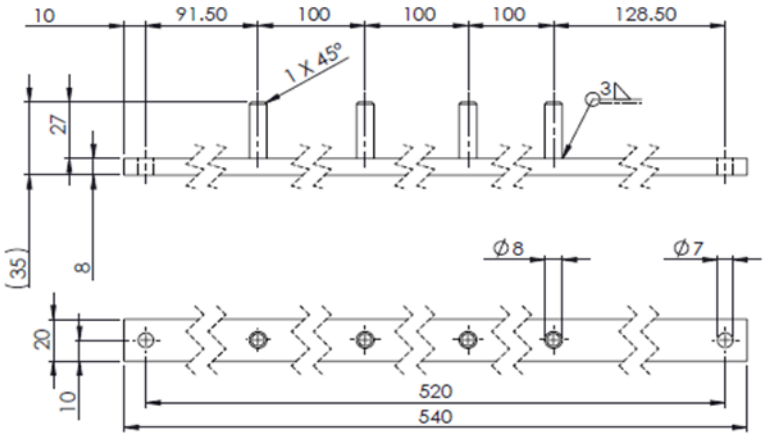
Nomor I.S : Halaman : /

IKP
A Member of ASTRA Otoparts Group

INSPECTION SHEET

Kode Mold	-	Jenis Mold	-			
No. Mesin	-	Kode Kompound	-			
Group	-	Cavity / Sample	-			
Change level	-	Area / shift	-			
No.Eng.Change	-	Lokasi Inspeksi	-			
Pelanggan	-					
☐	Item baru	☐	Sub Kont	☐	Pindah mesin	
☐	Mold baru	☐	Awal prod	☐	Cleaning mold	
☐	Perbaikan mold	☐	Akhir prod	☐	Inspeksi ulang	

Kode Produk	Nama Produk	Nomor Produk
-	PIN PENAHAN PRODUK	PART 06



NO	Item Inspeksi	Nama Alat	Kode Alat	S.C	Std	Tol ±	NOMOR SAMPLE 1	2	3	4	5	6	7	8	9	10	Rata-rata	Range	Hasil
1	Jarak	Caliper			35	±0,2	*34.9*												*OK*
2	Jarak	Caliper			27	±0,1	*26.9*												*OK*
3	Jarak	Caliper			8	±0,1	*8*												*OK*
4	Jarak	Caliper			10	±0,1	*10*												*OK*
5	Jarak	Caliper			91.5	±0,2	*91.5*												*OK*
6	Jarak	Caliper			100	±0,2	*100*												*OK*
7	Jarak	Caliper			100	±0,2	*100*												*OK*
8	Jarak	Caliper			100	±0,2	*100*												*OK*
9	Jarak	Caliper			128.5	±0,3	128.5												*OK*
10	Jarak	Rol Meter			540	±0,4	*540*												*OK*
11	Jarak	Rol Meter			520	±0,4	*520*												*OK*
12	Jarak	Caliper			20	±0,1	*20*												*OK*
13	Jarak	Caliper			10	±0,1	*10*												*OK*
14	Diameter	Caliper			8	±0,1	*8*												*OK*
15	Diameter	Caliper			7	±0,1	*7.1*												*OK*

Note :

	Disetujui	Diinspeksi
Tanda Tangan		
Nama	Tino	Deri

	Tgl	Ttd / Nama	Revisi	Tanggal	Ttd/Nama	Keputusan
Dibuat	22/07/14	*Salman*				OK / NG
Dicheck		*Rizki*				
Disetujui		*Deddy R.*				

Keterangan : S.C = Special Characteristic

The Quality Control (QC) form above explains the inspection items that are measured and the measuring instruments used to measure the inspection items. There is a column for the standard dimensions of the inspection items, a column for the tolerances allowed for the inspection items, and a column for the actual measurement results that have been carried out on the inspection items. From the actual measurement results, the Quality Control (QC) results for the inspection items are obtained in the form of an OK or NG decision.

For the complete component Quality Control (QC) Form, see Appendix C.

4. Assembly Process

The Assembly Process is an activity to combine all components and is assisted by binding elements, so that they become a single unit and have a certain function.

The following are the stages of the Assembly Holing Machine process:

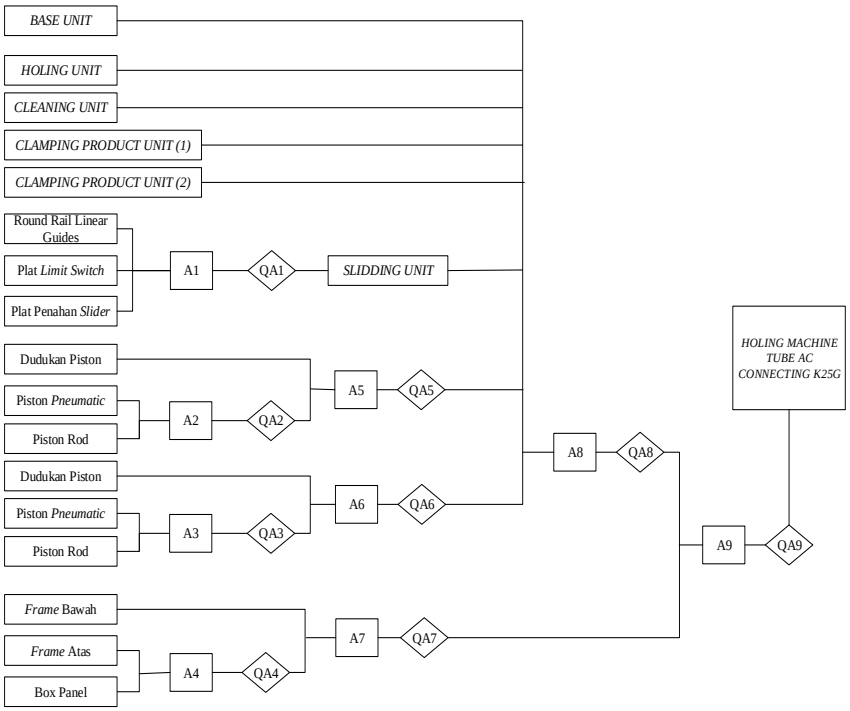


Figure 6. Holing Machine assembly process diagram

Table 7. Quality Assembly (QA) Holing Machine

No	Quality Assembly	Splicing Method	Target Assembly	Results
1	QA1	Bolt	Limit Switch Plate and Slider Holder Plate are mounted perpendicular to the Round Rail Linear Guides.	The Limit Switch Plate and Slider Holder Plate are mounted perpendicular to the Round Rail Linear Guides.
2	QA2	Bolt	Firmly Mounted	The piston rod is firmly attached to the Pneumatic Piston
3	QA3	Bolt	Firmly Mounted	The piston rod is firmly attached to the Pneumatic Piston
4	QA4	Bolt	Firmly Mounted	firmly installed Upper

				Frame Holing Machine.
5	QA5	Bolt	Firmly Mounted and perpendicular to the installed Pneumatic Piston.	Pneumatic Piston Mounted firmly and perpendicularly on the piston seat
6	QA6	Bolt	Firmly Mounted and perpendicular to the installed Pneumatic Piston.	Pneumatic Piston Mounted firmly and perpendicularly on the piston seat
7	QA7	Bolt	Firmly Mounted.	The Upper Frame is firmly attached to the lower frame of the Holing Machine.
8	QA8	Bolt	Parts are Firmly Mounted on the Base Unit	The parts or units of the Holing Machine are firmly attached to the Holing Machine base unit.
9	QA9	Weld	Base Unit is Firmly Mounted on the Unit Frame and in Line.	The base unit is mounted firmly and parallel to the Holing Machine unit frame.

For a complete diagram of the Holing Machine assembly process, please see Appendix D.

Trial

After the machine is finished being assembled, the next step is a trial to check whether the machine is functioning properly or not. The following are the stages of the trial process carried out.

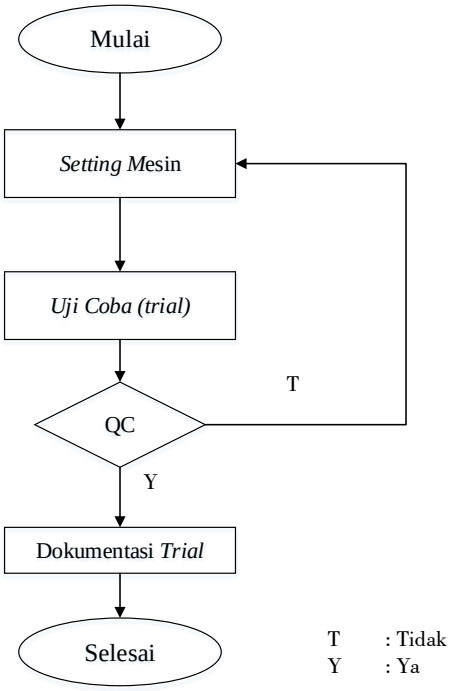


Diagram 7. Trial diagram of Holing Machine

Table 8. Explanation of Holing Machine trial diagram

Stages	Explanation
Machine Setting	Before conducting a trial, first set the position of the electrical die grinder with the holing unit; Make sure the position of the product is properly installed on the clamping product unit.
Trial	The product position is installed correctly on each clamping product unit holder; Turn on the Holing Machine and observe the hole-punching process on each product that has been gripped; Make sure the rotation of the electrical die grinder is not hampered or stopped when performing the hole-punching process.
Quality Control (QC)	Check the product resulting from the trial process by measuring the dimensions of the resulting hole diameter and the hole position on the product (see table 3.9).
Trial Documentation	Document the trial process results data, either in the form of written data or image data from the trial process.

This Holing Machine trial was conducted to test the performance of the Holing Machine in terms of the dimensions and position of the holes produced on the Tube AC Connecting K25G product by the Holing Machine and to ensure that the condition of the holes produced is close to

uniform. The target holes produced can be seen in Figure 8.

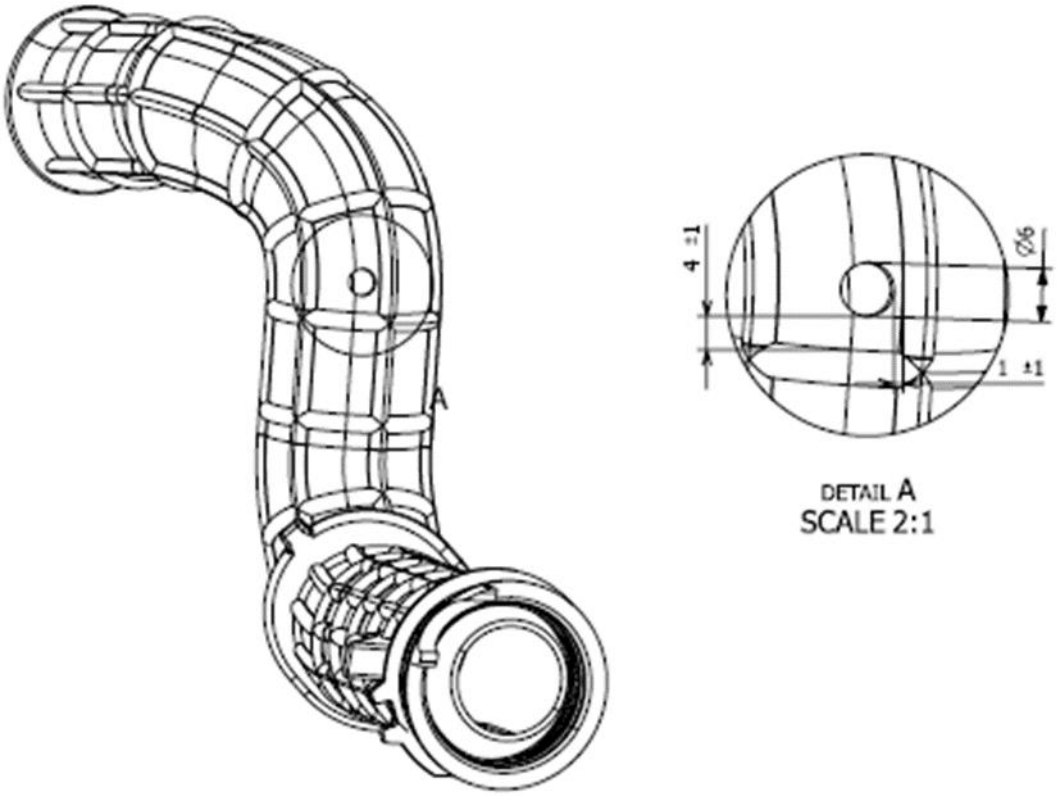


Figure 8. Dimensions and hole distances on the Tube AC Connecting K25G product

Information	Dimensions (MM)	Tolerance (MM)
Hole Diameter	6	0.4
Distance I	4	1
Distance II	1	1

1. Trial Result Data

Trial result data is data taken from the Holing Machine trial process that has been carried out. The Holing Machine trial result data is obtained by conducting a trial of perforating several Tube AC Connecting K25G products, then on the trial product, the Quality Control (QC) process is carried out in the form of measuring the dimensions of the holes and the position of the holes on the Tube AC Connecting K25G product. For this trial result data, there are 2 data, namely the trial result data carried out during the trial process and the trial data carried out by the Quality Control (QC) section after the trial process. The following is the measurement data for the Tube AC Connecting K25G product carried out during the Holing Machine trial process:

Table 9. Measurement results data for the Tube AC Connecting K25G product during the trial

Position	1	2	3	Visual Measurement Process
Dimension	6.00	4.00	1.00	
Upper Limit	6.40	5.00	2.00	
Lower Limit	5.60	3.00	0.00	
No. Sample :				
1	6.10	3	1	
2	6.04	5	1	
3	5.90	4	1.5	
4	6.00	3	1.5	
5	5.96	4	1	
6	6.30	4	2	
7	6.10	5	1	
8	5.86	4.5	1	
9	5.90	4	1	
10	6.10	5	1	
11	5.80	4	1	
12	6.34	5	2	
13	6.08	4.5	1	
14	5.90	4	1	
15	6.20	3	2	
16	6.16	4	1	

The table above contains measurement data on 12 samples of Tube AC Connecting K25G products used in the trial process. In the table above, Position 1 shows the dimensions of the holes in the Tube AC Connecting K25G product, while positions 2 and 3 show the distance between the holes in the Tube AC Connecting K25G product. In the table above, there are rows of upper and lower limits which are the size tolerances to decide whether the measurement results are OK or NG (Not Good). The following is the measurement data for the Tube AC Connecting K25G product carried out by the Quality Control (QC) department after the trial process.

Table 10. Measurement results data of Tube AC Connecting K25G product by Quality Control (QC)

IKP	DATA Cp & Cpk (N=30)					PT. Indokarlo Perkasa			Judgement	
						Approved	Checked	Prepared		
Pelanggan	PT. ROKI INDONESIA								OK	NG
Part Name	TUBE AIR/ C CONNECTING									
Part Number	17253-K50-T000							04/12/14		
Portion	1	2	3							
Dimension	Ø6	4,00	1,00							
Tolerance	6,40	5,00	2,00							
	5,60	3,00	0,00							
1	6,07	3,99	0,45							
2	6,00	3,42	0,91							
3	5,90	3,37	1,63							
4	6,04	4,21	1,54							
5	5,87	3,70	0,57							
6	6,05	3,18	0,38							
7	6,06	4,21	0,95							
8	6,08	3,70	1,38							
9	6,07	3,95	1,29							
10	5,98	4,64	1,69							
11	6,12	3,58	1,97							
12	6,04	3,78	2,00							
13	6,06	3,45	1,33							
14	5,98	3,82	1,58							
15	6,08	3,85	1,68							
16	6,09	3,62	1,07							
17	5,98	4,21	1,72							
18	6,18	4,08	1,02							
19	6,09	3,22	1,40							
20	6,07	3,88	1,46							
21	6,08	3,94	0,84							
22	5,90	3,53	1,03							
23	6,11	4,59	1,18							
24	6,08	4,64	1,58							
25	5,85	3,45	1,47							
26	5,87	3,71	1,85							
27	5,99	3,99	1,11							
28	6,00	4,42	1,83							
29	5,90	4,43	1,80							
30	6,02	4,62	1,10							

In the table above, Position 1 shows the dimensions of the holes in the Tube AC Connecting K25G product, while position 2 and position 3 show the distance of the holes in the Tube AC Connecting K25G product. While numbers 1 to 30 show samples of the Tube AC Connecting K25G product. The trial data above is the data from the actual measurement of the Tube AC Connecting K25G product by the Quality Control (QC) department.

RESULT AND DISCUSSION

Estimation is a mathematical calculation method used to estimate the working time and costs that must be incurred in a job or project. In making a Holing Machine, the estimation calculation is used to determine the time and costs required. The stages of calculating the estimated time and cost of making a Holing Machine can be seen from the following flow diagram:

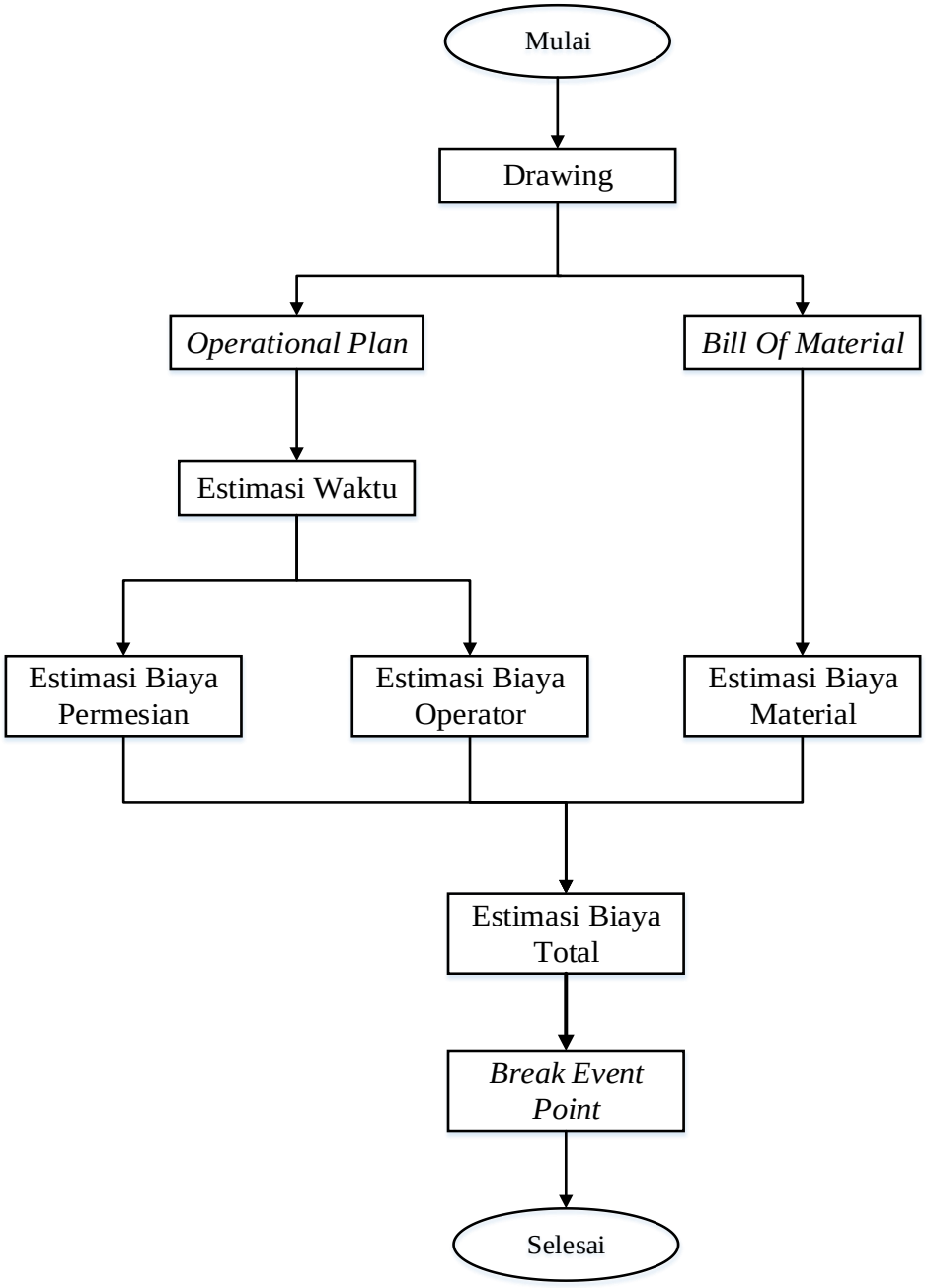


Diagram 9. Time estimation diagram and cost estimation for making Holing Machine

Table 11. Explanation of the diagram of estimated time and estimated cost of making a Holing Machine

No	Process	Explanation
1	Start	Planning and designing the Holing Machine construction concept by engineering staff and industrial engineering staff.
2	Drawing	Creating construction designs and working drawings of the Holing Machine.
3	Operational plan	Planning the process stages for component manufacturing.
4	Time Estimation	Calculating the estimated time required to manufacture the Holing Machine
5	Machining Cost Estimation	Calculating the estimated cost of each machining process used in manufacturing the Holing Machine.
6	Operator Cost Estimation	Calculating the estimated operator costs required for each machining process used in manufacturing the Holing Machine.
7	Bill Of Material	Describing the materials (standard components and non-standard components) that will be used to manufacture the Holing Machine.
8	Material Cost Estimation	Calculating the estimated cost of materials (standard components and non-standard components) required to manufacture the Holing Machine
9	Total Cost Estimation	Calculating the estimated total cost that must be incurred to manufacture the Holing Machine
10	Break Event Point	Calculating the break-even point of product sales to recover the cost of manufacturing the Holing Machine.
11	Finish	The entire sequence of calculating the estimated time and estimated cost of manufacturing the Holing Machine has been passed.

Time Estimation

Based on the operational plan that has been made, the estimated machining process time for various non-standard components of the Holing Machine is obtained. The following are the details of the estimated machining process time and the estimated total time for making the Holing Machine:

Table 12. Holing Machine machining time estimation table

ESTIMASI WAKTU PEMESINAN																					
No	Komponen	QTY	BO		BU		FR		CW		FC		LS		RO		BD		KB		TNC		Total Waktu Part
			TC	TNC	TC	TNC	TC	TNC	TC	TNC	TC	TNC	TC	TNC	TC	TNC	TC	TNC	TC	TNC	SD	QC	
1	Base	1	24.0	48.0	-	-	-	-	-	-	7.0	28.0	-	-	-	-	-	-	140.0	2.0	5.0	45.0	**255.0**
2	Dudukan Piston	1	1.6	21.0	-	-	-	-	14.0	12.0	-	-	2.2	13.0	-	-	-	-	-	-	5.0	9.0	**69.8**
3	Dudukan Piston	1	1.9	27.0	-	-	-	-	11.0	17.0	-	-	1.2	13.0	-	-	-	-	-	-	5.0	17.0	**77.1**
4	Dudukan Penahan Kanan	1	9.6	26.0	-	-	124.8	31.0	-	-	-	-	4.4	13.0	-	-	-	-	15.0	2.0	5.0	31.0	**231.8**
5	Dudukan Penahan Kiri	1	9.6	26.0	-	-	124.8	31.0	-	-	-	-	4.4	13.0	-	-	-	-	15.0	2.0	5.0	31.0	**231.8**
6	Holder Produk Atas	1	5.1	21.0	-	-	-	-	34.0	26.0	-	-	7.4	16.0	-	-	-	29.0	-	-	5.0	35.0	**144.5**
7	Pin Penahan Produk	1	2.2	19.0	16.0	76.0	-	-	12.0	9.0	-	-	1.0	13.0	-	-	-	-	-	-	8.0	23.0	**157.2**
8	Dudukan Shaft Sliding	2	11.8	76.0	-	-	71.49	46.0	-	-	13.6	28.0	2.5	24.0	-	-	-	-	-	-	10.0	36.0	**285.3**
9	Shaft Sliding	2	7.2	32.0	69.5	46.0	-	-	-	-	-	-	-	-	-	-	-	-	20.0	2.0	10.0	34.0	**188.6**
10	Dudukan Plat Holder	1	10.4	22.0	-	-	67.1	31.0	-	-	6.5	14.0	1.6	13.0	-	-	-	-	60.0	2.0	5.0	28.0	**233.6**
11	Plat Holder Bawah	4	4.0	84.0	-	-	-	-	124.0	72.0	-	-	2.4	20.0	-	36.0	-	64.0	-	-	20.0	124.0	**430.4**
12	Plat Holder Atas	4	3.0	64.0	-	-	-	-	108.0	40.0	-	-	-	-	-	36.0	-	48.0		-	20.0	60.0	**323.0**
13	Base	2	11.0	32.0	-	-	59.6	46.0	-	-	-	-	-	-	-	-	-	-	-	-	10.0	22.0	**160.6**
14	Poros Stopper	1	-	-	4.8	19.0	-	-			-	-	-	-	-	-	-	-	-	-	5.0	3.0	**29.8**
15	Sambungan Piston	1	11.0	13.0	-	-	21.6	23.0			-	-	-	-	-	-	-	-	-	-	5.0	11.0	**74.6**
16	Plat Limit Switch	2	22.7	34.0	-	-	-	-	18.0	18.0	-	-	-	-	-	-	-	24.0	-	-	10.0	24.0	**128.7**
17	Plat Penahan Slider	2	10.9	28.0	-	-	-	-	18.0	18.0	-	-	-	-	-	-	-	24.0	-	-	10.0	18.0	**110.9**
18	Base Plat Clamp	1	16.7	16.0	-	-	76.4	31.0	-	-	-	-	-	-	-	-	-	-	-	-	5.0	11.0	**146.1**
19	Plat Clamp	1	-	-	-	-	-	-	25.0	8.0	-	-	2.4	10.0	-	21.0	-	13.0	-	-	5.0	11.0	**85.4**
20	Dudukan	1	19.5	13.0	-	-	55.2	35.0	-	-	-	-	-	-	-	-	-	-	-	-	5.0	14.0	**128.7**
21	Pengunci	1	-	-	-	-	-	-	-	-	10.2	14.0	-	-	-	-	-	-	-	-	5.0	6.0	**30.2**
22	Plat Clamp	1	-	-	-	-	-	-	25.0	8.0	-	-	2.4	5.0	-	21.0	-	13.0	-	-	5.0	11.0	**80.4**
23	Base Plat Clamp	1	6.9	15.0	-	-	83.7	31.0	-	-	-	-	-	-	-	-	-	-	-	-	5.0	11.0	**142.6**
24	Holder Nozzle	4	162.9	140.0	249.5	116.0	-	-	-	-	-	-	-	-	-	-	-	-	160.0	4.0	20.0	64.0	**856.4**
25	Lubang Slider	2	48.9	26.0	-	-	47.8	50.0	-	-	-	-	-	-	-	-	-	-	-	-	10.0	32.0	**184.7**
26	Sambungan Piston	1	3.8	14.0	-	-	22.7	23.0	-	-	-	-	-	-	-	-	-	-	-	-	5.0	9.0	**69.6**
27	Base	1	-	-	-	-	61.2	31.0	-	-	-	-	-	-	-	-	-	-	-	-	5.0	20.0	**98.2**
28	Nozzle Angin	4	241.4	52.0	318.0	116.0	-	-	-	-	-	-	-	-	-	-	-	-	40.0	12.0	20.0	60.0	**803.4**
29	Tuas Pengunci	1	1.0	13.0	23.9	19.0	-	-	-	-	5.5	16.0	0.2	13.0	-	-	-	-	-	-	5.0	17.0	**97.5**
30	Pin Tuas	1	1.2	8.0	6.3	9.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0	8.0	**30.5**
31	Pin Clamp	1	1.2	8.0	8.4	9.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0	8.0	**32.6**
Total waktu			**649.6**	**878.0**	**696.3**	**410.0**	**816.4**	**409.0**	**389.0**	**228.0**	**42.8**	**100.0**	**32.0**	**166.0**	**0.0**	**114.0**	**0.0**	**215.0**	**450.0**	**26.0**	**248.0**	**833.0**	
Total waktu per proses			**1527.6**		**1106.3**		**1225.4**		**617.0**		**142.8**		**198.0**		**114.0**		**215.0**		**476.0**		**1081.0**		
Total Waktu Pengerjaan			**6703.2**																				

The total estimated machining time for making Holing Machine is 6703.2 minutes or 111.72 hours. If the estimated total machining process time is converted into working days, then we get:

$$x \text{ working days} = \frac{total\ machining\ process\ time}{Time\ one\ working\ day\ (Effective)}$$

$$\frac{111.72\ hours}{7.5\ hours/day} = \mathbf{14.9\ days} \approx \mathbf{15\ days}$$

This machining time estimate is the basis for calculating the machine and operator rental costs for the time estimate table in Appendix E.

Cost Estimate

The cost estimate is obtained from the sum of the material cost estimate, machining cost estimate, operator cost estimate, and overhead cost. The following is a description of each stage in determining the cost of making a Holing Machine.

1. Machining Cost Estimate

The machining cost is obtained from the machining time estimate multiplied by the

machine rental price per hour. The machine rate used is the machine rate applicable at PT. Indokarlo Perkasa.

Table 13. Machining cost estimation table

No	Proses	Waktu		Tarif Sewa	Total Biaya
		(menit)	(jam)	(Rp/jam)	(Rp)
1	Bubut	1094.35	18.24	Rp 68,000.00	Rp 1,240,261.26
2	Frais	1225.36	20.42	Rp 60,000.00	Rp 1,225,359.54
3	Bor	1527.64	25.46	Rp 55,000.00	Rp 1,400,332.42
4	*Flame Cutting*	142.83	2.38	Rp 45,000.00	Rp 107,119.19
5	*Cutting Wheels*	617.00	10.28	Rp 37,000.00	Rp 380,483.33
6	Las	61.40	1.02	Rp 45,000.00	Rp 46,050.00
8	*Rolling* mesin	114.00	1.90	Rp 24,000.00	Rp 45,600.00
9	*Bending* mesin	215.00	3.58	Rp 24,000.00	Rp 86,000.00
10	Kerja bangku	476.00	7.93	Rp 20,000.00	Rp 158,666.67
Total Biaya Pemesinan					**Rp 4,689,872.41**

2. Operator cost estimation

Operator cost is obtained by multiplying the total estimated machining time of all components by the operator rate per hour. The operator rate used is the operator rate applicable at PT. Indokarlo Perkasa.

Table 14. Operator cost estimation table

No	Proses	Waktu		Tarif Operator	Total Biaya
		(menit)	(jam)	(Rp/jam)	(Rp)
1	Bubut	1094.35	18.24	Rp 14,500.00	Rp 264,467.48
2	Frais	1225.36	20.42	Rp 14,500.00	Rp 296,128.56
3	Bor	1527.64	25.46	Rp 14,500.00	Rp 369,178.55
4	Flame Cutting	142.83	2.38	Rp 14,500.00	Rp 34,516.18
5	Cutting Wheels	617.00	10.28	Rp 14,500.00	Rp 149,108.33
6	Las listrik	61.40	1.02	Rp 14,500.00	Rp 14,838.33
8	*Rolling* mesin	114.00	1.90	Rp 14,500.00	Rp 27,550.00
9	*Bending* mesin	215.00	3.58	Rp 14,500.00	Rp 51,958.33
10	Kerja bangku	476.00	7.93	Rp 14,500.00	Rp 115,033.33
11	QC	1093.00	18.22	Rp 14,500.00	Rp 264,141.67
Total Biaya Pemesinan					**Rp 1,586,920.76**

3. Material Cost Estimation

Based on the bill of materials that has been created, the following is a calculation of

the price of the manufacturing materials.

Table 15. Holing Machine material cost estimation table

No	Item	Harga	
1	Raw Material	Rp	4,803,791.88
2	Komponen Standar	Rp	10,954,910.00
Total		**Rp**	**15,758,701.88**

4. Estimated Cost of Goods Sold

The manufacturing cost of the Holing Machine is obtained from the sum of the estimated material costs, estimated machining costs, estimated operator costs, and 20% overhead costs.

Table 16. Estimated cost table

No	Item	Biaya	
1	Material	Rp	15,758,701.88
2	Pemesinan	Rp	4,689,872.41
3	Operator	Rp	1,586,920.76
4	Overhead (20%)	Rp	4,407,099.01
Total Biaya		**Rp**	**26,442,594.07**

Percentage Comparison of the Hole Process

This chapter will explain the advantages of the Holing Machine that has been made in terms of the production time of the Tube AC Connecting K25G product and the reduction in the hole process time of the Tube AC Connecting K25G product.

1. Percentage reduction in the production time of the Tube AC Connecting K25G product

Table 17. Product manufacturing process mechanism before using the Holing Machine

Mekanisme proses pembuatan produk *Tube AC connecting K25G*					
No	**Proses**	***Pcs/Cycle***	***Cycle time (second)***	**Produk/*shot***	***Cycle time/shot (second)***
1	*Pressing*	4	360	4	360
2	*Finishing*	1	25	4	100
3	*Marking*	1	30	4	120
4	*Holing*	1	90	4	360
5	*Checking*	1	8.37	4	33.48
Total waktu pembuatan produk/*shot*					**973.48**
Total waktu pembuatan produk/*pcs*					**243.37**

Table 18. Product manufacturing process mechanism after using the Holing Machine

Mekanisme proses pembuatan produk *Tube AC connecting K25G*					
No	**Proses**	***Pcs/Cycle***	***Cycle time (second)***	**Produk/*shot***	***Cycle time/shot (second)***
1	*Pressing*	4	360	4	360
2	*Finishing*	1	25	4	100
3	*Marking*	-	-	-	-
4	*Holing*	4	180	4	180
5	*Checking*	1	8.37	4	33.48
Total waktu pembuatan produk/*shot*					**673.48**
Total waktu pembuatan produk/*pcs*					**168.37**

In table 16 and table 17 above, it can be seen that there are changes in the stages of the Tube AC Connecting K25G product manufacturing process where after using the Holing Machine, the product marking process is no longer needed because the hole position has been set on the Holing Machine. In addition, the presence of this Holing Machine also reduces the process time for making Tube AC Connecting K25G products from the previous 243.37 second/pcs to 168.37 second/pcs.

Based on the data in table 16 and table 17, the percentage reduction in the process time for making Tube AC Connecting K25G products is as follows:

Percentage reduction in the process time for making Tube AC Connecting K25G products = [process time before using the Holing Machine (Original value) - process time after using the Holing Machine (Reduction value)] / process time before using the Holing Machine (Original value) x 100%

$$= \frac{[243.37 - 168.37]}{243.37} \; x \; 100\%$$

$$= 30.81\ \%$$

2. Percentage reduction in product punching process time waste

Based on the data in table 16 and table 17 above, the following data were obtained:

1. Before using the Holing Machine
   - Marking process time : 120 *second/shot*
   - Holing process time : 360 *second/shot*
   - Total product manufacturing time : 973.48 *second/shot*
2. After using the Holing Machine
   - Marking process time : -
   - Holing process time : 180 *second/shot*
   - Total product manufacturing time : 673.48 *second/shot*

The punching process of Tube AC Connecting K25G products includes the marking process and the holing process. From the data above, the Percentage of the punching process time of Tube AC Connecting K25G products will be obtained before and after using the Holing Machine:

Percentage of the punching process time of Tube AC Connecting K25G products = [Punching process time] / Total product manufacturing time x 100%

Before using the Holing Machine:

$$= \frac{480}{973.48}\ x\ 100\%$$
$$= 49.31\ \%$$

After using Holing Machine:

$$= \frac{180}{673.48}\ x\ 100\%$$
$$= 26.72\ \%$$

So from the calculation above, the percentage of reduction in wasted time in the hole making process on the Tube AC Connecting K25G product is obtained as follows: Percentage reduction in hole making process time = Percentage of hole making time before using the Holing Machine - Percentage of hole making time after using the Holing Machine.

$$= 49.31\ \% - 26.72\%$$
$$= 22.59\%$$

With this Holing Machine, there is a decrease in the hole making process time on the Tube AC Connecting K25G product by 22.59% from previously requiring 49.31% of the total product making process time to 26.72% of the total product making process time.

3. Break Event Point (BEP)

Break Event Point (BEP) is the break-even point where the amount of income and costs incurred are the same or balanced so that there is no profit or loss.

The following is the calculation of the Break Event Point (BEP) for making the Holing Machine:

Description:

Cost of making holing machine	: Rp. 26,442,594.07
Product selling price per piece	: Rp. 4,500.-
Total product demand	: 30000 pcs
Product demand per month	: 2500 pcs

$$Break\ Event\ Point\ (BEP) = \frac{Total\ Cost\ of\ Machine\ Manufacturing}{Product\ Selling\ Price}$$

$$= \frac{\text{Rp.26,442,594.07}}{\text{Rp.4,500.}-}$$

$$= \mathbf{5876.132\ pcs} \approx \mathbf{5877}\ \boldsymbol{pcs}$$

When converted to time, it can be calculated by:

$$Time = \frac{BEP}{Product\ demand\ per\ month}$$

$$= \frac{5877\ pcs}{2500^{pcs}/_{month}}$$

$$= \mathbf{2.4\ months} \approx \mathbf{3\ months}$$

From the calculation above, the Break Event Point (BEP) for making Holing Machine occurs after selling 5877 products and the time required is 3 months. The company will start to make a profit after passing the 3rd month of selling Tube AC Connecting K25G products. The Break Event Point (BEP) above is only calculated from the selling price of the product and the price of making Holing Machine by ignoring other variables that affect it because this calculation only focuses on the break-even point of making Holing Machine, not the overall production process.

CONCLUSION

Based on the results of the discussion, it can be concluded that the manufacture of Holing Machine to support the process of making holes in the Tube AC Connecting K25G product goes through several important stages. The process begins with planning the manufacture of the machine, selecting materials, and continued with machining processes such as lathes, milling, drilling, and cutting with flame cutting. The fabrication process includes welding, rolling, and bending, followed by assembly and machine testing. After each component is completed, quality control is carried out to ensure compliance with specifications. The estimated time to manufacture the Holing Machine is around 6703.2 minutes (111.72 hours), with an estimated cost of Rp 26,442,594.07. A comparison between the production process before and after using this machine shows a significant increase in efficiency. The production time for the Tube AC Connecting K25G product was reduced by 30.81%, from 243.37 seconds per unit to 168.37 seconds per unit. Likewise, the time to make holes in the product, which experienced a decrease in time of 22.59%, from 120 seconds to only 45 seconds.

Break Even Point (BEP) for Holing Machine is estimated to be achieved after the sale of 5877 units of Tube AC Connecting K25G, or about three months, if converted in time.

Some suggestions that can be given to improve the effectiveness and efficiency of making Holing Machines and the production process of Tube AC Connecting K25G products are as follows:

First, to minimize errors in the component manufacturing process, it is recommended that companies prepare a detailed process stage form. This will help avoid negligence and ensure that each step is carried out correctly in the specified order.

Second, it is recommended to add a vacuum system to the top of the Holing Machine to suck up dust from cutting Tube AC Connecting K25G products. This is important so that dust does not interfere with machine components, especially the electrical die grinder, which can be contaminated and damaged.

Third, greater attention needs to be paid to providing spare components for the Holing Machine, especially for standard components such as electrical die grinders and tungsten carbide (baby grinders). These components are susceptible to damage and require sufficient supplies to maintain smooth operations.

Fourth, to make production process time more efficient, it is recommended that companies consider making additional Holing Machines with some improvements to the components or parts. One of them is the improvement of the electrical die grinder holder component found in the holing machine unit, to improve performance and speed up the manufacturing process of the Tube AC Connecting K25G product.

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