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WORD COUNT

334 Words

CHARACTER COUNT

22892 Characters

PAGE COUNT

6 Pages

FILE SIZE

565.9KB

SUBMISSION DATE

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Time and Cost Efficiency Analysis of Quick Die Change System on Metal Stamping Industry

Rudi Kurniawan Arief

Abstract—Manufacturing cost and setup time are the hot topics to improve in Metal Stamping industry because material and components price are always rising up while customer requires to cut down the component price year by year. The Single Minute Exchange of Die (SMED) is one of many methods to reduce waste in stamping industry. The Japanese Quick Die Change (QDC) dies system is one of SMED systems that could reduce both of setup time and manufacturing cost. However, this system is rarely used in stamping industries. This paper will analyze how deep the QDC dies system could reduce setup time and the manufacturing cost. The research is conducted by direct observation, simulating and comparing of QDC dies system with conventional dies system. In this research, we found that the QDC dies system could save up to 35% of manufacturing cost and reduce 70% of setup times. This simulation proved that the QDC die system is effective for cost reduction but must be applied in several parallel production processes.

Keywords—Press die, metal stamping, quick die change, QDC system, single minute exchange die, manufacturing cost saving, SMED.

I. INTRODUCTION

In a metal stamping companies, dies installation process is one of the biggest waste. While stamping process can produce hundreds of parts in an hour, the setup process itself may take 30 to 60 minutes due to size and the complexity of the dies. Quick Die Change (QDC) or also called SMED is one of the methods used to reduce some waste in stamping process [9].

QDC provides high efficiency in continuous production with fast changeover from one product to another. QDC system could improve the setup time quicker to below 10 minutes or half of the time use to set up. The implementation of the QDC system could reduce set up time, manufacturing time and cost significantly. So, this system could be the best key to efficiency.

II. LITERATURE REVIEW

A. QDC Methods

Shigeo Shingo was invented the SMED system from years of experience and experiments. The first concept of SMED was started where bottleneck in large body pressed production happened at Toyo Kogo's Mazda plant during spring of 1950. The problems reduced by making a clear concept of activity between the time of internal setup (IED) and external setup (OED) so the activity time can be managed and reduced. In summer 1957, a low production capacity problem happened in Mitsubishi Heavy Industry Shipyard Company. The idea of

using a second planner table to set up dies in queue come after some research and observation and this increase 40% of the production capacity. By 1969, Shingo then helped Toyota Motor Company to reduce setup time of 1000 tons machine from 4 long hours to only 90 minutes. Then after three extra months of struggling then the setup time fall down to 3 minutes as Toyota's management challenge is completely achieved. This SMED system is based on theory and years of practical experimentation and this scientific approach can be applied in any factory to any machine [8].

B. Manufactured Die Components

Regular construction of conventional die unit usually consists of several components that assembly together to become a die unit or die set. Die set components consist of 2 categories; manufactured parts and standard purchased parts [10].

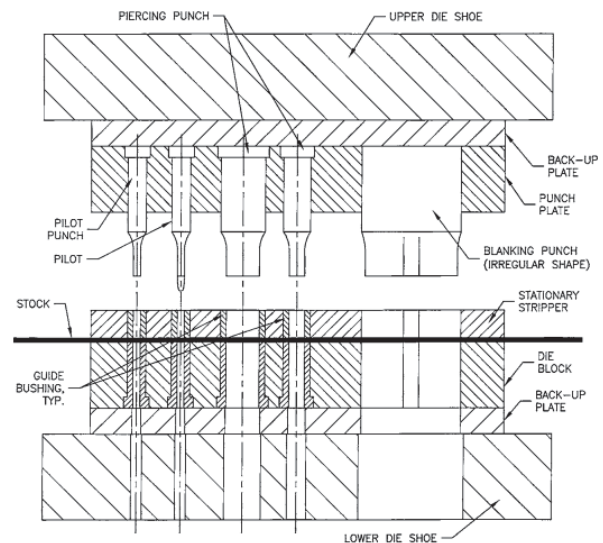


Fig. 1 Die Set with Stationary Stripper [1]

Manufactured components are die components that have unique shape and dimensions than need to be manufactured. This will involve some machinery process from simple mills to C.N.C and wire-cutting process.

1. Upper Plate (Upper Die Shoe)

This is the upper part of the die that use to clamped the die unit into machine's upper block.. This plate held all the upper

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components and the guide posts together. Upper plate made of mild steel such SS400 or equivalent. Both of surface smoothly machined or grind. This component clamp to the machine's Ram directly by clamping device or thru Shank for small die units. Shank itself usually use to clamp the upper unit to Ram and to centering the die.

2. Backup Plate

This is the protector component, to hold the force transmitted from the punch during working. Piercing punch usually small in size or diameter could make a sink hole because of the pressure force to a mild steel. As the function as a backing, this component has to be stronger than the upper plate but milder than the punch material, S45C or equivalent often used. Usually backup plate is using for piercing die which consist of several small punches but unnecessary to blanking process which have a large size punch.

3. Punch Plate

A blanking punch with big dimension usually taken directly from the die plate after cut by wire cutting machine, in this situation the function of punch plate becoming a raiser plate to add the thickness of punch to fit the overall construction to the machine. For regular shaped piercing, it uses to hold the punched by it'd neck since no threat available to hold it. The punch plate made of mild steel or medium strength steel such as S45C or equivalent will be better.

4. Punch

Punch together with Die are the main and basic components to build the Die unit construction. Without these pairs, there would be no process happens in this unit. Punches is manufactured precisely to fit the shaped hole of die, not just the clearance but also the alignment. Small misalignment will produce reject part with high burrs, huge misalignment will destroy the shapes of punch and dies. Small clearance will shorten tool's life and loose clearance means we have to manufacture a new one. Regular shaped punches usually available as purchased parts in the market, while irregular shapes must be manufactured. This punch is made of tool steel and hardened after machining to have a high strength. These punches then assembled to punch plate (punch holder).

5. Stripper Plate

This manufactured component is to eject the strip plate out of the punches after being stamped. With this component the strip plate prevented to dragged upwards by the upper die unit. There are two types of this Stripper plate; fixed / stationery type (as shown in Fig. 1) and moving / spring stripper (Fig. 1). Moving type usually use for thin and light force process, coil springs or urethane rubbers are used to eject strip plate. Fixed type is usually used for a thick and heavy plate where springs are no longer efficient to eject the strips.

6. Die

Die block is in the manufactured components category. This made of tool steel that hardened after machined. Same as punch, dies with standard regular shape also available in the market as

purchased parts, called button dies. Irregular shaped dies usually manufactured after hardened by wire cutting machine. Cutting surface of dies have a straight surface called "land" which can be grinded for several re-sharpening. Below "land" surface shape become wider making a 2^0 tapered surface for the scraps easy to escape. Punch and die that acted as cutting side made of hardened tool steel such as SKD-11, DC-53 or equivalent [5]. This component then hardened to 58-62 HRC for increasing cutting ability and wear resistant.

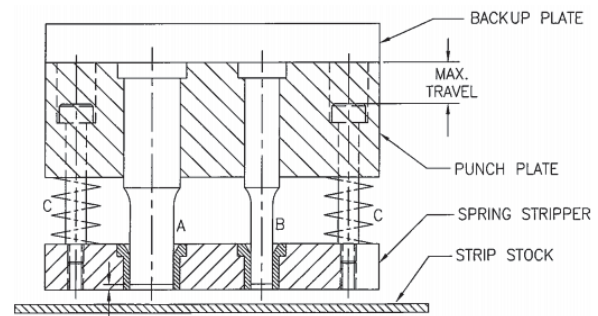


Fig. 2 Spring type stripper [1]

7. Base Plate (Lower Die Shoe)

Base plate is the lower part of die unit wick clamped to the machine's bed. This plate held all the upper components and the guide posts together. Lower dies shoe (base plate) plate made of mild steel such SS400 or equivalent.

C. Purchased Die Components

Purchased components mainly available in the market with various specification to choose. Most of the parts are mass production parts that unnecessary to manufacture.

1. Springs

Main function of spring is to eject the strip plate in order to avoid it to get stuck to the punch. Spring must be well arranged to keep balance for the ejecting force well distribute. For small force and low production quantity, urethane springs could be use. For longer use and high production rates coil spring is the best choice.

2. Pilots

For dies with multiple process, accuracy in each step of the process is vital. Pilots will guide the strip plate to be precise during the process.

3. Guide Posts

Many kind forces applied to die construction during the process, therefor a guiding device is needed to protect from any misalignment factors. Overall, the die is guided and protected against a movement, shift, or thrust, by its own guiding system [1]. This guiding unit called guide post, consists of guide bushings attached to the upper and base plate, and a guiding pin attached to the guide post at the lower positions. Basically, guiding arrangements are of two kinds: the first is that where the pin slides over a ball-bearing-lined guide bushing, in the second, the pin is sliding in a plain-surface-bearing [1].

With the rapid development of technology there are more

components than can be applied to the dies construction. Those mention above are generally main components that must be available for a die unit to be able to work properly. But too complicated components will cost high and require more setup time [2].



Fig. 3 Conventional die unit (courtesy of PT.SPI)

The QDC system also have those kind of components, but QDC can reduce manufacturing cost for die unit due to its common use. This paper will show how QDC will reduce manufacturing cost for investing die unit.

D. The QDC System

The QDC / SMED system is the result of adopting the Just in Time (JIT) manufacturing system. JIT require precise quantity of production, precision quality, precise delivery time and precise time of production. Long period of die set up time will lead to a fall of JIT system. The QDC / SMED was introduced about decade ago and become a solution for reducing this set up time in most stamping shop [6]. Some benefits of QDC/SMED systems are:

- Reduced production cost
- Reduced die manufacturing cost
- Reduced inventory space
- Increase productivity
- Increase process flexibility

Basic concept of QDC is avoiding or reducing the IED and move it to OED so the preparation can be done while production in process. But with this stamping QDC system even external process also reduced. By this system the setup process can reduce under 10 minutes (single digit minute).

1. QDC Unit

The QDC Unit is the physical system that build thru manufacturing process as the application of QDC system. This system combining of two parts, housing system and die system. punch and die will manufacture separately to be inserted to completed this unit. The die inserts are exchangeable (as shown in Fig. 5), this will reduce manufacturing and purchased cost for base and upper plate, guide bushings, etc. This also reduce along setup time.

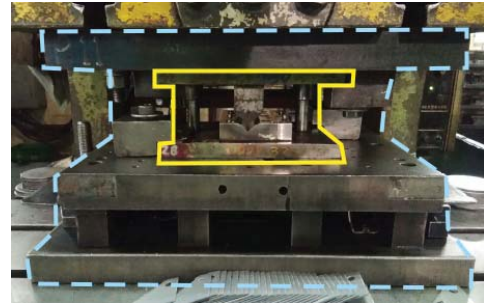


Fig. 4 QDC Unit (courtesy of PT.SPI)

2. QDC Housing

Mostly all the components are the same as the conventional die with the absence of punch and dies. The punch and dies systems will be inserted into this QDC housing (Fig. 5.)



Fig. 5 QDC Housing (courtesy of PT.SPI)

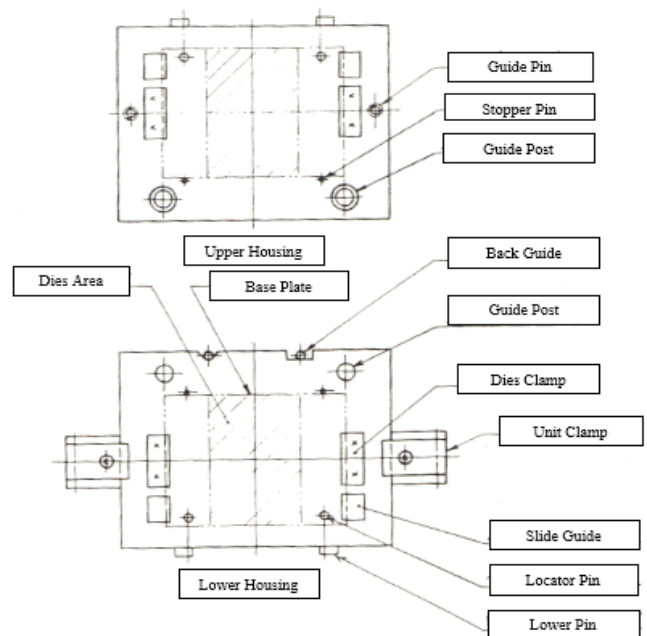


Fig. 6 Design of QDC Housing [4]

3. QDC Die

Due to the big size of the stamping press machine, some die unit have to build bigger than it should be this will cost a lot for nothing. QDC die is a small and compact construction of dies that will be inserted to the QDC Unit. We can also say that this

is the mini and yet simple version of conventional die unit.



Fig. 7 QDC Die (courtesy of PT.SPI)

III. METHODOLOGY

This research using direct observation and interview with the machine operator and supervisor at PT.SPI near Jakarta, Indonesia. This company has been implemented QDC die system for almost 10 years that adopted from Japan's head office.

IV. EFFICIENCY ANALYSIS OF QDC

In term of manufacturing cost, the QDC Unit might be a little bit expensive than conventional unit, but for long term investment it far economical than conventional die unit. This chapter will analyze the comparison of QDC unit and Conventional Die Unit in term of cost. Purchase, manufacturing and material costs will be the subject to analyze

A. Manufacturing Cost Efficiencies

The QDC unit consist of 2 main assembly, the die unit and the QDC housing. The die unit is exchangeable so the QDC unit might be use for some different die unit. Fig .5 shows the components of assembled QDC Unit.

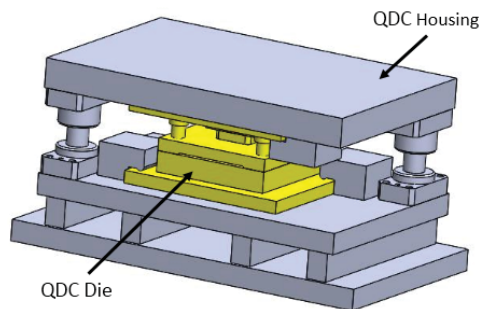


Fig. 8 QDC Unit

By breaking down the components of QDC we can analyze the cost that spend for manufacturing and then make the comparison analyzed on both type of die unit. The comparison tables below taken by simulated a blanking die with 3D software. The price of purchased parts taken from MISUMI catalogue by converting the currency from Japanese Yen to Indonesian Rupiah, machining rates refer to a Japan owned manufacturing company's rate in Bekasi. The prices below may not accurate and only for comparison purpose. Below is

manufacturing cost needed to manufacture a QDC die that will inserted to QDC housing for stamping process.

TABLE I
TABLE OF MATERIAL COST FOR QDC

No	Components	Weight	Material	Price (IDR)	Material Cost (IDR)
1	Upper Plate	0,6 Kg	SS400	9.500	5.700
2	Backing Plate	0,1 Kg	S45C	45.000	4.500
3	Stripper	0,25 Kg	S45C	45.000	11.250
4	Punch & Die Plate	0,45 Kg	SKD45	60.000	27.000
5	Base Plate	0,6 Kg	SS400	9.500	5.700
Total Material Cost (A)					54.150

TABLE II
TABLE OF PURCHASED COMPONENTS COST FOR QDC

No	Components	Qty	Price @ (IDR)	Parts Cost (IDR)
1	Guide pin	4	66.640	266.560
2	Guide bush	4	79.730	318.920
3	Bolt M8	16	714	11.424
4	Bolt M16	4	5.950	23.800
5	Dowel pin	6	3.213	19.278
Total Purchased Cost (B)				639.982

TABLE III
TABLE OF MACHINERY COST FOR QDC

No	Process	Unit	Machine Rates (IDR)	Costs (IDR)
10	Wire cut	11.520 mm	45	518.400
11	Milling	12 h	47.300	567.600
12	Grinding	6 h	65.000	390.000
13	Radial Drill	8 h	40.500	324.000
14	Heat treatment	0,45 Kg	60.000	27.000
15	Assembly	3 h	30.750	92.250
Total Machining Cost (C)				1.919.250

Total Manufacturing Process for QDC die are Material Cost + Components Cost + Manufacturing Cost = 54.150 + 639.982 + 1.919.250 = 2.613.382 (currency in IDR)

Usually QDC Housing will set for a serial process of metal stamping. If a process finished, then the inserted QDC dies will be replace by another while QDC housing are remains installed. Here's manufacturing cost for the housing.

TABLE IV
TABLE OF MATERIAL COST FOR QDC HOUSING

No	Components	Weight	Material	Price (IDR)	Material Cost (IDR)
1	Upper Plate	3,6 Kg	SS400	9.500	34.200
2	Clamp Block	0,6 Kg	S45C	45.000	27.000
3	Base Plate	2,5 Kg	SS400	9.500	23.750
4	Raiser	0,9 Kg	SS400	9.500	8.360
5	Lower Plate	3 Kg	SS400	9.500	28.500
Total Material Cost (A)					121.810

Total Manufacturing Process for QDC housing are: Material Cost + Components Cost + Manufacturing Cost = 121.810 + 541.688 + 1.628.150 = 2.281.648 (currency in IDR). Manufacturing cost of QDC Housing is relatively small because no expensive material (tool steel) and no precision machinery like wire cut required.

TABLE V
TABLE OF PURCHASED COMPONENTS COST FOR QDC HOUSING

No	Components	Qty	Price @ (IDR)	Parts Cost (IDR)
1	Guide post set	2	254.660	509.320
2	Bolt M8	12	714	8.568
3	Bolt M16	4	5.950	23.800
Total Purchased Cost (B)				541.688

TABLE VI
TABLE OF MACHINERY COST FOR QDC HOUSING

No	Process	Unit	Machine Rates (IDR)	Costs (IDR)
2	Milling	18 h	47.300	851.400
3	Grinding	4 h	65.000	260.000
4	Radial Drill	12 h	40.500	486.000
5	Assembly	1 h	30.750	30.750
Total Machining Cost (C)				1.628.150

Conventional full die unit seems like the combination of QDC die set and QDC housing set. The cost will be as below.

TABLE VII
TABLE OF MATERIAL COST FOR CONVENTIONAL DIE

No	Components	Weight	Material	Price (IDR)	Material Cost (IDR)
1	Upper Plate	1,8 Kg	SS400	9.500	17.100
2	Backing Plate	0,3 Kg	S45C	45.000	13.500
3	Stripper	0,25 Kg	S45C	45.000	11.250
4	Punch & Die Plate	0,45 Kg	SKD45	60.000	27.000
5	Base Plate	1,4 Kg	SS400	9.500	13.300
6	Raiser	0,7 Kg	SS400	9.500	6.650
7	Lower Plate	2,1 Kg	SS400	9.500	19.950
Total Material Cost (A)					108.750

TABLE VIII
TABLE OF PURCHASED COMPONENTS COST FOR CONVENTIONAL DIE

No	Components	Qty	Price @ (IDR)	Parts Cost (IDR)
1	Guide post	4	254.660	1.018.640
2	Bolt M10	24	1.700	40.800
3	Bolt M8 x30	12	714	8.568
4	Dowel pin 8 x30	6	3.213	19.278
5	Bolt M8 x 90	4	4.284	17.136
6	Dowel pin 8x90	2	4.522	9.044
Total Purchased Cost (B)				1.113.466

TABLE IX
TABLE OF MACHINERY COST FOR CONVENTIONAL DIE

No	Process	Unit	Machine Rates (IDR)	Costs (IDR)
1	Wire cut	11.520 mm	45	518.400
2	Milling	26 h	47.300	1.229.800
3	Grinding	12 h	65.000	780.000
4	Radial Drill	10 h	40.500	405.000
5	Heat treatment	0,45 Kg	60.000	27.000
6	Assembly	5 h	30.750	153.750
Total Machining Cost (C)				3.113.950

Total Manufacturing Process for Conventional die are:
Material Cost + Components Cost + Manufacturing Cost =
108.750 + 1.113.466 + 3.113.950 = 4.336.166 (currency in IDR)

Compare from data above, to build a QDC housing will cost 2.281.648 IDR, a QDC die will cost 2.613.382 IDR and to build

a conventional die set will cost 4.336.166 IDR.

To run one-part production with QDC will cost 2.281.648 IDR + 2.613.382 IDR = 4.895.030 IDR, and 4.336.166 IDR to run with Conventional die set. But to run production of 10 parts with QDC will cost round 2.281.648 IDR + (10 x 2.613.382 IDR) = 28.415.468 IDR.

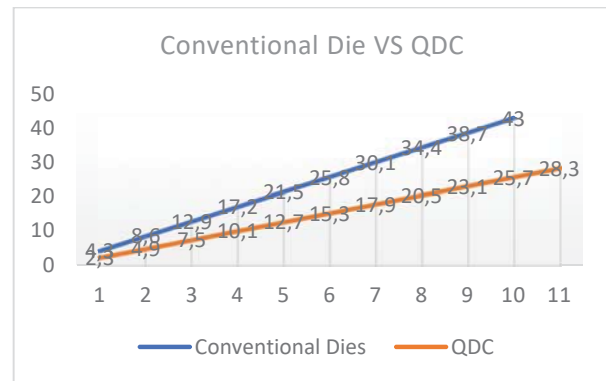


Fig. 9 Manufacturing cost comparison for 10 units of dies

To run 10 parts productions with Conventional die set will cost = 10 x 4.336.166 IDR = 43.361.660 IDR. Die manufacturing cost decrease for about 35% if using QDC die system and will decreased further with more dies.

B. Setup Time Efficiency

1/3 of total production time is wasting on setup [3]. Beside the decreasing of manufacturing cost, QDC will also directly reducing the setup time of dies. Observation result in a stamping company near Jakarta, Indonesia shows that QDC system also create huge decreasing setup time.

TABLE X
SETUP TIME FOR STAMPING DIE ON 80 TONS MACHINE

Activities	QDC (s)	Conventional Die(s)
Pickup dies	13	90
positioning	5	26
Inching	4	9
Clamping	78	192
Unclamps	66	152
Unload dies	15	120
Total Time	181	589

QDC takes only about 3 minutes to setup while conventional die took about 10 minutes.

The QDC system clearly optimized the efficiency of metal stamping company, the setup process decreased to less than 10 minutes as the ultimate goals of SMED system where QDC is a part of it [7]. But, we have to keep in mind that QDC steel need a Housing to setup. The setup efficiency will useless if QDC operate as stand-alone operation because the housing setup time will be added.

V. CONCLUSION

The QDC system indeed give big impact in efficiency of a company. QDC could save almost 35% of material manufacturing cost and 70% of setup time. But those

advantages could only effective if applied for some serial of die. Company should arrange the production schedule to process more serial parts or process in QDC die, otherwise it will become less efficient than it should. The more QDC to manufacture and use in production, the higher efficiency will be reach and also contrary.

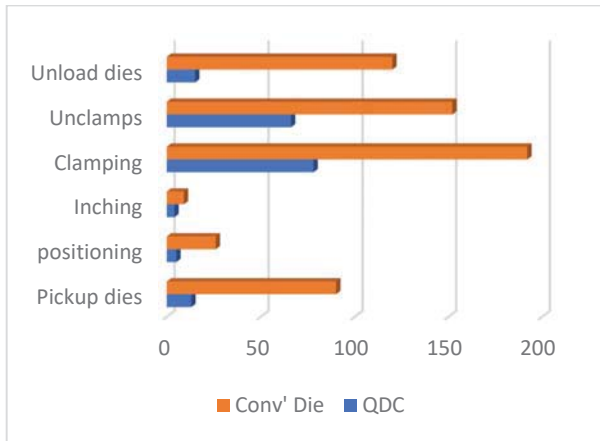


Fig. 10 Setup Time Chart Conventional Die vs QDC

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