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

Rudi Kurniawan Arief

INTERNATIONAL SCIENTIFIC RESEARCH AND EXPERIMENTAL DEVELOPMENT

KUALA LUMPUR, MALAYSIA

FEBRUARY, 12-13, 2018

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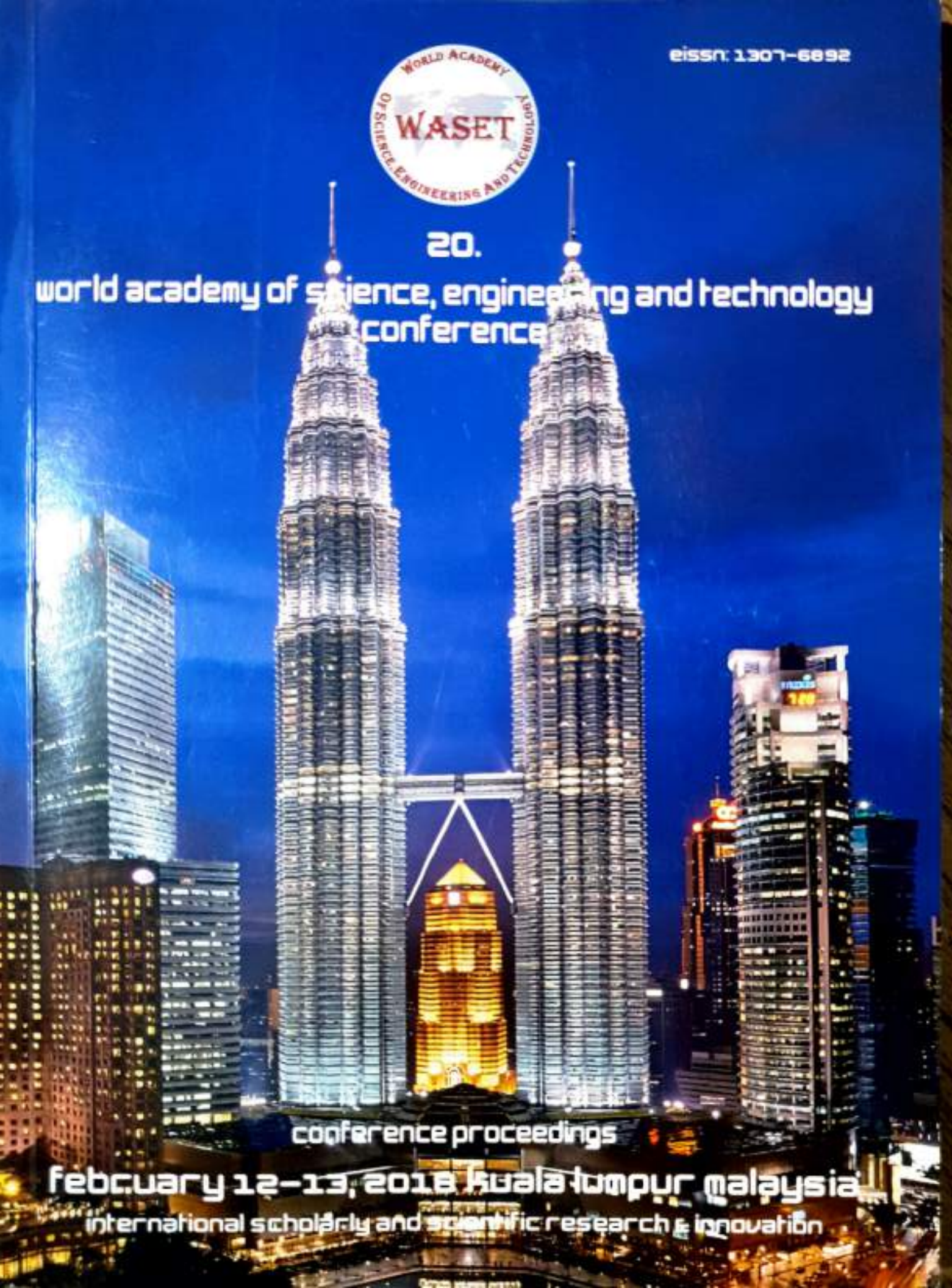

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CONFERENCE REGISTRATION
February 12, 2018 from 07:30 to 13:00

CONFERENCE PROGRAM
February 12, 2018
Session I: 07:45-09:00

Chair: Hanaa El-Rafie, Gilwon Yoon

1		Management of Acute Appendicitis with Preference on Delayed Primary Suturing of Surgical Incision	N. A. D. P. Niwunhella, W. G. R. C. K. Sirisena General Hospital Trincomalee Sri Lanka
2	e-Poster	Anti-Angiogenic Effects of the Macrovipera lebetina obtusa Snake Crude Venom and Obtustatin	Narine Ghazaryan, Joana Catarina Macedo, Sara Vaz, Naira Ayvazyan, Elsa Logarinho L. A. Orbeli Institute of Physiology NAS RA Armenia
3		Bioactivities and Phytochemical Studies of Acrocarpus fraxinifolius Bark Wight and Arn	H. M. El-Rafie, A. H. Abou Zeid, R. S. Mohammed, A. A. Sleem National Research Center Egypt
4		Generation of Electro-Encephalography Readiness Potentials by Intention	Seokbeen Lim, Gilwon Yoon Seoul National University of Science and Technology Korea, Republic Of
5		Characterization of the GntR Family Transcriptional Regulator Rv0792c: A Potential Drug Target for Mycobacterium tuberculosis	Thanusha D. Abeywickrama, Inoka C. Perera, Genju Kurisu University of Colombo Sri Lanka
6	e-Poster	E-Learning in Promoting Community Health: Case Study of Nutrition Education in a Rural Community in Taiwan	Ching-Ju Chiu National Cheng Kung University Taiwan
7	e-Poster	The Role of Chemerin and Myostatin after Physical Activity	Mohammad Javad Pourvaghar, Mohammad Ebrahim Balcam University of Kashan Iran, Islamic Republic Of

February 12, 2018
Session II: 09:00-09:35

Group photo will be taken at the end of the session in the conference room.
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Chair: Manho Kim, Mohammad Abdollahi

1		Surgical Repair of Various Conditions under Butorphenol Romifidine with Ketamine Induction and Isoflurane Anaesthesia in Cattle and Buffalo	D. Dilipkumar, Venkatgiri, S. M. Ustarge, B. V. Shivaprakash, Sagar Pandav, Bhagwantappa, D. Jahangir, Arun Tikekar Karnataka Veterinary, Animal and Fisheries Sciences University India
2	e-Poster	Ginfomin, a Part of Panax Ginseng, Can Be Increased Production Rate by New Purification Technology, and Safe and Potentially Beneficit for Human Trial	Jangsup Moon, Sun-Hye Choi, Ji-Young Shim, Hyun-Jung Park, Min-Jung Oh, Manho Kim, Seung-Yeol Nah Seoul National University Hospital Korea, Republic Of
3	e-Poster	Application of Metarhizium anisopliae against Meloidogyne javanica in Soil Amended with Oak Debris	Mohammad Abdollahi Yasouj University Iran, Islamic Republic Of
4	e-Poster	Tarom-F-Jelodar, Novel Rice Cultivar, a High-Yielding Variety Released for the Ecosystem of Northern Iran	Nadali Babaeian Jelodar, Nadali Bagheri Sari Agricultural Sciences and Natural Resources University Iran, Islamic Republic Of
5	e-Poster	The Evaluation of Antioxidant and Antimicrobial Activities of Essential Oil and Aqueous, Methanol, Ethanol, Ethyl Acetate and Acetone Extract of Hypericum scabrum	Ali Heshmati, Mohmad Yosef Alikhani, Mohama Taghi Godarzi, Mohamad Reza Sadeghimanesh Hamadan University of Medical Sciences Iran, Islamic Republic Of

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Coffee Break: 11:20-11:30

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1		The Use of Indicators to Evaluate Minor Heritage Areas in a City	J. L. Oliver, T. Agryzkov, L. Tortosa, J. F. Vicent, J. Santacruz University of Alicante Spain
2		Religion, Education, and Nation: Anticlerical Principle of France and Private School Law of South Korea	Minjeoung Kim University of Seoul Korea, Republic Of

3		Conventional and Islamic Perspective in Accounting: Potential for Alternative Reporting Framework	Shibly Abdullah Charles Sturt University, Study Centre, Sydney Australia
4		A Genre Analysis of University Lectures	Lee Kok Yueh, Fatin Hamadah Rahman, David Hassell, Au Thien Wan Universiti Teknologi Brunei Brunei Darussalam
5		Understanding the Multilingualism of the Mauritian Multilingual Primary School Learner and Translanguaging: A Linguistic Ethnographic Study	Yesha Devi Mahadeo-Doorgakant Mauritius Institute of Education Mauritius
6		The Issue of Pedagogical Approaches in Higher Education: Public Universities as an Example	Majda El Moufarej Sidi Mohammed Ben Abdellah Morocco
7		Quality Assurance in Higher Education: Doha Institute for Graduate Studies as a Case Study	Ahmed Makhoukh Doha Institute for Graduate Studies,*Doha,Qatar* Qatar

February 12, 2018
Session IV: 11:30-12:30

Group photo will be taken at the end of the session in the conference room.

Chair: Sunghun Jung, Chinsuk Hong

1	e-Poster	Understanding the Qualitative Nature of Product Reviews by Integrating Text Processing Algorithm and Usability Feature Extraction	Cherry Yieng Siang Ling, Joong Hee Lee, Myung Hwan Yun Seoul National University Korea, Republic Of
2		Unmanned Aerial System Development for the Remote Reflectance Sensing Using Above-Water Radiometers	Sunghun Jung, Wonkook Kim Chodang University Korea, Republic Of
3	e-Poster	Flow Characteristics around Rectangular Obstacles with the Varying Direction of Obstacles	Hee-Chang Lim Pusan National University Korea, Republic Of
4		Active Transmitted Noise Control for the Openings of Acoustic Enclosures	C. Hong, J. M. Ku, W. B. Jeong Ulsan College Korea, Republic Of
5		Time and Cost Efficiency Analysis of Quick Die Change System on Metal Stamping Industry	Rudi Kurniawan Arief Universitas Muhammadiyah Sumatera Barat Indonesia

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

Rudi Kurniawan Arief

***Abstract*—**In a rapid growth of manufacturing business, each company must give their best to increase the production capacity. Many effort are given to eliminate every kind of waste. Material waste, time waste, power waste, movement waste even man power waste to gain lower waste of cost in every line of manufacturing process. One of the manufacturing process wich need long set up time is metal stamping process. Quick Die Change (QDC) or other also called Single Minute Exchange of Die (SMED) is one of the method used to reduce some waste in stamping process. The quick changeover time between current process to next process is the key for efficency of production process. This paper analyzed that the QDC system could give deep impact to efficiency in a stamping company. QDC system is able to decrease the manufacturing cost and setup time significantly.

***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 one of the biggest waste happens in set up process. While stamping process can produce hundreds of part in an hour, the set up process itself may take 30 to 60 minutes due to size and the complexity of the dies. Quick Die Change (QDC) or other also called Single Minute Exchange of Die (SMED) is one of the method used to reduce some waste in stamping process [9]. QDC provide high efficiency in continuous production with fast changeover from one product to another. This system introduce a quick way to do the set up that the time could reduce to less than 10 miutes or at least half of norml set up time. Not just reducing time, the QDC system also reduce manufacturing time and cost significantly. So, this system could be the best key to efficiency.

II. LITERATURE REVIEW

A. QDC Methods

Shigeo Shingo was formerly found the Single Minute Exchange Die system thru a long years of experience and experiments. The first concept of SMED was started at Toyo Kogo's Mazda plant during spring of 1950 when bottleneck happened in production of large body pressed. The problems reduced by making a clear conceprt 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. Doing some research and observation, Shingo the came up with the idea of adding a second planner table to setup new dies in queue, this then increase the production capacity by 40%. By the year of 1969, Shingo then help 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 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].

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B. Manufactured Die Components

Regular construction of conventional die unit usually consist 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].

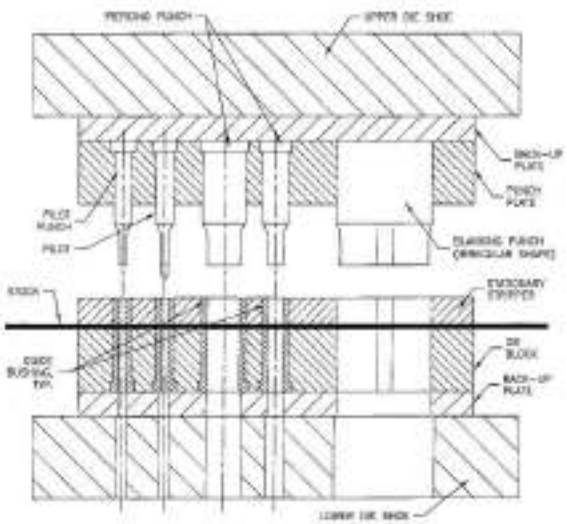

Fig 1. Die Set with Stationary Stripper [1]

Manufactured parts are customized die components that have to be manufactured. This will involve some machinery process from simple mills to cnc and wirecutting process.

a. Upper Plate (Upper Die Shoe)

Upper plate is the upper part of die unit wich clamped to the Ram (upper and moving parts of stamping machine). This plate held all the upper 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.

b. 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 have 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.

c. 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 use 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.

d. Punch

Punch together with Die are the main and basic components to built 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).

e. 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 (fig 1) and moving / spring stripper (fig 1). Moving type usually use for thin and light force process, coil springs or urethane rubbers are use to eject strip plate. Fixed type usually use for a thick and heavy plate where springs no longer efficient to eject the strips.

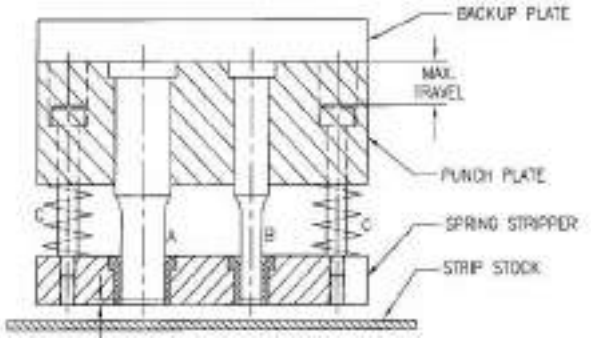

Fig 2. Spring type stripper [1]

f. 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.

g. Base Plate (Lower Die Shoe)

Base plate is the lower part of die unit wich 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.

a. 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.

b. Pilots

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

c. 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 Internal setup time (IED) and move it to external setup (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).

a. 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 (fig 5.), this will reduce manufacturing and purchased cost for base and upper plate, guide bushings, etc. This also reduce along setup time.

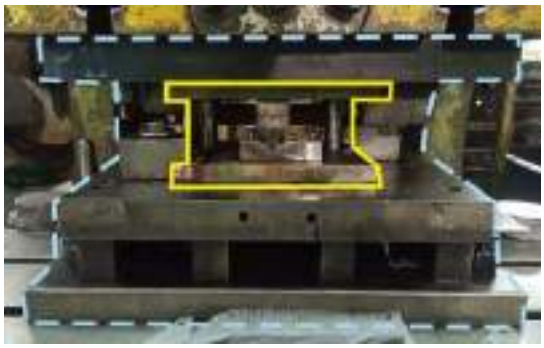

Fig.4 QDC Unit (courtesy of PT.SPI)

b. 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)

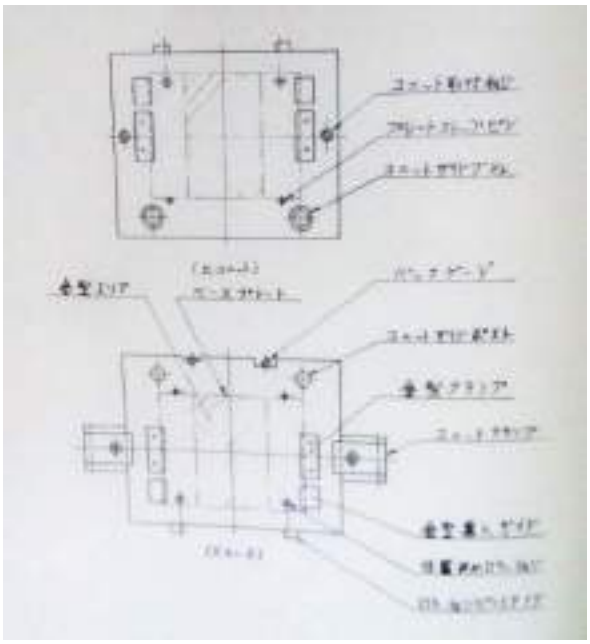

Fig.6 Design of QDC Housing [4]

c. 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 below shows the components of assembled QDC Unit.

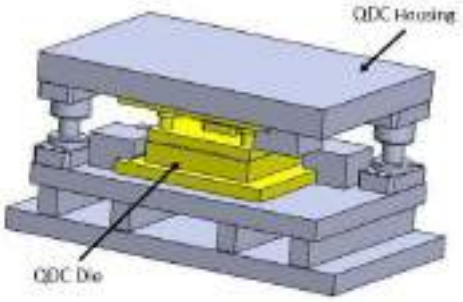

Fig 8. QDC Unit

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.

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	40.000	4.350
3	Stripper	0,25 Kg	S45C	40.000	10.250
4	Punch & Die Plate	0,45 Kg	SKD11	60.000	27.000
5	Base Plate	0,6 Kg	SS400	9.500	5.700
				Total Material Cost (A)	54.350

Fig 9. Table of Material Cost for QDC

No	Components	Qty	Price @ (IDR)	Parts Cost (IDR)
6	Guide pin	4	66.840	268.360
7	Guide bush	4	79.750	318.928
8	Bolt M8	16	714	11.424
9	Dowel pin	6	3.215	19.278
10	Bolt M16	4	5.950	23.800
			Total Purchased Cost (B)	639.882

Fig 10. Table of Components Cost for QDC

No	Process	Unit	Machine Rates (IDR)	Costs (IDR)
11	Wire cut	11520 mm	45	518.400
12	Milling	32 h	47.300	367.600
13	Grinding	6 h	65.000	390.000
14	Radial Drill	8 h	40.500	324.000
15	Heat treatment	0,45 Kg	60.000	27.000
16	Assembly	3 h	30.750	92.250
			Total Machining Cost (C)	1.919.250

Fig 11. Table of Machinery Cost for QDC

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.

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	0,88 Kg	SS400	9.500	8.360
5	Lower Plate	3 Kg	SS400	9.500	28.500
				Total Material Cost (A)	121.810

Fig 12. Table of Material Cost for QDC Housing

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

Fig 13. Table of Components Cost for QDC Housing

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

Fig 14. Table of Machinery Cost for QDC Housing

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 wirecut required.

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

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	SKD11	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

Fig 15. Table of Material cost for Conventional die

No	Components	Qty	Price @ (IDR)	Parts Cost (IDR)
8	Guide post	4	254.660	1.018.640
9	Bolt M10	24	1.700	40.800
10	Bolt M8 x30	32	714	8.568
11	Dowel pin 8 x30	6	3.213	19.278
12	Bolt M8 x 50	4	4.284	17.136
13	Dowel pin 8x50	2	4.522	9.044
			Total Purchased Cost (B)	1.113.466

Fig 16. Table of Components cost for Conventional die.

No	Process	Unit	Machine Rates (IDR)	Costs (IDR)
14	Wire cut	11520 mm	45	518.400
15	Milling	26 h	47.500	1.235.000
16	Grinding	12 h	65.000	780.000
17	Radial Drill	10 h	40.500	405.000
18	Heat treatment	0.45 Kg	60.000	27.000
19	Assembly	5 h	30.750	153.750
			Total Machining Cost (C)	3.113.950

Fig 17. Table of Machinery cost for Conventional die.

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.

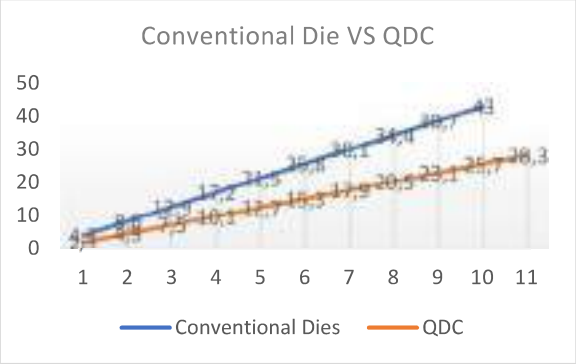

Fig 18. Manufacturing cost comparation for 10 units of dies.

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.

Fig 16. Table of Setup Time for Stamping Die on 80 Tons Machine.

TABLE I
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.

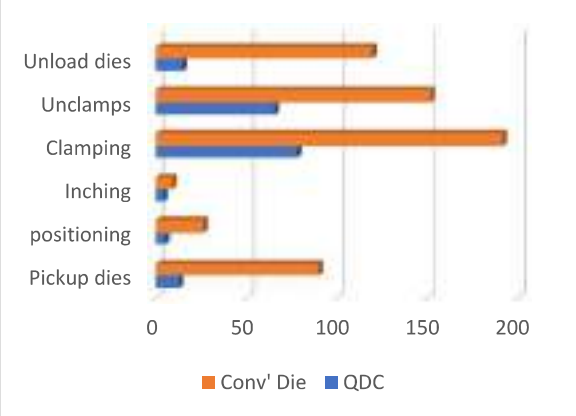

Fig 19 . Setup Time Chart Conventional Die vs QDC

The QDC system clearly optimized the efficiency of metal stamping company, the setup process decreasse 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.

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