TURNITIN Efficiency enhancement of die design

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Efficiency enhancement of die design for G2R-1A relay terminal using progressive tool

Lydia Anggraini [a,b,*], Josep Ginting [c], Trivia Nola [a], Kazunori Takagi [d]

[a] Mechanical Engineering Study Program, President University, Jababeka Education Park, Cikarang, Bekasi 17550, Indonesia
[b] Professional Engineer Study Program, Atma Jaya Catholic University of Indonesia, Jl. Jendral Sudirman No. 51, Jakarta 12930, Indonesia
[c] Accounting Study Program, President University, Jababeka Education Park, Cikarang, Bekasi 17550, Indonesia
[d] Omron Corporation, Nishikusatsu, Kusatsu City, Shiga 525-0035, Japan

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ABSTRACT

A progressive die is a set of tools performing series or several sheet-metal operations with a single tool. It has two or more workstations for the production of products. Every pressing stroke involves one operation, and the strip stock advances through the die strip. The main functional advantage of progressive die for the manufacturing industry is that it takes less time and gives a high volume of production. It can build precision tools with less time-consumption. The main task is to design a die for one of the parts of a relay product called G2R-1 Station Terminal A. The process of making this part is ineffective and uncomfortable under these conditions because it must go through three different stages of the process, which is a waste of time. This study discusses the design using the progressive die concept from Excess Hybrid or the CADD application as the initial sketch and Solid work as the visualization to achieve cost effectiveness and shorten the production process time. The result of total cost saving is 528,200,151 IDR per year.

Selection and peer-review under responsibility of the scientific committee of the Fourth International Conference on Recent Advances in Materials and Manufacturing 2022.

1. Introduction

Technology in the experimental-industrial field has advanced rapidly in the current era of globalization [1–6]. Many industries in the industrial sector no longer use human or conventional labor [7–15]. However, many industries have turned to automation systems [6,16–22].

The industries that use production aids can produce quality products in large quantities in a relatively short time. A sophisticated technology, of course, has supporting components [23–28]. One of the function of the relay component, for example, controls and supplies electricity to a system [29–32]. Relays have many types and different functions in each type. In this study, the authors focus on the G2R-1 12Vdc relay type. In this type of product, there is a component called G2R-1 Station Terminal A which functions as a current conductor when the relay is in the on position.(See Fig. 1)

The process of making components for G2R-1 Station Terminal A at Omron Manufacturing of Indonesia has three process stages, first is the P1 is hoop manufacturing process, second is the riveting process, and last is the P2 or cutting process [33–37]. Each has a different die and machine types [38–42]. Due to the numerous processes involved in producing the components of Terminal A Station G2R-1, the production process takes a long time and has high production costs. Departing from the problems above, the authors took the initiative to redesign the G2R-1 A terminal station product using the progressive tools method. The objective is to shorten production time and costs, to obtain high-quality and high-precision products.

2. Experimental

The product design of progressive tool has been defined by PT Omron Manufacturing Indonesia. The hoop terminal material used is C2680R-1/2H with AgSnIn + Cu contacts. The thickness is 0.5 mm. The tools needed in the assembly process are easy to disassemble and maintain with a T-slot and clamping jig gripping type. In addition, the machine requirement is a maximum capacity

* Corresponding author at: Mechanical Engineering Study Program, President University, Jababeka Education Park, Cikarang, Bekasi 17550, Indonesia.
E-mail address: lydia.anggra@president.ac.id (L. Anggraini).

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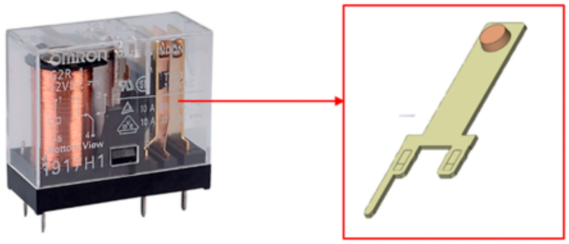

Fig. 1. G2R-1 12Vdc station at A relay terminal.

of 45 tons with the same upper and lower bolster with the upper and lower plate sizes for the minimum and maximum, respectively.

The layout of materials in the progressive die design process is shown on Fig. 2. This was selected based on aspects of technical and economic assessment. The advantages of the desired layout are for one product to be more economical, die maintenance is simple, and the material pitch distance between products is close together so as to create high product precision. Otherwise, the disadvantage is that the layout of the material cannot be formed symmetrically.

In order to identify the number of sections and the distance between sections in a die, the process is reviewed. The machine tonnage is used based on calculations as one reference for selecting the minimum press machine. After the tonnage of the press machine has met the calculation of the required engine force, the next aspect to be reviewed is the dimensions of the ram and bolt. If the dimensions of the ram and bolts have been met, the next step is to consider the die height of the machine. Table 1 shows the machine specifications determined by PT Omron Manufacturing Indonesia.

3. Results and discussion

The calculations of the cutting force are used as in the Eqs. (1)–(3), where Fs is the cutting force [N], U is the perimeter of the cut area [mm], s is the effective cutting thickness [mm], and Rm is the broken stress or the maximum resistance [N/mm^2].

$$F_s = 0.8 \times U \times s \times \sigma_b \tag{1}$$

$$F_{sp1.2} = F_{sp1} \times n \tag{2}$$

$$F_{total} = F_{sp1.2} + F_{sp3} \tag{3}$$

There are two types of cut area perimeters: 6.283 and 7.728. The calculation result of first piercing process (F_{sp}) is 929.88 N, second is 1859.77 N and third is 1143.74 N. The total cutting force of piercing process is 3003.51 N. Fig. 3 shows the layout of each force in the progressive die design.

The calculation of the blanking process (F_{sb}) is following the Eq. (1). The layout of the cutting force in the blanking process of progressive die design is shown in Fig. 4. The results of cutting force of blanking process 1 to 5 are 1567.91 N, 7270.05 N, 4229.84 N, 3136.12 N, and 1901.80 N. The total cutting force of the blanking process is 18105.72 N.

Furthermore, the calculation of the notching process (F_{sn}) is also following the Eq. (1). The layout of the cutting force in the notching process of progressive die design is shown in Fig. 5. The results of cutting force of notching process 1 to 3 are 1130.57 N, 366.15 N and 451.40 N. The total cutting force of the notching process is 18105.72 N.

The calculation of the total cutting force is the sum of the calculation of the cutting force in the piercing (F_{sp}), blanking (F_{sb}), and notching (F_{sn}) processes in equation (4). The result of total cutting force is 23057.35 N. The force of forming (F_e) of compression load is defined by equation (5), where K_r is deformation resistance [N/mm^2], A_{proy} is punch projection areaa [mm], and n is number of processes.

$$F_{stotal} = F_{sp} + F_{sb} + F_{sn} \tag{4}$$

$$F_e = k_r \times \text{Aproy} \times n \tag{5}$$

Brass type of Ms63 is used with the strength σ_b ranging from 370 to 440 N/mm^2 and the deformation resistance k_r for each embossing and deep coining ranging from 200 to 300 N/mm^2 and 1500–1800 N/mm^2, respectively [40–42]. The force of embossing process (F_{emb}) result is 1393.8 N, which was calculated by Eq. (5), where the deformation resistance K_r is 300 N/mm^2, the punch projection area A_{proy} is 2.323 mm and the number of processes *n* is 2. Fig. 6 shows the layout of embossing process in the progressive die design.

The force of chamfering process (F_{chm}) result is 667.8 N, which was calculated by equation (5), where the deformation resistance K_r is 300 N/mm^2, the punch projection area A_{proy} is 2.226 mm, and the number of processes n is 1. Fig. 7 shows the layout of chamfering process in the progressive die design. The total forming force $F_{e\ total}$ is calculated by Eq. (6). The result of total embossing and chamfering forces is 2061.6 N. (See Fig. 8 and Fig. 9.)

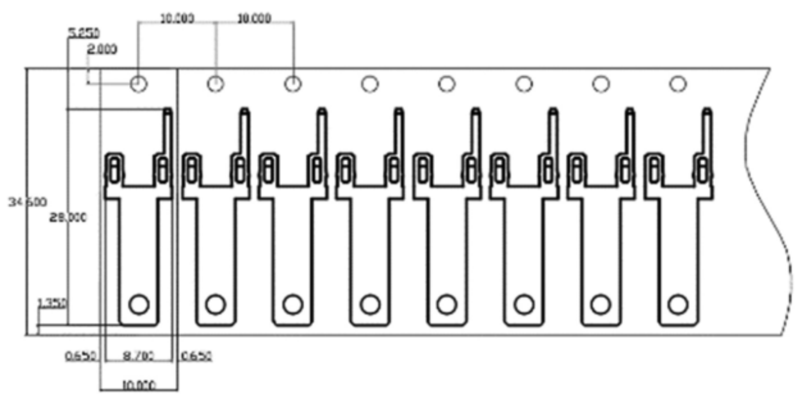

Fig. 2. The layout of materials in the progressive die design process.

Table 1
Machine Specifications.

Item	Variation Type			
No. Model	EH-45 L			
Pressure (ton)	45			
Fixed stroke	30	50	60	80
Speed per Minutes (spm)	100	100	100	100
	350	300	270	225
Die height (mm)	330	320	315	305
Smooth adjustment amount (mm)			30	
Slide area (mm)	800 × 650 × 140			
Bolster area (mm)	800 × 420			
Side opening (mm)	290			
Electric power (kW)	7.5			
Table weight (ton)	7.8			
Control box	EM Organ Box			

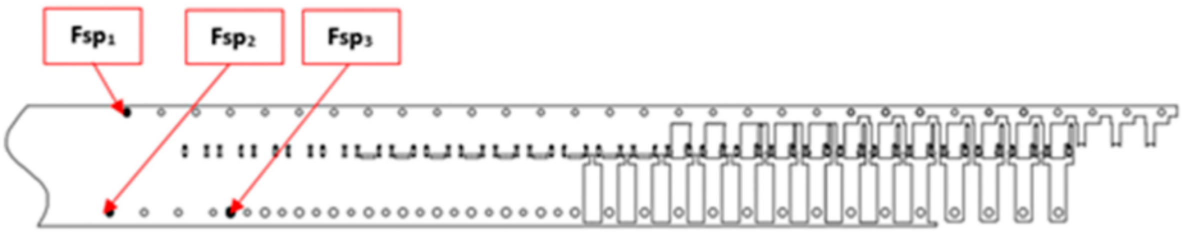

Fig. 3. The layout of each force in the progressive die design.

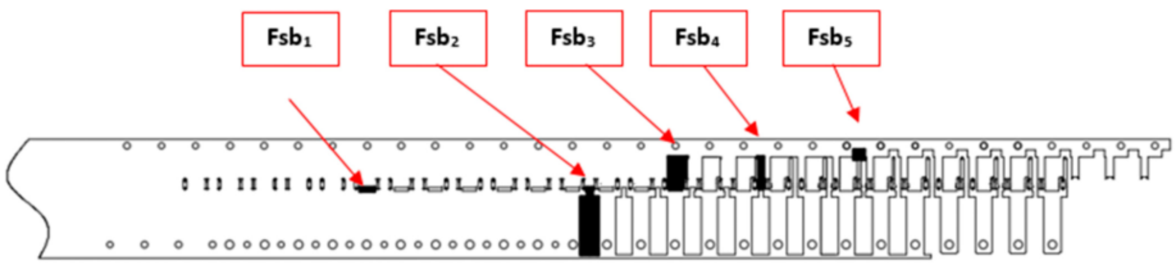

Fig. 4. The layout of cutting force in the blanking process of progressive die design.

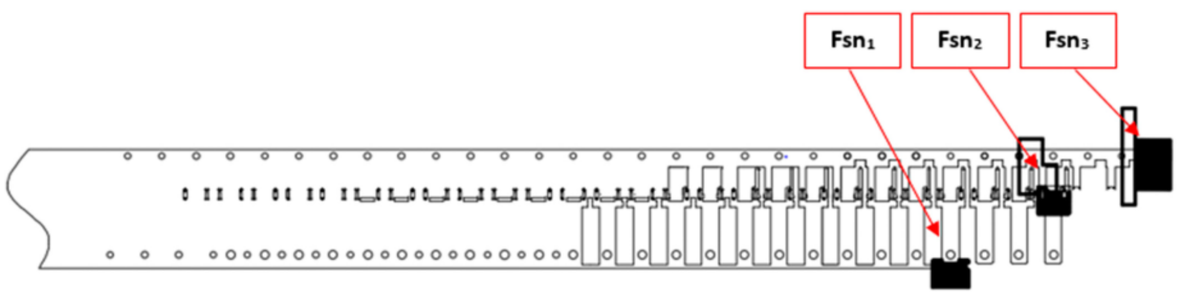

Fig. 5. The layout of cutting force in the notching process.

$$F_{etotal} = F_{emb} + F_{chm} \tag{6}$$

The force of stripper $F_{stripper}$ is calculated by Eq. (7), where × is the percentage of stripper force based on material thickness [%]. The blank force is calculated by the total cutting force and the compression load [N]. The result of F stripper is 2511.89 N. The force of pad is also calculated by equation (6), with a result of 2009.52 N.

$$F_{stripper} = x\% \times F_{blanktotal} \tag{7}$$

$$F_{blanktotal} = F_{cutting} \times F_{compressionload} \tag{8}$$

The tonnage capacity of the press machine is obtained by the force occurs in the tool, as calculated in the equation (9). The total force result is 29640.37 N. Moreover, the engine force is calculated

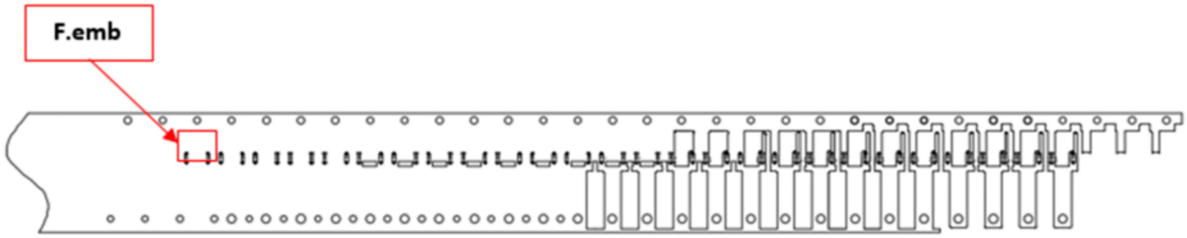

Fig. 6. The layout of embossing process in the progressive die design.

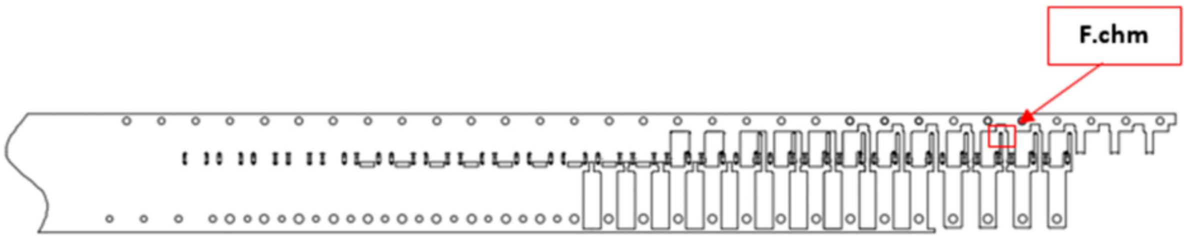

Fig. 7. The layout of chamfering process in the progressive die design.

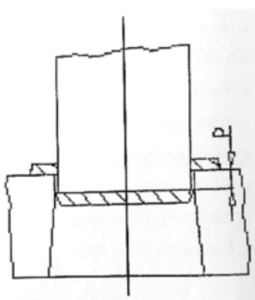

Fig. 8. Dimension of penetration.

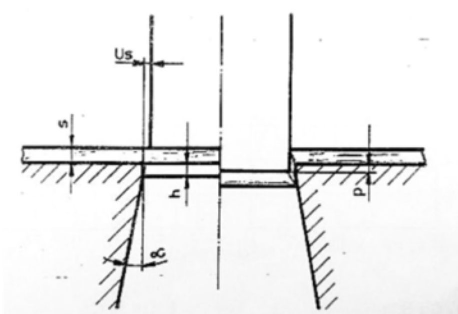

Fig. 9. Dimension of clearance.

in the equation (10) with a result of 35.5 kN. The type of press machine used in this study is the Yamada Dobby with an EH – 45 II (L, HS) type.

$$F_{tool} = F_{cutting} + F_{compressionload} + F_{stripper} + F_{pad} \quad (9)$$

$$F_{engine} = 120\% \times F_{tool} \quad (10)$$

The penetration and clearance are calculated in the equations (11) and (12), where p is the penetration [mm], U_s is the clearance [mm], s is the material strip thickness [mm] and c is the working factor. The result of p is 1 mm with s 0.5 and U_s is 0.02 mm with c 4%.

$$p = (1\ 3) \times s \quad (11)$$

$$U_s = s \times c\% \quad (12)$$

Progressive tool construction requires spring calculation. This is because the spring functions have to resist the free force of the construction as shown in Fig. 10. Therefore, the spring calculation is a determinant of the design construction that is categorized for safety. The stripper force is 2511.89 N, with 8 numbers of springs. The spring force is 313.98 N with 6 mm total deflection. The calculation of spring constant is in the equation (13), with result is 52.33 N/mm.

$$k_{spring} = \frac{F_{spring}}{totaldeflection} \quad (13)$$

Based on the spring constant calculation result, the Misumi spring with SWL 30–45 type is used. The spring spesifications are as follows: k_{spring} is 65.9 N/mm, total deflection is 14.4 and initial length L_0 is 45 mm. Therefore, F_{spring} is 948.96 N. In addition the reason for choosing Misumi spring with SWL 30–45 type are the standard spring F is larger than the required F_{spring} (948.96 N $\leq$ 313.98 N) and the constant spring standard k is bigger than the required constant spring (65.9 N/mm $\leq$ 52.33 N/mm). In consequence, the spring with SWL 30–45 type is considered safe to use. The pad spring calculation is also calculated with the equation (12), where the pad force is 2009.52 N, the total spring is 20 pieces, the force for each spring is 100.48 N, and the total deflection is 6 mm. Hence, the spring constant is 16.75 N/mm.

Moreover, a Misumi spring of the WM 655 type is used, with k_{spring} specifications of 55.9 N/mm, total deflections of 19.2, and an initial length of spring L_0 is 55 mm. Therefore, the F_{spring} is 1073.28 N as calculated with the equation (12). Fig. 11 shows the spring dimension.

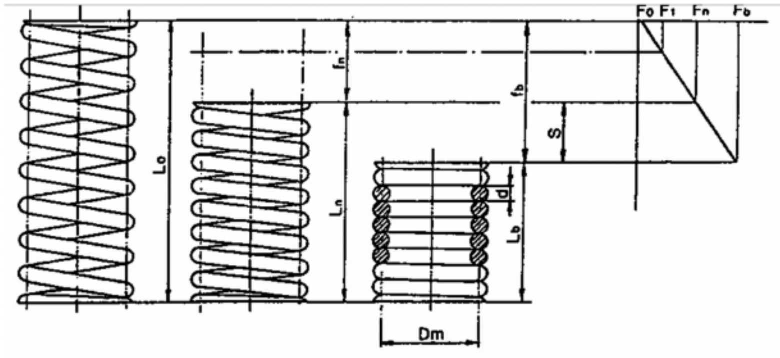

Fig. 10. Dimension of spring calculation in the progressive die design.

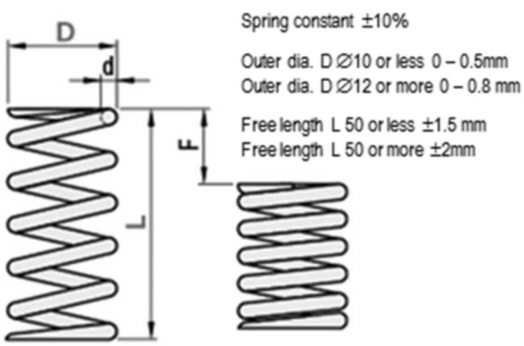

Fig. 11. Spring dimension of Misumi WM 655 type.

Misumi WB6-55 spring type was chosen because the standard F_{spring} is larger than the required F_{spring} (1073.28 N ≤ 100.48 N). Another reason is the standard k_{spring} is bigger than the required k_{spring} (55.9 N/mm ≤ 16.75 N/mm). Hence, the spring with WB 6–55 type is considered safe to use. As shown in Fig. 12, the efficiency cost is calculated in three steps: P1, riveting, and P2.

Table 2 shows the electricity consumption, which includes the total quantity of mass production per month for the current condition and after improvement. It shows that the current electricity consumption is 17.397 kWh and can be reduced to 4.762 kWh after improvement. The total saving cost after reducing electricity, manpower and overtime is reach to 528,200,151 IDR per year, as shown in Table 3.

The return of investment (ROI) and payback period (PP) is calculated in the equation (14), where the profit is 528,200,151 IDR/-year, the investment fee is 1,000,000,000 IDR, the depreciation is 5 years. The cost of depreciation is calculated in the equation (13), where the maintenance fee is 20,000,000 IDR/year and the operating cost is 220,000,000 IDR/year. The cost of depreciation is 200,000,000 IDR/year by using the straight line methods.

$$Costofdepreciation = \frac{The\,valueofin\,vestmentassets}{Usefullifeoftheassets} \tag{13}$$

$$ReturnofIn\,vestment(ROI) = \left[\frac{(Netprofitaftertax)}{Totalassets}\right] \times 100\% \tag{14}$$

The ROI is 30%. The payback period (PP) is calculated in the equation (15), where the cash flow is the profit minus the investment fee. The result of PP is 3.24 years. Refers to the ROI of 30% and Payback Period of 3.24 years as indicated in red arrow on Fig. 13, economically the progressive die design process is very effective. Fig. 13 shows the distribution of cost reduction per year.

$$PP = \frac{Totalcashinflowofin\,vestment}{Initialcashoutflowforin\,vestment} \times 1year \tag{15}$$

4. Summary and conclusion

In this study, the progressive die design is applied for the G2R-1 station A terminal part on the 12Vdc relay. The conclusions are as follows:

1. The cutting force required to process the blank is 23057.35 N and the blank holding force is 17677.44 N.

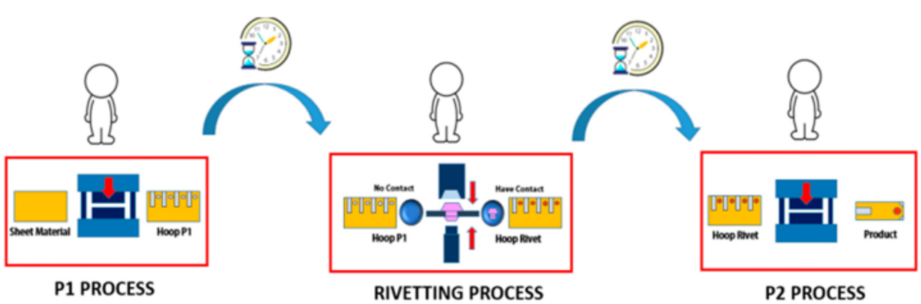

Fig. 12. Step by step progressive die design process.

Table 2
The total consumption of mass production of die.

[A] Massprod matrix – Current condition

Item No.	Line	Process	Die No.	Die Name	Order/ month	SPM	O/R	WH	Output/ day	Days need	Machine	Power Supply	Electricity Consump-tion
6600243–3	LINE A	P1	P408	G2R-1 STATION TERMINAL A (P1)	1,000,000	175	70%	1440	176,000	5.67	A1	30 kW	4,082 kWH
6600231–9	LINE C	R	RIVET	G2R-1 STATION TERMINAL A (R)	1,000,000	90	75%	1440	97,200	10.29	C1	25 kW	6,173 kWH
9981393–2	LINE B	P2	P701	G2R-1 STATION TERMINAL A (P2)	1,000,000	100	70%	1440	100,800	9.92	A6	30 kW	7,143 kWH
				Total Qty/month	3,000,000			Total main days		25.88	Total consumption		17,397 kWH
								Balancing		26.00			

[B] Massprod matrix – After improvement

Item No.	Line	Process	Die No.	Die Name	Order/ month	SPM	O/R	WH	Output/ day	Days need	Machine	Power Supply	Electricity Consump-tion
9981393–2	LINE A/B	AUTO	OMI-01	G2R-1 STATION TERMINAL A (AUTO)	1,000,000	150	70%	1440	151,200	6.61	A6	30 kW	4,762 kWH
				Total Qty/month	1,000,000			Total running time		6.61	Total consumption		4,762 kWH
								Balancing		7			

Table 3
The total savings cost of all reduction in the production of die.

No.	Item	Reduction Amount/Month	Reduction Amount/Year (IDR)	Reduction Amount/Year ($)
1	Electricity reduction	20,216,679	242,600,151	16,909
2	Manpower reduction	16,000,000	192,000,000	13,383
3	Overtime reduction	7,800,000	93,600,000	6,524
Total Saving Cost		44,016,679	528,200,151	36,816

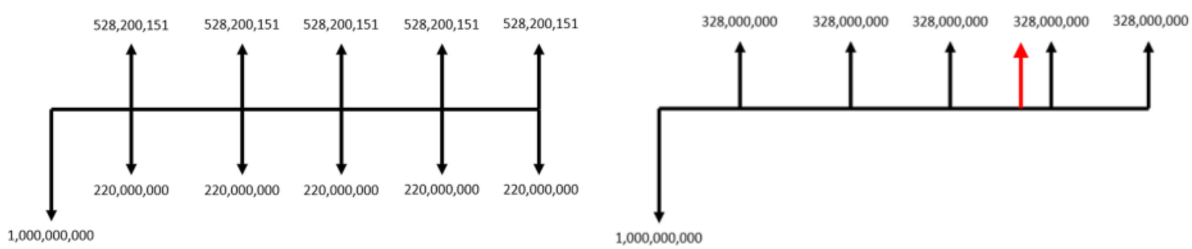

Fig. 13. Distribution of cost reduction per year (IDR).

2. In order to prevent clashes or burry defects, the clearance between punch and die is 0.02 per side.
3. To achieve a spring constant greater than the required force, the SWL spring 30–45 is used to resist the stripper force and the WB6-55 spring is used to resist the pad force.
4. The total cost savings from this project are IDR 528,200,151, or $36,816 per year. The Return of Investment of this project is 30%, and the payback period (PP) is 3.24 years.

CRediT authorship contribution statement

Lydia Anggraini: Conceptualization, Methodology, Validation, Formal analysis, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition. **Josep Ginting:** Conceptualization, Validation, Data curation, Writing – review & editing, Visualization, Project administration, Funding acquisition. **Trivia Nola:** Conceptualization, Methodology, Software, Investigation, Resources, Writing – original draft, Supervision. **Kazunori Takagi:** Conceptualization, Resources, Project administration.

Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] J. Guimón, Policies to benefit from the globalization of corporate R&D: an exploratory study for EU countries, Technovation 31 (2–3) (2011) 77–86, https://doi.org/10.1016/j.technovation.2010.08.001.

[2] E. Rauch, C. Linder, P. Dallasega, Anthropocentric perspective of production before and within Industry 4.0, Comput. Ind. Eng. 139 (2020), https://doi.org/10.1016/j.cie.2019.01.018.
[3] J. Nelles, S. Kuz, A. Mertens, C.M. Schlick, Human-centered design of assistance systems for production planning and control: The role of the human in Industry 4.0. In 2016 IEEE International Conference on Industrial Technology (ICIT), 2016, pp. 2099-2104, DOI: 10.1109/ICIT.2016.7475093.
[4] B.G. Mark, E. Rauch, D.T. Matt, Worker assistance systems in manufacturing: A review of the state of the art and future directions, J. Manuf. Syst. 59 (2021) 228–250, https://doi.org/10.1016/j.jmsy.2021.02.017.
[5] B.C. Pirvu, C.B. Zamfirescu, D. Gorecky, Engineering insights from an anthropocentric cyber-physical system: A case study for an assembly station, Mechatronics 34 (2016) 147–159, https://doi.org/10.1016/j.mechatronics.2015.08.010.
[6] G. Beier, A. Ullrich, S. Niehoff, M. Reißig, M. Habich, Industry 4.0: How it is defined from a sociotechnical perspective and how much sustainability it includes–A literature review, J. Clean. Prod. 259 (2020), https://doi.org/10.1016/j.jclepro.2020.120856.
[7] E. Kaasinen, F. Schmalfuß, C. Özturk, S. Aromaa, M. Boubekeur, J. Heilala, P. Heikkilä, T. Kuula, M. Liinasuo, S. Mach, R. Mehta, Empowering and engaging industrial workers with Operator 4.0 solutions, Comput. Ind. Eng. 139 (2020), https://doi.org/10.1016/j.cie.2019.01.052.
[8] C.W. Rudolph, B. Allan, M. Clark, G. Hertel, A. Hirschi, F. Kunze, K. Shockley, M. Shoss, S. Sonnentag, H. Zacher, Pandemics: Implications for research and practice in industrial and organizational psychology, Ind. Organ. Psychol. 14 (1–2) (2021) 1–35, https://doi.org/10.1017/iop.2020.48.
[9] T. Nam, Technology usage, expected job sustainability, and perceived job insecurity, Technol. Forecast. Soc. Chang. 138 (2019) 155–165, https://doi.org/10.1016/j.techfore.2018.08.017.
[10] I. Zambon, M. Cecchini, G. Egidi, M.G. Saporito, A. Colantoni, Revolution 4.0: Industry vs. agriculture in a future development for SMEs, Processes 7 (1) (2019) 36, https://doi.org/10.3390/pr7010036.
[11] R.R. Sinclair, T. Allen, L. Barber, M. Bergman, T. Britt, A. Butler, M. Ford, L. Hammer, L. Kath, T. Probst, Z. Yuan, Occupational health science in the time of COVID-19: now more than ever, Occupational Health Sci. 4 (1) (2020) 1–22, https://doi.org/10.1007/s41542-020-00064-3.
[12] L. Chernyak-Hai, E. Rabenu, The new era workplace relationships: Is social exchange theory still relevant?, Ind Organ. Psychol. 11 (3) (2018) 456–481, https://doi.org/10.1017/iop.2018.5.
[13] Y.K. Dwivedi, D.L. Hughes, C. Coombs, I. Constantiou, Y. Duan, J.S. Edwards, B. Gupta, B. Lal, S. Misra, P. Prashant, R. Raman, Impact of COVID-19 pandemic on information management research and practice: Transforming education, work and life, Int. J. Inf. Manag. 55 (2020), https://doi.org/10.1016/j.ijinfomgt.2020.102211.
[14] V. Sima, I.G. Gheorghe, J. Subić, D. Nancu, Influences of the industry 4.0 revolution on the human capital development and consumer behavior: a systematic review, Sustainability 12 (10) (2020) 4035, https://doi.org/10.3390/su12104035.
[15] D.D. Camacho, P. Clayton, W.J. O'Brien, C. Seepersad, M. Juenger, R. Ferron, S. Salamone, Applications of additive manufacturing in the construction industry–A forward-looking review, Autom. Constr. 89 (2018) 110–119, https://doi.org/10.1016/j.autcon.2017.12.031.
[16] D. Zuehlke, SmartFactory—Towards a factory-of-things, Annu. Rev. Control. 34 (1) (2010) 129–138, https://doi.org/10.1016/j.arcontrol.2010.02.008.
[17] M. Attaran, The rise of 3-D printing: The advantages of additive manufacturing over traditional manufacturing, Bus. Horiz. 60 (5) (2017) 677–688, https://doi.org/10.1016/j.bushor.2017.05.011.
[18] T. Bock, The future of construction automation: technological disruption and the upcoming ubiquity of robotics, Autom. Constr. 59 (2015) 113–121, https://doi.org/10.1016/j.autcon.2015.07.022.
[19] K. Zhou, T. Liu, L. Zhou, Industry 4.0: Towards future industrial opportunities and challenges, in: 2015 12th International conference on fuzzy systems and knowledge discovery (FSKD) IEEE, pp. 2147-2152, 2015. DOI: 10.1109/FSKD.2015.7382284,
[20] V. Marinoudi, C.G. Sørensen, S. Pearson, D. Bochtis, Robotics and labour in agriculture. A context consideration, Biosyst. Eng. 184 (2019) 111–121, https://doi.org/10.1016/j.biosystemseng.2019.06.013.
[21] H.W. Barkema, M.A. von Keyserlingk, J.P. Kastelic, T.J.G.M. Lam, C. Luby, J.P. Roy, S.J. LeBlanc, G.P. Keefe, D.F. Kelton, Invited review: Changes in the dairy industry affecting dairy cattle health and welfare, J. Dairy Sci. 98 (11) (2015) 7426–7445, https://doi.org/10.3168/jds.2015-9377.
[22] S. Pfeiffer, Robots, Industry 4.0 and humans, or why assembly work is more than routine work, Societies 6 (2) (2016) 16, https://doi.org/10.3390/soc6020016.
[23] Y. Huang, M.C. Leu, J. Mazumder, A. Donmez, Additive manufacturing: current state, future potential, gaps and needs, and recommendations, J. Manuf. Sci. Eng. 137 (1) (2015), https://doi.org/10.1115/1.4028725.
[24] S.H. Huang, P. Liu, A. Mokasdar, L. Hou, Additive manufacturing and its societal impact: a literature review, Int. J. Adv. Manuf. Technol. 67 (5) (2013) 1191–1203, https://doi.org/10.1007/s00170-012-4558-5.
[25] M. Schneider, M. Romer, M. Tschudin, H. Bolio, Sustainable cement production—present and future, Cem. Concr. Res. 41 (7) (2011) 642–650, https://doi.org/10.1016/j.cemconres.2011.03.019.
[26] S. Ford, M. Despeisse, Additive manufacturing and sustainability: an exploratory study of the advantages and challenges, J. Clean. Prod. 137 (2016) 1573–1587, https://doi.org/10.1016/j.jclepro.2016.04.150.
[27] M. Geiger, M. Kleiner, R. Eckstein, N. Tiesler, U. Engel, MicroformingCIRP Ann. 50 (2) (2001) 445–462, https://doi.org/10.1016/S0007-8506(07)62991-6.
[28] R.N. Kostoff, R.R. Schaller, Science and technology roadmaps, IEEE Trans. Eng. Manage. 48 (2) (2001) 132–143, https://doi.org/10.1109/17.922473.
[29] F. Blaabjerg, Y. Yang, D. Yang, X. Wang, Distributed power-generation systems and protection, Proc. IEEE 105 (7) (2017) 1311–1331, https://doi.org/10.1109/JPROC.2017.2696878.
[30] S. Lanzisera, A.R. Weber, A. Liao, D. Pajak, A.K. Meier, Communicating power supplies: bringing the internet to the ubiquitous energy gateways of electronic devices, IEEE Internet Things J. 1 (2) (2014) 153–160, https://doi.org/10.1109/JIOT.2014.2307077.
[31] M. Kezunovic, J.D. McCalley, T.J. Overbye, Smart grids and beyond: Achieving the full potential of electricity systems, in: Proceedings of the IEEE, 100(Special Centennial Issue), 2012, pp. 1329-1341, DOI: 10.1109/JPROC.2012.2187131.
[32] A. Emadi, S.S. Williamson, A. Khaligh, Power electronics intensive solutions for advanced electric, hybrid electric, and fuel cell vehicular power systems, IEEE Trans. Power Electron. 21 (3) (2006) 567–577, https://doi.org/10.1109/TPEL.2006.872378.
[33] M. Heino, D. Korpi, T. Huusari, E. Antonio-Rodriguez, S. Venkatasubramanian, T. Riihonen, L. Anttila, C. Icheln, K. Haneda, R. Wichman, M. Valkama, Recent advances in antenna design and interference cancellation algorithms for in-band full duplex relays, IEEE Commun. Mag. 53 (5) (2015) 91–101, https://doi.org/10.1109/MCOM.2015.7105647.
[34] J.D. Williams, W. Wang, Microfabrication of an electromagnetic power relay using SU-8 based UV-LIGA technology, Microsyst. Technol. 10 (10) (2004) 699–705, https://doi.org/10.1007/s00542-004-0396-1.
[35] Y. Sun, Y. Cao, M. Zhou, T. Wen, P. Li, C. Roberts, A hybrid method for life prediction of railway relays based on multi-layer decomposition and RBFNN, IEEE Access 7 (2019) 44761–44770, https://doi.org/10.1109/ACCESS.2019.2906895.
[36] J.J. Yao, RF MEMS from a device perspective, J. Micromech. Microeng. 10 (4) (2000) R9.
[37] L. Lu, W. Chen, T. Xu, L. Yu, High-performance ternary blend polymer solar cells involving both energy transfer and hole relay processes, Nat. Commun. 6 (1) (2015) 1–7, https://doi.org/10.1038/ncomms8327.
[38] M.M. Pawade, D. Goyal, S.S. Banwait, Evaluation of die-sinking Electric Discharge Machine with Smart Machine Controller, Met. Powder Rep. 76 (1) (2021) 25–31, https://doi.org/10.1016/j.mprp.2020.02.001.
[39] S. Rezaei, An adaptive bidirectional protective relay algorithm for ferroresonance in renewable energy networks, Electr. Pow. Syst. Res. 212 (2022), https://doi.org/10.1016/j.epsr.2022.108625.
[40] T. Khurshaid, A. Wadood, S.G. Frakoush, T.H. Kim, K.C. Kim, S.B. Rhee, Optimal allocation of directional relay for efficient energy optimization in a radial distribution system, Energies 15 (13) (2022) 4709, https://doi.org/10.3390/en15134709.
[41] M.S. Anwar, D. Ghosh, N. Frolov, Relay synchronization in a weighted triplex network, Mathematics 9 (17) (2021) 2135, https://doi.org/10.3390/math9172135.
[42] H. Awad, A. Hafez, Optimal operation of under-frequency load shedding relays by hybrid optimization of particle swarm and bacterial foraging algorithms, Alex. Eng. J. 61 (1) (2022) 763–774, https://doi.org/10.1016/j.aej.2021.06.034.

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