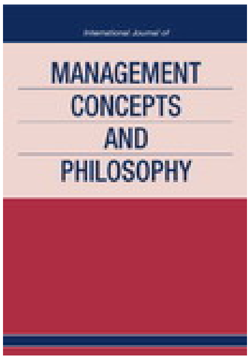


International Journal of Management Concepts and Philosophy

ISSN online: 1741-8135 - ISSN print: 1478-1484
https://www.inderscience.com/ijmcp

Benefits using PDCA cycle of continuous improvement in manufacturing industry - a case study

Jagdeep Singh, Surjit Kumar Gandhi

DOI: 10.1504/IJMCP.2023.10054603

Article History:

Received:	26 January 2023
Last revised:	28 January 2023
Accepted:	02 February 2023
Published online:	30 November 2023

Benefits using PDCA cycle of continuous improvement in manufacturing industry – a case study

Jagdeep Singh*

Mechanical Engineering Department,
Ludhiana College of Engineering and Technology,
Katani-Kalan, Ludhiana, Punjab, 141113, India
Email: jagdhoor605@yahoo.com
*Corresponding author

Surjit Kumar Gandhi

PCTE Institute of Engineering and Technology,
Ludhiana, Punjab, 142021, India
Email: skgandi21@gmail.com

Abstract: Plan-Do-Check-Act (PDCA) is the cycle of continuous improvement for making small incremental changes. In the present study, root cause analysis has been performed to ascertain the benefit occurred. The die punch inspection gives a brief analysis of the total inspection recorded from the ring crank rejection analysis with action taken. The rejection quantity is presented in percentage from 0%–20%. A brief graph is raised showing a steep decrease of rejection from 15.5 to 15.0 and 6.12 to 0 point. In the starting month, the percentage of defective pieces was higher. After analysis and implementation of PDCA cycle, the rejection rate decreases drastically. In the later months, the rejection rate has been reduced to zero.

Keywords: root cause analysis; Plan-Do-Check-Act; PDCA; continuous improvement.

Reference to this paper should be made as follows: Singh, J. and Gandhi, S.K. (2024) 'Benefits using PDCA cycle of continuous improvement in manufacturing industry – a case study', *Int. J. Management Concepts and Philosophy*, Vol. 17, No. 1, pp.83–97.

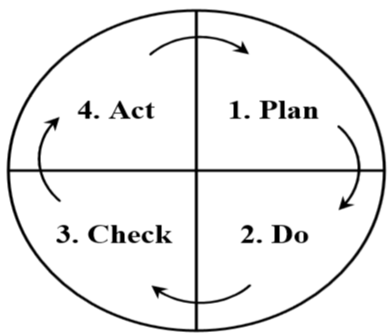
Biographical notes: Jagdeep Singh received his Bachelor's in Mechanical Engineering, Master's in Production Engineering and PhD in Mechanical Engineering. He has published a good number of research papers in international journals of high repute. He is an editorial board member of five reputed journals. His areas of interest are management of production systems and operations management.

Surjit Kumar Gandhi received his Bachelor's in Mechanical Engineering, Master's in Industrial Engineering and PhD in Industrial and Production Engineering. His areas of interest are lean manufacturing, supply chain management and management of production system.

1 Introduction

Many articles are available to know the history of continuous quality improvement. In 1950, Deming utilise Shewhart's fact-based four phase approach. Plan-Do-Check-Act (PDCA) cycle rests on analysis of objective data and collection of facts (Bhulyan and Baghel, 2005). The PDCA cycle assists in the analysis of problems, using tools and studies to define causes and solutions that are prioritised to solve them. Its use is carried out in phases, in order to plan the execution, guarantee this execution in an appropriate way, evaluate the results obtained and establish means to maintain the good results. Its use presents a great use in solving problems, having a very widespread use (Yu et al., 2017). Due to these reasons, intensification of the development of activities is necessary that reduces losses of any nature. PDCA cycle is the methodology of effectiveness in continuous improvement, tool being used in companies having problems of improvements (Rosa and Broday, 2018). Figure 1 shows cycle of continuous improvement Deming cycle PDCA.

Figure 1 PDCA cycle of continuous improvement



Source: Nasution (2005)

Tough competition in market has lead to reevaluation of their manufacturing operations. Elaboration of product has been carried out to identifying map and identifying their management tools. Upgradation of products should be there because quality improvement the important issue in this competitive world (Dhounchak and Biban, 2017). Customer loyalty has been maintained by minimising defects in the process (Realyvásquez-Vargas et al., 2018). Proper planning and preparation of product is important in this competitive world (Chakraborty, 2016). Maintaining a process and implementing PDCA cycle is needed to maintain quality and minimising it. As the process is applicable to business, process and organisation as it is utilised by the industry, implementation at individual level to improve the productivity is quiet essential to improve the same at bigger level. PDCA cycle helps individual to become accountable, which helps to make product line, group and organisation for improving the quality of product (Patel and Deshpande, 2017).

The paper is organised as follows: Section 2 describes the detailed literature review, Section 3, Section 4, Section 5 and Section 6 describe detailed implementation of PDCA cycle of continuous improvement, and finally, conclusions and limitations are drawn in Section 7.

2 Literature review

The researcher studied the strategic and practical implementation of PDCA cycle work productivity, service quality and innovation capabilities of private universities. 243 responses have been obtained which are valid. Structural equation modelling has been applied using the SmartPLS 3.0 software. From the results and discussion, hypotheses framed are accepted, that indicate implementation PDCA concept has significant and positive effect on work productivity, service quality and innovation capabilities. Work productivity and innovation capability have significant and positive effect on service quality. Work productivity and innovation capability have significant positive effect on relationship between service quality and PDCA cycle. A model has been prepared to enhance the service quality of private universities and to enhance the application of PDCA cycle through work productivity innovation capability as mediator (Manik et al., 2020). They found that people who are interested in our study are greatly adapted to their working environment and efficiently handle any challenging situation (Hasan and Hossain, 2018). The aim of research is to reduce at least 20% the defects that are generated during the welding process. In addition, it is intended to increase 20% the capacity of three double production lines where electronic boards are processed. As method, the PDCA cycle, is applied. The Pareto charts and the flowchart are used as support tools. As results, defects decreased 65%, 79%, and 77% in three analysed product models. As conclusion, the PDCA cycle, the Pareto charts, and the flowchart are excellent quality tools that help to decrease the number of defective components (Realyvásquez-Vargas et al., 2018). A case study was conducted at GPEM Laboratory, Vietnamese German University, Vietnam. In this case study, the current packaging style with Styrofoam material was analysed and replaced by new packaging material and methods after applying the PDCA cycle for continuous quality improvement. Targets of the research were to find the new packaging method using friendly environment materials, to improve the quality, and to reduce the defect ratio due to packaging for fine-stone round surface fountains. Moreover, the extra cost should not be higher than 20% compared with the current packaging cost. The article proposes a simplified way that focuses on the combination of quality tools in the PDCA multiple phases to solve these problems. New packaging design was been produced and tested successfully. 100% of new packaging boxes for the mid-weight fountains (under 15 kg) passed the dropping test condition. Nearly 10% of the heavier weight products (above 15 kg) still had some small cracks on their top and bottom due to drop tests (Nguyen et al., 2020).

Garza-Reyes et al. (2018) reported approach of PDCA cycle to conduct environmental-value stream mapping (E-VSM). Green sustainability performance as been improved by implementing PDCA cycle. Islam and Islam (2017) claimed the quality improvement can be achieved using statistical quality control approach. The control tools used were variable control charts and attribute control charts. The process output of an RMG manufacturing factory was studied. Using ‘Minitab 17’, the above-mentioned control charts were developed. The control charts were used to analyse the current process stability. After analysing it, Deming’s PDCA cycle was used to identify and select opportunities for improving quality control. The PDCA cycle was developed based on the current state of the process and rate of defective products. Management personnel were involved with the generation of PDCA cycle. It was found that the process was not stable during the study period. The model of the PDCA cycle contains proposal for further improvement of the process.

Che Ani et al. (2019) studied continuous improvement modified PDCA cycle viz. check-act-plan-do (CAPDo) for improvement in production efficiency. Results of investigation claim that there is significant process improvement for upstream process. Chen and Li (2019) performed a case study of quality accidents in construction. The correlation of construction quality management and construction quality make significant improvement in the construction quality control. With application of PDCA cycle, level of project management has been increased. Jones et al. (2020) implemented Six Sigma using PDCA cycle in the systematic manner. A framework was established to operationalises the Six Sigma with PDCA cycle and quality management in order to achieve executive commitment. Criscione-Naylor (2020) identified assumptions, values, and behaviours associated with leaders during the implementation of kaizen PDCA process and identify post-participation effect on professional practice. Structured conversations and observations have been performed with leaders certified to facilitate a kaizen event. The issues taken in the research includes theory of constraints non-traditional role of the kaizen leaders in the service-based environment. Berhe (2022) studied the practices of kaizen philosophy and its effect on manufacturing companies of Ethiopian. The improvement in production volume, sales volume, productivity and machine productivity are 28.69%, 31.53%, 2.77% and 10.14%. Suárez-Barraza et al. (2021) analysed explored, studied, and implemented Kaizen-Kata PDCA methodology in a food organisation, which was facing challenges in different operational processes that affect and influence the case company performance and customer satisfaction. The average reduction in problem of 70% was obtained after implementation of kaizen PDCA cycle. Routines of some Kaizen-Kata have been identified in a service process environment. Kharub et al. (2023) analysed the factors responsible for practical completion of kaizen events using PDCA cycle. The characteristics of work-study man’s, the conduct of supervisor and autonomy of kaizen team implementation of PDCA cycle. Results indicated that the performance of supervisors conduct and work-study man is directly related to the success of implementation of PDCA cycle through kaizen events. It was shown that supervisors might influence the outcomes of KEs only by moderating the human aspects. Additionally, the degree of autonomy of the kaizen team was found having a significant positive relationship with the success of KEs.

3 Methodology adopted and case study setting

Pareto chart indicates (Figure 3), that the crankcase RH P-90 has maximum rejection for six months. Figure 3 also represents that the maximum number of rejections was of crank case RH P-90, i.e., 9,949. Minimum trend of rejection in quality was seen in the cylinder block KTNA, i.e., 1,156 and the lowest most in its category. 2,541 product rejection rate was the medium one as shown in Figure 3 by CCC left KTR SS part. Red colour represents the data in percentage and blue colour data is known to be rejected quality data. All the analysis helps in maintaining the product quality to the best efforts in the industry in order to increase production rate.

Figure 2 A case study: flowchart

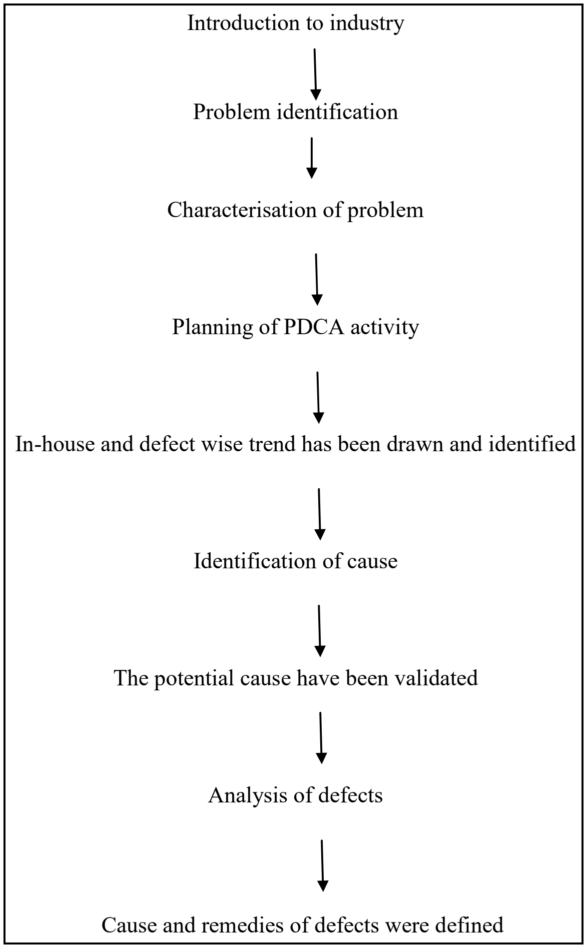


Figure 4, i.e., the Pareto chart also indicates the flaw wise trend of critical product. Chart shows that the ring crack rejection contributes maximum to the whole rejection. It represents the selected defect wise data of components utilised in the industry to increase the production rate. Ring crank has been placed as the maximum in the number of defects of value 2,085 found during real time analysis. Minimum numbers of defects were found in the case of machining activities in the machines, i.e., 365 in number. The heated crank was placed as medium number of defected pieces driven during the production processes, i.e., 735.

The graph line shown in increasing order with red line marking, showing defects in ten number and were taken in the analysis. Red colour represents the data in percentage and blue colour data is known to be rejected quality data.

Table 1 Characterisation of problem

Sr. no.	*Problems*	*Categorisation (A, B and C)*
1	Carbon in cap 30 mm in KWAG	A
2	Non-filling in cover tappet adj. P-90	A
3	Letter missing in bracket 306	A
4	Carbon in cap 14 mm	A
5	Soldering in chassis bracket	A
6	Blow hole in crank case RH CD-100	A
7	Ring crack in crank case RH P90	A
8	Non-filling in crank case RH P90	A
9	Catching in mounting arm	A
10	Unclean in bracket 306	A
11	Non-filling in cap 14 mm	A
12	Gate damage in HH under P17	A
13	Carbon deposition in fuel door ring	A
14	Gate broken in crank case CD-100	A
15	Chip off at slide in fuel door ring	B
16	Ej. pin (up/down) in mounting arm	B
17	Chip-off at lock in fuel door ring	B
18	Scratch in cap 3 0mm in KRYH	A
19	Ejector pin up/down in CCCL KSTK (SS)	A
20	Ejector pin up/down in HH under P17	B
21	Blow hole in crank case RH P-90	A
22	Hole taper in chassis bracket	A
23	Non-filling in HH under P17	A
24	Chip-off at overflows in fuel door ring	B
25	Ring crack in crank case RH P-90	A
26	Gate broken in cover tappet adj. P-90	A
27	Ring crack in crank case RH CD-100	C
28	Blow hole in cap water inlet	A
29	Carbon in HH under P17	B
30	Non-filling in CCCL KSTK (SS)	B
31	Chip-off at gate (O/D) in fuel door ring	B
32	Chip-off in bracket 306	B
33	Blow hole in HH under P17	A
34	Chip-off in mounting arm	B

Figure 3 Pareto chart for maximum rejection of components (see online version for colours)

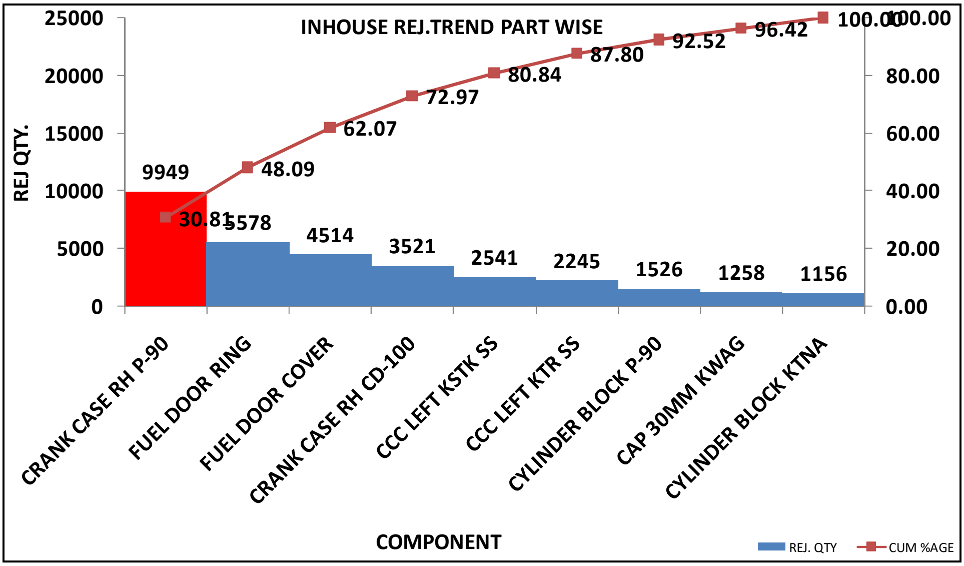
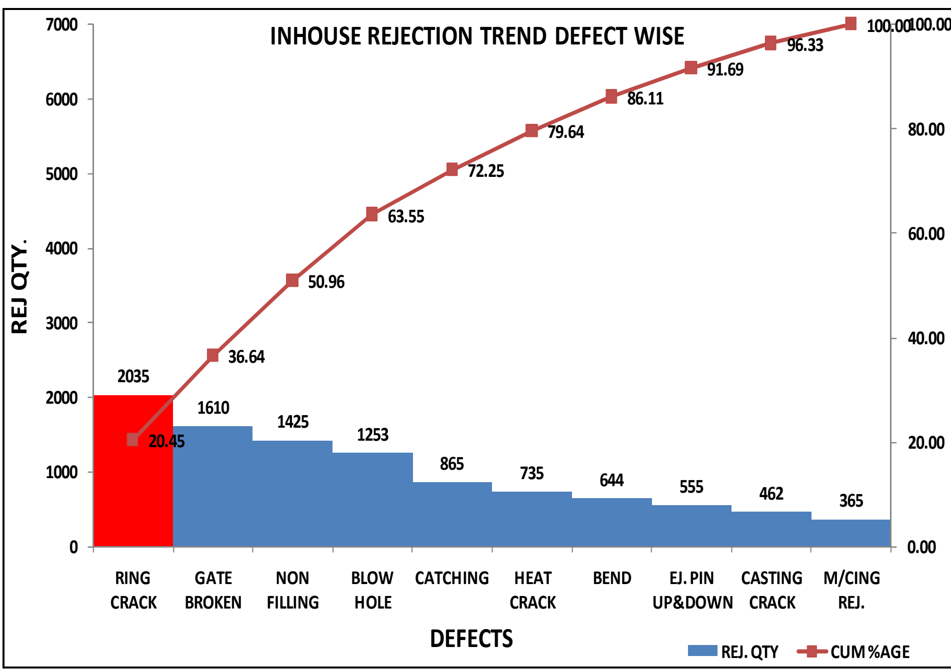


Figure 4 Trend of product on the basis of defect (see online version for colours)



4 Planning of PDCA activities

PDCA describes: P – plan, D – do, C – check and A – act. Various activities under the PDCA cycle have been identified and implemented to remove the ring crack in the critical product. The detail function of PDCA is mentioned in Table 2. After the investigation, the various causes were determined. The PDCA analysis follows a step, on which the further investigations have been conducted. The procedure starts with planning which a combination on identification of problem, selection of problem and defining of problem. For any analysis, the identification of problem of problem formulation is very important. The next step is do (D), in which analysing of problems, identification of cause, finding the root cause, data analysis for cause validation, development of solution and foreseeing probable resistance are the main function of DO. The third step is check (C), after analysing and identification of problem, trial implementation and checking the performance has been done. This step provides a trial of the defect and check that the solution of defect is correct or not. If there is any problem found, further investigations have been performed.

Table 2 Detail description of PDCA analysis

Plan (P)	Identification of work related problem
	Selection of problem
	Defining the problem
Do (D)	Analysing the problem
	Identification of cause
	Finding the root cause
	Data analysis for cause validation
	Development of solution
	Foreseeing probable resistance
Check (C)	Trial implementation and checking performance
Act (A)	Regular implementation
	Follow-up and review

5 Identification of cause

The root cause of the problem has been identified through brainstorming session. The details are mentioned in Table 3. First cause is made by man itself, in which firstly the fatigue is recorded by labour and results claimed that unskilled operator is the main cause of the problem. In case of material, various kind of causes were identified that are firstly identified, includes the impurities in metal, ring undersize with hardness and thickness are recorded because no preheating was done. Method is the other parameter cause in which the improper die temperature variation and speed position factor were also been the major cause. In similar way, the other factors and their subdivisions are stated in Table 3.

Table 3 Identification of causes

Man	Fatigue
	Unskilled operator
Material	Impurities in metal
	Ring undersize and oversize
	Degassing not done properly
	Ring hardness not correct
	Ring thickness not correct
	Preheating not done
Machine	Water leakage in die
	Gate thickness variation
	Die life over
	Metal temperature low and high in furnace
	Leakage in machine
	Oil temperature low and high
	Ring die holding punch bulge
Method	Process parameters not as per specification
	Die temperature variation
	Ring checking method not defined
	Die opening and close time variation
	Variation in high speed position

6 Validation of potential cause

Each probable cause has been checked for its validation by assigning duties to employees and by adopting appropriate method. Table 4 shows the detail analysis of case study, Column 2 shows the problem cause, column 3 shows the method, column 4 shows the machine number by which the defect was indicated, and column 5 shows the conclusion.

The validation of potential cause is presented in Table 4, in which real time analysis has been done by involving employee in industry for effective proof of validation of quality processes. Various persons have been assigned with duties adopted for various methods like checking the work load and checking the skill matrix, by visual inspection and by thermocouple.

After the validation of cause and deriving effects from various causes and processes, there is another part of causes that has been chosen from Serial no. 11, in which different cause's parameters are taken with employee contribution and put in deep contribution doing work on different machines like 630-1. After possible cause validation analysis of various kind of results and conclusion has been raised, which mainly contribute toward non-valid causes.

After the validation of cause and deriving effects from various causes and processes there is another part of causes as shown in Serial number 24, in which different cause's parameters are taken with employee contribution of the study in industry that was put in deep contribution doing work on different machines like 630-1 and 630-3. After possible validation analysis, various kind of results and conclusion has been raised which mainly contribute toward non-valid causes.

Figure 5 Trial implementation status, (a) gauge not available for inspection of CI ring (b) new gauge available to die punch inspection (c) no gauge available to die punch inspection (d) new ring gauge provide to die punch inspection (see online version for colours)

(a) (b) (c) (d)

Notes: Figure shows the investigation process of case study. Figure 5(a) case shows that when gauge was not available for the inspection of the CI ring that leads to the process losses which is analysed in the why-why analysis. Figure 5(b) shows that the gauge is provided for the inspection of the CI ring at FDC end point. Shown in Figure 5(c) where there is no gauge was available for inspection and Figure 5(d) was provided for the new ring provided to die punch which was beneficial for better production.

Table 4 Analysis table of case study

Sr. no.	*Probable cause*	*Method*	*M/C number*	*Result*	*Conclusion*
1	Fatigue	By checking work load	Each operator	Two person deputed at each every M/C	Invalid cause
2	Unskilled operator	By checking skill matrix	Each operator	All found skilled up to mark	Invalid cause
3	Water leakage in die	Visual	630-1	Found ok	Invalid cause
4	Gate thickness variation	With DVC	630-1	All found ok	Invalid cause
5	Die life over	With data of shots	630-3	All found ok	Invalid cause
6	Air vent jam	Visual	630-1	All found ok	Invalid cause
7	Over flow block	Visual	630-3	All found ok	Invalid cause
8	Metal temp. low and high in furnace	Thermocouple	630-1	Found ok	Invalid cause
9	Biscuit thickness variation	With DVC	630-1	All found ok	Invalid cause
10	Any leakage from machine	Visual	630-1	All found ok	Invalid cause
Validation of potential cause (Part-2)					
11	Excess N2 pressure	Visual	630-3	All found ok	Invalid cause
12	Oil temp. low and high	Visual	630-3	All found ok	Invalid cause
13	N2 pressure less	Visual	630-1	All found ok	Invalid cause
14	Less clearance B/W ring locating punch and CI ring	DVC	630-1	Found NG	Valid cause
15	Ring die holding punch damage	Visual	630-3	Found NG	Valid cause
16	Impurities in metal	Visual	630-1	All found ok	Invalid cause
17	Degassing not done properly	Visual	630-1	All found ok	Invalid cause
18	Metal composition	Spectrometer	630-1	All ok	Invalid cause
19	CI ring under and over size	DVC/micrometer	630-3	All found ok	Invalid cause
20	CI ring hardness not correct	Hardness machine	630-1	All found ok	Invalid cause
21	Ring pre-heating not done	Visual	630-1	All found ok	Invalid cause
22	Process parameter not as per standard	Visual	630-3	All found ok	Invalid cause
23	Die. temp. variation	Laser gun	630-1	All found ok	Invalid cause

Table 4 Analysis table of case study (continued)

Sr. no.	*Probable cause*	*Method*	*M/C number*	*Result*	*Conclusion*
Validation of potential cause (Part-3)					
24	Variation in die opening and close time	Visual	630-3	All found ok	Invalid cause
25	CI ring checking method not define	Visual	630-3	All found ok	Invalid cause
26	Die punch checking method not define	Visual	630-1	All found ok	Invalid cause

During study, it has been found that less clearance has been provided between punch and CI ring. Clearance is generally provided in between punch and dies so that less wear out could takes place. In similar way, the clearance has been provided. Figure 5 shows the steps for process held in case study. Similarly, Figure 6 shows the why-why analysis for ring dies and holding punch damage.

Figure 6 Why-why analysis for less clearance between ring locating punch and CI ring

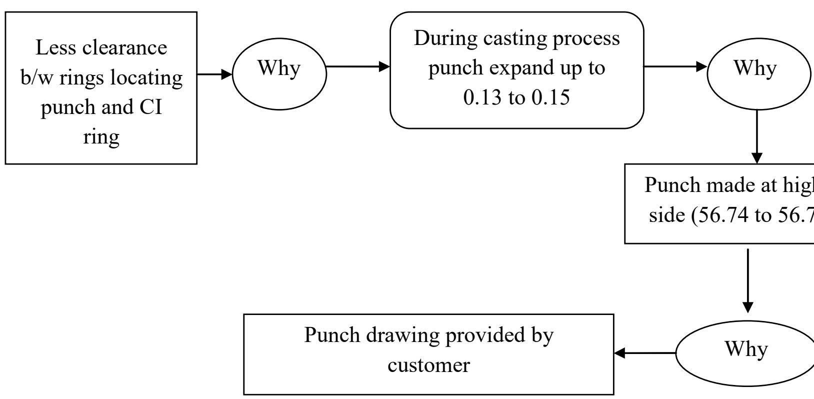
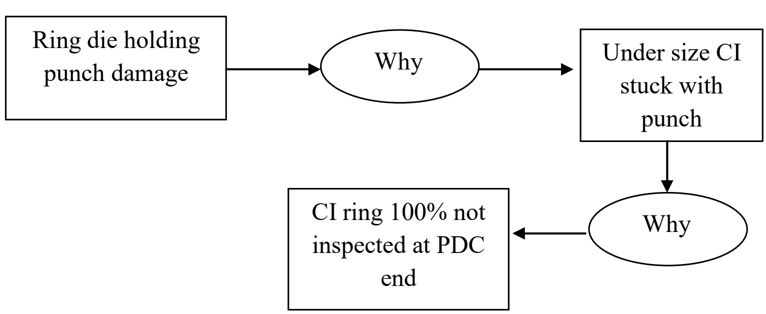


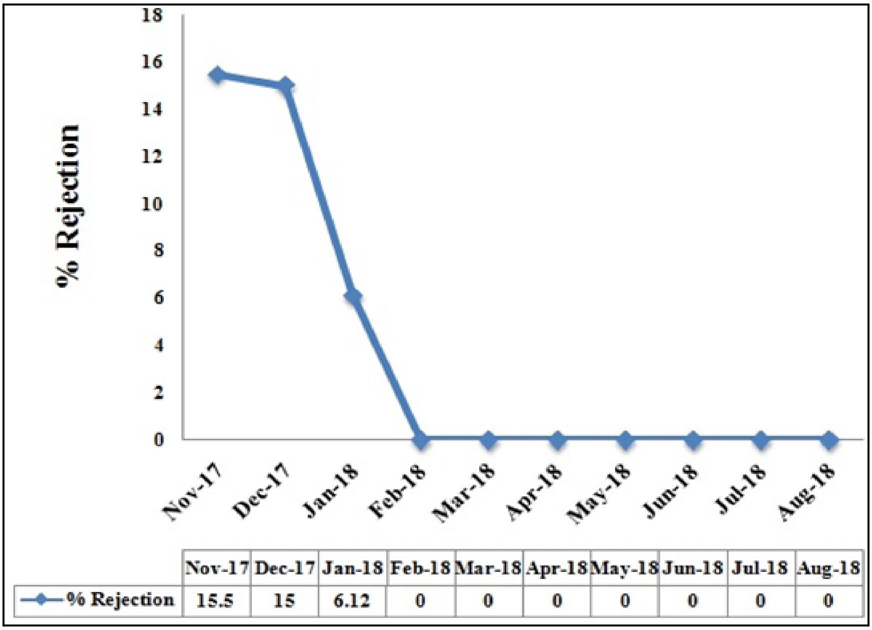
Figure 7 Why-why analysis for ring die holding punch damage



The why-why analysis has been done over the punch and CI ring. The flowchart shows the various stages happened in the process. In the first instance, it shows that there is less clearance problem happening while locating the punch and ring with rectification remarks as punch drawing provided by the customer.

Why-why analysis of ring die holding punch damage has been done as shown in Figure 7. Why-why dies holding analysis shows that, with the parameter under consideration, the ring holding get damaged with undersized CI ring struck with punch due to clash in during operation. The whole process is giving the results that the CI ring was not inspected which results in production losses.

Figure 8 The rejection trend after action taken (see online version for colours)



	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18
% Rejection	15.5	15	6.12	0	0	0	0	0	0	0

7 Conclusions and limitations

PDCA cycle plays a significant role in improving the current manufacturing system processes by reducing rejection rates. The present case study has been done in medium scale manufacturing industry for reducing rejection to 0% for the critical product. Why-why analysis has been performed to implement PDCA cycle step wise. In the central process, the action results have been compared with target. The clearance between rings locating punch and CI rings was less, expansion of punch was on high side and corrective actions were taken. The continuous and repeated nature of continuous improvement approach is found out by the PDCA cycle. The limitation of the study includes limited benefit of implementing PDCA cycle. Other benefits like production rates, cost reduction, and safety can be obtained by implementing this cycle. The selection of case study has been done on convenient sampling or snow ball sampling technique.

References

Berhe, H.H. (2022) 'Application of kaizen philosophy for enhancing manufacturing industries' performance: exploratory study of Ethiopian chemical industries', *International Journal of Quality & Reliability Management*, Vol. 39, No. 1, pp.204–235.

Bhulyan, N. and Baghel, A. (2005) 'An overview of continuous improvement: from the past to the present', *Management Decision*, Vol. 43, No. 5, pp.761–771.

Chakraborty, A. (2016) 'Importance of the PDCA cycle for SMEs', *International Journal of Mechanical Engineering*, Vol. 3, No. 5, pp.30–34.

Che Ani, M.N., Kamaruddin, S. and Azid, I.A. (2019) 'Leanness production system through improving of upstream process based on check-act-plan-do cycle', *International Journal of Six Sigma and Competitive Advantage*, Vol. 11, Nos. 2/3, pp.95–113.

Chen, Y. and Li, H. (2019) 'Research on engineering quality management based on PDCA cycle', *IOP Conf. Series: Materials Science and Engineering*, Malaysia, pp.12–28.

Criscione-Naylor, N. (2020) 'Kaizen (continuous improvement) and systems thinking: exploring how kaizen facilitators operationalise values and assumptions', *International Journal of Management Practice*, Vol. 13, No. 5, pp.547–564.

Dhounchak, D. and Biban, L.K. (2017) 'Total quality management and its applications', *International Journal of Scientific Research in Mechanical and Materials Engineering*, Vol. 1, No. 1, pp.15–17.

Garza-Reyes, J.A., Romero, J.T., Govindan, K., Cherrafi, A. and Ramanathan, U.A. (2018) 'PDCA-based approach to environmental value stream mapping (E-VSM)', *Journal of Cleaner Production*, Vol. 18, No. 4, pp.335–348.

Hasan, Z. and Hossain, M.S. (2018) 'Improvement of effectiveness by applying the PDCA cycle or kaizen: an experimental study on engineering students', *Journal of Scientific Research*, Vol. 10, No. 2, pp.159–173.

Islam, T. and Islam, M.S. (2017) 'Developing control charts in a manufacturing industry and improvement of quality using PDCA cycle', *International Conference on Mechanical, Industrial and Materials Engineering 2017 (ICMIME2017)*, RUET, Rajshahi, Bangladesh, 28–30 December.

Jones, E.C., Parast, M.M. and Adams, S.G. (2020) 'A framework for effective Six Sigma implementation', *Total Quality Management Business Excellence*, Vol. 21, No. 1, pp.415–424.

Kharub, M., Gupta, H., Rana, S. and McDermott, O. (2023) 'Employee's performance and kaizen events' success: does supervisor behaviour play a moderating role?', *The TQM Journal* [online] https://doi.org/10.1108/TQM-06-2022-0203.

Manik, C.D., Karolina, Triyadi, Wardani, E.S. and Sunarsi, D. (2020) 'The effect of PDCA cycle on service quality, innovation capability, and work performance of Indonesian private universities', *PalArch's Journal of Arcaeology of Egypt*, Vol. 17, No. 6, pp.8462–8483.

Nasution, M.N. (2005) *Manajemen Mutu Terpadu*, Ghalia Indonesia, Bogor.

Nguyen, V., Nguyen, N., Schumacher, B. and Tran, T. (2020) 'Practical application of Plan-Do-Check-Act cycle for quality improvement of sustainable packaging: a case study', *Applied Sciences*, Vol. 10, No. 1, pp.1–15.

Patel, P.M. and Deshpande, V.A. (2017) 'Application of Plan-Do-Check-Act cycle for quality and productivity improvement – a review', *International Journal for Research in Applied Science & Engineering Technology*, Vol. 7, No. 1, pp.197–201.

Realyvásquez-Vargas, A., Arredondo-Soto, K., Carrillo-Gutiérrez, T. and Ravelo, G. (2018) 'Applying the Plan-Do-Check-Act (PDCA) cycle to reduce the defects in the manufacturing industry – a case study', *Applied Sciences*, Vol. 8, No. 11, pp.11–17.

Rosa, A.C.M. and Broday, E.E. (2018) 'Comparative analysis between the industrial and service sectors: a literature review of the improvements obtained through the application of Lean Six Sigma', *International Journal for Quality Research*, Vol. 12, No. 1, pp.227–252.

Suárez-Barraza, M.F., Miguel-Dávila, J.A. and Morales-Contreras, M.F. (2021) 'Application of Kaizen-Kata methodology to improve operational problem processes. A case study in a service organization', *International Journal of Quality and Service Sciences*, Vol. 13, No. 1, pp.29–44.

Yu, G.J., Park, M. and Hong, K.H. (2017) 'A strategy perspective on total quality management', *Total Quality Management & Business Excellence*, Vol. 4, No. 2, pp.1–14.