

Analysis of Downtime Causes and Proposed Belt Conveyor Performance Improvement Using Root Cause Analysis and Plan-Do-Check-Action Methods at PT X

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Abstract

This study analyzes the causes of downtime and proposes performance improvement solutions for Belt Conveyor machines at PT X using an integrated approach of Root Cause Analysis (RCA) and Plan-Do-Check-Action (PDCA) methods. Operating in the tobacco processing industry in Mojokerto, East Java, PT X faces significant production inefficiency challenges, with Belt Conveyors (M-08) contributing 47.09% of total downtime (103.93 hours) in March 2025. The research employs Pareto Diagram to identify priority problems and Fishbone Diagram to map root causes across six factors: Machine, Method, Man, Material, Measurement, and Environment. Analysis reveals that the dominant causes are jammed roller idlers and motor overheating due to tobacco dust accumulation. The 5W+1H method is utilized to formulate corrective and preventive actions, including upgrading bearings to Rubber Sealed type (6204-2RS) and establishing systematic motor cleaning procedures. Implementation results project a 50% downtime reduction from 103.93 hours to 52 hours, with machine availability increasing from 98.51% to 99.26%. The study demonstrates that integration of RCA and PDCA provides an effective framework for identifying root causes and implementing sustainable maintenance solutions. Standardization of component specifications and cleaning procedures is established to ensure continuous improvement and optimal operational performance in tobacco processing operations.

Keywords: Availability; Belt Conveyor; Downtime; Fishbone Diagram; PDCA; Preventive Maintenance; Root Cause Analysis

1. Introduction

PT X is a company that plays a vital role in processing raw tobacco leaves into high-quality raw materials for cigarette factories and export markets. Operating in Mojokerto, East Java, the company focuses on tobacco processing, packaging, and delivery services with strict quality standards. Like PT X, achieving timely production targets, particularly due to being tied to harvest seasons, heavily depends on human resource productivity. Skilled and efficient labor becomes a key factor ensuring the sorting, drying, and handling processes of thousands of tons of tobacco can run smoothly according to plan, thereby guaranteeing quality and continuous supply to customers.

The tobacco industry in Indonesia is a strategic labor-intensive sector, within which there are processing service companies like PT X, which plays a vital role in processing raw tobacco leaves into high-quality raw materials for cigarette factories and export markets. Operating in Mojokerto, East Java, PT ITS focuses on tobacco processing, packaging, and delivery services with strict quality standards. Similar to PT ITS, achieving timely production targets, especially due to being tied to harvest seasons, heavily depends on human resource productivity. Skilled and efficient workers at PT ITS become key factors ensuring the sorting, drying, and handling processes of thousands of tons of tobacco can run smoothly according to plan, thereby guaranteeing quality and continuous supply to customers.

In this internship activity, the author was placed in the Warehouse Division and Processing Division of PT X to study tobacco processing procedures, quality control of processed tobacco, and production machine maintenance and reliability management. The main method used in analyzing machine productivity disruptions is the integration between Root Cause Analysis (RCA) and Plan-Do-Check-Action (PDCA) methods. The RCA method is used in the planning (Plan) phase to trace the root causes of problems qualitatively using Pareto Diagram and Cause-and-Effect Diagram (Fishbone Diagram) approaches. Subsequently, the PDCA framework is used to formulate systematic improvement steps, starting from action plan formulation using 5W+1H, technical improvement implementation (Do), damage reduction target evaluation (Check), to maintenance procedure standardization (Act). Through this research, it is expected to provide concrete and applicable solution proposals to address dominant root problems, thereby minimizing unplanned downtime. This in turn will become the foundation for the company in designing more effective preventive maintenance strategies to maintain overall production volume stability.

Through this independent internship program, the author is expected to gain insights into equipment and production machine effectiveness analysis for improving Processing Division productivity. This observation aims to help the company reduce losses due to machine inefficiency (such as breakdowns, speed reduction, and defective products) and prevent cost waste. The knowledge and experience gained

directly through the application of Root Cause Analysis methods and the Plan-Do-Check-Action cycle will greatly help students apply operational management theory, particularly maintenance and quality management learned during lectures, into real practice, so that graduates can be ready to face workplace challenges equipped with insights and experience in optimizing production assets.

2. Research Method

2.1. Research Problem formulation and objectives

This research focuses on implementing the integration of Root Cause Analysis (RCA) and Plan-Do-Check-Action (PDCA) cycle methods. The RCA method is used in the planning (Plan) phase to trace the fundamental root causes of each machine damage incident using the cause-and-effect diagram (Fishbone Diagram) approach. Subsequently, the PDCA method is applied as the main framework for formulating concrete improvement plans (Plan), implementing technical corrective actions (Do), evaluating damage reduction effectiveness (Check), and conducting maintenance standardization (Action). Through this approach, the research aims to provide performance improvement recommendations and effective preventive maintenance strategies, so that downtime periods on Belt Conveyor machines can be significantly minimized and the continuity of tobacco processing at PT X can be maintained at a high reliability level.

The intensive operational conditions impact high accumulation of downtime, both caused by operational factors (operational downtime) and machine damage (machinery downtime). Based on field data until the end of March 2025, significant total downtime was recorded, impacting the effectiveness of production target achievement (General Efficiency of 91.02%). The high frequency of grade changes (Clean/Change Grade) and technical disruptions to critical components such as Conveyors indicate fundamental problems that cannot be resolved solely through quick repairs (corrective repair). The following is the Accumulated Downtime data occurring in the production line during the March 2025 period:

Table 1: Percentage of Downtime Occurring on Production Machines

Code	Machine Name	Downtime (Hours)	Percentage (%)	Cumulative (%)
M-08	Belt Conveyors	103,93	47,09%	47,10%
M-26	Fishburne Press	31,33	14,20%	61,30%
M-27	Electric Motors	16,02	7,26%	68,50%
M-29	Boilers	11,63	5,27%	73,80%
M-19	Separators	10,58	4,79%	78,60%
M-21	Shakers	9,68	4,39%	83,00%
M-18	Treshers	9,52	4,31%	87,30%
M-28	Electric Panels	8,33	3,77%	91,10%
M-03	Bundler Buster	7,08	3,21%	94,30%
M-15	Distributors	4,25	1,93%	96,20%
M-02	Tips Cut Knives	3,13	1,42%	97,60%
M-25	Press Scales	2,5	1,13%	98,80%
M-09	Cond. Cylinder	1,23	0,56%	99,30%
M-24	Redryer	1	0,45%	99,80%
M-06	Tips Separator	0,33	0,15%	99,90%
M-05	Tips Cylinder	0,17	0,08%	100,00%
Total Downtime		220,71	100,00%	

Based on the data in the table above, it is known that the Belt Conveyors machine (M-08) is the largest contributor to production inefficiency with downtime duration reaching 103.93 hours. This figure is equivalent to 47.10% of total overall downtime, indicating that problems with this material transportation system are critical and cannot be resolved solely through reactive corrective repair when damage occurs.

To reduce this high downtime duration, in-depth investigation is needed to find specific root causes in the Belt Conveyor unit. Therefore, this research applies the Root Cause Analysis (RCA) method as the main diagnostic step. The analysis process is conducted using Pareto Diagram instruments to validate the dominance of Belt Conveyor damage compared to other machines, and the Fishbone (Ishikawa) Diagram to comprehensively map the root causes of damage based on machine, method, man, material, and environment factors.

2.2. Root Cause Analysis

Root Cause Analysis (RCA) is a systematic problem-solving method used to identify the fundamental origins of faults or problems rather than merely addressing their superficial symptoms [7]. In the context of the manufacturing industry, this approach is essential for enhancing equipment reliability and minimizing production downtime by ensuring that corrective actions are targeted at the source of the failure [5]. The implementation of RCA is frequently supported by the Cause-and-Effect Diagram, also known as the Fishbone Diagram, which helps categorize potential causes into distinct factors such as man, machine, material, method, and environment to visualize the root of the problem comprehensively [8], [3]. Furthermore, the application of RCA is often integrated with other quality frameworks to provide a structured approach for continuous improvement, allowing companies to evaluate the effectiveness of the maintenance strategies applied [2].

2.3. Plan-Do-Check-Action (PDCA)

The Plan-Do-Check-Act (PDCA) cycle, also widely known as the Deming Wheel, is an iterative management method used essentially for the control and continuous improvement of processes and products [10]. The cycle commences with the Plan phase, where objectives and processes are established to deliver results in accordance with the expected output, followed by the Do phase, which involves the implementation of the plan on a small scale to test its efficacy [1]. Subsequently, the Check phase is critical for monitoring and measuring the processes and products against policies, objectives, and requirements to report the results, ensuring that any deviation is identified early [4]. Finally, the Act phase entails taking corrective actions to improve process performance continuously; if the trial is successful, the new method is standardized to prevent the recurrence of previous errors [9]. In the context of the manufacturing industry in Indonesia, this methodology is frequently integrated with quality control tools to systematically reduce waste and enhance overall equipment effectiveness [6].

3. Result and Discussion

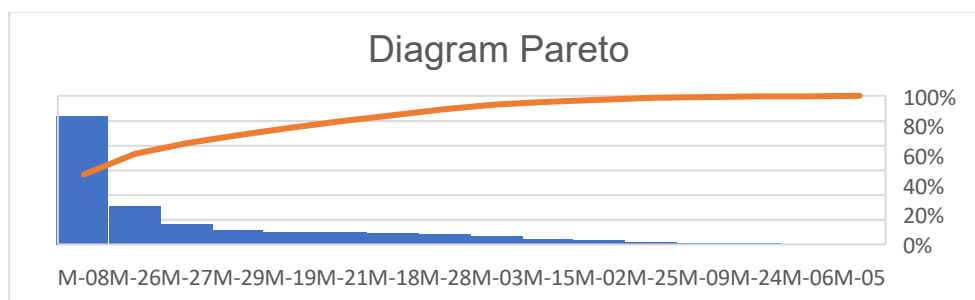
3.1. Plan-Do-Check-Action Method Cycle

1. Plan (Root Cause Analysis)

a) Pareto Diagram

In machine maintenance strategy, the Pareto rule (80/20) is used as an analytical instrument to identify components or failure types that are most influential, where a small portion of critical elements (vital few) make the largest contribution to total downtime occurring (Pratama et al., 2024). Based on historical machine damage data during the March 2025 period, analysis was conducted to map the main sources of inefficiency. Subsequently, a Pareto diagram was compiled to identify machines providing the most dominant downtime contribution in the tobacco processing production line at PT X. Visualization of problem priority order for machines based on downtime duration can be seen in the graph below:

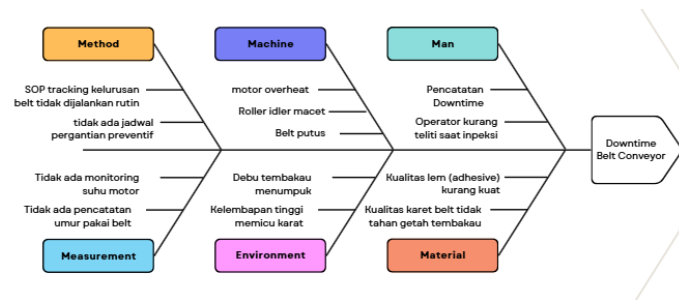
Fig. 1: Production Machine Downtime Pareto Diagram



Based on the Pareto diagram graph above, it is significantly visible that Belt Conveyors (M-08) is the single largest contributor to production inefficiency, with total downtime duration reaching 103.93 hours. This figure represents 47.09% of total overall downtime, meaning almost half of total technical problems on the production floor originate from this one machine type. Given the magnitude of this damage impact dominance, this research is focused in-depth (in-depth analysis) specifically on Belt Conveyors. This approach was chosen to enable more detailed analysis of critical sub-components such as rollers, belt splicing, and drive systems. Subsequently, root cause identification will be conducted using the Fishbone Diagram.

b) Fishbone Diagram

Fig. 2: Belt Conveyor Fishbone Diagram



It is known that the fishbone diagram figure above shows the factors causing downtime on the Belt Conveyor machine. Of the 6 factors, the factors most potential for improvement are Machine and Environment factors. This is based on findings that high downtime on Belt Conveyors (103.93 hours) is dominated by technical problems. Referring to the diagram above and actual field conditions, in the Machine factor, main problems were found in the form of jammed Roller idlers and Motor overheat. This condition is exacerbated by the Environment factor, namely accumulated tobacco dust. Extreme dust accumulation in the work environment enters roller bearing components and covers motor cooling fins, triggering jamming and excessive heat causing the machine to stop operating (breakdown).

c) 5W+1H Methods

The following are improvement proposals using the 5W+1H method from the Belt Conveyor machine fishbone diagram:

1. Machine Factor

Table 2: 5W+1H Method Machine Factor

Factor	What	Why	Where	When	Who	How
	Motor Overheat	Cooling fins covered with dirt/dust so heat is trapped	Main Drive Motor	Every end of shift	Operator & Cleaning	Conduct routine blowing of motor fins so air circulation is smooth
Machine	Roller Idler Jammed	Bearing broken or jammed due to dust/rust entry	Along conveyor path	First Shift	Technician	Replace open type bearing with Sealed type (2RS) that is dust-proof
	Belt Broken	Excessive friction due to jammed roller or loose	Belt Connection	During breakdown / Maintenance Day	Technician & Foreman	Perform reconnection (splicing) with more precise method

2. Methods Factor

Table 3: 5W+1H Methods Factor

Factor	What	Why	Where	When	Who	How
	Belt Misalignment	Belt tracking (straightness) SOP not routinely executed	Conveyor Path	Weekly	Supervisor & Operator	Enforce SOP discipline for belt tracking adjustment every beginning of week
Method	Sudden Damage	No preventive component replacement schedule	Maintenance Departement	Beginning of Month	Supervisor	Compile Preventive Maintenance (PM) schedule based on component lifespan estimation

3. *Man Factor***Table 4:** 5W+1H Method *Man Factor*

Factor	What	Why	Where	When	Who	How
Man	Damage Symptoms Overlooked	Operator not careful when conducting visual inspection	Operator Work Area	Beginning of Shift	Foreman / SPV	Provide brief briefing (One Point Lesson) on how to detect rough sounds on rollers

4. *Materials Factor***Table 5:** 5W+1H Method *Materials Factor*

Factor	What	Why	Where	When	Who	How
Material	Belt Connection Loose	Quality of adhesive used is not strong enough	Sparepart Warehouse	During goods procurement	Purchasing / Teknisi	Evaluate adhesive specifications and propose upgrade to stronger industrial brand/type

5. *Measurement Factor***Table 6:** 5W+1H Method *Measurement Factor*

Factor	What	Why	Where	When	Who	How
Measurement	Motor Burned / Trip	No periodic motor temperature monitoring	Panel & Motor	Every 4 Hours	Operator	Provide Thermal Gun tool and motor temperature recording table
	Belt Life Unpredictable	No recording of belt lifespan data since installation	Logbook Maintenance	During new replacement	Technical Admin	Create Machine History Card to record belt installation date

6. *Environment Factor***Table 7:** 5W+1H Method *Environment Factor*

Factor	What	Why	Where	When	Who	How
Environment	Tobacco Dust Accumulation	Dust particles from production process fly to machine area	Drive Motor & Roller Area	Daily (Shift Change)	Cleaning Staff	Create special cleaning duty schedule for moving parts component areas
	Components Rusted	High air humidity triggers metal corrosion	Frame & Roller	Monthly	Maintenance	Conduct lubrication or repainting on areas prone to rust

2. **Do**

The Do phase is the actual execution phase of improvement plans formulated in the 5W+1H table in the planning (Plan) phase. Based on analysis of dominating root causes, namely high component damage due to tobacco dust exposure (Environment Factor) and mechanical wear (Machine Factor), improvement implementation focuses on a combination of corrective and preventive actions. The first step is conducted through corrective action by replacing bearing components on Roller Idlers that frequently experience jamming; bearing

specifications are upgraded from standard type to Rubber Sealed type which has double rubber seals to prevent dust particles from entering the rotating mechanism.



Fig. 3: Example of *Rubber Sealed Bearing*

Subsequently, preventive action is implemented by conducting thorough Deep Cleaning of Main Drive Motor cooling fins using high-pressure compressors to remove dust layers triggering overheating. To complement these technical improvements, Method improvement is also applied by compiling and socializing simple Daily Checksheets for operators, aimed at detecting early damage symptoms such as rough sounds on rollers or abnormal motor temperatures so that handling can be done earlier before fatal damage occurs causing high downtime.

3. Check

After a series of improvement actions (Improvement) were formulated and gradually implemented at PT X, effectiveness evaluation was conducted to measure the impact of solutions on Belt Conveyor machine performance. Referring to observation duration limitations, success analysis is based on comparison between historical data (baseline) and Improvement Projection Target. Based on this data, there is a significant increase in Machine Availability indicator which is directly proportional to downtime duration reduction. This increase indicates that the strategy of replacing critical components (Sealed Bearing) and motor cleanliness standardization can restore machine reliability to optimal levels, so that potential losses due to production flow stoppage can be minimized.

a) *Availability Belt Conveyor*

$$\begin{aligned} \text{Availability Belt Conveyor} &= \frac{\text{total time} - \text{downtime}}{\text{total time}} \times 100\% \\ &= \frac{419.329 - 6.236}{419.329} \times 100\% \\ &= \frac{413.093}{419.329} \times 100\% = 98,51\% \end{aligned}$$

b) *Target Downtime*

$$\begin{aligned} \text{Downtime target (minutes)} &= \text{Actual Downtime} \times 50\% \\ &= 6.236 \times 0,5 = 3.118 \text{ minutes (equivalent to 52 hours)} \end{aligned}$$

c) *Target Availability*

$$\begin{aligned} \text{Target Availability belt conveyor} &= \frac{419.329 - 3.118}{419.329} \times 100\% \\ &= \frac{416.211}{419.329} \times 100\% = 99,26\% \end{aligned}$$

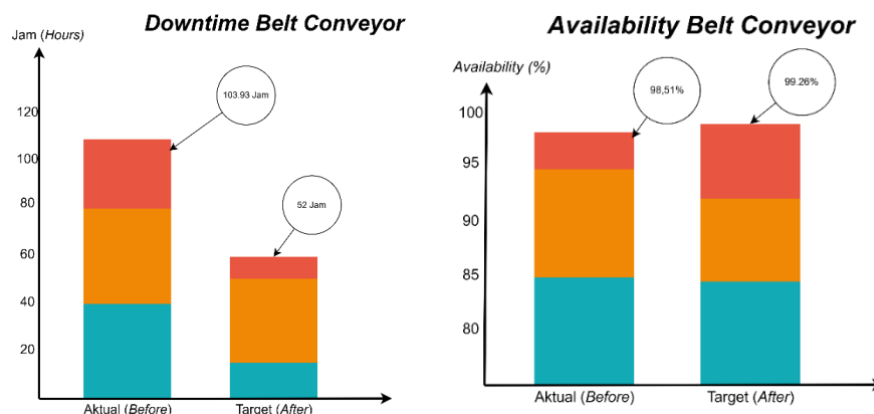


Fig. 4: Target Downtime and *Availability Belt Conveyor Graph*

4. Check

The Action phase is the final step in one PDCA cycle aimed at standardizing proven effective improvement results and determining next steps to ensure process sustainability. Based on evaluation in the Check phase, the strategy of replacing components to Sealed Bearing type and implementing Deep Cleaning is technically proven to significantly reduce Belt Conveyor machine damage risk. For this achievement to be permanent and not return to initial conditions, new standards are compiled and work procedures are legalized as follows:

1. Component Specification Standard Establishment (Part Standardization): A new policy is established in sparepart procurement specifically for dusty Processing Division areas, where all bearing replacements on conveyor rollers use 6204-2RS specifications (figure 3.3). Use of open type bearings is no longer allowed for critical areas to prevent dust contamination entry.
2. Cleaning Schedule Institutionalization (Cleaning Standard): Motor fin cleaning activities (motor fin blowing) which were previously incidental, are now established as routine procedures in Daily Work Instructions (IK). Operators are required to conduct light cleaning for 5 minutes every end of shift and record in Machine Cleaning Logbook.
3. Control Visualization (Visual Management): Installation of normal temperature limit indicator labels on motors and visual marks on roller inspection areas to facilitate operators in conducting early detection without having to dismantle machines.

As long-term follow-up action (Future Plan), the success of improvements on Belt Conveyor M-08 machine is recommended for duplication (horizontal deployment) to other similar machine units in the Processing Division having similar problem characteristics. Thus, a culture of Continuous Improvement can be formed comprehensively in PT X's work environment.

4. Conclusion

Based on the results of analysis and discussion conducted, it can be concluded that application of the PDCA method to address high damage on Belt Conveyor (M-08) machines has provided measurable positive impact. Problem identification using Pareto Diagram and Fishbone successfully mapped that dust accumulation and use of open bearing components are the main root causes of high actual downtime of 103.93 hours. Implementation of improvement solutions through component replacement to Sealed Bearing type and motor cleanliness standardization proved effective, where technical evaluation projects downtime duration reduction of 50% to 52.00 hours. This disruption reduction is directly proportional to machine efficiency improvement, marked by Availability value increase from 98.51% to 99.26%, which is then followed up with maintenance procedure standardization to ensure optimal operational performance sustainability. Meanwhile, for further research, considering this study uses estimated data due to time limitations, it is highly recommended to conduct actual data validation over a longer time span (3-6 months) to test downtime reduction consistency. Future researchers are also recommended to expand analysis scope to financial aspects (Cost Benefit Analysis) to calculate real maintenance cost savings, and examine the potential application of IoT-based predictive maintenance technology or Reliability Centered Maintenance (RCM) methods to obtain a more holistic and comprehensive production system efficiency picture.

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