

Hot Melt Machine Maintenance Effectiveness Analysis Using Mean Time Between Failures (MTBF) and Mean Time to Repair (MTTR) Methods

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Abstract. Hot Melt Machine 01 at PT. Nutech Pundi Artha Purwakarta is a critical machine in the coating and bonding process of BZ340 Carpet material. However, during the period from September 2025 to February 2026, this machine frequently experienced technical disturbances that caused repeated downtime, while the company had no quantified data to objectively assess its maintenance performance. This study aimed to analyze the machine's operational performance based on failure frequency and interval, evaluate the effectiveness of repair time, identify the causes of damage, and formulate improvement proposals to enhance machine reliability. A quantitative descriptive approach was applied using six months of historical downtime, failure frequency, and repair time data collected through observation, documentation, and interviews, which were processed using the Mean Time Between Failures (MTBF), Mean Time to Repair (MTTR), Availability, Pareto Diagram, and Fishbone Diagram methods with a Man, Method, Material, Machine, and Environment approach. The results showed that the machine experienced fifteen failures over a total operating time of 992 hours, yielding an average MTBF of 69 hours per month and an average Availability of 94%, while the average MTTR was 3.9 hours per occurrence out of a total downtime of 58 hours, with the weakest performance occurring in November and January. Pareto analysis revealed that spray-nozzle replacement, pump-PCB damage, and control-board damage were the dominant causes, with the top ten types of damage contributing nearly 80% of total downtime, while Fishbone analysis identified that the root causes lay in the absence of a daily inspection checklist and inconsistent completion of the maintenance logbook. These findings led to a proposal to develop a daily checklist and optimize the maintenance logbook as early-detection instruments, which are expected to increase MTBF, reduce MTTR, and improve machine Availability.

Keywords: Machine Maintenance Effectiveness; Mean Time Between Failures (MTBF); Mean Time to Repair (MTTR); Fishbone Diagram; Pareto Diagram.

A. INTRODUCTION

The development of the manufacturing industry in the era of globalization requires every company to increase the productivity and effectiveness of its production processes. Increasingly tight competition forces companies to optimize all their resources, including machines, labor, and production time. One effort that can be made is to analyze the effectiveness of production equipment to ensure that the production process runs optimally and according to target.

Effectiveness is the level of success of a system or activity in achieving its established objectives. In the context of the manufacturing industry, effectiveness is related to the ability of machines and production systems to run the production process optimally while minimizing operational disturbances (Putri et al., 2023). Machine effectiveness is influenced by the level of downtime, failure frequency, and the ability of the maintenance system to keep the machine in optimal condition; machines that frequently break down disrupt the production process and reduce the company's operational effectiveness. Machine effectiveness can also be measured through the Availability level, since Availability reflects the machine's readiness to support the

production process; a high Availability value indicates good operational performance with a low downtime level (Purba et al., 2024).

PT. Nutech Pundi Artha (PT NPA) is a manufacturing company that runs its production activities in one work shift per day, among others producing BZ340 Carpet. In its production line, the company uses several light machines, namely a carpet cutting machine, and two main high-capacity machines, namely a 200-ton Press Machine and a Hot Melt Machine, which is used for the hot-gluing (coating and bonding) process.

The Hot Melt Machine has a specific working mechanism based on heating and spraying liquid adhesive at high temperature to bond material layers. The smoothness of this process is highly dependent on the stability of temperature, pressure, and a constant material flow. However, from preliminary observation, the bottleneck problem most frequently encountered does not originate from the cutting or press machines, but from this Hot Melt Machine. It was found that before production starts, the Hot Melt Machine requires a pre-heating time to reach an ideal temperature of 250°C, and its performance is disrupted if it operates below the 200°C threshold. This unstable condition affects the achievement of production targets and reduces operator work efficiency.

Field observation showed that the Hot Melt Machine frequently experienced technical disturbances. Historical downtime data of the machine during the September 2025-February 2026 period showed a consistent damage pattern with a significant impact on line operations. Fluctuation of the accumulated monthly downtime hours indicates a high frequency of component failure that directly caused sudden, unplanned stoppages of line operations, proving that the maintenance strategy implemented during that period had not been able to accurately predict the saturation point of the components.

Without quantified data records, the company was certainly unable to make an objective assessment of overall machine performance, failed to identify recurring damage trends, and was slow in formulating a proactive maintenance strategy; as a result, machine-maintenance decisions were often based only on assumptions and empirical experience rather than on comprehensive, real data analysis.

To answer this challenge, a measurable approach is required that focuses on two key aspects of maintenance performance: machine reliability and repair-time efficiency. Mean Time Between Failures (MTBF) is the main parameter used to calculate the average optimal duration a machine operates before experiencing a failure, while Mean Time To Repair (MTTR) is used to measure the average real time required to restore machine function after damage occurs. By analyzing the comparison of both parameters in an integrated manner, management can obtain a complete picture of maintenance-team performance, identify weak points (critical components) that require extra monitoring, and design a more responsive and effective preventive-repair procedure. The use of this approach is strongly recommended and relevant to current Industrial Engineering literature: analysis of the MTBF and MTTR parameters is an essential step in determining preventive-maintenance scheduling policy, minimizing excessive repair costs, and preventing losses caused by production-line stoppages (Silvia et al., 2023); moreover, a company's success in increasing MTBF and reducing MTTR duration has been empirically shown to significantly raise machine Availability, which has a strong linear correlation with the achievement of manufacturing production-volume targets (Purba et al., 2024).

A number of previous studies on MTBF and MTTR in various manufacturing contexts were used as references and comparisons for this research, including printing-machine performance analysis using FMEA and OEE (Putri et al., 2023), the effect of stamping-machine Availability on production output (Purba et al., 2024), preventive maintenance analysis on blow-molding equipment (Silvia et al., 2023), spot-welding machine maintenance management

using Total Productivity Maintenance (Sihab & Setiafindari, 2022), minimization of machine maintenance cost through preventive and breakdown maintenance (Ali & Arhami, 2021), maintenance management of office facilities (Winaryanti et al., 2025), web-based equipment-maintenance management (Asraf & Rasyidah, 2023), preventive-maintenance analysis of forklifts and reach trucks (Novarika et al., 2025), determination of press-machine maintenance intervals (Saputra & Iriani, 2026), productive maintenance analysis of welding machines (Firmansyah & Sirait, 2025), downtime reduction through preventive maintenance (Rachmawan et al., 2025), IoT-based predictive maintenance (Khalid et al., 2025), usage-based preventive maintenance optimization (Ramadhan & Fitriani, 2024), machine-reliability analysis to determine critical machines using MTTR and downtime (Syaeudin et al., 2025), motor-grader downtime analysis using RCM II and FMEA (Adelard et al., 2026), lean-manufacturing production-capacity design (Anom et al., 2025), production-cost calculation analysis (Saputri et al., 2025), MTBF analysis in an industrial plant (Pratama & Paundra, 2024), preventive-maintenance analysis based on MTBF and MTTR (Alfionita & Alifin, 2023), MTBF analysis of oil-production machines (Laksono, 2025), MTBF and MTTR analysis of cold-storage machines (Habibi et al., 2025), effectiveness analysis of preventive maintenance on forklift operational performance (Habeahan et al., 2026), performance-maintenance analysis of a blowout preventer using MTBF, MTTR, and degradation testing (Bastari & Varayesi, 2024), tofu quality control using checksheet, Pareto, and Fishbone diagrams (Adhim et al., 2025), and quail-egg quality control using the seven-tools method (Bilqis et al., 2025).

Based on the description above, this study aims to (1) analyze the operational performance of Hot Melt Machine 01 based on failure frequency and inter-failure time using the MTBF method; (2) evaluate the effectiveness of Hot Melt Machine 01 repair time using the MTTR method; (3) identify the factors causing damage and performance instability of Hot Melt Machine 01; and (4) provide improvement proposals to increase machine reliability and minimize repair time. The study is limited to a six-month historical dataset of Hot Melt Machine 01 at PT. Nutech Pundi Artha Purwakarta and does not cover maintenance cost, other production-line machines, or direct technical testing of machine components.

B. METHOD

The research was conducted at PT. Nutech Pundi Artha Purwakarta, specifically in the production section on Hot Melt Machine 01, over a six-month observation period from September 2025 to February 2026. This location and period were selected because of the recurring machine-damage problem that caused high downtime and disrupted the production process. This study used a quantitative descriptive approach because the data analyzed were numerical, such as machine operating time, number of failures, and repair time. The data were processed using the Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR) methods to produce objectively measurable values, while the descriptive approach was used to describe the actual condition of Hot Melt Machine 01's performance based on the results of the data processing, including the downtime level and the effectiveness of the applied maintenance system.

Data were collected through three techniques: (1) observation of the operational condition of Hot Melt Machine 01, including the work process, machine condition, and maintenance activities performed by technicians; (2) documentation of company records, comprising machine downtime data, failure-frequency data, repair-time data, and maintenance reports, which served as the main source for the MTBF and MTTR calculations; and (3) interviews with the machine operator and maintenance technicians to obtain additional information on the causes of damage and the repair procedures performed. Data processing was carried out systematically to obtain the MTBF, MTTR, and Availability values, through

the following steps: grouping machine-damage data based on the research period, calculating total machine operating time, calculating the number of failures, and calculating the total repair time.

Data analysis consisted of four methods. MTBF calculation was used to determine the machine's reliability level, where a high MTBF indicates the machine rarely fails and a low MTBF indicates the machine frequently fails. MTTR calculation was used to determine the effectiveness of the repair process, where a low MTTR indicates fast and efficient repair and a high MTTR indicates slow and less effective repair. Availability analysis was used to determine the machine's readiness level in supporting the production process. Finally, Fishbone diagram analysis was carried out to identify the main factors causing machine damage - human, machine, method, material, and environment factors - and served as the basis for compiling the improvement proposals.

The formulas used were as follows:

$$\text{Availability} = \frac{\text{Total Time} - \text{Downtime}}{\text{Total Time}} \times 100\% \quad (1)$$

$$\text{MTBF} = \frac{\text{Total Operating Time}}{\text{Breakdown Frequency}} \quad (2)$$

$$\text{MTTR} = \frac{\text{Total Downtime Due to Failure}}{\text{Number Of Failures}} \quad (3)$$

This study has several limitations: the data used are limited to a period of approximately six months and not all damage events may have been documented; variation in machine operating conditions may affect the analysis results; no direct technical testing of machine components was performed; and the improvement proposals given are recommendations that have not yet been implemented directly in the field.

C. RESULT AND DISCUSSION

1. Machine Profile and Operating Time

Hot Melt Machine 01 (MC-HM-01) is the final stage of the BZ340 Carpet production process at PT. Nutech Pundi Artha Purwakarta. The machine plays an important role in coating and bonding carpet material using hot-melt adhesive so that the resulting product meets the company's bonding-strength and quality standards. The machine's operating process consists of material preparation, adhesive heating, machine-parameter setting, adhesive application, material bonding, adhesive cooling, and result inspection. Table 1 presents the machine operating time for each month during the six-month observation period.

Table 1. Machine Operating Time

Month	Operating Time (Days)	Operating Time (Days)	Operating Time (Days)
September	21	8	168
October	22	8	176
November	20	8	160
December	22	8	176
January	20	8	160
February	19	8	152

Source: Processed data, 2026

Table 1 shows that the monthly operating time ranged from 152 to 176 hours, depending on the number of working days in each month, with a total of 992 operating hours over the six-month period.

2. Failure Frequency and Downtime

During the September 2025-February 2026 period, Hot Melt Machine 01 experienced fifteen recorded failure and maintenance events, including spray-nozzle damage, seal-gun leakage, temperature-control disturbances, heater-gun damage, pump disturbances, and periodic service activities such as manifold cleaning, tank cleaning, and temperature-sensor calibration. Table 2 summarizes the number of failures and the total downtime for each month.

Table 2. Machine Failure Frequency and Downtime

Month	Date	Type of Failure	Planned Duration	Work	Number of Failures	Total Downtime (Hours)
September	18/09/2025	Broken air spray gun nozzle (Nozzle Replacement)	4	2	2	8
	25/09/2025	Spray nozzle replacement (Technician – Urgent)	6	6		
October	07/10/2025	Temperature drop in machine (Control Board Replacement)	6	5	3	12
	24/10/2025	Manifold cleaning due to glue buildup	4	3		
	18/02/2025	Periodic maintenance (Tank and gun cleaning, seal replacement)	6	4		
November	08/11/2025	Gun lead error, temperature drop (Gun Heater Replacement)	4	4	3	9
	21/11/2025	Temperature calibration and sensor adjustment	4	2		
	28/11/2025	Repair of temperature sensor wiring	4	3		
December	09/12/2025	Machine error, pump error (Pump PCB Replacement – Technician)	6	6	2	9
	20/12/2025	Gun seal replacement, leaking gun (Worn Adapter)	4	3		
January	10/01/2025	Leaking spray gun (Gun Cleaning and Seal Replacement)	4	3	3	13
	21/01/2025	Pump PCB replacement due to error	6	6		
	30/01/2025	Gun seal replacement (Leaking)	4	4		
February	11/02/2025	Gun seal replacement (Leaking)	4	2	2	7
	18/02/2025	Periodic maintenance (Tank and gun cleaning)	6	5		

Source: PT. Nutech Pundi Artha

The number of failures per month ranged from two to three events, with monthly downtime between 7 and 13 hours. January 2026 recorded the highest downtime, at 13 hours, caused by spray-gun leakage, control-board damage, and pump-PCB replacement, followed by October at 12 hours, caused by a temperature disturbance, manifold cleaning, and periodic service. Several types of failure - seal-gun leakage, spray-nozzle damage, and temperature-control disturbances - recurred more than once during the observation period, indicating that these components contribute significantly to machine downtime and require more intensive inspection and maintenance.

3. Availability

Availability represents the probability or readiness level of a machine to operate and perform its expected function when needed within a certain time period; the higher the Availability value, the higher the machine's readiness to support the production process (Purba et al., 2024). Availability was calculated using the formula presented in Section 2 for each month, as summarized in Table 3.

Table 3. Availability Calculation

Month	Month	Month	Month
September	8	168	95%
October	12	176	93%
November	9	160	94%
December	9	176	95%
January	13	160	92%
February	7	152	95%
Average			94%

Source: Processed data, 2026

Table 3 shows that the machine's Availability ranged from 92% to 95%. The highest Availability occurred in September, December, and February, at 95%, indicating that the machine was able to operate almost the entire planned time with relatively low downtime. The lowest Availability occurred in January, at 92%, caused by the highest downtime of the period (13 hours). In October and November, Availability reached 93% and 94% respectively, still indicating a fairly good readiness level despite several operational disturbances. Overall, the average Availability during the six-month observation period was 94%, indicating that Hot Melt Machine 01 has a high readiness level and is able to support the production process effectively, although there remains room for improvement through downtime reduction, particularly in the months with a higher disturbance frequency.

4. Mean Time Between Failures (MTBF)

MTBF is a measure used to determine the average operating time of a machine before it experiences a failure; MTBF indicates the failure interval so that it can be used as an indicator of equipment reliability, and the higher the MTBF value, the longer the machine can operate without disturbance. MTBF is also used as a basis for compiling a maintenance program to improve machine performance and reliability (Pratama & Paundra, 2024; Alfionita & Alifin, 2023). The MTBF results for each month are presented in Table 4.

Table 4. MTBF Calculation

Month	OperatingTime	Number of Failures	MTBF (Hours)
September	168	2	84
October	176	3	59
November	160	3	53

Desember	176	2	88
January	160	3	53
February	152	2	76
Total			413
Average			69

Source: Processed data, 2026

Table 4 shows that the highest MTBF occurred in December, at 88 hours, followed by September at 84 hours and February at 76 hours, indicating that the machine was able to operate for a relatively longer time before requiring maintenance during these periods. In contrast, the lowest MTBF occurred in November and January, at 53 hours each, indicating that the machine experienced disturbances or required maintenance more frequently during these months, while October recorded an MTBF of 59 hours, still below the overall average. Overall, the total MTBF during the observation period reached 413 hours with an average of 69 hours, indicating that Hot Melt Machine 01 was, on average, able to operate for 69 hours before experiencing a disturbance or requiring maintenance. This relatively high MTBF value indicates a fairly good operating interval, although more effective maintenance efforts are still required to increase the inter-failure operating time, particularly in the months with lower MTBF values, such as October, November, and January.

5. Mean Time to Repair (MTTR)

MTTR is the average time required to repair a machine or equipment after a failure occurs until the machine can return to normal operation, describing the ability of the maintenance system to restore the machine from a failure state to a ready-to-use state (Syaefudin et al., 2025). MTTR is an important indicator for evaluating repair-process effectiveness because it is directly related to the downtime duration experienced by the machine; the smaller the MTTR value, the more effective the repair process and the higher the machine's Availability level (Habibi et al., 2025). Table 5 presents the MTTR results for each month.

Table 5. MTTR Calculation

Month	Downtime (Hours)	Maintenance Frequency	MTTR (Hours)
September	8	2	4,0
October	12	3	4
November	9	3	3
December	9	2	4,5
January	13	3	4
February	7	2	4
Total			23,3
Average			3,9

Source: Processed data, 2026

Based on Table 5, the machine's MTTR ranged from 3.0 to 4.5 hours. The lowest MTTR occurred in November, at 3.0 hours, indicating that the repair process in that month could be carried out more quickly than in other months, while the highest MTTR occurred in December, at 4.5 hours, indicating that repair activities in that month required more time to resolve the disturbances that occurred. In September, October, January, and February, MTTR values were relatively stable, at around 4.0 hours. Overall, the total MTTR during the observation period was 23.3 hours, with an average of about 3.9 hours per maintenance event, indicating that the maintenance team generally required less than four hours to return Hot Melt Machine 01 to normal condition each time a disturbance occurred. This result indicates that the damage-

handling process on Hot Melt Machine 01 is fairly good and responsive; nevertheless, improvement efforts, such as ensuring adequate spare-part availability, applying a more effective maintenance procedure, and improving technician skills, are still required so that repair time can be further reduced and machine downtime minimized.

6. Pareto Analysis

The Pareto diagram was used to identify the most dominant types of failure on Hot Melt Machine 01 during the research period. The diagram was constructed based on the downtime frequency of each type of failure, sorted from the largest to the smallest value and complemented with a cumulative percentage, as presented in Table 6.

Table 6. Pareto Analysis of Machine Failures

No	Type of Failure	Total Downtime (Hours)	% Downtime	% Cumulative
1	Spray Nozzle Replacement (Technician-Urgent)	6	10,34%	10,34%
2	Machine Error, Pump Error (Pump PCB Replacement-Technician)	6	10,34%	20,69%
3	Machine Stopped Again (Control Board Replacement-Technician)	6	10,34%	31,03%
4	Machine Temperature Drop (Control Board Replacement)	5	8,62%	39,66%
5	Periodic (Tank and Gun Cleaning)	5	8,62%	48,28%
6	Periodic Maintenance (Tank and Gun Cleaning & Seal Replacement)	4	6,90%	55,17%
7	Gun Lead Error, Temperature Drop (Gun Heater Replacement)	4	6,90%	62,07%
8	Pump PCB Replacement Due to Error	4	6,90%	68,97%
9	Manifold Cleaning Due to Glue Buildup	3	5,17%	74,14%
10	Temperature Sensor Wiring Repair	3	5,17%	79,31%
11	Gun Seal Replacement, Leaking Gun (Worn Adapter)	3	5,17%	84,48%
12	Leaking Spray Gun (Gun Cleaning and Seal Replacement)	3	5,17%	89,66%
13	Broken Air Spray Gun Nozzle (Nozzle Replacement)	2	3,45%	93,10%
14	Temperature Calibration and Sensor Adjustment	2	3,45%	96,55%
15	Gun Seal Replacement (Leaking)	2	3,45%	100,00%
Total		58	100,00%	

Source: Processed data, 2026

The Pareto analysis of the machine downtime data showed that the most dominant types of failure originated from spray-nozzle replacement (technician - urgent), machine error due to pump-PCB damage, and machine shutdown due to control-board damage, each contributing 6

hours of downtime, or 10.34% of total downtime. This was followed by machine temperature drops caused by control-board damage and scheduled service (tank and gun cleaning), each contributing 5 hours or 8.62%. Scheduled service (tank, gun cleaning, and seal replacement), gun-lead error caused by heater-gun damage, and pump-PCB replacement each contributed 4 hours or 6.90%, so that the cumulative downtime percentage reached 79.31% after the first ten types of failure. This indicates that most of the machine's downtime is influenced by damage to the control board, pump PCB, heater gun, and spray-gun components requiring nozzle and seal replacement, along with the need for periodic maintenance of the adhesive-application system.

Following the Pareto principle (80/20), improvement priority should be focused on the types of failure that cumulatively contribute up to about 80% of total downtime, namely damage to the spray nozzle, control board, pump PCB, and heater gun, along with preventive maintenance activities such as tank, gun, and manifold cleaning. Compared with previous studies, this pattern is consistent with findings that show preventive-maintenance activities concentrated on a small number of critical components substantially improve machine reliability, as reported for forklifts and reach trucks with an MTBF of around 717 hours and an MTTR of 1.79 hours after optimal maintenance intervals were applied (Novarika et al., 2025), and for cold-storage machines where MTBF and MTTR were used to determine maintenance effectiveness on similarly critical components (Habibi et al., 2025). By prioritizing these dominant causes, the company is expected to significantly reduce total machine downtime, increase production-process effectiveness, and reduce the frequency of recurring failures. The results of this Pareto analysis were subsequently used as the basis for constructing the Fishbone (cause-and-effect) diagram to identify the root causes of the failures that are the priority for improvement.

7. Fishbone Diagram Analysis

The Fishbone diagram in Figure 1 was constructed based on the results of the Pareto analysis, which showed that about 79.31% of machine downtime originated from the ten main types of failure. The causal factors were grouped using the 4M+1E approach, namely Man, Method, Material, Machine, and Environment.

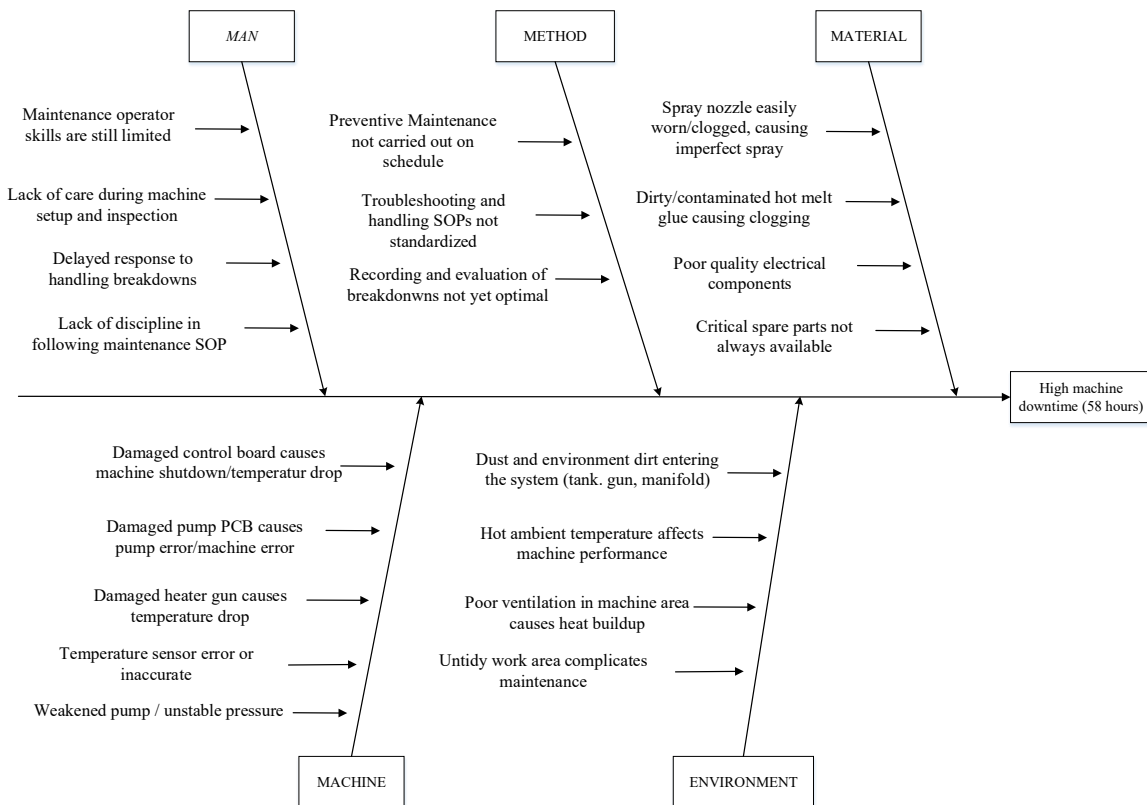


Figure 1. Fishbone Diagram of Hot Melt Machine 01 Failure Causes

Source: Processed data, 2026

On the Man factor, the main causes identified were limited maintenance skills of operators, insufficient thoroughness during machine set-up and inspection, delayed handling of damage, and low discipline in following the maintenance SOP. The Method factor included preventive maintenance that had not been carried out optimally, a troubleshooting SOP that was not yet standardized, and recording and evaluation of failures that had not been carried out consistently. On the Material factor, the identified causes were spray nozzles that easily wore out or clogged, contaminated hot-melt adhesive, poor-quality electrical components, and limited spare-part availability.

On the Machine factor, damage was found in the control board, pump PCB, heater gun, and temperature sensor, as well as a decline in pump performance, causing the machine to error, experience a temperature drop, or stop operating. The Environment factor included dust and dirt entering the system, high working-area temperature, poor ventilation around the machine, and an untidy work area that hindered the maintenance process.

Based on this analysis, it can be concluded that the high machine downtime was not only caused by machine-component damage, but was also influenced by human factors, working methods, material quality, and working-environment conditions. The improvement proposals were therefore focused on improving preventive-maintenance implementation, SOP compliance, operator and technician competence, component-quality control, and working-environment conditions, in order to reduce the failure frequency and downtime of the Hot Melt Machine.

8. Improvement Proposals

Based on the results of the Pareto and Fishbone analyses, it is known that the main causes of the high failure frequency of Hot Melt Machine 01 originate not only from machine factors but also from method and human factors. The identified root causes include the absence

of a daily machine-inspection checklist, inconsistent completion of the maintenance logbook, insufficiently consistent implementation of the machine set-up SOP, and the absence of routine machine set-up time recording. These conditions cause potential damage to go undetected at an early stage, thereby increasing the risk of breakdown and machine downtime. Table 7 summarizes the identified root causes and the corresponding improvement proposals.

Table 7. Root-Cause Identification and Improvement Proposals

No	Root Cause	Proposed Improvement	Implementation Form
1	No daily machine inspection checklist is currently available	Develop a daily checklist for Hot Melt Machine 01	Daily checklist for Hot Melt Machine 01
2	Maintenance logbook entries are not consistently completed	Optimize the use of the Maintenance Logbook	Maintenance Logbook
3	The machine set up SOP is not consistently implemented	Increase supervision of SOP implementation during machine setup	Operator supervision and briefing

Source: Processed data, 2026

Of the proposals listed in Table 7, this study focused the discussion on two: the development of a Daily Checklist for Hot Melt Machine 01 and the optimization of the Maintenance Logbook. Both were selected because they are the most suitable for the company's current condition, are easy to implement without requiring additional equipment investment, and are able to support maintenance-effectiveness improvement through routine inspection activities and more systematic maintenance-history recording.

The Daily Checklist is proposed as an early-inspection medium used before the machine is operated, covering the adhesive tank system, heater system, glue pump, hoses and adhesive lines, nozzle and manifold, pneumatic system, control panel and electrical components, machine-area cleanliness, and other general checks. Each inspection item is marked OK when the component condition meets the standard, or NOK (Not OK) when a discrepancy or indication of damage is found, in which case the operator is required to immediately report it to the maintenance technician for inspection and corrective action before the machine is operated. With this checklist, machine inspection no longer depends on each operator's individual habit but is carried out systematically according to an established inspection standard, and is expected to help detect potential damage earlier, increase MTBF, reduce MTTR, and improve the Availability of Hot Melt Machine 01.

The Maintenance Logbook is proposed to record important information such as the date of the failure, the machine stoppage time, the type of failure, the repair action taken, the components replaced, the repair duration, and the name of the technician performing the work. Consistent recording will provide the company with a historical database that can be used to evaluate maintenance-system effectiveness, identify components with the highest failure rates, and compile a more accurate preventive-maintenance schedule, while also serving as the data source for monitoring the development of MTBF and MTTR over time. With optimized use of the Maintenance Logbook, maintenance decision-making is expected to rely less on experience alone and more on well-documented data, so that maintenance-system effectiveness can continue to be improved.

D. CONCLUSION

This study analyzed the maintenance effectiveness of Hot Melt Machine 01 at PT. Nutech Pundi Artha Purwakarta using the MTBF and MTTR methods over the September 2025-February 2026 period. The results showed that the machine experienced fifteen failures across a total operating time of 992 hours, with an average MTBF of 69 hours per month and an average Availability of 94%, while the average MTTR was 3.9 hours per event out of a total

downtime of 58 hours, with the weakest performance occurring in November and January. Pareto analysis identified spray-nozzle replacement, pump-PCB damage, and control-board damage as the dominant causes, with the top ten types of failure contributing nearly 80% of total downtime, while Fishbone analysis identified that the main root causes were the absence of a daily inspection checklist and inconsistent completion of the maintenance logbook. These findings led to a proposal to develop a Daily Checklist for Hot Melt Machine 01 as an early-inspection medium and to optimize the use of the Maintenance Logbook as a medium for documenting failure and repair history. Both proposals are expected to enable earlier detection of potential damage, increase MTBF, reduce MTTR, and improve the Availability of Hot Melt Machine 01, thereby ensuring greater stability and efficiency of the BZ340 Carpet production process in the future.

For practical implementation, it is recommended that PT. Nutech Pundi Artha immediately apply the Daily Checklist and Maintenance Logbook consistently at the start of every work shift, accompanied by socialization and training for operators and maintenance technicians so that both documents function as part of the daily work routine rather than as administrative formalities. The company should also periodically evaluate the MTBF and MTTR data recorded in the logbook, particularly ahead of months with historically high failure frequency such as October, November, and January, so that the preventive-maintenance schedule can be adjusted more precisely, and should secure the availability of critical spare parts, such as spray nozzles, pump PCBs, heater guns, and control boards, through better inventory planning to reduce repair time (MTTR) in the event of sudden failure. Future research is recommended to extend the scope of analysis to include maintenance cost and the financial impact of downtime, to cover other machines within the production line, and to complement the root-cause analysis with direct technical testing of machine components, so that the results can more comprehensively support maintenance decision-making at PT. Nutech Pundi Artha.

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