

RESEARCH ARTICLE



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Analyzing Dyeing Machine Stoppage and Its Impact on Production Efficiency in Knit Dyeing Processing Units

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Abstract: This paper is “Analyzing Dyeing Machine Stoppage and Its Impact on Production Efficiency in Knit Dyeing Processing Units”. This paper discusses a significant issue of production losses and the causes of dyeing machine stoppages in the textile industry. The machine has to stop when machine defects occur, and then machine faults are corrected, which results in time loss and efficiency loss. Those fabrics used for dyeing will be rejected if they do not meet quality standards; not only that, but this rejection may also be due to various factors related to the dyeing process and machine downtime. Effective monitoring is crucial for preventing defects, maximizing productivity, and ensuring high-quality output in any process, especially in manufacturing. For machine stoppage, many defects are produced, and time is wasted. To fulfill the buyer's delivery timeline and quality, it is crucial to identify and prevent these causes from recurring. The study identifies numerous causes for dyeing machine stoppages, including a lack of batch supply, power supply issues, trolley shortages, laboratory problems, maintenance challenges, air supply issues, water problems, and steam supply difficulties.

The analysis reveals three main categories of defects that reduce productivity: batch-related issues, Machine breakdowns, and other factors. It has been found that 64% of dyeing machine stoppages are due to a lack of batch supply, 17% to machine breakdowns, and 19% to other causes.

Keywords: *Dyeing Machine Stoppage, Production Efficiency, Knit Dyeing, Batch efficiency in knit dyeing units, reducing utilization and quality.*

1. Introduction

This study investigates the causes of dyeing machine stoppages and analyzes their magnitude and impact on production. In the dyeing production process, various minor stoppages lead to a decrease in overall dyeing

output [1]. The more frequent the stoppages, the lower the production levels become [2]. Numerous factors contribute to these stoppages, which not only halt production but also hinder efficiency [3]. These issues cannot be considered merely as production losses; they also result in wasted time and increased costs [4]. Although the stoppages are primarily caused by minor issues with short durations, their cumulative effect can lead to significant losses [5].

This study identifies the common causes of stoppages, graphically represents their magnitudes, and calculates their impact on production in the dyeing sector. Dyeing is the process of adding color to textile products, including fibers, yarns, and fabrics. This process typically involves a special solution containing dyes and specific chemical agents [6]. Once the dyeing is complete, the dye molecules form strong chemical bonds with the fiber molecules [7]. Temperature and time management are two critical factors in dyeing [8]. Production efficiency, therefore, is directly linked to how effectively these processes are controlled and how stoppages are minimized [9].

Batch processing is a controlled process overseen by the dyeing manager in the batching section [10]. This involves preparing a batch for dyeing based on machine capacity, ensuring that an equal amount of fabric passes through each nozzle of the dyeing machine, while also considering order and priority [8]. Certain dyeing parameters must be adjusted according to the products' characteristics during the knit dyeing process [6]. Lower GSM (Grams per Square Meter) and higher GSM garments require dyes with better migration properties, higher dyeing temperatures, lower liquor ratios, and careful circulation of goods [7].

Various issues can arise during this process, with shade variation along the length of the fabric being a

common problem [11]. Additionally, there may be variations in shading from side to side, as well as between the center and the left and right edges of the fabric's width [12]. Accurate measurement of temperature and pH is essential and should be conducted using appropriate monitoring and control equipment [13].

Modern advanced dye cycle controllers and optimization methods are increasingly supported by machine learning and predictive maintenance frameworks, which ensure reproducibility and efficiency [4]. RFT (Right-First-Time) dyeing is generally more effective when all aspects of the bulk dyeing process are standardized and automated [11]. In exhaust dyeing, steps such as filling the machine to the appropriate liquor ratio, controlling the temperature rise and liquor circulation, maintaining the top temperature for the required duration, and cooling and draining must be reproducible [11]. Recent studies emphasize that predictive models, advanced scheduling algorithms, and smart monitoring systems can significantly enhance productivity while reducing stoppages and re-dyeing rates [9].

Essentially, it involves creating something using basic inputs. In economics, productivity measures the output per unit of input, such as labor, capital, or other resources. It is often calculated as the ratio of gross domestic product (GDP) to working hours [9].

The gray fabric is sourced from either the gray fabric storage or the knitting department to be dyed a specific color. In this context, only knit dyeing is being performed, utilizing a single type of dyeing machine: the winch dyeing machine [6]. Certain dyeing parameters must be adjusted according to the products' characteristics during the knit dyeing process [7]. Lower GSM (Grams per Square Meter) and higher GSM garments require dyes with better migration properties, higher dyeing temperatures, lower liquor ratios, and careful circulation of goods [11].

Various issues can arise during this process, with shade variation along the length of the fabric being a common problem [12]. Additionally, there may be variations in shading from side to side, as well as between the center and the left and right edges of the fabric's width [13]. Accurate measurement of temperature and pH is essential and should be conducted using appropriate monitoring and control equipment [5].

Modern advanced dye cycle controllers are robust, user-friendly, and ensure high levels of reproducibility [4]. This is particularly important when applying chemical finishing treatments, such as chemical cross-linking finishes, on cellulosic and cellulosic blend fabrics [11]. RFT dyeing is generally more effective when all aspects of the bulk dyeing process are standardized and automated [11]. In exhaust dyeing, the

processes such as filling the machine to the appropriate liquor ratio, controlling the temperature rise and liquor circulation, maintaining the top temperature for the required duration, and cooling and draining must be reproducible [11]. Additional resources, such as books and practical handbooks, provide fundamental insights into dyeing process management and troubleshooting techniques [13]. The textile dyeing sector, particularly within knit dyeing processing units, faces persistent challenges related to machine stoppages that significantly hinder production efficiency and cost competitiveness. While previous studies have examined various dimensions of textile process optimization—such as predictive maintenance systems, machine learning-based dyeing control, and scheduling improvements—comprehensive analyses of dyeing machine stoppages and their quantifiable impact on production efficiency remain limited. Most existing research focuses on isolated variables under controlled or laboratory conditions, providing insufficient insight into the complex operational dynamics of industrial dyeing environments in developing manufacturing contexts.

Despite technological advancements in automation and data-driven production management, many knit dyeing facilities continue to depend on manual batch scheduling, reactive maintenance, and operator-based decision-making. Consequently, the cumulative effects of frequent yet short-duration stoppages—arising from batch preparation errors, equipment breakdowns, laboratory delays, and unstable utility supplies—are not adequately captured in current literature. Furthermore, the empirical relationship between Right-First-Time (RFT) dyeing performance, stoppage hours, and overall production efficiency has not been rigorously modeled in real-world industrial operations. This lack of empirical evidence creates a significant gap in understanding how operational inefficiencies translate into measurable productivity losses.

Addressing this knowledge gap, the present study undertakes a systematic investigation of dyeing machine stoppages within a knit composite industry, utilizing operational data from York Composite Ltd. The research aims to identify, categorize, and quantify stoppage causes and evaluate their direct effects on production efficiency. Through statistical modeling, the study explores the correlation between RFT performance and stoppage duration to provide a predictive understanding of efficiency loss. By integrating empirical data analysis with practical recommendations, this research contributes to developing an evidence-based framework for optimizing machine utilization, enhancing production reliability, and advancing sustainable manufacturing practices in the knit dyeing industry.

The objectives of this study are:

1. To identify and categorize the primary causes of dyeing machine stoppages.
2. To quantify the impact of stoppages on production efficiency and output loss.
3. To recommend practical strategies for minimizing stoppages and improving productivity

By addressing these issues, knit dyeing units can improve utilization rates, strengthen RFT performance, and maintain a competitive advantage in the global textile sector.

2. Materials And Methods Factors for Dyeing Machine

Stoppages:

Dyeing machine stoppages can occur for various reasons, which can be classified into three main categories: batch issues, machine breakdowns, and external factors. To achieve optimum dyeing production, it is essential to address these three critical factors: (see Table 1 for detailed breakdown issues) (see Table 6 for summary of three main categories)

1. Batch Issues
2. Machine Breakdown Problems (see Table 1 for detailed breakdown issues)
3. External/Other Factors

● Batch and storage -Related Issues:

1. Fabric Supply: Inadequate or delayed delivery of fabric to the dyeing machine can result in delays and stoppages.
2. Chemical Supply: Insufficient or delayed supply of dyes, chemicals, or other necessary materials can halt the dyeing process.
3. Batch Preparation: Wrong decisions or inconsistencies in batch preparation, such as incorrect measurements or mixing, can also lead to machine stoppages.

● Machine-Related Issues:

1. Mechanical Failures: Breakdowns of the dyeing machine, including pumps, motors, valves, and other critical components, are common causes of downtime.
2. Electrical Problems: Issues with the machine's electrical system, such as power overload, faulty wiring, or malfunctioning sensors, can lead to stoppages.
3. Control System Issues: Problems with the machine's control system, including sensors, PLCs (Programmable Logic Controllers), or

software malfunctions, can disrupt the dyeing process.

4. Trolley Problems: Wheels can break due to a variety of reasons. Transport issues with trolleys may lead to dyeing machine stoppages.

● Other Factors:

1. Water Supply: Insufficient water, water quality issues (e.g., hardness), or interruptions in the water supply can halt the dyeing process.
2. Steam Supply: Problems with the steam supply, such as low pressure or fluctuations, can affect the dyeing temperature and lead to stoppages.
3. Air Supply: Issues with the air supply, such as low pressure or contamination, can impact the machine's operation.
4. Power Supply: Power outages, fluctuations, or other electrical problems can interrupt the dyeing process.
5. Laboratory Issues: Errors or delays in the laboratory, such as incorrect dye formulations or inaccurate measurements, can affect the dyeing process.
6. Maintenance: Scheduled or unscheduled maintenance activities can lead to machine downtime.
7. Lack of Operator: lack of operator during machine operation or maintenance can also contribute to stoppages.

For this study, I analyzed 10 different reasons for machine stoppages in the knit fabric dyeing process and examined eight types of knit fabrics. The stoppage reasons included: batch problems, trolley problems, lab problems, scheduled maintenance, breakdown maintenance, air problems, water problems, steam problems, power problems, and others.

The types of fabrics investigated were single jersey, double jersey, terry, rib, lycra, single lacoste, double lacoste, and pique. These fabrics varied in parameters such as GSM (grams per square meter), diameter, WPI (wales per inch), and CPI (courses per inch), and they were constructed from different yarn counts.

I maintained a record of the daily reasons for dyeing machine stoppages. During this process, I encountered various issues, including batch, trolley, lab, maintenance, and utility-related problems. From this experience, I gained practical insights and developed strategies to minimize machine stoppages and reduce faults in both dyeing and finishing operations.

Impact of Dyeing Machine Stoppages on Production Efficiency: The issues related to the graphical dyeing machine stoppage for the goal are summarized in Figure 1.

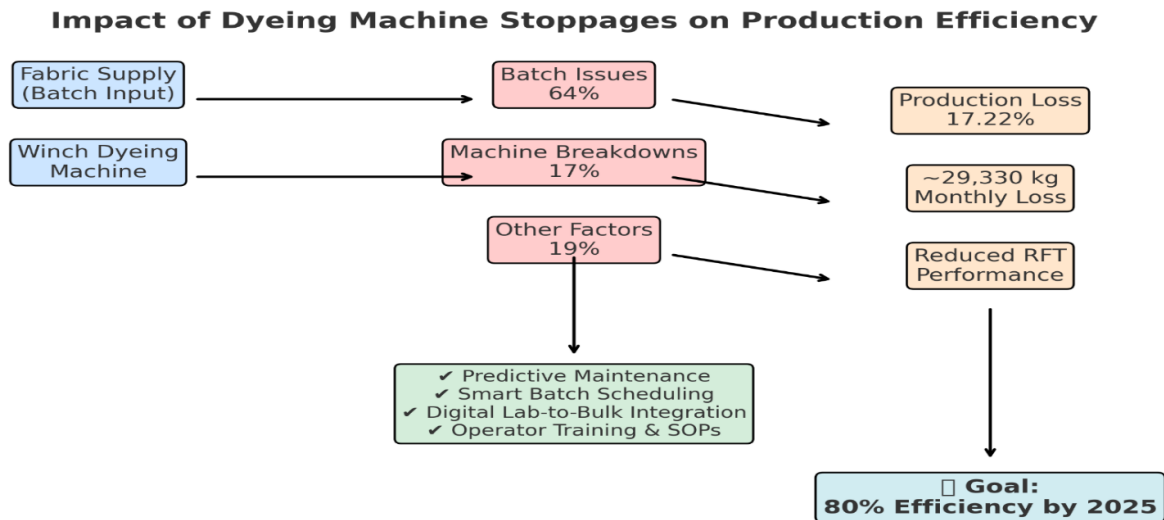


Fig. 1. Graphical dyeing Machine stoppage reason and goal

Causes of Dyeing Machine Stoppage:

Major Reasons for Stoppage on the Dyeing Floor:

1. Batch Issues
2. Trolley Problems
3. Laboratory Issues
4. Scheduled Maintenance
5. Breakdown Maintenance
6. Air Supply Problems
7. Water Supply Issues
8. Steam Supply Problems
9. Power Supply Issues
10. Other Factors

2.1. Batch section in Textile:

The batch section is a preparatory stage in the dyeing process. It serves as the receiving area for gray fabric

and the starting point for dyeing it with color. Batching involves preparing the fabrics that need to be dyed and processed for a specific order or lot.

Function or purpose of the batch section:

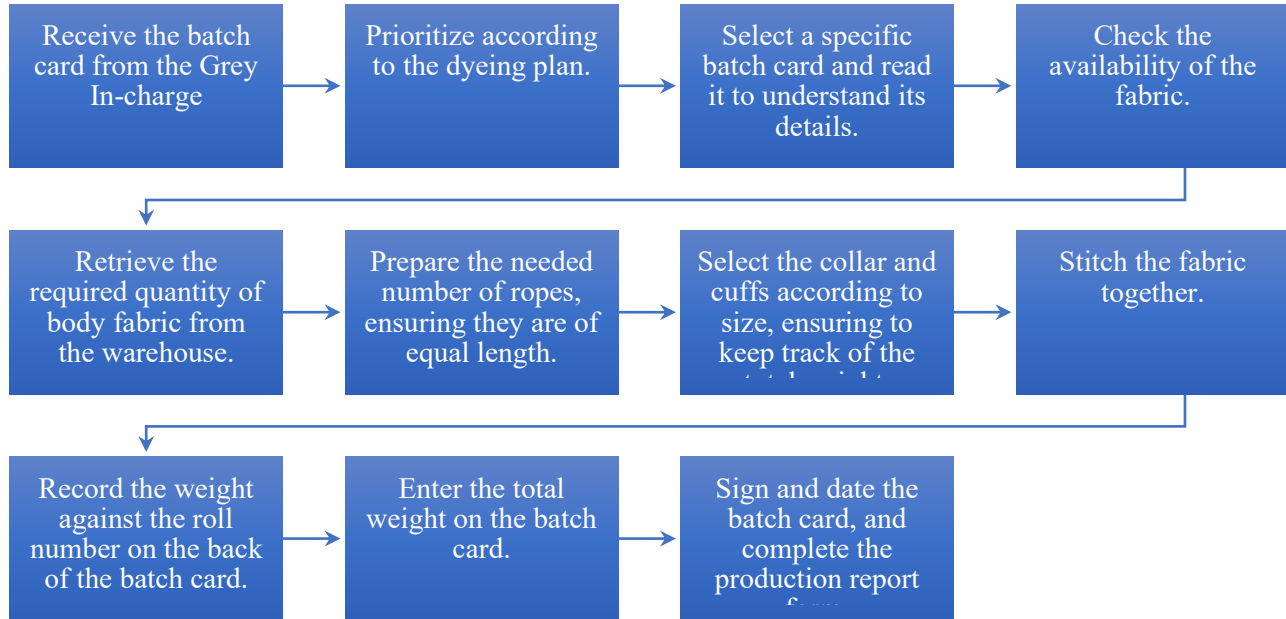
Batching involves sending gray fabric to both the receiving section and the dyeing section for processing. It is the process of preparing fabrics that are designated for dyeing and are part of a specific order lot.

Roll-formed gray fabrics are sourced from the knitting section or other suppliers. If necessary, the gray fabric is turned using a turning machine.

To prepare batches of fabric for dyeing, follow these criteria:

1. Send the gray fabric along with a batch card to the dyeing floor.
2. Maintain records of each previous dyeing process

Batch Processing Flow Chart: The flowchart for batch processing is illustrated below



2.2. Breakdown Maintenance Issues:

Various types of Breakdown Maintenance Issues are seen in Table-1 for detailed breakdown issues

Table 1. Machine Breakdown Maintenance Issues

Machine Breakdown Problem			
Motor Problem	Gasket Problem	Dosing Motor Problem	Switch Problem
Level Indicator Problem	Filter Problem	Dosing Valve Problem	Addition Tank Problem
Filter Nut Problem	Cooling Valve Problem	Winch Problem	Steam Valve Problem
Operator Crisis	Nozzle Problem	Drain Valve Problem	Steam Motor Problem
Condense Line Problem	Tank Problem	Heat Exchanger Problem	Reserve Tank Problem
Monitor Problem	Reel Problem	Cooling Exchanger Problem	Rubber Stick Change
Main Pump Problem	High-Pressure Problem	Main Valve Problem	Cooing Valve Problem
Pump Switch Problem	Safety Valve Problem	Power Stop Problem	Water Line Problem
steam silencer Problem	Flow Meter Problem	Water Level Problem	Stock Tank Problem
Programming set Problem	Steam Line Problem	Chemical Tank Problem	PLC Card Problem

2.3. Standard Time for Dyeing:

1. Efficiency is determined based on standard time (hours) and comments provided.
2. If there is a complete scoring batch, 2.5 hours will be deducted from the standard time.
3. If there is a 50-minute reduction process, this time will be added.
4. The time spent on (scouring unload, polyester part unload, and incomplete unload batches) will be added once those batches are completed. or the first time, any lost time

5. Scheduled Maintenance time will be subtracted from the lost time.
 6. If any batch is unloaded before the standard time (without a valid reason), this time will be considered as the new standard time.
- Different types of shades are desired. The corresponding standard times are presented in Table 2, which summarizes the Standard Allowed Hours (SAH) for each shade type

Table 2. Shade-wise Standard Allowed Hours (SAH) for Dyeing

Shade type	Existing Standard Allowed Hour for all Buyer Times	Standard Allowed Hour Only for Centric Buyer	Standard Allowed Hour Only for LPP Buyer	Shade %	Remarks
Yarn Dyeing (Normal Wash)	2.50	2.50	2.50		
White	3.5	3.5	3.50		4 hrs. with Brightener
Grey Mellange	3.00	3.00	3.00		3.5 hrs. with Brightener
Lt Color	7.50	9.00	9.50	0.01% - 0.99%	
Medium Color	9.00	10.50	11.00	1% - 2.99%	
Dark Color	10.00	11.00	12.00	3% - 5.5%	
Ex. Dark	10.50	11.00	12.00	5.5% - Above	
Turquoise/ Royal Blue	11.00	12.00	13.00		
Both Part (Color)	Lt-10.00	11	11.00		
	ME-11.00	12	12.00		
	DK-11.50	12.50	12.00		
	EX.DK-12	13.50	13.00		
Both Part (White)	7	7	7		
Only Polyester Part (100% Polyester)	5.5	5.5	5.5		
Only Polyester Part with Scouring	8	8	7		

Note: Buyer Name: Centric, LPP

2.4. Right First Time Dyeing (RFT):

The dyeing and finishing industry often suffer from a negative reputation regarding quality and reliability. This perception may stem from a traditional mindset that accepts rework as a normal part of daily operations. "RFT dyeing," which stands for "Right First Time Dyeing," is a concept used to evaluate dyeing efficiency. A company's efficiency is considered good if it exceeds its dyeing capability; if not, it may be perceived poorly. Essentially, RFT dyeing measures how effectively we can dye a fabric. If the dyeing process is completed on the first attempt, it is classified as RFT dyeing. However, if the process is not executed correctly, it does not meet the criteria for RFT dyeing. RFT dyeing refers to a successful dyeing process completed without any errors, meaning the dyed fabric does not need to be placed back into the dye bath to achieve the desired shade.

2.4.1. Benefits of RFT dyeing:

RFT dyeing not only avoids the additional costs associated with correcting faulty dyeing but also offers several other benefits. The shorter processing times in RFT dyeing procedures lead to less fiber degradation and improved product quality post-dyeing. This is particularly important when applying chemical

finishing treatments, such as chemical cross-linking finishes, on cellulosic and cellulosic blend fabrics.

RFT dyeing enhances machine productivity and dyeing capacity while improving production planning, resulting in reduced capital expenditures on processing equipment. Additionally, it helps to lower the costs of chemicals and auxiliaries used in the dyeing process. Many dye manufacturers now provide comprehensive dyeing packages in which the dyestuffs, chemicals, and auxiliaries are specifically chosen to optimize dyeing performance. However, some dyehouses continue to use cheaper textile auxiliary products that are often less effective with the same dyestuffs and typically have lower concentrations of active chemical constituents. This decision can impair RFT dyeing performance, and ultimately, opting for inferior auxiliaries can be more expensive for the dyehouse in the long run.

RFT dyeing is generally more effective when all aspects of the bulk dyeing process are standardized and automated. In exhaust dyeing, the processes such as filling the machine to the appropriate liquor ratio, controlling the temperature rise and liquor circulation, maintaining the top temperature for the required duration, and cooling and draining must be reproducible. Accurate measurement of temperature and pH is essential and should be conducted using appropriate monitoring and control equipment. Modern

advanced dye cycle controllers are robust, user-friendly, and ensure high levels of reproducibility.

2.4.2. Relationship between Right First Time (RFT) performance and Machine stoppage time:

The relationship between Right First Time (RFT) performance and machine stoppage time can be nuanced, but understanding this connection is essential for effectively analyzing production efficiency in dyeing processes.

1. 1. Defining RFT Performance: RFT performance is a measure of how successfully a dyeing process is executed on the first attempt without addition. When RFT metrics are high, it indicates that a significant percentage of dyeing runs are completed without needing rework, which can save time and resources.
2. 2. Impact on Downtime: When a dyeing process requires reworking or correction, it typically leads to machine stoppage. This can occur while the machine is reset to address a dyeing shade correction or while waiting for the specific conditions to retry the dyeing shade. High RFT performance means fewer incidences of machine stoppage related to faults in previous runs.
3. 3. Analyzing Machine Stoppage Time: To understand the correlation between RFT and downtimes, one would assess historical data on machine performance. If RFT metrics are high, one would expect to see a corresponding decrease in machine stoppage times. In contrast, lower RFT performance might indicate frequent stoppages due to the need for corrections or adjustments during dyeing.
4. 4. Link to Efficiency Metrics: RFT performance is often a critical efficiency metric. By analyzing RFT data alongside machine stoppage records, analysts can draw conclusions about overall operational efficiency. For instance, if a specific process consistently shows low RFT rates, causing increased downtime, it could identify a need for equipment upgrades or re-evaluation of the dyeing parameters used.
5. 5. Causes of Downtime: If the analysis reveals a direct correlation between low RFT performance and increased downtime, it can lead to further investigation into underlying causes, such as flaws in the dyeing machine, improper settings, or inferior quality auxiliaries. This can help in strategic decision-making regarding maintenance, equipment investment, or procedural changes.
6. 6. Continuous Improvement: Ultimately, using RFT metrics to inform downtime analysis

contributes to a continuous improvement process. By reducing errors in dyeing through effective RFT practices, facilities can minimize machine stoppage time, leading to higher productivity and better overall performance.

2.5. Stage of Dyeing: The dyeing is presented in Table 3.

Table 3. Stage of Dyeing & Standard Time

Stage of Dyeing	Standard Time
Fabric Loading to Levelling Process	3:30 Hr
Fabric Loading to Levelling Process (No Enzyme use)	2:30 Hr
Levelling Process to Bath Drain (BD)	3:30 Hr
Bath Drain (BD) to Fabric Unload	3:00 Hr (Dk shade) 2:50 Hr (Med shade) 2:00 Hr (LT shade)

N.B. - For the Reduction process (Lycra & High GSM), 30 Minutes extra time will be added

2.5.1 Calculation Formula of the Production Efficiency of the Dyeing Machine:

- Production Capacity (kg/Day)

$$= \frac{\text{Batch Loading Capacity} \times \text{Machine Loading Efficiency} \times 24}{\text{Dyeing Standard Time (hours)}}$$
- Production Efficiency

$$\% = \frac{\text{Production} \times \text{Standard Time (Hrs)}}{\text{Machine Capacity} \times \text{Machine Loading Efficiency} \times \text{Use Time (Hrs)}} \times 100$$
- Machine Load Efficiency % =

$$\frac{\text{Grey Fabric Load (Kg)}}{\text{Machine Capacity (kg)}} \times 100$$
- On Standard Efficiency

$$\% = \frac{\text{Standard Time (hrs)}}{\text{Use Time (hrs)} - \text{Lost Time (hrs)}} \times 100$$
- Overall Efficiency

$$\% = \frac{\text{Standard Time (hrs)}}{\text{Use Time (hrs)}} \times 100$$
- Utilization Calculation %

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- Machine Utilization%: = 83%

$$\frac{\text{Working Hour} - \text{Lost Hour}}{\text{Working Hour}} \times 100$$

$$\text{Lost\%} = \frac{10918.63}{63033} \times 100$$

$$= 0.17 \times 100$$

- Capacity Utilization%

$$= \frac{\text{Actual Output}}{\text{Maximum Possible Output}} \times 100$$

$$= 17\%$$

- ❖ Standard 35,064.82, Use time=61,686.92, Lost time=15,681.04

On Standard Efficiency % =

$$\frac{3506482}{61686.92 - 15681.04} \times 100$$

$$= \frac{35064.82}{46005.88} \times 100$$

$$= 0.76 \times 100$$

$$= 76\%$$

$$\text{Overall Efficiency \%} = \frac{3506492}{61686.92} \times 100$$

$$= 0.568 \times 100$$

$$= 57\%$$

Calculation Utilization Calculation %

No. of Machine 9, Machine Capacity= 8410kg/day,

working Day= 24.38, Grey fabric load

=6986.38kg/Day, Standard time = 34,545.37Hrs.

Use time=63033hrs, total lost time=10918.63hrs,

Working Hours= 63033hrs, Actual

Output=170327.92kg, Maximum output=205035.8

Kg, M/C Time/day= (9×24) or 216 hrs.

$$\text{Machine Utilization \%} = \frac{63033 - 10918.63}{63033} \times 100$$

$$= \frac{52114.37}{63033} \times 100$$

$$= 0.826 \times 100$$

$$= 83\%$$

$$\text{Capacity Utilization\%} = \frac{170327.92}{205035.8} \times 100$$

$$= 0.83 \times 1$$

$$= 83\%$$

$$\text{Machine Load Efficiency \%} = \frac{6986.38}{8410} \times 100$$

$$= 0.83 \times 100$$

3. Survey Results & Analysis

I conducted a survey of the causes and problems related to stoppages of dyeing machinery, with a specific focus on the Knit Dyeing Machine at York Composite Limited, where I have practical experience. The following section identifies the causes and issues associated with stoppages in various dyeing machines within this industry. This report highlights the percentage of major dyeing machine stoppages for different types of knit fabrics in both current and developing processes. By implementing the remedies discussed below, it is possible to significantly reduce the existing fault percentages.

The monthly production stoppage data for dyeing machinery at York Composite Ltd. is presented in Tables 4 and 5.

Table 4. Monthly Dyeing machinery stoppage problem data found in York Composite Ltd.

York Composite Ltd. Utilization Calculation															
Problem %		17.00%		1.45%	4.38%	0.02%	0.08%	2.92%	0.00%	0.11%	0.27%	1.67%	5.22%	1.22%	
	Utilization %		83%	8.36%	25.29%	0.14%	0.36%	16.83%	0.00%	0.61%	1.58%	9.61%	30.15%	7.05%	
Total	63060	10918.63	17%	912.71	2761.54	15	39.5	1837.45	0.5	67	173	1049.52	3392.46	769.95	
Months	Total W. HR/Day	Total Lost HR/Day	% of lost hours	Batch Problem	Batch Not Available	Trolley Problem	Lab Problem	Break-down Maintenance	Air Problem	Water Problem	Steam Problem	Power Problem	No Sample	Others (Production Gap)	Days
January	5508	940.74	17.08%	13	211.08	8	0	99.42	0	67	0	14.98	435.26	92	25.5
February	5076	706.84	13.93%	35	188.22	0	0	48	0	0	11	23.75	356.7	44.17	23.5
March	5616	828.8	14.76%	0	297.66	0	4.5	90.4	0	0	2	50.12	333.97	50.15	26
April	4320	574.59	13.30%	21.65	153.3	0	0	87.79	0	0	0	71.32	211.53	29	20
May	5724	1073.4	18.75%	53.75	200	2	0	233.5	0	0	3	64.98	504.17	12	26.5
June	4104	860.66	20.97%	246.84	20	0	0	138	0.5	0	0	84.82	181	24	19
July	5373	1304	24.27%	144.5	386	0	0	160.5	0	0	0	270	332	11	25
August	5091	482.5	9.48%	83	129	0	0	74.5	0	0	0	45.5	150.5	0	24
September	5616	1229.09	21.89%	184.83	181.83	5	0	579.75	0	0	11.5	209.68	31.5	25	26
October	5832	1326.49	22.75%	25.44	390.08	0	19	230.86	0	0	0	173.7	338.41	149	27
November	5400	602.04	11.15%	47.05	136.35	0	16	68.58	0	0	140	30.06	139.5	24.5	25
December	5400	989.48	18.42%	57.65	468.02	0	0	26.15	0	0	0	10.61	277.92	149.13	25

Table 5. Monthly Dyeing Production in York Composite Ltd.

York Composite Ltd.																
Dyeing Monthly Summary Status																
Month	Dyeing Production (Kg)	Efficiency %		RFT %		No. Of Batch	Process Loss %	Re-Work %	Dyes-Chemical Costing (TK/Kg)				Total Available (Hrs.)	Total NPT (Hrs.)	Total NPT% (Hrs.)	Days
		Overall Efficiency	On Standard Efficiency	Lab To Bulk %	Bulk To Bulk %				Chemical (Cost/Kg)	Dyes (Cost/Kg)	Finishing (Cost/Kg)	Total (Cost/Kg)				
January	176,192.00	55.16%	76.41%	63.21%	72.97%	1.59	9.73%	4.02%	24.76	20.74	0.62	46.12	5508:00:00	940:44:31	17.08%	25.5
February	164,126.00	56.25%	73.80%	57.14%	74.62%	1.66	8.85%	3.17%	23.99	20.82	0.61	45.42	5076:00:00	706:50:30	13.93%	23.5
March	176,917.00	56.07%	72.70%	54.10%	72.97%	1.63	8.83%	4.95%	25.27	14.55	0.65	40.46	5616:00:00	828:48:00	14.76%	26
April	126,879.00	53.90%	73.91%	63.74%	81.95%	1.64	8.18%	6.35%	26.53	22.04	0.97	49.54	4320:00:00	574:35:32	13.30%	20
May	186,460.00	47.14%	68.28%	62.89%	72.28%	1.53	6.29%	6.86%	22.94	13.27	1.32	37.53	5724:00:00	1073:23:57	18.75%	26.5
June	137,521.50	63.57%	82.86%	55.22%	76.86%	1.64	8.31%	1.95%	28.62	25.39	0.88	54.89	4104:00:00	860:40:00	20.97%	19
July	162,415.00	55.01%	78.43%	55.41%	76.00%	1.55	9.46%	5.24%	26.44	17.60	0.98	45.01	5400:00:00	1304:04:00	24.15%	25
August	161,165.50	65.53%	78.19%	65.31%	72.22%	1.83	10.02%	5.74%	25.09	13.34	0.83	39.26	5184:00:00	482:30:00	9.31%	24
September	190,046.00	59.09%	79.38%	65.28%	80.25%	1.85	9.27%	3.10%	22.42	11.77	0.61	34.80	5616:00:00	1229:05:40	21.89%	26
October	209,194.00	58.74%	80.00%	67.57%	78.72%	1.76	9.42%	4.05%	22.50	14.43	0.63	37.56	5832:00:00	1326:29:34	22.75%	27
November	173,011.50	59.20%	76.61%	64.63%	74.26%	1.71	8.80%	5.90%	25.83	17.42	0.77	44.03	5400:00:00	602:02:40	11.15%	25
December	180,007.50	54.77%	75.29%	71.62%	75.25%	1.64	9.13%	4.70%	24.10	16.57	0.65	41.33	5400:00:00	989:29:00	18.32%	25
Total	2,043,935.00												63,396:00:00	10,918:39:24	205%	292.5
Average Month	170,327.92												5283:00:00	909:53:17		24.38
Average Day	6,986.38	57.04%	76.32%	62.18%	75.70%	1.67	8.86%	4.67%	24.88	17.33	0.79	43.00	216:00:00	37:25:00	17.22%	1.00

A common problem that occurs at York Composite Ltd. is presented in Figure 2

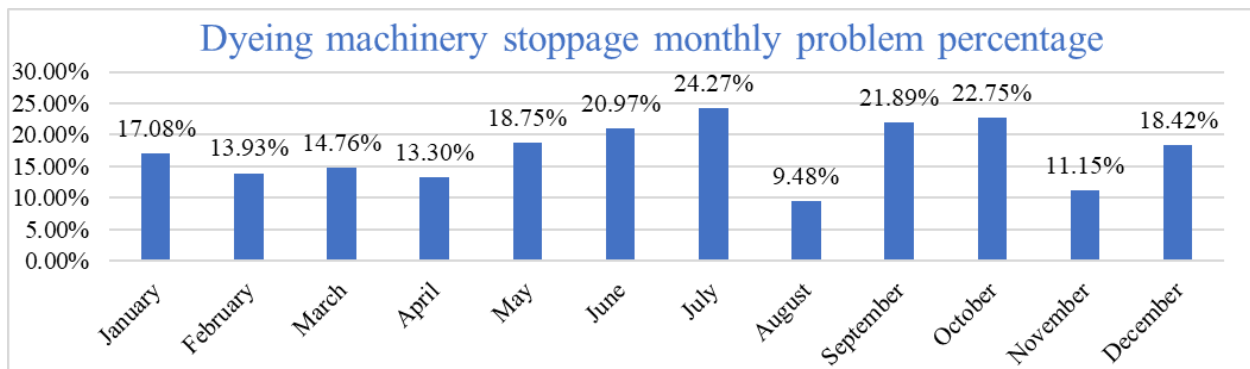


Fig. 2. Representing the Monthly Total dyeing machinery stoppage problem fund in York Composite Ltd.

The common causes that occurred one year at York Composite Ltd. are presented in Figure 3.

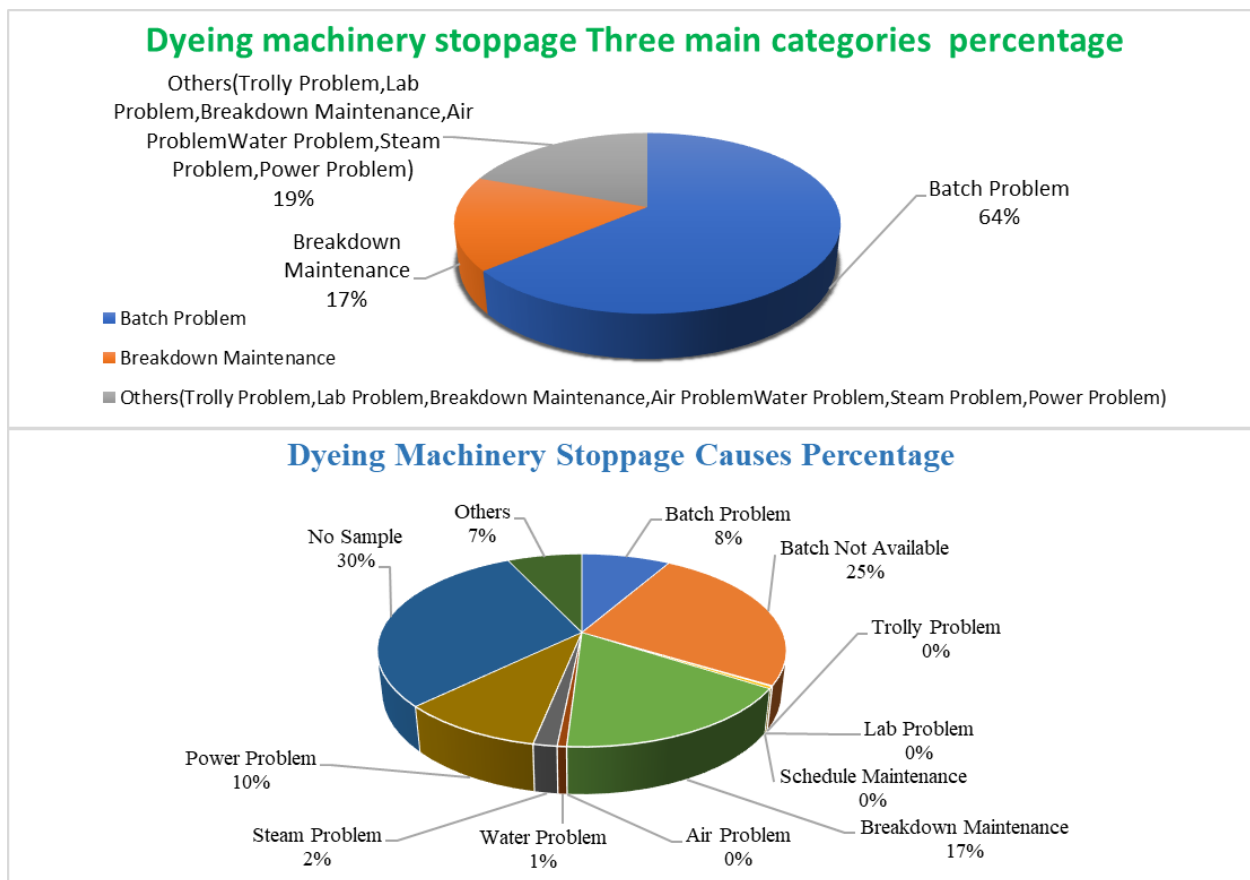


Fig. 3. Representing one year of dyeing machinery stoppage problem found in Yrk Compsite Ltd.

Note: Batch Problem :(Batch issue+ Batch not Available +No Sample)

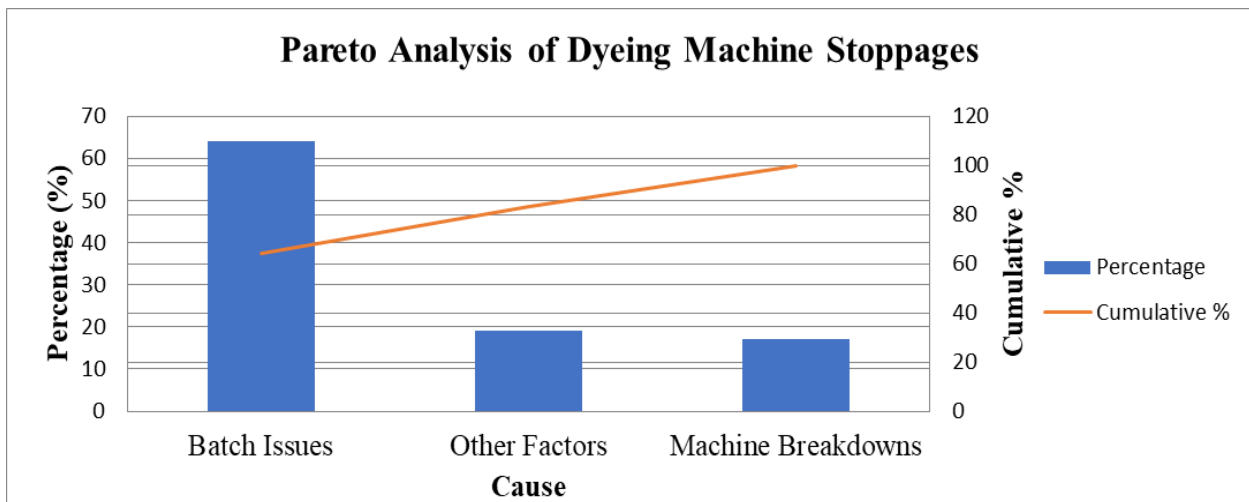
Dyeing machinery stoppage, three main categories: Dyeing machinery stoppage, three main categories are summarized in Table 6.

York Composite Ltd.
Table 6. Monthly Dyeing machinery stoppage, three main categories

Dyeing Working Hour Utilization Calculation						
Utilization %	83%	17%	11%	3%	3%	
Date	Total W. HR/ Day	Total Lost HR/ Day	% of lost hours	Batch Problem	Breakdown Maintenance	Others (Trolley Problem, Lab Problem, Production Gap, Air Problem, Water Problem, Steam Problem, Power Problem)
January	5508.00	940.74	17.08%	659.34	99.42	181.98
February	5076.00	706.84	13.93%	579.92	48.00	78.92
March	5616.00	828.80	14.76%	631.63	90.40	106.77
April	4320	574.59	13.30%	386.48	87.79	100.32
May	5724	1073.4	18.75%	757.92	233.50	81.98
June	4104	860.66	20.97%	447.84	138.00	274.82
July	5373	1304	24.27%	862.50	160.50	281.00
August	5091	482.5	9.48%	362.50	74.50	45.50
September	5616	1229.09	21.89%	398.16	579.75	251.18
October	5832	1326.49	22.75%	753.93	230.86	341.70
November	5400	602.04	11.15%	322.90	68.58	210.56
December	5400	989.48	18.42%	803.59	26.15	159.74
Total	63060	10918.63	17.32%	6968	1838	2115
Total Problem %				64%	17%	19%

Pareto Analysis of Dyeing Machine Stoppages: Pareto Analysis of Dyeing Machine Stoppages the three main categories & loss hours summarized in Figures 4 (see Table 6 for summary of three main categories)

Category	Hours	Percent	Cumulative %
Batch Related	6968	64	64
Breakdown	1838	17	81
Others	2115	19	100



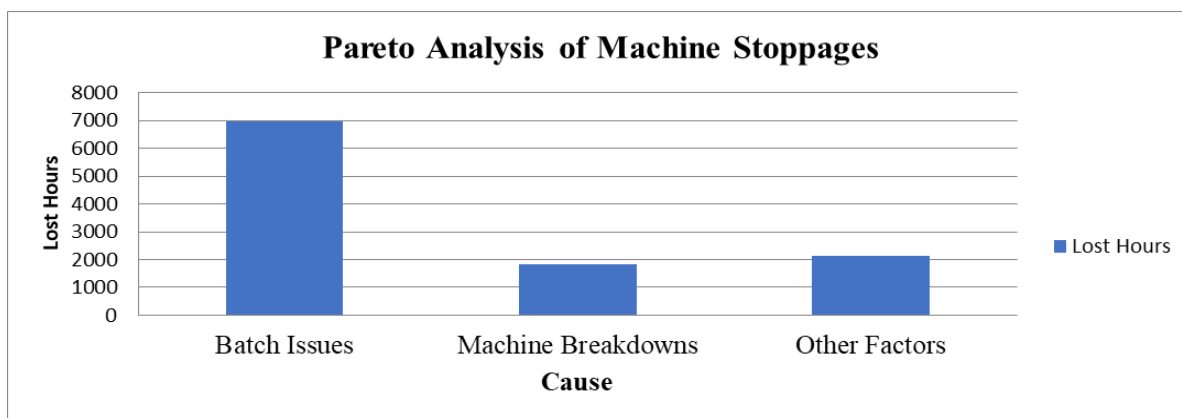


Fig. 4. Representing the Pareto Analysis of the Cause and Loss of Hurs dyeing the machinery stoppage.

Monthly Production Loss (kg) & Efficiency (%): The summary of grapes is shown in Figures 5, with Line Charts-1 & 2 presenting monthly production loss (kg) and efficiency%.

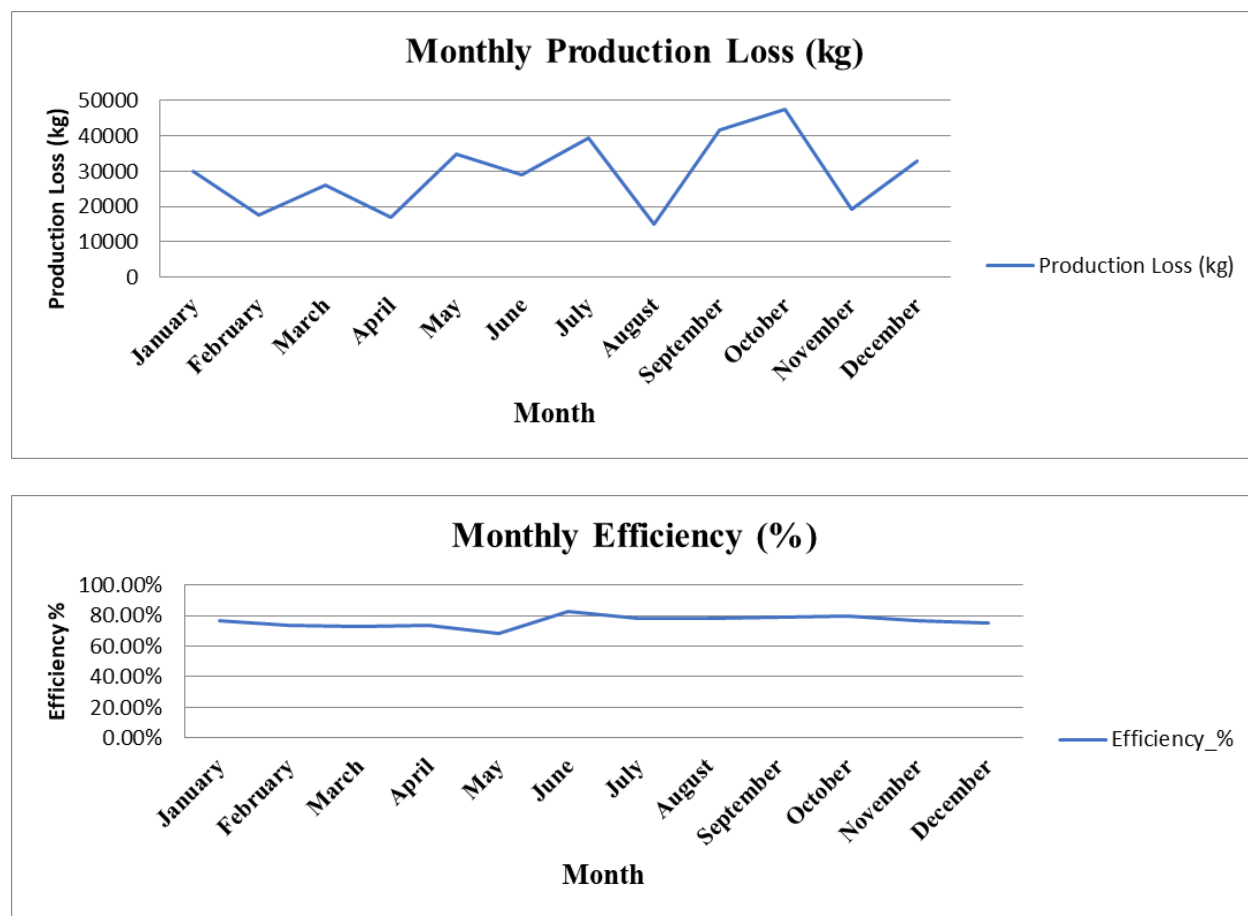


Fig. 5. Presenting the monthly production loss (kg) & Efficiency %

The analysis of the dyeing machinery stoppage and production data reveals that York Composite Ltd. operates at an average utilization rate of 83%, with 17%

of total working hours lost due to various stoppages. The primary cause of downtime is batch-related issues, which together account for the largest share of lost

hours, followed by breakdown maintenance and operational delays such as production gaps or lack of samples. Monthly trends indicate that July, October, and September suffer the highest downtime percentages, while February and August perform relatively better. Production efficiency averages 53.07% overall, with on-standard efficiency at 76.32%, but the Right First Time (RFT) rate from lab to bulk remains low at 62.18%, indicating a significant need for quality improvements to reduce reprocessing. Process loss is relatively minor at 1.86%, though reprocessing consumes 6.47% of capacity. Cost analysis shows that higher production costs often coincide with months of lower efficiency and higher stoppage rates, as seen in May and June, while more efficient months like August achieve lower costs. These findings highlight the need for improvements in batch scheduling, machinery reliability, and operational coordination to enhance efficiency, reduce costs, and increase overall productivity.

The study observed numerous dyeing machinery stoppage issues on the dyeing floor of York Composite Limited, identifying various problems each month. The percentage of these issues changes monthly. For example, I found a total problem percentage of 17.08% in January, 13.93% in February, 14.76% in March, 13.30% in April, 18.75% in May, 20.97% in June, 24.27% in July, 9.48% in August, 21.89% in September, 22.75% in October, 11.15% in November, and 18.42% in December. The analysis highlights the causes of machine stoppage and the loss of productivity effect in dyeing production over a year.

In January, production losses were attributed to machine stoppage time totaling 940.74 hours, resulting in a loss of 30093.59 kg. In February, machine stoppage time accounted for 706.84 hours, leading to a loss of 17674.25 kg. March saw production losses of 26112.95 kg due to 828.80 hours of machine stoppage time. In April, there were 574.59 hours of stoppage time, resulting in a loss of 16874.91 kg.

May experienced the most significant impact, with machine stoppage time amounting to 1073.4 hours, causing a loss of 34961.25 kg. In June, the loss was attributed to 860.66 hours of stoppage time, resulting in 28838.26 kg lost. In July, production was affected by

1304 hours of machine stoppage, leading to a loss of 39223.22 kg.

In August, machine stoppage time totaled 482.5 hours, resulting in a loss of 15004.51 kg. September had 1229.09 hours of stoppage time, resulting in a production loss of 41601.07 kg. In October, stoppage time reached 1326.49 hours, leading to a loss of 47591.64 kg. November saw 602.04 hours of stoppage time, resulting in a loss of 19290.78 kg. Finally, in December, there were 989.48 hours of stoppage time, leading to a loss of 32977.37 kg.

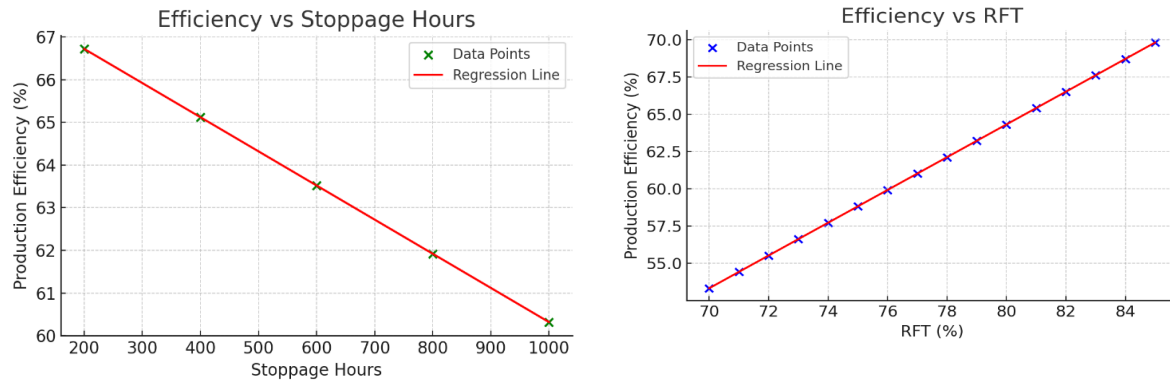
Overall, due to the issues faced throughout the Months, the average loss in dyeing production was realized at 17.22%, resulting in a monthly production loss of 29330.47 kg.

The analysis identifies three primary categories of defects that hinder productivity: batch-related issues, machine breakdowns, and other factors. It was discovered that 64% of stoppages in dyeing machines are caused by a lack of batch supply, 17% are due to machine breakdowns, and 19% result from other causes. During my observations on the dyeing floor at York Composite Limited, I noted various issues, with 64% of the stoppages attributed to batch supply shortages over the course of one year. This indicates a critical need for better inventory management and supply chain coordination. Additionally, 17% of the stoppages stem from machine breakdowns, highlighting the importance of regular maintenance and timely repairs to ensure operational efficiency. The remaining 19% of stoppages can be attributed to various other causes, which may encompass operator issues, material defects, and unforeseen circumstances. Throughout my observations on the dyeing floor at York Composite Limited, I encountered a range of challenges that contributed to production delays. Notably, I identified that 64% of the stoppages I recorded over the past year were specifically related to batch supply shortages. This recurring issue not only disrupts the workflow but also affects overall production output, underscoring the urgency for implementing effective solutions to mitigate these problems and enhance the efficiency of the dyeing operations. If these issues are addressed, production could improve by 17.22%. (See Table 7 for a detailed breakdown of downtimes of issues)

Multiple Regression Analysis of Efficiency (%) on RFT and Stoppage Hours: The summary of grapes and table is shown in Table -7 with Figure- 6 (Scatter plots), presenting the linear relationship between RFT%, Efficiency% and Stoppage hours.

Table 1. Multiple Regression Analysis of Efficiency (%) on RFT and Stoppage Hours

Predictor	Coefficient (β)	Std. Error	t-value	p-value	95% Confidence Interval
Constant	-19.60	9.87	-1.99	0.070	(-40.5, 1.3)
RFT (%)	1.099	0.105	10.47	<0.001	(0.85, 1.35)
Stoppage Hours	-0.008	0.002	-4.23	0.004	(-0.012, -0.004)

**Fig. 6.** Presenting the linear relationship RFT% Efficiency % and Stoppae hours**Regression Analysis:**

A multiple linear regression analysis was conducted to evaluate the impact of machine stoppages and Right-First-Time (RFT) performance on production efficiency in knit dyeing units. The dependent variable was production efficiency (%), while the independent variables included stoppage hours and RFT (%).

The estimated regression model was:

$$\text{Efficiency} = -19.60 + 1.099(\text{RFT}) - 0.008(\text{Stoppage Hours})$$

The results indicate that RFT (%) has a strong positive and statistically significant effect on efficiency ($\beta = 1.099$, $p < .001$). This suggests that each 1% increase in RFT leads to an improvement of approximately 1.1% in production efficiency. In contrast, stoppage hours demonstrated a significant negative influence ($\beta = -0.008$, $p = .004$), implying that every additional 100 stoppage hours reduces efficiency by nearly 0.8%.

The overall model fit was high, with $R^2 = .865$, indicating that 86.5% of the variation in production efficiency was explained by RFT and stoppage hours, $F(2, 9) = 28.80$, $p < .001$.

The scatter plots further support these findings. A strong positive linear relationship was observed

between efficiency and RFT, whereas efficiency showed a clear negative association with stoppage hours. These results highlight that improving RFT performance and reducing stoppage time are critical strategies for achieving the 2025 production efficiency target of 80%.

3.1. Improved cost-competitiveness & shorter customer lead times:**1. Indicators of Improved Cost-Competitiveness:**

- **Low Average Total Cost (TK/Kg):** The average total cost per Kg is 43.00 TK/Kg, with several months like October (36.57) and November (37.55) showing significantly lower costs — a sign of efficient resource usage and process control. Chemical and dye cost optimization is visible in months like November (18.74 + 17.76) and October (19.10 + 16.22).
- **Decreasing Re-Process %:** A low average re-process rate of 4.67% indicates reduced waste and rework costs. Months like March (2.03%) and July (2.45%) show high first-pass yield.
- **Process Loss Control:** With an average process loss of 1.86%, and some months like January (1.59%) and February (1.77%) showing excellent control, this contributes to better raw material usage and cost savings.

2. Indicators of Shorter Customer Lead Times:

- High Overall Efficiency %: The average overall efficiency is 57.04%, and peaks in October (65.00%), November (60.90%), and August (65.53%). This enables quicker throughput and reduced turnaround times.
- Improved Right-First-Time (RFT) %: Average RFT for Bulk to Bulk is 75.70%, with April (91.59%), June (85.51%), and December (75.52%) indicating solid quality on the first go, which accelerates delivery and reduces delays.

3.2. Dyeing Machine Stoppage Cause & Remedies:

Production disruptions occur due to the stoppage of dyeing machines. There are various causes for machine stoppages during the dyeing process. Below, the issues caused by dyeing machinery stoppages and their remedies are described.

1. Batch Problem:

Batch supply issues, which occur when a specific batch or lot of a product encounters problems, can arise from several factors. Common causes include manufacturing defects, variations in raw materials, and inadequate storage conditions. To address these issues, businesses can adopt strategies such as enhanced quality control, improved inventory management, and stronger relationships with suppliers.

Causes:

1. Defective Manufacturing Processes: defects in machinery settings or human mistakes lead to defective products.
2. Inconsistent Raw Materials: Variations in raw material quality can cause inconsistencies in finished goods.
3. Improper Storage Conditions: Unsuitable storage can result in spoilage or damage.
4. Incorrect Batch Tracking: Difficulties in tracking batches hinder issue identification.
5. Bullwhip Effect: Poor demand forecasting can create excessive inventory or shortages.

Remedies:

1. Enhanced Quality Control: Rigorous procedures to identify defects early.

4. Implement early drying processes.

- Low Non-Productive Time (NPT) %: The average NPT % is 17.22%, but March (10.87%) and February (11.93%) show that productivity can significantly improve with tighter downtime management.

Months such as October, November, and April demonstrate peak performance in cost control and production efficiency. Focusing on reducing rework and non-productive time, while increasing right-first-time rates and overall efficiency, is essential for maintaining or improving cost competitiveness and lead time.

2. Supplier Relationship Management: Strong relationships ensure consistent quality and timely delivery.

3. Robust Inventory Management: Effective tracking minimizes spoilage and damage risk.

4. Demand Forecasting and Planning: Improved communication and forecasting accuracy.

5. Diversification of Supply Sources: Multiple suppliers reduce disruption risk.

6. Risk Management Planning: Strategies for prevention and response to supply chain disruptions.

7. Cross-Functional Alignment: Ensuring teams are aligned on forecasts and strategies.

8. Technology Adoption: Use of supply chain management software for better visibility and efficiency.

2. Trolley Problem:

Causes:

1. Excess white batch and normal wash (Yarn dyed) batch fabric dyeing.
2. The trolley gets stuck due to issues in the finishing section
3. Delays in drying the finished fabric.
4. Crises related to the trolley.
5. Reprocessing dyeing leads to a stuck trolley.
6. The trolley wheels frequently break, causing delays in repairs.

Remedies:

1. Follow the dyeing plan for the white Batch and Normal wash (Yarn dyed) batch fabric dyeing.
2. Complete finishing early and ensure trolleys are available.
3. Purchase additional trolleys.

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5. Handle trolleys with care to avoid breaking wheels.

3. Laboratory Problem

Causes:

1. The "lab dip" is not properly closed.
2. Decision delay.
3. The accurate process is not maintained.
4. On time, not delivered on the Dyeing floor.
5. Urgently bulk section fabric dyeing due to shipment.

Remedies:

1. Properly "lab dip" close to provide the Bulk section
2. Properly decide at the right time
3. The actual recipe provides
4. A timely recipe provides
5. Properly plan before Shipment time

4. Breakdown Maintenance

Causes:

1. Mechanical issues affecting multiple components of the machinery.
2. Lack of proper monitoring of the maintenance team.
3. Delays in timely follow-up actions.
4. Poor control over the maintenance team, leading to time delays.
5. Inadequate monitoring of operators.

Remedies:

1. Ensure proper monitoring of the maintenance team.
2. Assign the maintenance team to resolve problems promptly.
3. Minimize machinery problems through effective maintenance practices.
4. Maintain proper control over all maintenance activities.
5. Monitor operators effectively.

5. Air Problem

Causes:

1. Electrical and compressor-related issues disrupting the air supply
2. Mechanical faults in the system.
3. Air Pipe Leakage

Remedies:

1. maintenance team.
in the batch section and during turning.
2. Prepare the recipe accurately.
3. Plan and make decisions in advance.

Remedies:

1. Ensure a properly compressed and uninterrupted air supply.
2. Maintain an efficient and well-monitored maintenance team.
3. Properly maintain the maintenance team to address air-related issues.

6. Steam Problem

Causes:

1. Steam problem occurs due to a gas crisis.
2. Unavailability of gas supply.

Remedies:

1. Ensure a proper and uninterrupted gas supply.

7. Power Problem:

Causes:

1. Power problems arise due to electricity shortages or crises.
2. The generator is not properly supplied and may suddenly stop.

Remedies:

1. Ensure that the power supply is properly connected and maintained

8. Others

Causes:

1. Lack of proper monitoring of the maintenance team.
2. Inadequate follow-up in the batch section and during turning.
3. Failure to prepare the recipe correctly.
4. Delay in planning and decision-making.

Remedies:

1. Ensure proper monitoring of the maintenance team.
2. Follow up properly in the batch section and during turning.
3. Prepare the recipe accurately.
4. Plan and make decision in advance

3.3. To reduce the Stoppage of dyeing machines, we need to follow these instructions:

1. Minimize batch problems.
2. Identify and reduce mechanical issues.
3. Resolve trolley-related problems.
4. The steam problem and gas crisis are removed.

5. Ensure a reliable power and generator supply.
6. Ensure timely and accurate recipe support is provided from the lab to the bulk section.
7. Emphasize the importance of skilled operators and technical personnel, and ensure careful follow-up.

By implementing these instructions, we can minimize the downtime of dyeing machinery in the dyeing sector. This will ultimately lead to increased productivity and contribute to remittances in the country, significantly impacting the global textile market. In this paper, I discuss various types of dyeing machine stoppage problems and the percentage of different causes that affect production. These issues have a significant impact on the productivity of the dyeing industry. During my practical work for this paper, I realized that this is a complex issue within the dyeing floor and the dyeing and finishing sector. Such stoppages hinder productivity and efficiency, interrupting production. I tried to identify the main problems and find ways to reduce them.

4. Research Gaps and Improvement

Solutions:

This study provides extensive descriptive insights into the causes of dyeing machine stoppages and their impact on production efficiency. However, several research and practical gaps remain, which must be addressed to achieve sustainable improvements in knit dyeing operations.

The following gaps and improvement strategies are identified:

4.1. Research Gaps:

1. Batch Management Gap:

While 64% of stoppages are linked to batch issues, the study does not explore advanced approaches such as digitalized batch scheduling or predictive demand planning. Current management practices remain largely reactive rather than proactive.

2. Preventive vs. Corrective Maintenance:

Machine breakdowns (17%) are addressed primarily through corrective maintenance. Predictive maintenance, utilizing IoT sensors and data-driven diagnostics, remains absent. (See Table 1 for a detailed breakdown of issues)

3. Laboratory–Production Integration:

Lab delays significantly affect Right-First-Time (RFT) performance, yet there is no framework for

real-time synchronization between lab approval and bulk production.

4. Limited Data Utilization:

Although substantial data on stoppages is collected, statistical modeling (e.g., Regression, ANOVA, time-series forecasting) is not applied to predict or quantify root causes.

5. Operator Skill & Training:

Operator crisis and human error are acknowledged but underexplored. No structured training, performance measurement, or competency evaluation system has been implemented.

4.2. Improvement Solutions:

1. Smart Batch Scheduling:

- Implementation of ERP/AI-based scheduling to ensure synchronized batch allocation.
- Integration of knitting, batching, and dyeing schedules to minimize supply delays.

2. Predictive Maintenance Framework:

- Installation of IoT sensors for continuous monitoring of pumps, valves, motors, and pressure systems.
- Data analytics to anticipate failures and reduce unplanned stoppages.

3. Digital Lab-to-Bulk Workflow:

- Deployment of a Lab Information Management System (LIMS) for digital recipe approval.
- Automated shade matching to eliminate manual errors and decision delays.

4. Advanced Statistical & Data-Driven Analysis:

- Use of Pareto analysis to prioritize critical stoppage causes.
- Application of correlation studies to assess the relationship between RFT performance and stoppage hours.
- Forecasting models to predict stoppage trends and optimize planning.

5. Human Resource & Training Development:

- Structured training programs for machine operators and technicians.
- Standard Operating Procedures (SOPs), error-proofing mechanisms (poka-yoke), and regular skill assessments.

6. Lean Tools & Process

- Automation: Adoption of continuous improvement (Kaizen) and root cause analysis (5 Whys, Fishbone Diagram).
- Application of SMED principles to reduce loading/unloading downtime.
- Process automation to minimize rewash and rework.

5. Conclusion

This study demonstrates that stoppages in knit dyeing machines significantly reduce production efficiency, with batch supply delays alone accounting for nearly two-thirds of downtime. Machine breakdowns and other operational issues contribute further losses, leading to an average efficiency gap of over 17%. Regression analysis highlights the critical role of RFT performance and stoppage reduction in achieving higher efficiency.

To address these challenges, knit dyeing units should prioritize smart batch scheduling, predictive maintenance frameworks, and digital lab-to-bulk integration. Strengthening operator training and enforcing standardized procedures are equally essential. Collectively, these strategies can improve utilization, reduce production costs, and enhance competitiveness in the textile industry. Beyond efficiency gains, such improvements contribute to cleaner production practices and align with global sustainability objectives for Bangladesh's ready-made garment sector. By addressing the root causes and implementing systematic monitoring, industries can achieve higher output, improved product quality, and greater competitiveness in the textile market.

Data Availability Statement:

The datasets generated and/or analyzed during the current study are not publicly available due to confidentiality agreements with York Composite Ltd., but are available from the corresponding author on reasonable request.

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Mr. Salim Khan, Managing Director of York Group, is a distinguished business leader known for his dedication, integrity, and dynamic leadership. He pursued higher education in the United States, where he developed a vision to return to Bangladesh and contribute to the upliftment of underprivileged communities. He is especially committed to empowering disadvantaged women by creating opportunities for them to build better futures. Under his guidance, York Group operates with strong ethical values and social responsibility. His leadership continues to drive the organization's contribution to the country's socio-economic development.