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Understanding Material Allowance as a Systemic Issue in Garment Manufacturing: An Activity-on-Arrow Case Study

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Abstract
One recurring challenge in garment production is material allowance, which refers to excess material usage beyond planned requirements and may increase production costs while reducing resource efficiency. This study aims to analyze production business processes and identify factors contributing to material allowance in the manufacturing of Tommy Hilfiger products at PT XYZ, an export-oriented garment company in Indonesia. This research adopts a descriptive qualitative approach by applying the Activity-on-Arrow (AOA) method to map activity sequences and interdepartmental relationships across the production workflow. Primary data were collected through direct observation and semi-structured interviews, while secondary data were obtained from internal company documents and material usage records. Quantitative analysis of raw material consumption was conducted across three production seasons—Fall 2021, Pre-Spring 2022, and Spring 2022. A fishbone diagram was used to analyze the root causes of material allowance. The results show that material allowance consistently occurred at approximately 2% across all observed production seasons. AOA-based analysis identifies cutting and sewing processes as critical stages where rework and quality deviations frequently arise. Human-related factors and method-related issues were found to be the primary contributors to material allowance.
Keywords: *garment manufacturing, material allowance, activity – on – arrow, production process analysis, textile waste*

Abstrak
Salah satu permasalahan yang sering muncul dalam proses produksi garmen adalah *material allowance*, yaitu penggunaan bahan baku yang melebihi kebutuhan yang direncanakan. Penelitian ini bertujuan untuk menganalisis proses bisnis produksi serta mengidentifikasi faktor-faktor penyebab terjadinya material allowance pada produksi produk Tommy Hilfiger di PT XYZ. Penelitian ini menggunakan pendekatan kualitatif deskriptif dengan menerapkan metode *Activity-on-Arrow (AOA)* untuk memetakan urutan aktivitas dan keterkaitan antar departemen dalam alur produksi. Data primer diperoleh melalui observasi langsung dan wawancara semi-terstruktur, sedangkan data sekunder berasal dari dokumen internal perusahaan dan catatan penggunaan bahan baku. Analisis kuantitatif terhadap penggunaan bahan baku dilakukan pada tiga musim produksi, yaitu Fall 2021, Pre-Spring 2022, dan Spring 2022. Selain itu, *diagram fishbone* digunakan untuk menganalisis akar penyebab *material allowance*. Hasil penelitian menunjukkan bahwa material allowance terjadi secara konsisten sebesar sekitar 2% pada setiap musim produksi. Analisis AOA mengidentifikasi proses cutting dan sewing sebagai tahap kritis yang paling berpotensi menimbulkan pemborosan bahan. Faktor manusia dan metode kerja merupakan penyebab utama terjadinya *material allowance*.
Kata Kunci: *industri garmen, material allowance, activity-on-arrow, analisis proses produksi, limbah tekstil*

1. Introduction

Indonesia's manufacturing sector continues to play a major role in supporting national economic growth, particularly through export-oriented industries that must respond quickly to dynamic global demand. Recent trade statistics indicate that Indonesia's export performance remained relatively stable throughout 2024, highlighting the need for manufacturers to maintain reliable production schedules and timely delivery to international markets [1]. Within this context, the textile and apparel industry occupies a

strategic position due to its significant contribution to export revenue and employment, while simultaneously facing intense global competition and strict buyer requirements [2].

For make-to-order garment manufacturers, production performance is highly dependent on effective raw material inventory management. Raw materials must be available in the right quantity and at the right time to support uninterrupted production, while excessive inventory levels can increase storage and handling costs. Inaccurate inventory planning may result in material shortages, production delays, and failure to meet delivery commitments. Previous studies have shown that weak inventory control directly affects production reliability and order fulfilment performance in manufacturing systems [3]. However, ensuring material availability alone is not sufficient; manufacturers must also control how materials are consumed throughout the production process.

In garment production, inefficiencies frequently appear in the form of material allowance, defined as the use of materials beyond planned requirements. This issue commonly arises during cutting, sewing, and finishing processes due to cutting inaccuracies, rework, specification mismatches, or inconsistencies in production data. Recent research highlights that pre-consumer waste, particularly fabric scraps generated during the cutting stage, can account for a substantial proportion of total textile waste [4]. Furthermore, a systematic review on fashion and textile waste management emphasizes that limited process visibility and poor coordination across production stages remain key contributors to material waste in garment manufacturing [5], [10], [11]. Consequently, material allowance not only increases operational costs but also reduces resource efficiency and weakens a company's competitive position.

This study is conducted at PT XYZ, a make-to-order garment manufacturer producing export products for internationally recognized brands. The company manages a diverse range of products and buyer specifications, requiring close coordination among departments such as marketing, purchasing, warehousing, and production. Preliminary observations indicate that material allowance most frequently occurs in the cutting, sewing, and finishing departments, where process deviations and coordination gaps can directly affect fabric consumption. Despite its impact, material allowance is often addressed through isolated corrective actions rather than through an integrated analysis of how interrelated activities across departments collectively contribute to the problem.

To address this gap, this research applies the Activity-on-Arrow (AOA) method to map the sequence and logical relationships among activities across the production workflow. In this study, AOA is not used solely as a scheduling technique but as a structured approach to visualize interdepartmental process linkages, identify critical activity paths, and locate stages that potentially propagate material allowance. Prior studies on garment production waste emphasize the importance of systematic process mapping to support waste reduction and operational improvement [4], [5]. By analyzing the production process of Tommy Hilfiger products at PT XYZ, this research aims to provide practical insights for improving interdepartmental coordination and strengthening raw material control, thereby reducing material allowance and enhancing overall operational performance.

2. Material and Methods

To address the research objectives and examine how material allowance emerges within the production process, a structured methodological approach was adopted. This study focuses on analyzing interdepartmental workflows, activity sequences, and material usage practices within a real industrial environment. The methods employed are designed to capture actual operational conditions and to identify critical process stages that contribute to excess material consumption. By combining qualitative process analysis with empirical production data, the research framework enables a systematic evaluation of material allowance from both procedural and operational perspectives.

Research Design

This study employs a descriptive qualitative research design to analyze business processes and identify factors contributing to material allowance in garment production. A qualitative approach is considered appropriate because the objective of the study is to understand how production activities are carried out in practice, how departments interact, and how inefficiencies emerge within a real industrial setting, rather than to test hypotheses statistically. This approach allows an in-depth examination of activity sequences and operational practices that influence material usage [6].

Research Object and Scope

The research was conducted at PT XYZ, a garment manufacturing company operating under a make-to-order production system for international buyers. The scope of the study focuses on the production of

Tommy Hilfiger products, specifically within the cutting, sewing, and finishing processes. These production stages were selected because they directly affect fabric consumption and are commonly associated with material inefficiencies and pre-consumer waste in garment manufacturing.

Data Types and Data Sources

To obtain a comprehensive understanding of the production process, this study utilizes both primary and secondary data. Primary data were collected through direct observation of shop-floor activities and semi-structured interviews with personnel involved in production planning, material handling, and production execution. These methods enable the researcher to capture actual workflow conditions and operational practices as they occur during daily production activities.

Secondary data were obtained from internal company documents, including Bills of Materials (BOM), standard operating procedures, work instructions, and historical production records related to material usage. The combination of multiple data sources supports data triangulation and strengthens the credibility of the case-based qualitative analysis [7].

Operational Definition of Material Allowance

In this study, material allowance is defined as the excess consumption of fabric beyond the planned or standard material requirements during the garment production process. This excess usage may occur due to cutting inaccuracies, rework, specification mismatches, or coordination gaps between departments. Material allowance is operationally identified by comparing planned material usage derived from BOM data with actual material consumption observed during cutting, sewing, and finishing activities.

Activity – on – Arrow (AOA) Method

The Activity-on-Arrow (AOA) method is applied as the primary analytical tool to examine the production workflow. In AOA, activities are represented by arrows, while nodes indicate the start or completion of events. Although AOA is traditionally used in project scheduling, its logic of representing activity precedence and interdependencies is also suitable for analyzing production processes that involve sequential and interconnected activities [9].

In this research, the AOA method is used to:

1. Map the sequence of production and material-handling activities from order receipt to product completion.
2. Identify critical activity paths that influence material usage.
3. Analyze how delays, rework, or coordination gaps in earlier activities may propagate material allowance in subsequent production stages.

By applying AOA, material allowance is examined as a systemic issue arising from interrelated activities rather than as an isolated operational problem.

Research Procedure

The research procedure follows a structured sequence of stages, as illustrated in Figure 1. The stages include preparation, familiarization with the company environment, observation of production activities, identification of business processes, literature review, data collection, and data processing. Collected data were transformed into AOA network diagrams, activity sequence tables, and material usage comparison tables, which were then analyzed to identify patterns related to material allowance.

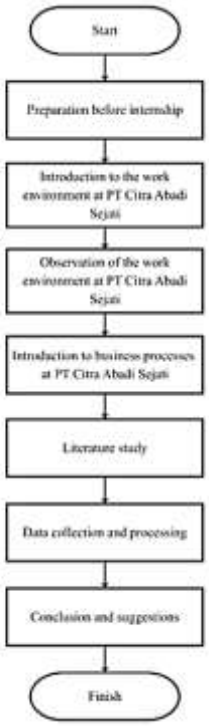

Figure 1. Research Flow Diagram

Data Analysis Technique

Data analysis was conducted qualitatively by interpreting the AOA network diagrams to identify critical activities, coordination gaps, and activity relationships that influence material usage. The analysis follows established qualitative data analysis procedures, including data reduction, pattern identification, and interpretation, to derive meaningful insights from the observed production processes [8]. The results of this analysis form the basis for recommendations aimed at improving raw material control and production efficiency.

4. Results and Discussion

This section presents and discusses the results of the study based on the application of the Activity-on-Arrow (AOA) method, analysis of production process flows, and evaluation of raw material usage data at PT XYZ. The discussion integrates qualitative findings from process mapping with quantitative evidence of material usage to provide a comprehensive understanding of material allowance in the garment production process. The results are structured to first describe the business and production processes, followed by an analysis of raw material usage across production seasons, and finally an examination of the underlying factors contributing to material allowance. This integrated approach ensures that the discussion not only describes observed conditions but also explains how process interdependencies and operational practices influence material efficiency.

Business and Production Process Analysis

The Activity-on-Arrow (AOA) method was used to map the production business process of Tommy Hilfiger products at PT XYZ, from order receipt to shipment. As illustrated in **Figure 2**, the process begins with order reception by the marketing department, followed by coordination with the sample department to ensure material conformity with buyer specifications. After approval, material requirements planning is conducted and forwarded to the purchasing department for procurement using a Material Requirements Planning (MRP) approach. Incoming materials are inspected by the warehouse, and only conforming materials are released to production, while non-conforming materials are returned to suppliers.

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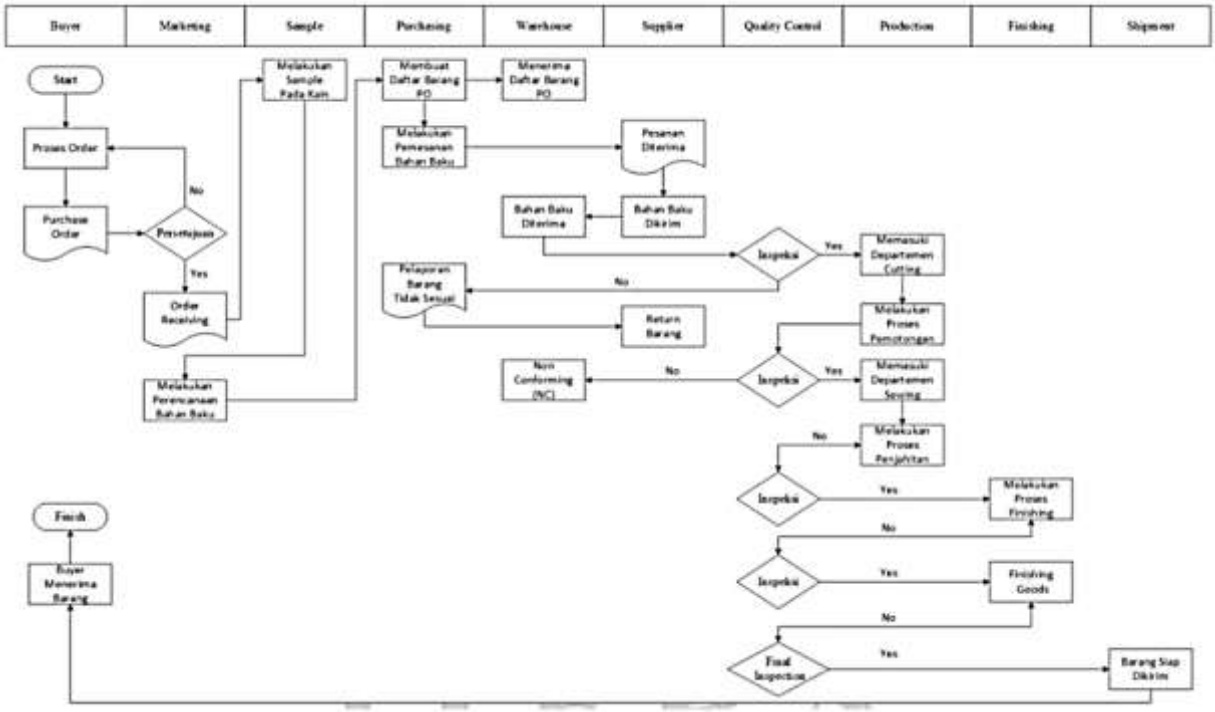

Figure 2. Business Process of PT ABC

The detailed production workflow shown in **Figure 3** confirms that cutting, sewing, and finishing are the main operational stages, each accompanied by inspection activities. While these inspection points ensure product quality, they also indicate potential rework, which may increase material usage when defects occur. Based on the AOA mapping, these stages are identified as critical activities where material allowance is most likely to arise.

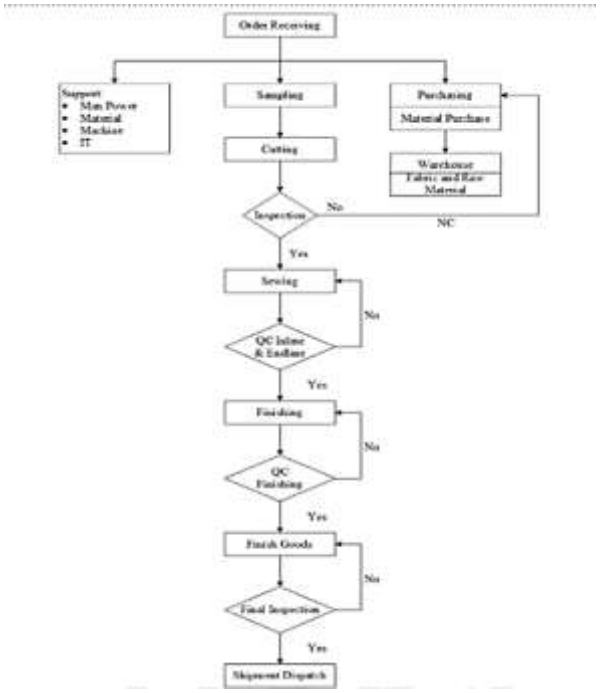

Figure 3. Production Process Flowchart

Raw Material Usage and Material Allowance Analysis

The raw material used in this study is Systentix Down 100% recycled polyester for Tommy Hilfiger jacket and vest products (style MW0MW18672). Raw material usage was analyzed across three production seasons: Fall 2021, Pre-Spring 2022, and Spring 2022. In the Fall 2021 season (**Table 1**), the planned raw

material requirement was 3,907.44 kg, while actual usage reached 3,985.59 kg, resulting in a difference of 78.15 kg or 2% material allowance. A remaining balance of 1,914.41 kg was still available for reuse.

Table 1. Raw Material Usage Fall 2021

Season	Style Name	Product			Raw Material		Loss (Kg)	Loss (%)	Current Balance
		Qty Pcs	Qty Needed	Qty Release	Item	Qty (Kg)			
Fall-21	Packable Circular Vest	2904	300,00	306,00	Systentix Down	5900,00	6,00	2,00	5594,00
Fall-21	Packable Circular Vest	8563	1222,80	1247,25	Systentix Down		24,46	2,00	4346,75
Fall-21	Packable Circular Jacket	8890	2044,70	2085,59	Systentix Down		40,89	2,00	2261,15
Fall-21	Packable Circular Jacket	1478	339,94	346,74	Systentix Down		6,80	2,00	1914,41

During Pre-Spring 2022 (**Table 2**), total planned material usage amounted to 1,896.20 kg, while actual usage reached 1,934.12 kg, indicating a material allowance of 37.92 kg (2%). The remaining raw material balance was 65.88 kg, which could be reused or resold.

Table 2. Raw Material Usage Pre-Spring 2022

Season	Style Name	Product			Raw Material		Loss (Kg)	Loss (%)	Current Balance
		Qty Pcs	Qty Needed	Qty Release	Item	Qty (Kg)			
PreSpring-22	Packable Circular Vest	2562	358,68	365,85	Systentix Down	2000,00	7,17	2,00	1634,15
PreSpring-22	Packable Circular Vest	2722	381,08	388,70	Systentix Down		7,62	2,00	1245,44
PreSpring-22	Packable Circular Jacket	470	108,10	110,26	Systentix Down		2,16	2,00	1135,18
PreSpring-22	Packable Circular Jacket	3622	833,06	849,72	Systentix Down		16,66	2,00	285,46
PreSpring-22	Packable Circular Jacket	936	215,28	219,59	Systentix Down		4,31	2,00	65,88

For the Spring 2022 season (**Table 3**), planned usage was 1,911.07 kg, while actual usage reached 1,949.29 kg, resulting in a difference of 38.22 kg, again corresponding to a 2% material allowance. The remaining balance of 1,050.71 kg could still be utilized for other styles.

Table 3. Raw Material Usage Spring 2022

Season	Style Name	Product			Raw Material		Loss (Kg)	Loss (%)	Current Balance
		Qty Pcs	Qty Needed	Qty Release	Item	Qty (Kg)			
Spring-22	Packable Circular Vest	5435	760,90	776,12	Systentix Down	3000	15,22	2,00	2223,88
Spring-22	Packable Circular Vest	683	95,62	97,53	Systentix Down		1,91	2,00	2126,35
Spring-22	Packable Circular Jacket	4585	1054,55	1075,64	Systentix Down		21,09	2,00	1050,71

A comparison of planned and actual material usage across seasons is shown in **Figure 4**. The results indicate that actual material usage consistently exceeds planned requirements, suggesting that material allowance is a recurring issue rather than an isolated incident.

Figure 4. Fabric Raw Material Usage Chart

These findings are consistent with previous studies reporting that fabric waste in garment manufacturing frequently originates from cutting and sewing activities, particularly when rework is required due to quality deviations or process inconsistencies [4], [11], [12]. Pre-consumer waste generated at these stages often results from inaccurate cutting, stitching errors, and insufficient coordination between production stages, leading to excess material consumption beyond planned requirements.

Analysis of Factors Causing Material Allowance

To identify the root causes of material allowance, a fishbone diagram was developed (Figure 5), categorizing factors into man, machine, material, method, and environment.

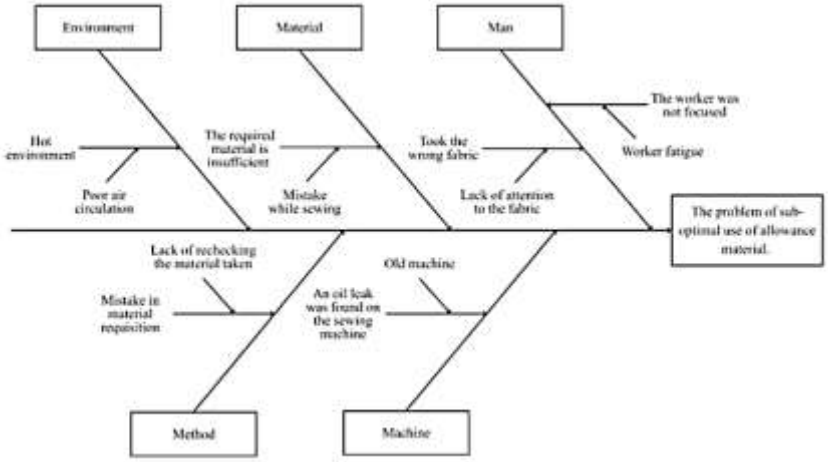

Figure 5. Fishbone Diagram

Human-related factors include worker fatigue and lack of focus during sewing, leading to stitching defects and rework. Machine-related issues mainly involve oil leakage from sewing machines, which can stain fabric and require material replacement. Material-related problems arise from sewing errors that necessitate additional fabric usage, especially when mockups are unavailable. Method-related factors include insufficient rechecking of materials and inconsistencies caused by staged material deliveries from suppliers, resulting in fabric shading differences. Environmental factors, such as high temperatures and poor air circulation, reduce operator comfort and concentration, increasing the likelihood of errors.

Similar findings have been reported in manufacturing quality studies, which indicate that human-related factors such as fatigue and lack of attention, as well as method-related issues including inadequate standardization and insufficient process control, are closely associated with quality deviations and rework [13], [14].

Overall, human and method-related factors have the strongest influence on material allowance, while machine and environmental factors act as contributing conditions. These findings indicate that material allowance results from the interaction of multiple operational factors within the production system.

Discussion Summary

The integration of AOA-based process mapping, raw material usage analysis, and fishbone analysis provides a concise yet comprehensive understanding of material allowance at PT XYZ. The AOA method identifies critical production stages, quantitative data confirm consistent material allowance across seasons, and the fishbone analysis explains the underlying causes. Together, these results highlight the importance of improving coordination, standardizing operational methods, and enhancing working conditions to reduce material allowance and improve production efficiency.

4. Conclusion

This study shows that the production process of Tommy Hilfiger products with style name MW0MW18762 consistently exhibits a material allowance of approximately 2%, as observed across multiple production seasons. This allowance reflects excess material usage that occurs during production rather than a formally planned requirement. Based on process mapping and causal analysis, the main contributing factors include operator-related errors caused by fatigue and material inconsistencies resulting from insufficient fabric inspection prior to the sewing process.

The application of the Activity-on-Arrow (AOA) method helps identify critical production stages particularly cutting and sewing where rework and quality deviations are most likely to occur, leading to increased material usage. These findings highlight the importance of strengthening quality control and monitoring mechanisms at each production stage, as well as improving operator training and workload management to reduce error rates and material loss.

From a managerial perspective, these results suggest that process standardization, continuous monitoring, and systematic improvement initiatives aligned with lean manufacturing principles can support efforts to reduce material allowance and improve production efficiency [15].

For future research, it is recommended to apply more in-depth or integrated business process analysis methods, such as simulation-based analysis or the integration of process mapping with lean manufacturing tools, to obtain a more comprehensive understanding of material allowance behavior and to develop more effective reduction strategies.

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6. Abbreviations

AOA	Activity-on-Arrow
BOM	Bill of Materials
MRP	Material Requirements Planning
QC	Quality Control
NC	Non-Conforming
MTO	Make-to-Order
PCS	Pieces
KG	Kilogram

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