A Comparative Study Between Unit Production System and Progressive Bundle System in Apparel Production

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Abstract

The apparel manufacturing industry in Bangladesh experiences dynamic inefficiencies in its production system, which are interconnected with various unforeseen events. These inefficiencies hurt productivity, increase costs, and lead to increased rates of defects. This article conducts a comparative analysis between two predominant production systems, namely the progressive bundle system (PBS) and the unit production system (UPS). The study involved an examination of critical aspects such as material handling, floor space utilization, standard minute value (SMV), output, productivity per operator, product quality, efficiency, manpower allocation, and work-in-progress. The overall performance and suitability of these systems are evaluated through a quantitative analysis of primary data. To carry out this study, we have collected data from the operation breakdown of men's hoodie jackets, which is a critical product in the apparel industry. The results have indicated that the unit production system outperforms the progressive bundle system. We also demonstrate that the results may vary from one factory to another, as well as from style to style. Indeed, the results can depend on the skills and expertise of the workforce.

Keywords:
Apparel manufacturing, Labor Productivity, Progressive bundle system, Product quality, Unit production system

Introduction:
Over the last few decades, the apparel fashion industry has been extremely competitive having unforeseen changeable product demands from its consumers. Due to this, manufacturers constantly need to refine their production process to stay ahead of the game and deliver their products as efficiently and cost-effectively as possible. However, with the complexities of the manufacturing sector, it can be difficult for manufacturers to identify the most efficient and reliable solutions for their production needs to ensure their success in the industry(Noor et al. 2022). Despite this awareness, many Bangladeshi apparel industries still have a worker productivity rate of around 40%, which is considered below par compared to neighboring RMG industries that have flourished during this time(Textile Today, Available: https://www.textiletoday.com.bd/barriers-productivity-efficiency-growth-bangladeshs-apparel-industry, Accessed on: November 23, 2023). Regardless of attracting reputable international buyers for its cost-effectiveness and quality products, the sector faces challenges regarding labor training, capability enhancement, and productivity, especially in the sewing section(NIKKEI Asia, Available: https://asia.nikkei.com/Economy/Trade/Bangladesh-ready-to-topple-China-as-top-clothing-exporter-to-EU- Nikkei Asia, Accessed on November 13, 2023). Bangladeshi apparel manufacturers are facing challenges in adapting to new technology, meeting fast fashion demands, managing diverse customer requests, and dealing with economic conditions. To stay competitive, they need to invest in technology, skilled labor, and agile production strategies (Textile Today, Available: https://www.textiletoday.com.bd/apparel-industry-facing-multifaceted-challenges, Accessed on November 13, 2023) . Several approaches have already been made in many countries around the world to enhance productivity in their respective apparel manufacturing industries (Mahbub et al. 2021).

When choosing a right production system for apparel, factors like value, flexibility, quality, and serviceability are crucial(online clothing study, Available: https://www.onlineclothingstudy.com/2011/02/comparison-between-progressive-bundle.html, Accessed on November 13, 2023) . Each apparel production system needs the right management, materials handling, factory layout, and worker training. Factories can mix and match these systems to meet specific clothing needs. Designing a production system ensures everything works smoothly in making clothes. In the field of apparel manufacturing, there are nine types of production systems available: the make-through system, section system, bundle system, progressive bundle system (PBS), straight-line system, synchro system, flexible line system, unit production system (UPS), and modular system(Textile Learner, Available: https://textilelearner.net/garment-production-system/, Accessed on November 13, 2023). Among these, the progressive bundle system, a traditional approach being widely used by Bangladeshi apparel manufacturers, involves moving bundles of garment parts sequentially from one operation to another(Scribd, Available: https://www.scribd.com/doc/65598283/Progressive-Bundle-System, Accessed on November 13, 2023). On the other hand, a Unit Production System (UPS) is a computer-controlled assembly line in apparel manufacturing that uses an overhead transport system to move individual garment components from one workstation to another. It's designed to produce a single garment and streamlines the manufacturing process resulting in cost-effective production (Textiles Pedia, Available: https://textilespedia.blogspot.com/2020/08/production-systems-in-garment-industry.html, Accessed on November 13, 2023).

The progressive bundle system belongs to mass production, while the unit production system falls under flexible specialization. In Bangladesh's garment industry, the bundle system reigns supreme due to its cost-effectiveness, versatility, and compatibility with the country's labor-intensive manufacturing. It's the go-to choose for large-scale production of various garment styles, enabling Bangladesh to maintain its status as a leading exporter. While the Unit Production System (UPS) isn't prevalent in Bangladesh, it holds immense potential. UPS can elevate quality, minimize waste, and enhance production flexibility. In an industry seeking to adapt to evolving consumer preferences and sustainability concerns, UPS offers a modern solution. Most companies in Bangladesh use a progressive bundling system to accommodate the production of high-volume garments in a small number of styles, making their sewing facilities less flexible to support the production of various styles of garments. While the industry is known for producing basic garment items, it's striving to enter the high-value-added garment manufacturing segment. To achieve this, production facilities must be suitable for producing complex apparel, which requires a combination of different production systems and influences the garment production system selection. The unit production system is more suitable for the making of complex garments than the traditional progressive bundle system(Apparel Resources, Available: https://apparelresources.com/technology-news/manufacturing-tech/the-great-knowledge-divide-iv-unit-production-system/, Accessed on November 13 2023).

This article provides an in-depth examination of two critical production systems that are integral to the apparel industry: the progressive bundle system (PBS) and the unit production system (UPS). The study focuses on analyzing critical factors such as material handling, floor space utilization, standard minute value (SMV), output, productivity per operator, product quality, efficiency, manpower allocation, and work-in-progress. The study's accuracy is ensured by sourcing data from the operation breakdown of men's hoodie jackets. The results of the analysis reveal that the unit production system outperforms the progressive bundle system. However, it is important to note that results may vary depending on factors such as factory and style. Notably, the skill and expertise of the workforce significantly impact a system's performance. The study presents the quantitative analysis of primary data to evaluate the systems' overall performance and suitability while considering the human factor.

1.1 Objectives of the study

The primary objective of this work is to investigate the unique characteristics of two widely used manufacturing systems, namely unit production systems and progressive bundle systems, in the context of apparel manufacturing plants in Bangladesh. Through a thorough examination of the advantages and disadvantages of both systems, this study seeks to provide valuable insights for manufacturers and stakeholders in the garment industry, enabling them to make well-informed decisions when implementing manufacturing systems. The ultimate goal of this research is to foster long-term prosperity within the industry by promoting the adoption of effective manufacturing systems.

Literature Review:

Numerous researchers worldwide have endeavored to ameliorate production efficiency by focusing on topics such as lean manufacturing(Vasanth et al. 2020), productivity enhancement(Mahbub et al. 2021; Al Imran et al. 2021), line balancing(Yemane et al. 2020), process balancing(Karekatti and Tiwari 2021), and the feasibility of simulation techniques(Sime et al. 2019) for manufacturing companies. Consequently, the optimization of production systems has become a primary concern.

However, many Bangladeshi garment industries are hesitant to adopt new technologies such as simulation techniques for mass production quantity. Hence, the focus should be on selecting the appropriate production system to achieve the target goals of production. Manufacturing systems have seen remarkable transformations due to the ever-increasing expectations of customers. These changes have brought about numerous evolutions and paradigm shifts, making it necessary for businesses to adapt to the evolving market(Jana and Tiwari 2021). Thus this study aims to compare two primary production systems utilizing primary data collected from garment industries in Bangladesh to determine the optimal choice for the industry

A 1993 report from the AAMA Committee found that 80% of clothing manufacturers use the bundling system, but this may change as companies seek greater flexibility in their production methods. The progressive bundle system involves grouping clothing pieces together like a puzzle in a cutting room, which are then given to specialized sewing workers to increase efficiency and reduce costs. While this system allows for independent work, leading to high productivity and quality, there are some drawbacks. To maintain high efficiency, a significant amount of work-in-process (WIP) is required, which can result in longer production lead times. Additionally, workers may prioritize quantity over quality, potentially affecting the final product. This system's focus on familiar operations can also limit flexibility and hinder cross-functional training. Furthermore, high WIP levels can impact customer responsiveness as orders may take longer to fulfill(Bai and Zhang 2011).

A unit production system (UPS) is a line layout that uses an overhead conveyor system to move garment parts from one workstation to another for assembly(Bai and Zhang 2011). Garments are arranged on an overhead conveyor belt in a unit production system. Each garment station has an accumulator rail, and the main conveyor carries the hangers to each station. A study by Clemson Apparel Research at Clemson University compared the unit production system (UPS) to the progressive bundle system in the production of military shirts by two garment manufacturers. The implementation of UPS resulted in an 18.4% increase in operator productivity, a 9.7% reduction in direct labor content, and a 33.8% decrease in excess cost. UPS also led to an 11.1% reduction in defects, a 60.4% reduction in work-in-process levels, and an 11.8% reduction in indirect labor. The team environment in UPS enhances quality control and reduces defects, leading to higher operator productivity. Another research paper showed that the financial gain in the unit production section was higher due to lower SMV manpower and high hourly output. A study in Bangladesh revealed several advantages over the progressive bundle system, including a significant 46% decrease in defective goods variation. However, it's worth noting that installing a UPS can be quite expensive.

The appropriateness of these systems for the unique conditions and challenges of the Bangladeshi garment industry remains uncertain. Hence, the present research aims to bridge this gap by identifying which system is better suited for Bangladesh. Through the examination of these production methods, we aim to determine their compatibility with the workforce, infrastructure, and product diversity of Bangladesh's garment sector. This will enable us to ascertain whether their successful implementation can bring about positive changes to the industry in Bangladesh.

3. Methodology

Materials of the project

To conduct a comparative study of the progressive bundle system (PBS) and unit production system (UPS) for this research, we first chose a clothing manufacturing company (Liz Fashion Industry Ltd.) that used both of these production methods in their sewing unit. To do a comparative study, we collected the operation bulletin, DHU report, and daily production report for hoody jackets from the same buyer order having two different colors produced in two distinct production systems.

3.1.1 Product Description:

Table 1. Product description for PBS line

Buyer	Decathlon
Style No	338820
Product Category	Performance wear
Item Description	Hoody Jacket
Fabric Specification	100% Cotton
Gender	Men’s
Difficulty Level	Critical
Color	Oil green

Table 2. Product Description for UPS line

Buyer	Decathlon
Style No	338820
Product Category	Performance wear
Item Description	Hoodie Jacket
Fabric Specification	100% Cotton
Gender	Men’s
Difficulty Level	Critical
Color	Light pink

Figure 1. Hoody jacket (Oil green)

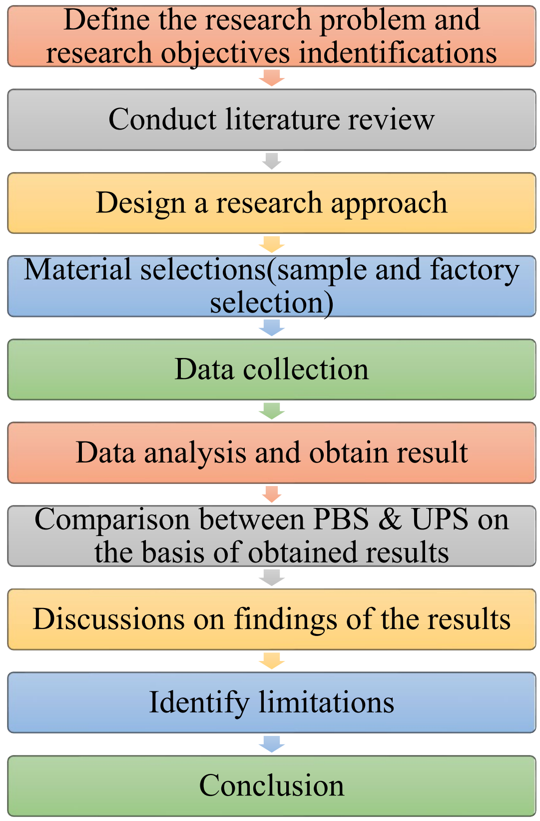
Figure 2. Hoody jacket (Light pink)

3.2 Methods of the project:

3.2.1 Types of Research

To achieve the research objectives, this project followed a quantitative research method. This approach allowed us for a comprehensive understanding of both systems and their impact on various performance indicators.

3.2.2 Methodology Framework



4. Data Collection:

Step 1: In this research project, information was gathered from the production lines of the case factory for the purpose of comparing the PBS and UPS production systems.

Step 2: The research was carried out by gathering secondary data from the case factory's historical records, which included daily production reports, line layouts, operation breakdowns, and production plans.

Step 3: Various sources, including articles, research papers, internet data, and information from books, were utilized as secondary data in the research project.

Statistical Approach:
The quantitative data underwent analysis through suitable statistical methods to draw comparisons in performance metrics between the unit production system and progressive bundle. This analysis aimed to identify any statistically significant differences in key variables. Microsoft Excel was employed for data visualization, presenting information through various graphical and tabular methods.

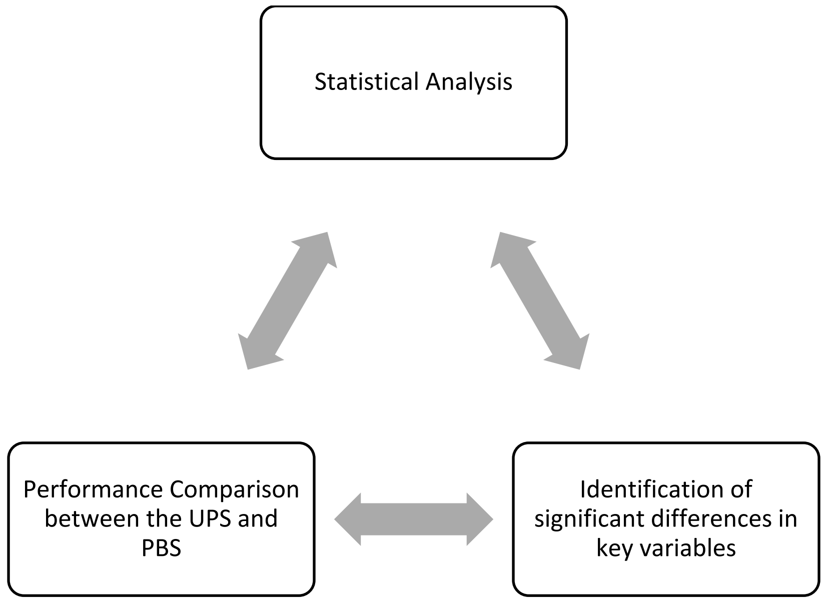


Figure 3. Statistical Approach of comparing the performance of UPS & PBS

Results & Discussion:

5.1 Numerical Results:

We gathered diverse production-related information about men's hoodie zip jackets from both manufacturing systems to conduct a comparative analysis between the progressive bundle system and the unit production system.

5.1.1 Results of SMV analysis:

The following table shows the SMV for both the progressive bundle system and unit production system from which we can compare the variation in SMV for both systems.

Table 3. SMV Analysis table

S/l no.	Operation	SMV		SMV Variation	SMV Variation%
		PBS	UPS		
1	Match all cut parts	0.5	0.45	0.05	10.00
2	Kangaroo pocket edge hem	0.334	0.31	0.024	7.19
3	Draw pocket position & matching front and back part	0.45	0.43	0.02	4.44
4	Attach kangaroo pocket's upper side at front part with top stitch	0.8	0.78	0.02	2.50
5	Top stitch by fold at kangaroo pocket bottom side	0.53	0.5	0.03	5.66
6	Tack pocket bottom & front side	0.6	0.58	0.02	3.33
7	Make bartacks at pocket	0.23	0.2	0.03	13.04
8	Outer hood makes	0.68	0.665	0.015	2.21
9	Topstitch outer hood	0.55	0.51	0.04	7.27
10	Point make,hole and eyelet attach	0.65	0.625	0.025	3.85
11	Inner hood make	0.6	0.58	0.02	3.33
12	Inner hood top stitch	0.53	0.5	0.03	5.66
13	Join inner hood with outer hood and make tack	0.73	0.71	0.02	2.74
14	Hem hood opening and trim	0.70	0.68	0.02	2.86
15	Drawstring insertion and make bartack to fix it	0.5	0.5	0	0.00
16	Servicing bottom hood	0.35	0.32	0.03	8.57
17	Shoulder join	0.375	0.355	0.02	5.33
18	Top stitch at shoulder	0.35	0.334	0.016	4.57
19	Join side seam with care label	0.58	0.567	0.013	2.24

20	Top stitch at sides seam	0.53	0.51	0.02	3.77
21	Sleeves making	0.6	0.58	0.02	3.33
22	Sleeve cuff make & tack	0.58	0.564	0.016	2.76
23	Cuff join with sleeve	0.7	0.68	0.02	2.86
24	Topstitch cuff sleeves	0.64	0.62	0.02	3.13
25	Sleeve join	0.8	0.751	0.049	6.13
26	Top stitch at armhole	0.7	0.67	0.03	4.29
27	Bottom rib make	0.86	0.847	0.013	1.51
28	Bottom rib join	0.534	0.521	0.013	2.43
29	Bottom rib top stitch	0.467	0.443	0.024	5.14
30	Point & attach zipper with body	1.025	1.015	0.01	0.98
31	Tack open-end zip head by fold	0.161	0.15	0.011	6.83
32	Zipper top stitch	1.02	1.01	0.01	0.98
33	Make stop stitch at join stitch	0.4	0.38	0.02	5.00
34	Hood join with neck	0.48	0.46	0.02	4.17
35	Attach back neck tape	0.51	0.5	0.01	1.96
36	Back neck top stitch with size label	0.55	0.5	0.05	9.09
37	Assemble labels with cloth & trim	0.53	0.5	0.03	5.66
38	Final thread cut	0.45	0.45	0	0.00
Total		**21.576**	**20.747**	**0.829**	**3.84%**

5.1.2 Hourly production target calculation

The following formula is used to calculate the hourly production target -

Daily production target = (60× Line target efficiency) ÷ SMV

Table 4. Hourly production target calculation for each operation

S/l no.	Operation	SMV		Target/hr @100%		Target/hr @ 70%	
		PBS	UPS	PBS	UPS	PBS	UPS
1	Match all cut parts	0.50	0.45	120.00	133.33	84.00	93.33

2	Kangaroo pocket edge hem	0.334	0.31	179.64	193.55	125.75	135.48
3	Draw pocket position & matching front and back part	0.45	0.43	133.33	139.53	93.33	97.67
4	Attach kangaroo pocket's upper side at front part with top stitch	0.80	0.78	75.00	76.92	52.50	53.85
5	Top stitch by fold at kangaroo pocket bottom side	0.53	0.50	113.21	120.00	79.25	84.00
6	Tack pocket bottom & front side	0.6	0.58	100.00	103.45	70.00	72.41
7	Make bar tack at pocket	0.23	0.20	260.87	300.00	182.61	210.00
8	Outer hood make	0.68	0.665	88.24	90.23	61.76	63.16
9	Topstitch outer hood	0.55	0.51	109.09	117.65	76.36	82.35
10	Point make,hole and eyelet attach	0.65	0.625	92.31	96.00	64.62	67.20
11	Inner hood make	0.60	0.58	100.00	103.45	70.00	72.41
12	Inner hood top stitch	0.53	0.50	113.21	120.00	79.25	84.00
13	Join inner hood with outer hood and make tack	0.73	0.71	82.19	84.51	57.53	59.15
14	Hem hood opening and trim	0.70	0.68	85.71	88.24	60.00	61.76
15	Drawstring insertion and make bar tack to fix it	0.50	0.50	120.00	120.00	84.00	84.00
16	Servicing bottom hood	0.35	0.32	171.43	187.50	120.00	131.25
17	Shoulder join	0.375	0.355	160.00	169.01	112.00	118.31
18	Top stitch at shoulder	0.35	0.334	171.43	179.64	120.00	125.75
19	Join side seam with care label	0.58	0.567	103.45	105.82	72.41	74.07
20	Top stitch at sides seam	0.53	0.51	113.21	117.65	79.25	82.35
21	Sleeves making	0.60	0.58	100.00	103.45	70.00	72.41
22	Sleeve cuffs make & tack	0.58	0.564	103.45	106.38	72.41	74.47
23	Cuff joins with sleeve	0.70	0.68	85.71	88.24	60.00	61.76
24	Topstitch cuff sleeves	0.64	0.62	93.75	96.77	65.63	67.74
25	Sleeve joins	0.80	0.751	75.00	79.89	52.50	55.93

26	Top stitch at armhole	0.70	0.67	85.71	89.55	60.00	62.69
27	Bottom rib makes	0.86	0.847	69.77	70.84	48.84	49.59
28	Bottom rib join	0.534	0.521	112.36	115.16	78.65	80.61
29	Bottom rib top stitch	0.467	0.443	128.48	135.44	89.94	94.81
30	Point & attach zipper with body	1.025	1.015	58.54	59.11	40.98	41.38
31	Tack open-end zip head by fold	0.161	0.15	372.67	400.00	260.87	280.00
32	Zipper top stitch	1.02	1.01	58.82	59.41	41.18	41.58
33	Make stop stitch at join stitch	0.4	0.38	150.00	157.89	105.00	110.53
34	Hood joins with neck	0.48	0.46	125.00	130.43	87.50	91.30
35	Attach back neck tape	0.51	0.50	117.65	120.00	82.35	84.00
36	Back neck top stitch with size label	0.55	0.50	109.09	120.00	76.36	84.00
37	Assemble labels with cloth & trim	0.53	0.50	113.21	120.00	79.25	84.00
38	Final thread cut	0.45	0.45	133.33	133.33	93.33	93.33
	Total	**21.576**	**20.747**				

5.1.3 Manpower allocation:

Table 5. Manpower allocation table

S/l no.	Operation	SMV		Target/hr @ 70%		Allocated Manpower	
		PBS	UPS	PBS	PBS	PBS	UPS
1	Match all cut parts	0.5	0.45	84.00	93.33	2	1
2	kangaroo pocket edge hem	0.334	0.31	125.75	135.48	1	1
3	Draw pocket position & matching front and back part	0.45	0.43	93.33	97.67	1	1

4	Attach kangaroo pocket's upper side at front part with top stitch	0.8	0.78	52.50	53.85	1	1
5	Top stitch by fold at kangaroo pocket bottom side	0.53	0.5	79.25	84.00	1	1
6	Tack pocket bottom & front side	0.6	0.58	70.00	72.41	1	1
7	Make bar tacks at pocket	0.23	0.2	182.61	210.00	1	1
8	Outer hood make	0.68	0.665	61.76	63.16	1	1
9	Topstitch outer hood	0.55	0.51	76.36	82.35	1	1
10	Point make,hole and eyelet attach	0.65	0.625	64.62	67.20	1	1
11	Inner hood make	0.6	0.58	70.00	72.41	1	1
12	Inner hood top stitch	0.53	0.5	79.25	84.00	1	1
13	Join inner hood with outer hood and make tack	0.73	0.71	57.53	59.15	1	1
14	Hem hood opening and trim	0.70	0.68	60.00	61.76	1	1
15	Drawstring insertion and make bar tack to fix it	0.5	0.5	84.00	84.00	1	1
16	Servicing bottom hood	0.35	0.32	120.00	131.25	1	1
17	Shoulder join	0.375	0.355	112.00	118.31	1	1
18	Top stitch at shoulder	0.35	0.334	120.00	125.75	1	1
19	Join side seam with care label	0.58	0.567	72.41	74.07	1	1
20	Top stitch at sides seam	0.53	0.51	79.25	82.35	1	1
21	Sleeves making	0.6	0.58	70.00	72.41	1	1
22	Sleeve cuff make & tack	0.58	0.564	72.41	74.47	1	1

23	Cuff join with sleeve	0.7	0.68	60.00	61.76	1	1
24	Topstitch cuff sleeves	0.64	0.62	65.63	67.74	1	1
25	Sleeve join	0.8	0.751	52.50	55.93	2	2
26	Top stitch at armhole	0.7	0.67	60.00	62.69	1	1
27	Bottom rib make	0.86	0.847	48.84	49.59	1	1
28	Bottom rib join	0.534	0.521	78.65	80.61	1	1
29	Bottom rib top stitch	0.467	0.443	89.94	94.81	1	1
30	Point & attach zipper with body	1.025	1.015	40.98	41.38	2	2
31	Tack open-end zip head by fold	0.161	0.15	260.87	280.00	1	1
32	Zipper top stitch	1.02	1.01	41.18	41.58	2	2
33	Make stop stitch at join stitch	0.4	0.38	105.00	110.53	1	1
34	Hood join with neck	0.48	0.46	87.50	91.30	1	1
35	Attach back neck tape	0.51	0.5	82.35	84.00	1	1
36	Back neck top stitch with size label	0.55	0.5	76.36	84.00	1	1
37	Assemble labels with cloth & trim	0.53	0.5	79.25	84.00	1	1
38	Final thread cut	0.45	0.45	93.33	93.33	1	1
	Total	**21.576**	**20.747**			**42**	**41**

5.1.4 Target vs. Achievement Calculation

The following formula is used to calculate the daily production target and achievement-

Daily production target = (Total working hour × Total manpower × Line target efficiency) ÷ SMV
Daily output achievement % = 100% - ((Daily target - Daily output) × 100 /Daily Target) %

Table 6. Target calculation table.

Production line	**Total working hour**	**SMV**	**Total Manpower**	**Target at 70% efficiency**
PBS(LC309)	10 hour (600min)	21.576	42	818
UPS(LC401)	10 hour (600min)	20.747	41	830

Table 7. Target vs. achievement calculation table

Day	**Target**		**Achieved output**		**Achievement %**		**Average Achievement %**	
	UPS	PBS	UPS	PBS	UPS	PBS	UPS	PBS
1	830	818	608	580	73.25	70.90	83.32	81.07
2	830	818	660	640	79.52	78.24		
3	830	818	650	618	78.31	75.55		
4	830	818	718	650	86.51	79.46		
5	830	818	708	735	85.30	89.85		
6	830	818	753	715	90.72	87.41		
7	830	818	744	704	89.64	86.06		

5.1.5 Productivity calculation
The following formula is used to calculate the productivity in the sewing section-
Total Labor Productivity = Total number of output per shift / Total number of workers.

For UPS line (LC401):

Total manpower = 41 persons

Total working minutes per shift (including overtime) = 10 hour

For PBS line (LC309):

Here,

Total manpower = 42 persons

Total working minutes per shift (including overtime) = 10 hour

Table 8. Productivity calculation table

Day	Total output		Productivity (pcs/shift)		Average productivity (pcs/shift)	
	UPS	PBS	UPS	PBS	UPS	PBS
1	608	580	14.83	13.81	16.87	15.79
2	660	640	16.10	15.24		
3	650	618	15.85	14.71		
4	718	650	17.51	15.48		
5	708	735	17.27	17.50		
6	753	715	18.37	17.02		
7	744	704	18.15	16.76		

5.1.6 Line efficiency calculation

The following formula is used to calculate line efficiency & productivity in sewing section-

Line Efficiency = (Total output per shift × SMV × 100) ÷ (Total manpower ×Total working minutes per Shift) %

For UPS line (LC401):

Here,

SMV = 20.547

Total manpower = 41 persons

Total working minutes per shift (including overtime) = 10 × 60 =600 minutes

And target line efficiency = 70%

Table 9. Line efficiency calculation table for UPS line

Day	Total output		Line efficiency %		Average line efficiency %	
	UPS	PBS	UPS	PBS	UPS	PBS
1	608	580	50.78	48.44	57.76	55.39
2	660	640	55.13	53.46		
3	650	618	54.29	51.62		
4	718	650	59.97	54.29		
5	708	735	59.14	61.39		
6	753	715	62.89	59.72		
7	744	704	62.14	58.80		

5.1.7 Quality analysis

The formula of calculating DHU is-

DHU = (Total number of defects found ×100) / Total pieces inspected

RFT % = (Total pieces inspected -Total number of defects found) ×100 / Total pieces inspected

Table 10. Quality Analysis Table.

Day	Total inspected quantity		Total QC pass		Total defects (Pcs)		DHU%		RFT%		Avg. DHU%	
	UPS	PBS	UPS	PBS	UPS	PBS	UPS	PBS	UPS	PBS	UPS	PBS
1	653	637	608	580	45	57	6.89	8.95	93.11	91.05	6.91	8.46
2	715	708	660	640	55	68	7.69	9.60	92.31	90.40		
3	695	673	650	618	45	55	6.48	8.17	93.53	91.83		
4	774	705	718	650	56	55	7.24	7.80	92.76	92.20		
5	758	795	708	735	50	60	6.60	7.55	93.40	92.45		
6	805	780	753	715	52	65	6.46	8.33	93.54	91.67		
7	800	772	744	704	56	68	7.00	8.81	93.00	91.19		

5.1.8 Work in Progress (WIP) calculation:

Work In Progress (WIP) indicates the number of tasks or items that are currently in the process of being completed but are not yet finished. It is calculated by deducting output from the input.

So, WIP = Output – Input

Table 11. WIP calculation table.

Day	Total input/ day		Total output/day		WIP		WIP %		Avg. WIP %	
	UPS	PBS	UPS	PBS	UPS	PBS	UPS	PBS	UPS	PBS
1	850	960	608	580	242	380	28.47	39.58	21.72	32.40
2	865	973	660	640	205	333	23.70	34.22		
3	854	987	650	618	204	369	23.89	37.39		
4	860	976	718	650	142	326	16.51	33.40		
5	900	1000	708	735	192	265	21.33	26.50		
6	915	980	753	715	162	265	17.70	27.04		
7	935	987	744	704	191	283	20.43	28.67		

5.2 Graphical Results:

In this project, we conduct a comparative analysis between the progressive bundle system and the unit production system. Here, we will discuss our findings from the comparative study.

5.2.1 Comparison of installation and maintenance cost

The unit production system requires a huge initial installation cost, which is expensive, while the progressive bundle system does not require any installation cost. The payback period of the investment takes a long time. As a unit production system uses an overhead system, the maintenance cost of a production line is higher than the progressive bundle system.

5.2.2 Comparison of space utilization and material handling:

Figure 4. Unit Production System (UPS)

Unit production system significantly reduces the floor space and the area per workstation as it requires less storage space for work-in-process during the production process. In the case of an overhead system, work-in-process is stored above the operator and machines are positioned closer together compared to typical progressive bundle systems. Materials are handled automatically from one workstation to another by an automatic hanger system and it reduces the material handling cost.

Figure 5. Progressive Bundle System (PBS)

On the other hand, a progressive bundle system requires more floor space to keep a bundle of each part on a long table or in the trolley, machines' positions are comparatively less close and materials are handled by helpers which requires more material handling cost.

5.2.3 Comparison of manpower and direct labor cost:

For making a single-piece hoody jacket in a progressive bundle system,42 manpower is needed, and 41 manpower is needed in the case of the unit production system. We can see that there is a reduction in manpower in UPS compared to PBS. In the case of the unit production system, there is no need for bundle handling and transporting to one workstation to another as the overhead system does the bundle handling work and for this reason unit production line requires less helper than the progressive bundle system. It reduces the direct manpower cost which reduces product and production costs. Unit production system requires highly skilled workers but in a progressive bundle system, comparatively less skilled workers can work.

5.2.4 Comparison of SMV:

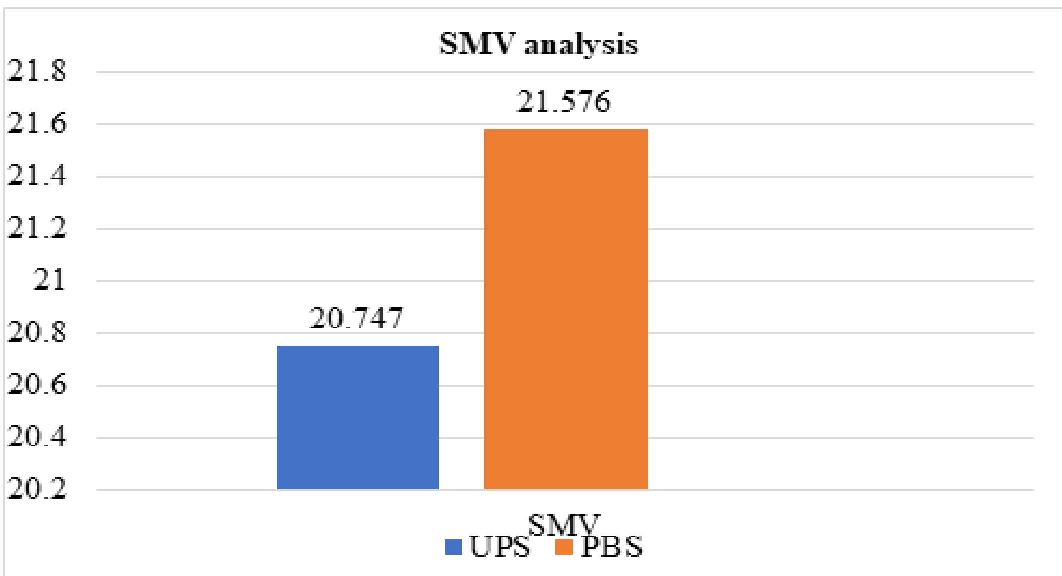


Figure 6. SMV comparison chart.

Standard Minutes Value (SMV) is used to measure the efficiency and productivity of the workforce and can be used for setting production targets and calculating the costs of products. Here, we can see that for a hoody jacket, SMV in the unit production system (UPS) is 20.747 and 21.576 in the progressive bundle system. Compared to the progressive bundle system, the unit production system requires 3.84 % less SMV which influences the productivity and efficiency of the line.

In the case of a progressive bundle system, garment components reach an operator in bundle form and the operator needs to spend a few times opening the bundle and tying it for every bundle which increases the pick-up and disposal time. For this reason, we need to add a bundle allowance as well where applicable.

On the other hand, in the unit production system, there is no need for bundle allowance, and requires less pickup and disposal time resulting in a reduction of time. As all components of the garments are kept together and moved from one workstation to the next, it creates peer pressure on the workers which results in decreasing the total standard minutes.

5.2.5 Comparison of output

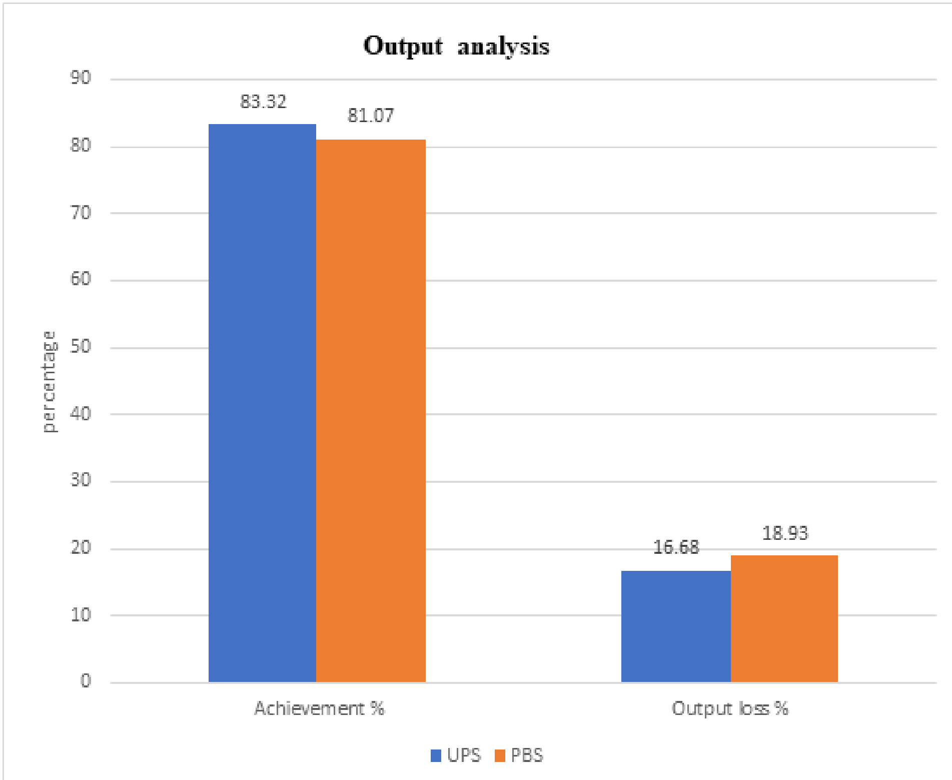


Figure 7. Comparison of output.

From the average of seven days of data on hoody jackets, we can see that the daily average achievement percentage of the unit production system is 83.32% whereas it is 81.07% for the progressive bundle system. It indicates that the output loss during the production process in a progressive bundle system is higher than unit production system. That means the unit production system works more efficiently than the progressive bundle system. Unit production system reduces the non-productive time during material transportation by using an automatic transportation system. It reduces by 2.25 % output loss compared to the progressive bundle system. It helps to run the production process more smoothly.

5.2.6 Comparison of productivity

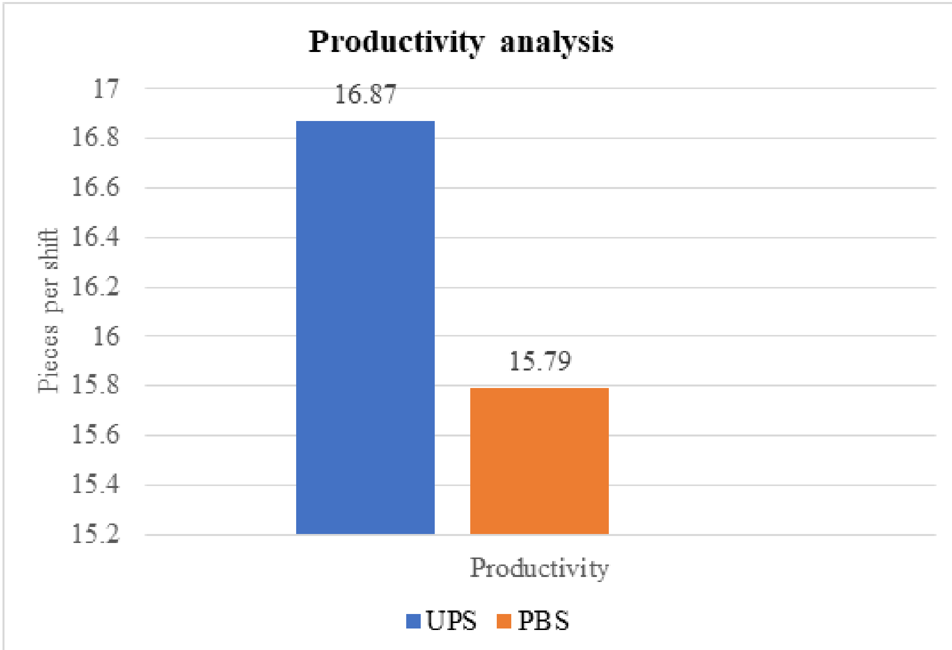


Figure 8. Comparison of productivity (pieces/shift)

Here, the column chart shows us that average labor productivity was 16.87 pieces per shift and 15.79 pieces per shift in average for unit production system and progressive bundle system respectively. The average productivity of the unit production system is 6.401% higher than the progressive bundle system.

Productivity mostly depends on the types of products and the order quantity. Unit production shows better productivity in the case of complicated products as it requires less floor space and less material movement. Products are passed as a single garment rather than a bundle which reduces production fault and non-productive time and increases the total output per shift. In case of short quantity order, a progressive system it not suitable as it passes the components as a bundle which results in more WIP and higher chances of defects which reduces the total output per day.

5.2.7 Comparison of line efficiency:

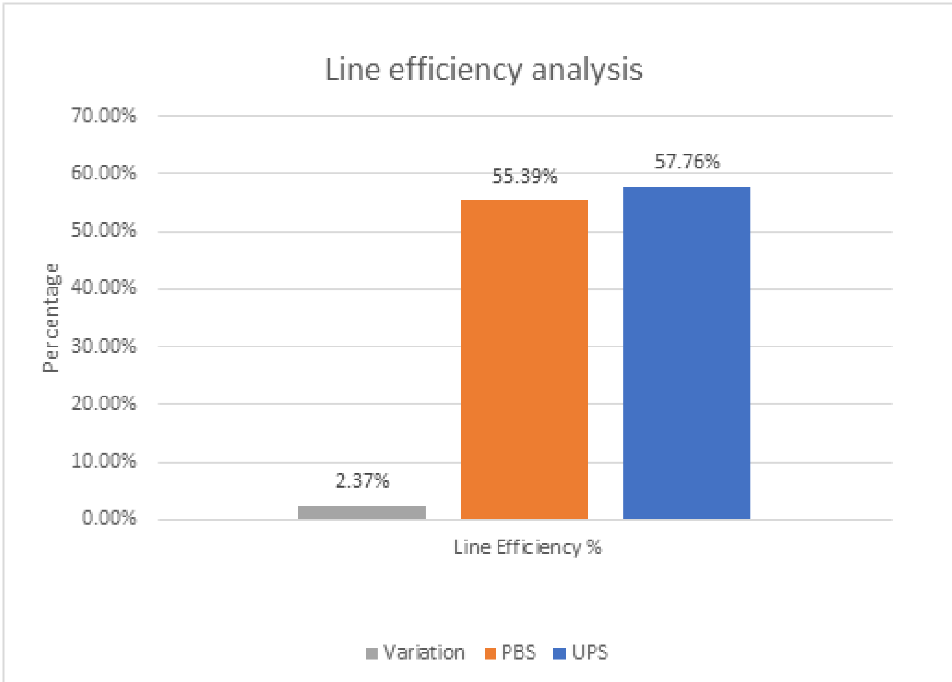


Figure 9. Comparison of line efficiency.

Here, the average line efficiency of the unit production line is 57.76 % and the line efficiency of the progressive bundle line is 55.39% when the target line efficiency is 70%. Compared to the progressive bundle system (PBS) line, the unit production system (UPS) line has 2.37% higher line efficiency. Line efficiency mostly depends on SMV, number of manpower, and working hours per shift. In this scenario, the working hour per shift is the same for both systems and variation in line efficiency was created by SMV and total manpower numbers. Unit production system (UPS) line runs at lower SMV and it requires less manpower than the progressive bundle system (PBS) line. Even with less manpower than PBS, the UPS system has better efficiency and smoother material flow. Efficiency increases when wastage is less. Unit production system has lower waste of time and materials which influences the line efficiency.

5.2.8 Comparison of Quality

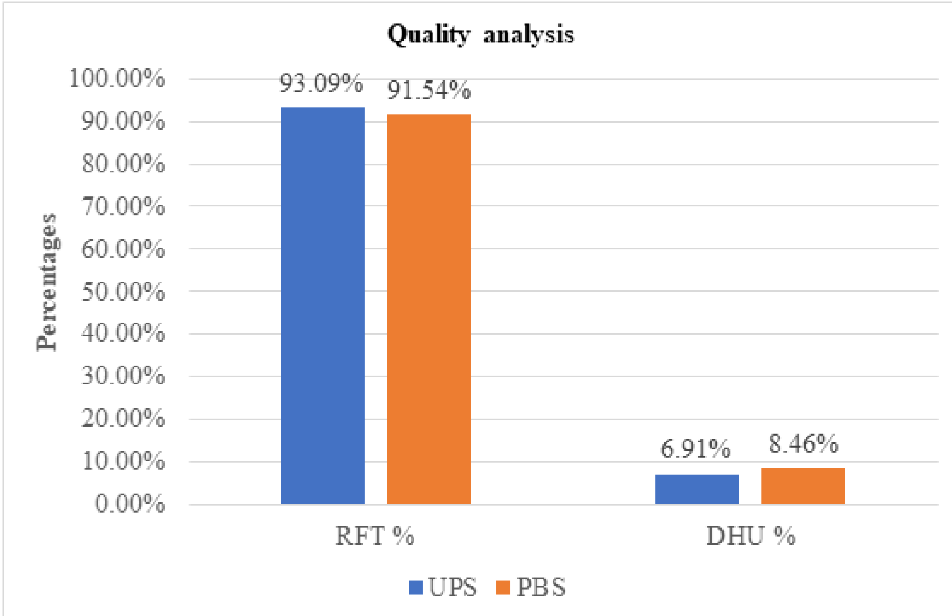


Figure 10. Comparison of quality.

Here, from the chart, we can see that the unit production system has 1.55% lower DHU % and higher RFT% than the progressive bundle system. It indicates that the unit production system has lower defect rates than the progressive bundle system.

Due to the automatic transportation of materials and single-piece flow process, the unit production system gives better quality products. Single piece flow system reduces shade variation faults, it reduces the stitching reworks by early identification of sewing faults and quality checking. It increases the right at a first-time percentage (RFT %) and reduces the DHU %. This reduces the production time & overall product cost.

On the other hand, due to the bundle system, the progressive system has higher defect rates as shade variation fault is higher in this system stitching faults have been identified lately and if any defects occur, they occur in the whole bundle which produces more defective products.

5.2.9 Comparison of WIP and Inventory Cost

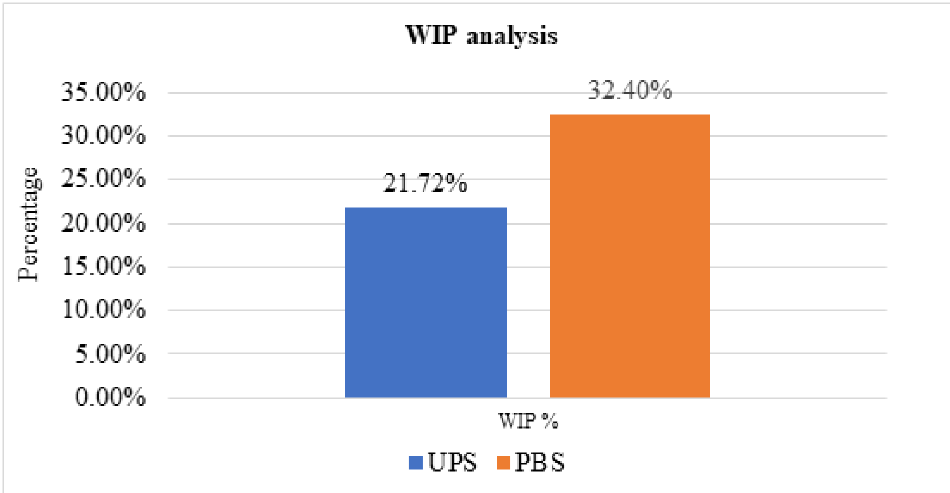


Figure 11. Comparison in work in progress.

From the above data, we can see that the average WIP% of the unit production system is 21.72% and the average WIP % in the progressive bundle system is 32.40%. There is a significant reduction in work-in-progress inventory in unit production system compared to the progressive bundle system.

Due to automatic material transportation and single piece flow unit production system has 10.68% lower work in process inventory than the progressive bundle system. Lower inventory causes a reduction in inventory costs. Less WIP indicates less wastage and defect rate which has significant importance in product quality, and production process efficiency.

The progressive bundle system requires more cut panels as cut panels are put together in bundle form which influences the cutting process and results in higher WIP at every operation and increases the inventory cost.

5.3 Proposed Improvements:

Our research has some limitations. Initially, we overlooked the fact that not all factories in Bangladesh can seamlessly transition from traditional methods of clothing production to the innovative approach we studied. The clothing industry in Bangladesh is heavily reliant on its workforce. Therefore, any shift in production methods necessitates careful consideration of the skills and workforce size in each factory.

The unique methods employed in clothing production in Bangladesh might pose challenges to the successful implementation of the new approach. Additionally, the adaptability of factories to alter their production methods based on demand and seasonal variations is crucial. However, the new method, optimized for intricate clothing production, may not be universally suitable for all clothing factories in Bangladesh.

Another significant challenge is the dependency on resources from other countries, incurring substantial setup costs. Collaboration with foreign companies is often essential for assistance in setup, worker training, and data collection, but this comes with a hefty price tag. Not all companies may have the financial capacity to afford these expenses, and some may be reluctant to comply with regulatory changes associated with altering clothing production methods.

Considering the historical mistreatment of workers in certain clothing factories in Bangladesh, it is imperative to ensure that the transition to the new method prioritizes the well-being of workers. However, determining the overall worth of the substantial financial investment in this new production approach may take a considerable amount of time.

For the successful implementation of the new method, meticulous planning, worker training, machine maintenance, and careful batch production planning are indispensable. Neglecting these aspects may lead to issues such as high employee turnover, subpar product quality, and insufficient production output

6. Conclusion

This project compares two distinct production systems- the progressive bundle system and the unit production system. Through extensive research, data collection, and observation of real-world manufacturing environments, the study examines the efficiency and effectiveness of these systems in different industrial settings.

By analyzing data of the progressive bundle system and unit production system, we found out that the unit production system is better than the progressive bundle system in terms of productivity, efficiency, and product quality as it has higher line efficiency, higher labor productivity with lower SMV, lower manpower and lower defect rates as well as lower WIP. It is more suitable for short-quality orders and critical items having more garment components. However, UPS has higher overhead & maintenance costs as it has an overhead system that requires regular maintenance for running smooth production.

On the other hand, the progressive bundle system has a higher WIP which causes a higher cutting rate and higher inventory. Defect rates and SMV are also higher with lower line efficiency and lower productivity. As it needs more manpower than the unit production system, it increases the direct labor cost. Material handling and transportation costs is higher due to the bundling system in PBS as it requires more helpers than the unit production system. It is not suitable for short quantity orders due to frequent layout changes and more work in the process which leads to higher production costs. It is suitable for the less critical items having fewer garments' components.

The conclusion we can say, that the choice between the two systems depends on specific industry requirements, product characteristics, and production volumes. Businesses can benefit from adopting the most suitable system to optimize their production processes and meet evolving customer demands

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Biographies

Mahmuda Akter has been working as an associate professor at the Bangladesh University of Textiles. She has completed her Ph.D. from Erciyes University, Turkiye, under the prestigious CoHE (Council of Higher Education) Ph.D. Fellowship. Prior to that, Dr. Mahmuda obtained her B.Sc. and M.Sc. in Textile Engineering from Bangladesh University of Textiles (BUTEX). Before becoming a faculty member of BUTEX, she had professional and industrial experience in textile factories. Her major fields of study and research interests are wearable technology, graphene and 2D materials, textile materials, fiber-reinforced polymer composites, textile structural composites, nanocomposites, bio composites, technical textiles and sustainable materials.

Sazid Elahi is serving as Assistant Professor at BUTEX. Having a great interest over research and teaching-learning, he joined as a faculty member at the department of Apparel Engineering under the faculty of Fashion Design and Apparel Engineering so that he can contribute as a stakeholder to Bangladesh textile and apparel sector. He is currently pursuing his M.SC in Textile Engineering degree from department of Apparel Engineering. He has completed his first semester and got a GPA of 4.00 out of 4.00. He achieved his B.SC in Textile Engineering degree from department of Apparel Engineering under the faculty of Fashion Design and Apparel Engineering in 2018. He secured 1stposition in his department with CGPA of 3.83 out of 4.00. He received prestigious Prime Minister Gold Medal-2018 from the Honorable Prime Minister of People’s Republic of Bangladesh in 2020 for his excellent result in undergraduate level. His field of interest is Plasma Finish in Apparel Circular Fashion & Economy, Taxation system in Bangladesh RMG Sector, Labor Law & Human Rights in RMG Industry, Carbon Capture & Carbon Footprint Measurement in RMG Industry, Usage of Clean Energy in RMG Industry. Sazid Elahi has completed several workshop, trainings and seminar organized by IQAC BUTEX regarding:

- Foundation Training on Teaching-Learning for the Faculty Member
- Etiquette & Manners
- Administrative Rules & Regulations
- BLOOM’s Taxonomy
- Stress Management & Work-Life Balance
- Classroom Management & Good Lecturing
- Implementation of Outcome-Based Education (OBE)
- Application of Online Educational Tools

Sajid Hossain, an undergraduate researcher and a senior student of the Department of Industrial & Production Engineering at the Bangladesh University of Textiles. He is currently a research assistant at Bangladesh University of Textiles Department of Apparel Engineering. He is passionate to learn about Recyclable diversified textiles, sustainable fashion, technical textiles, biomaterials and composite. He is an award winner of an intra-university project presentation titled “From plastic trash to diversified textiles: A proper solution of recyclability” and as well as he published research papers in international journals. He is keen to learn something new and dedicated to exploring the versatile field of Science & Technology.

MD. Mahmudul Hasan, a final year student at the Bangladesh University of Textiles pursuing a bachelor's degree in Textile Engineering, has a forward-thinking approach to the textile industry. With strong engineering aptitude and talent for creativity, he is excited about making positive changes through innovation. Mahmudul is an eager research assistant, collaborating with respected professors on pioneering projects in textile technology, such as clothing manufacturing, nano technology, self-cleaning fabrics treated with plasma, and smart textiles. He is not just about academics; he actively participates in clubs and events, adding vibrancy to the campus community. Mahmudul Hasan’s current project on Industrial Revolution 4.0 explores plasma treatment, boosting productivity, and nano finishes, demonstrates his unwavering dedication to shaping the future of the textile industry. With a clear vision for contributing to the industry transformation, Mahmudul Hasan is poised to make a lasting impact in the textile sector and beyond.

Bebe Fatema Bristy, a final-year undergraduate student, is currently studying at the esteemed Bangladesh University of Textiles in the Department of Apparel Engineering, which is housed under the Faculty of Textile Fashion Design and Apparel Engineering. Bristy’s passion for research was sparked during her undergraduate studies in Textile Engineering. Since then, she has excelled as a research assistant while maintaining exemplary academic performance. She has explored various sectors of the textile field through her research projects, always striving to bring innovation to the field. Her projects have included nanotechnology, smart textiles, LCA of denim apparel, superhydrophobic functionalized textiles, textile wastewater management, and apparel production systems. Looking to the future, Bristy has ambitious plans to continue her academic journey while contributing to the textile industry in meaningful ways with her unwavering commitment to research and impressive track record.

Binu Shejuti Dey is currently a final-year student at the Bangladesh University of Textiles where she is pursuing an undergraduate degree in Textile Engineering specializing in Apparel Engineering. She possesses a strong work ethic and a keen interest in the intersection of apparel and industrial engineering. Shejuti has actively participated in rigorous coursework which reflected her passion for increasing her competency and looking for innovative solutions in the apparel industry. She has worked as an intern at Fakir Apparels Ltd, helping her gain hands-on experience. Her curiosity in the field of industrial engineering and system engineering stemmed from the experience and knowledge she gained during her internship. Upon graduation, she intends to pursue a career as a researcher.

Umme Habiba Saima is currently a final-year undergraduate student at Department of Apparel Engineering under the faculty of Fashion design and Apparel Engineering of Bangladesh University of Textiles. After completing graduation, she intends to pursue a M.Sc. degree in Textile Engineering and wants to continue her career as a researcher. Her main areas of research interest include industrial engineering, clothing comfort, sustainability in apparel industry, visual merchandising, technical textiles.