ENHANCE #### CUTTING DEPARTMENT PRODUCTIVITY

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LIST OF ABBREVIATIONS

VSM – Value Stream Mapping

VA – Value Added

NVA – None Value Added

PT – Process Time

CO – Change Over

NIOSH – National Institute for Occupational Safety and Health

ACGIH – American Conference of Governmental Industrial Hygienists

VOC – Volatile Organic Compounds

PPM – Parts per Million

LTO – Labour Turn Over

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1. INTRODUCTION

In a garment factory cutting department is a key stake unit, since those fuels input pieces to the Production floor. Due to the one-to-one direct relationship between production floor and the cutting department it is necessitate to well-functioning in cutting department. Even Small portion of malfunctions in cutting department may compromise with the delivery needs, thus continuous monitoring and management should be done upon throughput of cutting department.

Following diagram shows the cutting department process in ### Galle. Arrow shapes are corresponding to the information, document and material transactions throughout the process.

In current context, it is initiated a project to monitor cutting department process curriculum in ###. As a good management practice merely remedying of malfunctions is not sufficient since, it is advocated to adhere continuous improvements.

In that approach there are plenty of management tools to optimize manpower, material usage, time and space such as Value stream mapping (VSM), Root cause analysis, lost time reconciliations, etc.

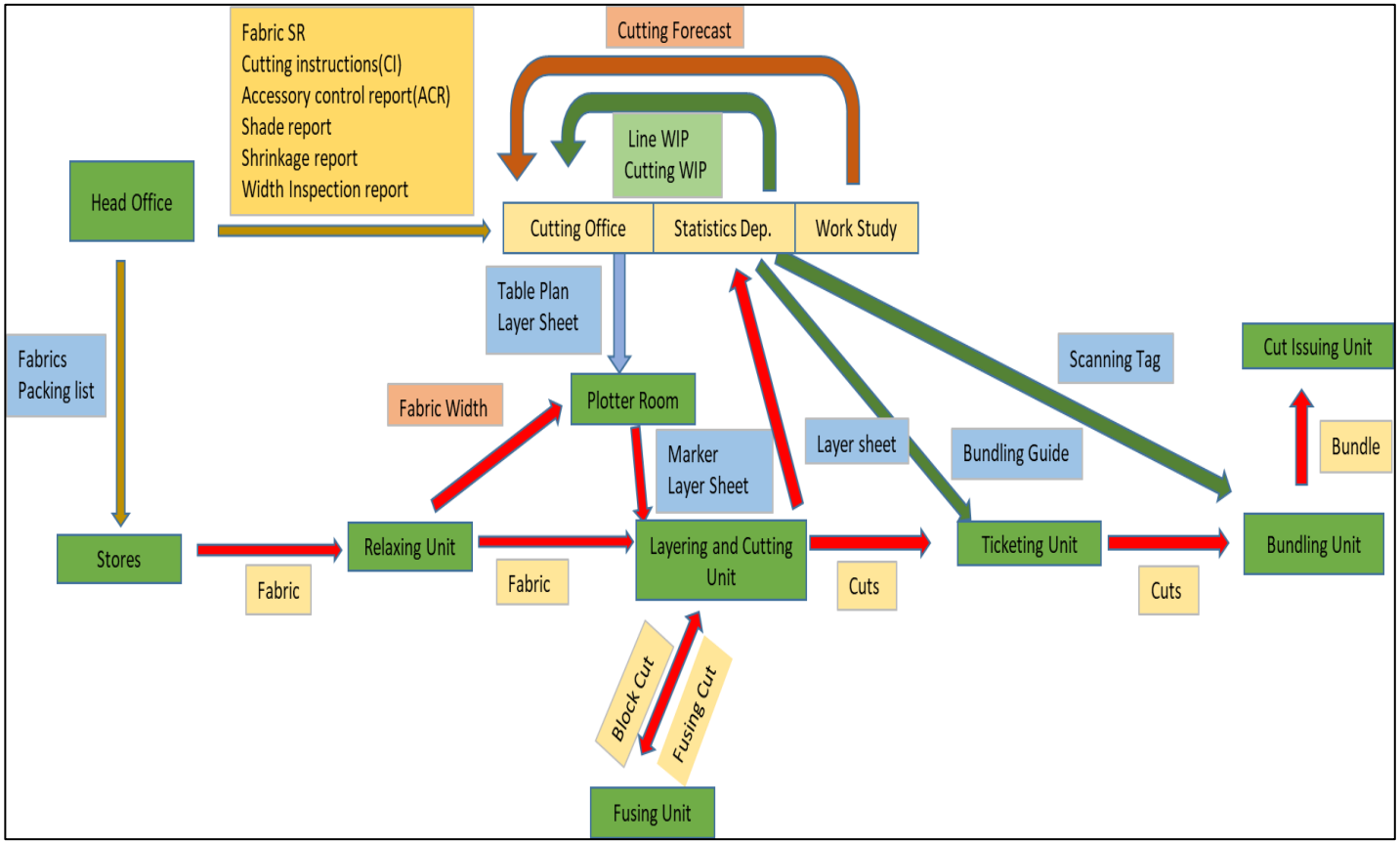

Figure 1: Cutting Department Process Diagram

1.1 Approach

In this project basically done an initial survey regarding cut panel issues in production floor (client of cutting department) after that Studied Existing cutting process and elicit ways of improving baseline conditions and manifest to increase cutting department productivity in 5%.

2. PROJECT TIMELINE

Task		Activity	Time Frame(Weeks)						
			1	2	3	4	5	6	7
Study existing cutting process	Documentation Process	Requesting fabric from CWH	■						
		Requesting fabric from Stores & Lay Planning	■						
		Table Plan Preparation	■						
		EMB/Printing/Bonding Process Coordinating		■					
		Guide/Tag card Printing Process		■					
	Physical Process	Fabric relaxing process			■				
		Fabric layering & cutting Process			■				
		Numbering & Bundling Process				■			
		Fusing & Piping Processes				■			
		Issuing(Input) Process				■			
Identifying existing Gaps		Inquiring the existing process and identifying the existing malfunctions & gaps					■		
Measure and quantify effects		Analysing the gaps and quantifying the impact						■	
Conclude findings		Suggest mitigation measures for existing gaps							■
		Elaborate novel solutions for productivity enhancement							■
		Complete project Report							■

Figure 2: Project timeline

3. OBJECTIVES

- Study baseline context of cutting department for management purpose.
- Disclose existing malfunctions for possible improvements.
- Introduce remediation measures to enhance productivity in 5%.

4. DATA ANALYSIS

4.1 Baseline Conditions

4.1.2 VSM

Scope: This Project Examine Processes since fabric relaxing up to line input issuing.

Assumption: 100pcs consumes 100yds

Remark: All the time measurement in minutes.

Table 1: VSM Data

Process		Attribute	**Code**	**P**rocess **T**ime(100yds)	**C**hange **O**ver time	Average **I**nventory **T**ime	Average Manpower
Primary Process	Relaxing	Relax	**R (24,48)**	12	3.5	Default (1440,2880)	6
		Non relax	**R'**	6.5	0.8	360	4
	Lay	Spreader lay	**L**	24	1		3
		Manual lay	**L'**	160	3.2		2
	Cutting	Auto cut	**C**	12	5		2
		Manual cut	**C'**	62	4		2
	QC	QC	**Q**	60		60	1
	Numbering & Bundling	Numbering & Bundling	**N**	52	4	720	4
	Line Input issuing	Line Input issuing	**I**	10	10		2
Auxiliary Process	Piping	Piping	**P**	60	6		3
	Fusing	Fusing	**F**	73	N/A		6
External	EMB/Print	EMB/Print	**E**	N/A	N/A		N/A

According to the above observed data there are 64 (2^6) possible pathways of throughput(Cut panels in any style). By deducting correlations those pathways can be zipped into following 48 possible pathways.

Table 2: Relaxing to Input throughput pathways

Pathway No:	**Pathways (Relaxing to Input Stage)**								
1	R	L	C			Q	N	E	I
2	R	L	C			Q	N		I
3	R	L	C	P	F	Q	N	E	I
4	R	L	C	P	F	Q	N		I
5	R	L	C		F	Q	N	E	I
6	R	L	C		F	Q	N		I
7	R	L	C	P		Q	N	E	I
8	R	L	C	P		Q	N		I
9	R	L	C'			Q	N	E	I
10	R	L	C'			Q	N		I
11	R	L	C'	P	F	Q	N	E	I

12	R	L	C'	P	F	Q	N		I
13	R	L	C'		F	Q	N	E	I
14	R	L	C'		F	Q	N		I
15	R	L	C'	P		Q	N	E	I
16	R	L	C'	P		Q	N		I
17	R	L'	C'			Q	N	E	I
18	R	L'	C'			Q	N		I
19	R	L'	C'	P	F	Q	N	E	I
20	R	L'	C'	P	F	Q	N		I
21	R	L'	C'		F	Q	N	E	I
22	R	L'	C'		F	Q	N		I
23	R	L'	C'	P		Q	N	E	I
24	R	L'	C'	P		Q	N		I
25	R'	L	C			Q	N	E	I
26	R'	L	C			Q	N		I
27	R'	L	C	P	F	Q	N	E	I
28	R'	L	C	P	F	Q	N		I
29	R'	L	C		F	Q	N	E	I
30	R'	L	C		F	Q	N		I
31	R'	L	C	P		Q	N	E	I
32	R'	L	C	P		Q	N		I
33	R'	L	C'			Q	N	E	I
34	R'	L	C'			Q	N		I
35	R'	L	C'	P	F	Q	N	E	I
36	R'	L	C'	P	F	Q	N		I
37	R'	L	C'		F	Q	N	E	I
38	R'	L	C'		F	Q	N		I
39	R'	L	C'	P		Q	N	E	I
40	R'	L	C'	P		Q	N		I
41	R'	L'	C'			Q	N	E	I
42	R'	L'	C'			Q	N		I
43	R'	L'	C'	P	F	Q	N	E	I
44	R'	L'	C'	P	F	Q	N		I
45	R'	L'	C'		F	Q	N	E	I
46	R'	L'	C'		F	Q	N		I
47	R'	L'	C'	P		Q	N	E	I
48	R'	L'	C'	P		Q	N		I

Due to interpreting cumbersome, Cutting Department Production process can be classified into three sub processes as Primary, Auxiliary and External Process (Table 01). Here Auxiliary Process is not sequentially aligned with the primary process and both are planned to do simultaneously. Hence it is impossible to calculate sequential process time for given style. However total time taken in working minutes span can be obtained from following formula for any given style as follows,

$T_{Total\ Minutes} = T_{\sum Primary\ process} + T_{\sum Auxilary\ process} + T_{External\ process}$ ---------- (*Equation 01)*

When considering working minutes among all those processes, there are two portions in process optimization perspective, those are *value added time* and *non-value-added time.*

Hence it can be given as following formula:

$T_{Total\ Minutes} = T_{Value\ added} + T_{Non\ Value\ added}$ ---------- (*Equation 02)*

Time for each Process step consist of Process time (**P/T**), Change Over time (**C/O**), Inventory Time (**I/T**)

here **P/T** Consider as Value added time rest are not.

Table 3: Primary process Time Segregation

Process step				P/T	C/O	I/T
Relax	Lay	Cut	QC + Numbering + Input			
R	L	C	QNI+	160	23.5	2940 ± 720
R	L	C'	QNI+	210	22.5	2940 ± 720
R	L'	C	QNI+	296	25.7	2940 ± 720
R	L'	C'	QNI+	346	24.7	2940 ± 720
R'	L	C	QNI+	154.5	20.8	1140
R'	L	C'	QNI+	204.5	19.8	1140
R'	L'	C	QNI+	290.5	23	1140
R'	L'	C'	QNI+	340.5	22	1140

If Relaxing time convention is R24 then I/T = 2220, Otherwise (R48) 3660.

Table 4: Auxiliary process time secretion

Piping	**F**using and **B**lock cut	P/T	C/O	I/T
P	F	133	6	0
P	F'	60	6	0
P'	F	73	0	0

Further External Process (EMB, Print) costs 2880 mins.

Let's consider Value Stream Map (VSM) for a basic style corresponding Sequence code **R24L'C'QNI** (24Hr relaxing, manual lay, Manual cut, QC, Numbering and bundling, Input, without Piping or Fusing or EMB/Print);

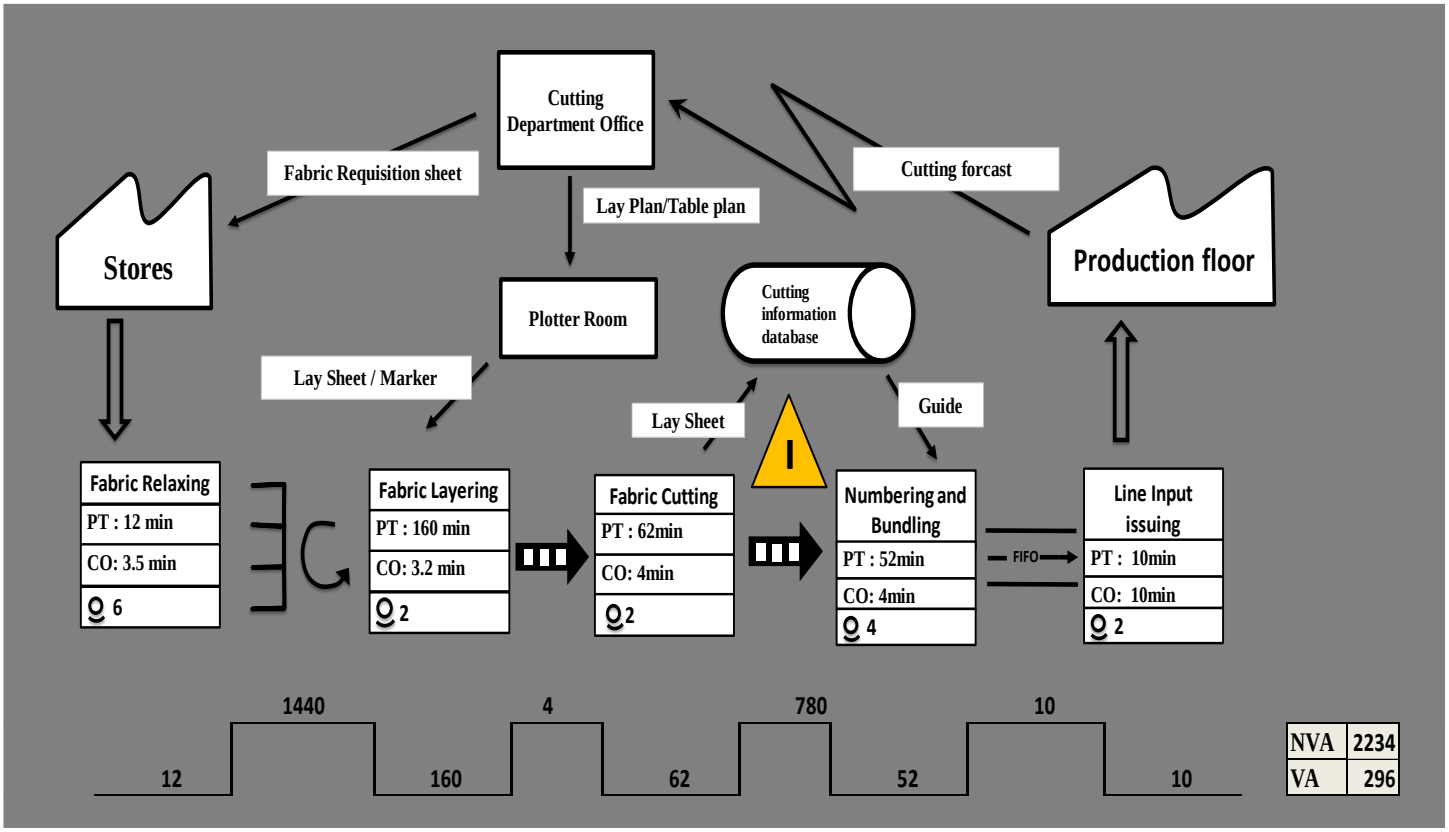

*Figure 3: VSM for Sequence code **R24L'C'QN***

Ratio between Value added and None Value added time for above throughput (**R24L'C'QN**) is 296:2234 and value-added time in allocated working minutes span is 12%.

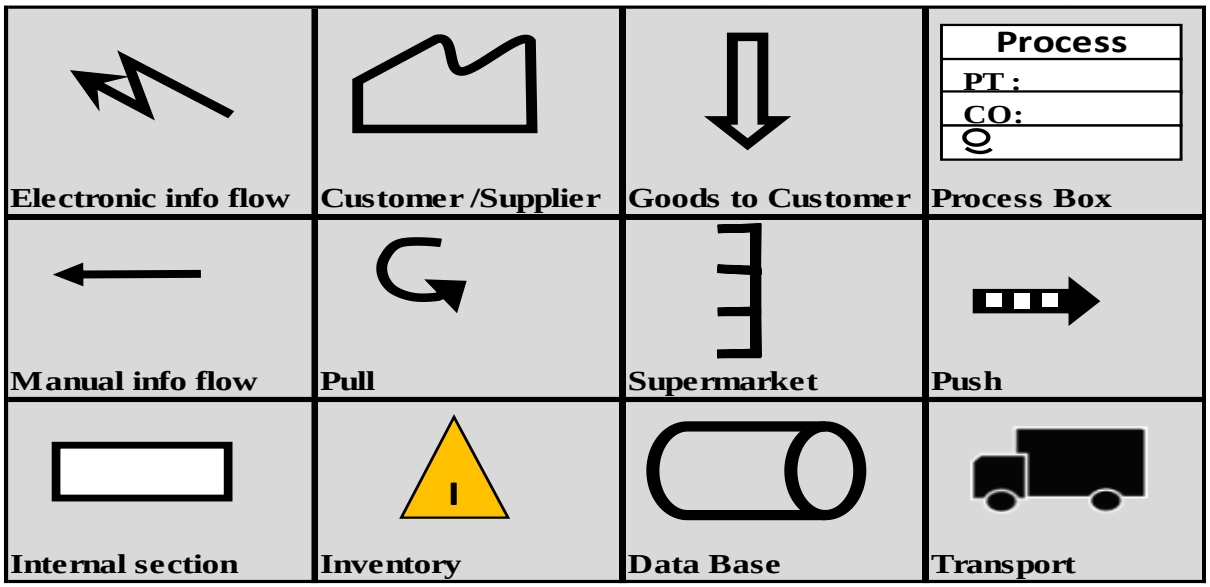

Figure 4: VSM symbols

When considering the process both primary and auxiliary processes are governed cutting department. EMB or printing process required external body which costs average two days (2880 mins) for proceedings.

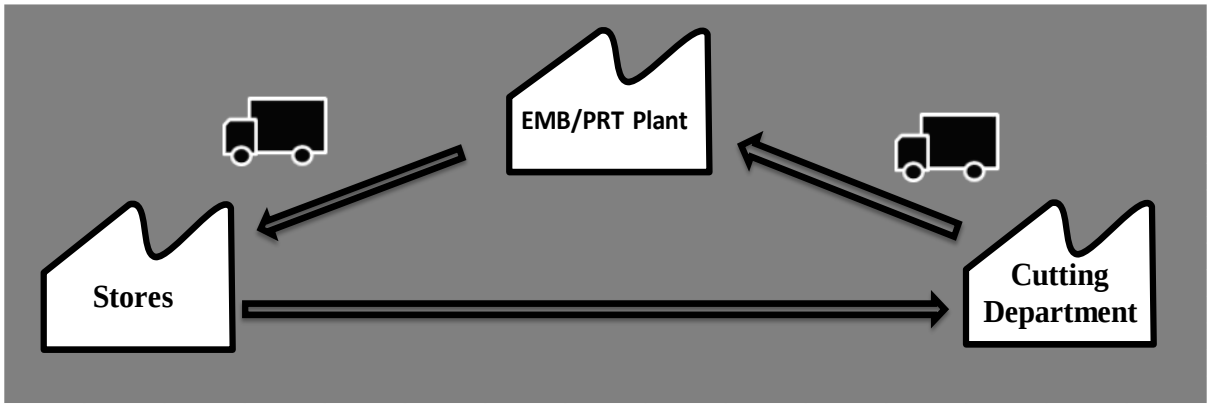

Figure 5: Cut panel EMB/Print External Process

Explanation:

Above (*Figure 3: VSM for Sequence code R24L'C'QN*) VSM prototype elicits the material flow for a basic style (Table 2, Pathway No:18) in cutting department. By using this material flows for other possible pathways can be derived also. Only difference there perhaps additional Piping, fusing or EMB/Print process. Among above possible pathways (Table 2: Relaxing to Input throughput pathways) most of the time consume for line input is corresponding to pathway No:19 (RL'C'PFQNEI) while least time consumption corresponds to pathway No:26(R'LCQNI). Hence any other possible pathway of given style rest between those.

Table 5: Min and Max pathways

Pathway	Total minutes	VA	NVA	VA%
RL'C'PFQNEI	7109.7	539	3690.7	13%
R'LCQNI	1315.3	154.5	1160.8	12%

Let's assume T for the Cumulative time taken by any given style then,

$$1315.3 \leq T \leq 7109.7$$ ---------- (*Equation 03)*

Hence using this concept value-added time and non-value-added time can be calculated any possible combination. It is elicited that random process pathway in figure 3, shares VA% as 12% which is approximately equal to min and max pathways in Table 5.

4.1.3 Line Input Forecast and supply

As per the data about line input demand and supply in 2023(NOV, DEC) there is approximately 120pcs slack (Slack rate = 120 pcs per day) respect to the cutting forecast for a random line in given day.

$$Avg\left(\left|\frac{d(Cutting\ input)}{dt}\right|\right) = 550$$ ---------- (*Equation 04)*

$$Avg\left(\left|\frac{d(Cutting\ Forcast)}{dt}\right|\right) = 670$$---------- (*Equation 05)*

4.2 Down time Analysis

As a case study let's take two successive months as 2023 November and December,

Table 6.1: Downtime Details 2023 DEC

Main reason	Sum of Downtime	%
No space	6503	41.9%
No input	2935	18.9%
Machine breakdown	1860	12.0%
Meeting	1455	9.4%
Marker Delay/Issue	820	5.3%
Delay preparation	810	5.2%
Other	735	4.7%
Re Work/ Additional Work	180	1.2%
Lay Length Width Issues	160	1.0%
Document issue/Delay	40	0.3%
Power Failure	40	0.3%

Table 6.2: Downtime Details 2023 NOV

Main reason	Sum of Downtime	%
No space	4830	32.4%
Delay preparation	2710	18.2%
Meeting	2255	15.1%
No input	2175	14.6%
Other	1440	9.7%
Machine breakdown	915	6.1%
Marker Delay/Issue	440	2.9%
Power Failure	90	0.6%
Document issue/Delay	65	0.4%

According to the recorded data most dominant downtime reason is not sufficient space for continuous working that takes averagely 37% from total Downtime. A significant insight is detected as Meetings cause average 12.25% total Downtime. Rather than reworks and layer issues almost all other downtime categories are similar among two months.

Table 7: Downtime mapping Nov and Dec months

Downtime issue	NOV	DEC	Avg	Daily Avg value	Downtime **:** WMP
No space	6503	4830	5666.5	226.66	37.78%
No input	2935	2175	2555	102.2	17.03%
Machine breakdown	1860	915	1387.5	55.5	9.25%
Meeting	1455	2255	1855	74.2	12.37%
Marker Delay/Issue	820	440	630	25.2	4.20%
Delay preparation	810	2710	1760	70.4	11.73%
Other	735	1440	1087.5	43.5	7.25%
Document issue/Delay	40	65	52.5	2.1	0.35%
Power Failure	40	90	65	2.6	0.43%
			∑	602.36	100.39%

As above, Common categories' cumulative downtime corresponds to wasting of working minutes of a single worker (10hr shift) approximately. Further "Downtime: WMP" ratio reflects that each downtime respect to a single worker's working minutes (10 hr shift). According to this scenario daily consumption of downtime is equal to total working minutes of a random worker. While factory have to pay the price for that worker and bear opportunity cost of that. When reconciliation of downtimes, immediate remedy measures can be deployed to downtimes due to meetings, No input and Delay of preparations because those are management loopholes. By remedying those daily saving would be 272mins that is 45% of working minutes of a single worker.

5. RESULT AND DISCUSSION

5.1 Baseline Production Conditions

5.1.1 Survey regarding Cut Panel Issues in Production Floor

Approach: Qualitative

Respondents: Line Supervisors

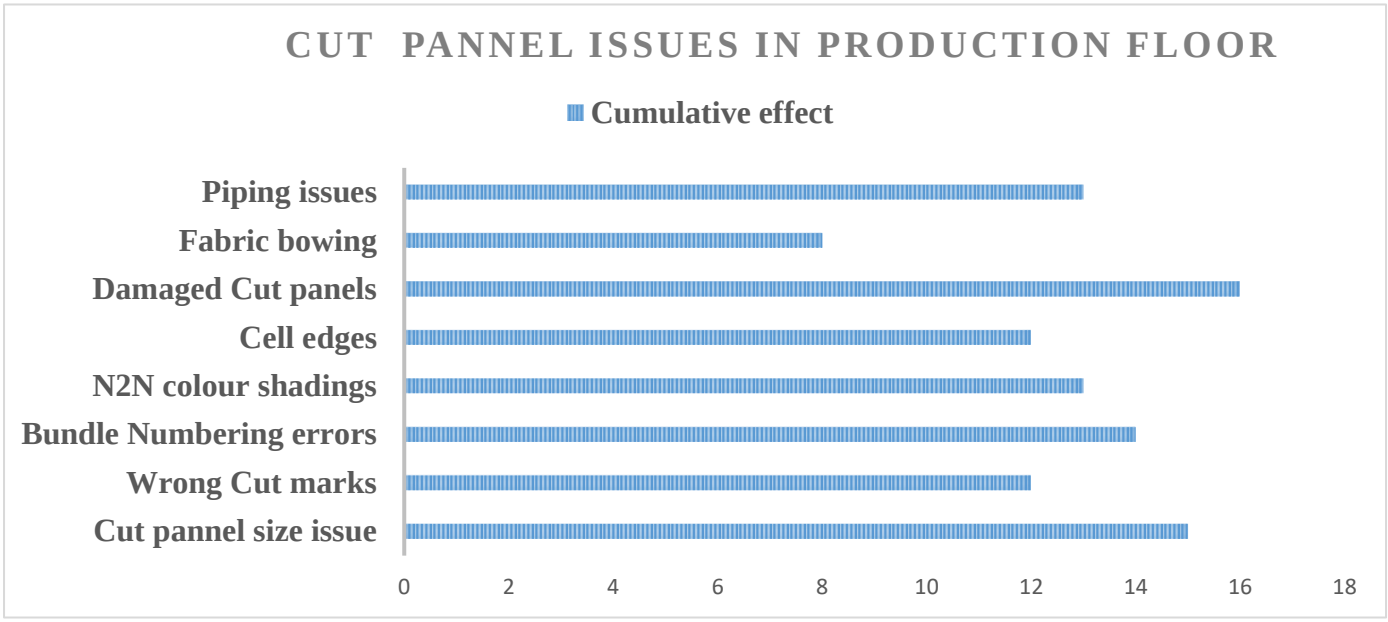

Figure 6: cut panel issues in production floor

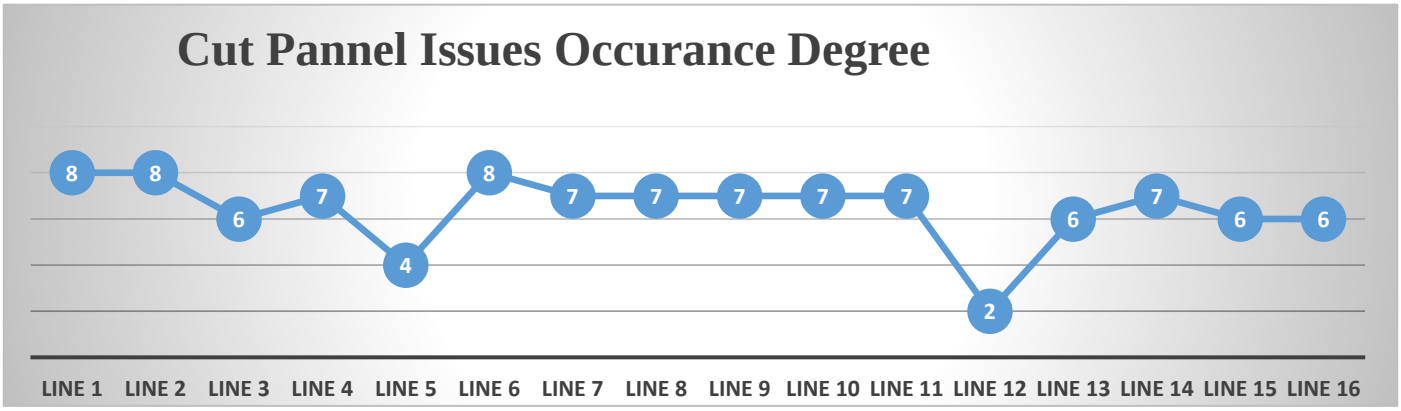

Figure 8: Cut panel issues occurrence Degree

Comments	
Line 1, 7 Fusing defects	
Line 16	Print issues
Line 04	uneven among

Here production line supervisors stated their concern upon given cut panel issue categories. Those categories were determined by a preliminary survey among input girls in production lines. Extra concerns are mentioned in comments section. Nonetheless heaviest crisis is production downtime due to cut panel delay that is not included as a category.

According to the survey results as above (figure 6, 7) heaviest burden that carries by the production floor is damaged cut panels. Then cut panel size issues. Other than piping issues and numbering and bundle errors almost all issues can be allocated to quality assurance malfunctioning. Line 16 undergo print defects which may be due to external factors. When considering the cut panel issues occurrence degree among lines, line1, 2 and 6 undergo almost all error types. While line 12 undergo least amount of error types.

To examine what are the reasons behind all those issues that production floor is undergoing, inspection of baseline conditions is mandatory.

5.1.2 Identified Existing Cutting Process Malfunctions (3M Category)

Approach: Observations and Surveying

Table 8: Existing malfunctions in Cutting department.

Process	Malfunction		
	Man	Method	Machinery
Fabric Ordering	Fabric ordering Delay		
Fabric Receiving	Fabric Requisition Delay		
Lay Plan	Document Handling Error • CI information • YY information • ACR information		
Table Plan	• Delayed Table Plan • Unachievable no. of markers • Unplanned Markers		
Plotter Room	• Print wrong Marker • Adjust Wrong Width • cut mark misallocation • wrong ratio (Draw marker) • wrong way (Draw marker) • violate matching requirements		Plotter machine efficiency slack
Layering	Common (solid, stripe) • Wrong way • fabric width and length adjustment error • Joint misplacement Manual Layering • violate matching requirements • Pin placement error		
Cutting	• cell edge allocation error		

	• cut file selecting error • cut mark embedding error • missing cut marks • matching parts not aligning • cut shrinking		
QC check			
Guide & Tag card print			
Numbering & Bundling	• Tag Card detail violations • Missing parts in bundles		
Fusing	• Fusing not stuck correctly • Panel shrunk due to high temperature • Inserting fusing panel at wrong face side	• Incorrect sequence of fusing the block cuts • Fusing the fabric panels with wrong fusing panels	• Fusing glue issue • Belt issue
Piping	• Incorrect Piping width • Sewing or cutting the piping in incorrect way • Incorrect colour		
Embellishment			
Input			

When considering malfunctions in cutting department most highlighted part is manmade error and random errors. Hence issues that production floor is undergoing (*Figure 6: Production floor Survey Concerns*) can be minimized by proper training of employees or hire skilled workers.

Method loopholes are caught as minimum perhaps due to lack of expertise knowledge of the project team in industry best practices. In other hand continues mistakes done by experienced workers may be induced by management or environmental factors in cutting department premises.

5.1.3 Value Stream mapping elaborations

When Observing VSM for a Random style as the figure 3, it discloses Value added time percentage as 12% from total time taken from relaxing to input, while Value added time percentage of maximum time consuming pathway and minimum exhibit 13% and 12% respectively. Hence cutting department average Value added time percentage is approximately 12%. Further increment of value added time can be done by reducing inventory times within the process and reducing change over times. When it comes to inventories, Inventory build in relaxing area is deliberate and it is mandatory for making Quality garments. Inventory build while non-relaxing (CTEX) start significant initiative because that prevents layering process draining while preventing average 16% of downtime.

However other inventories within process not only affect to the value added time of the garment and also fostering lost time due no space as the tables 6 and 7. Let's take VSM figure in figure 3, since it exhibit representative value added time percentage in cutting department. Reducing inventory before numbering and bundling process up to 92% (720/780) may result increase value added time up to 16% as increasing 4% from baseline, while deducting significant downtime portion due to no space cumulative.

Further when considering baseline VSM details Cutting department office supply essential information to proceed daily curriculum in cutting department, if any case of miscommunication or any other breakdown take place above mentioned value added time (12%) may be deviated than average value.

5.1.4 Department Layout Review

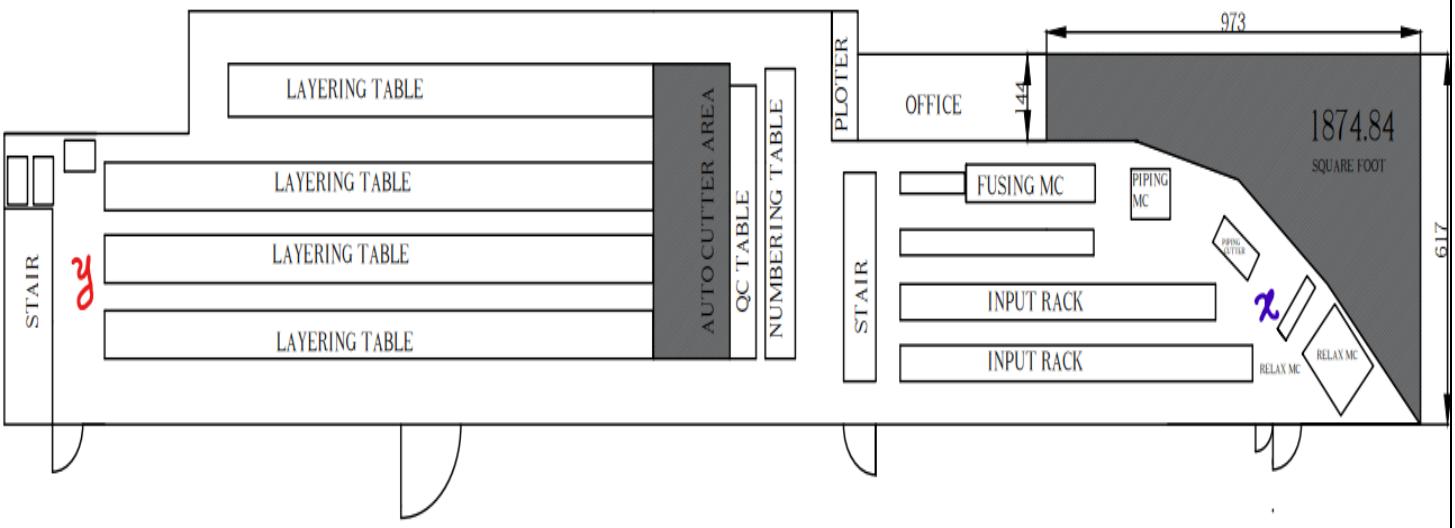

Figure 9: Cutting Department Layout

In current context in cutting department, layout doesn't aligned with the cutting process which is exhibited in VSM (figure 3). It is obvious that Due to this arrangement of work place, additional time consume for throughput circulation. For an instance after relaxing process fabric are travelled from point x to point y (figure 8) which costs 1.5 min per each time. Since average travel frequency is 20, 30mins (5% working minutes of a single person) waste due to internal transport per day.

5.1.5 Line input delay due to cutting department

As mentioned in the paragraph "*4.1.3 line input forecast and supply*" average 120pcs are slack for given line per day. This is reflected in the recorded lost time details in the lines. As 75% of total downtime are related with cutting department issues, among those 98% regarding cut panel delaying. To overcome this feasible downtimes should be recovered within the cutting department. It is observed that main reason behind the input delaying is auxiliary cutting process as mentioned in the "*Table 1: VSM Data"* doesn't functioning simultaneously with primary process. Hence total time taken for line input issuing follows sequential time span and costs more time as mentioned in the *"Equation 01(page 08)".*

5.2 Environmental Conditions

As the Environmental monitoring done by the National Institute for occupational Safety and Health on 5th of December following information was disclosed.

- Illumination

According to the NIOSH report Illumination details in cutting Department is fair, however illumination data near cutting tables and Cut panel numbering and bundling area should be concerned. As the report illumination measurement near cutting tables ranges from 955 to 2224 Lux; since it is acceptable for cutting(Conventional requirement 750 – 1000Lux) however first cut inspections also done in cutting tables which required standard condition of 1000 – 2000Lux. If any case of cutting table which having illumination margin 955 Lux, there might be made mistakes in cut panel inspection. Other issue is illumination status near Cut panel numbering and bundling section, it is recorded as 843 – 1151 Lux and there also a QC process which needs special visual requirements (conventional requirement 1000 – 2000 Lux). Hence by enhancing required level of illumination it can be minimize man made errors and style failures.

- Temperature

According to the data; temperature near fusing machine is 30.8℃ (wet bulb global temperature index) and near Cutting tables are 29.4℃. Threshold temperature limit of unacclimatized workers vary from 28℃ (0 -25% work efficiency) to 30℃ (75 -100% work efficiency) for eight hour work shift. Hence if workers are unacclimatized and expose to exceeding limits that would cause heat stress to the workers (ACGIH, 2023). To overcome that scenarios newly appointed workers should acclimatized to the temperature in critical premises. Further industrial engineering initiatives should be taken to minimize heat exposure to the workers.

- Humidity

According to the industrial conventions tolerance level of humidity rest between 40% - 70%; however SFCG cutting department premises having average 77% (Near fusing machine - 73%, Cutting area -82%) of relative humidity. Hence very small increment of the temperature may discomfort focus of the workers as mentioned above (temperature section)

- Indoor air Quality

According to the environment audit Hydrocarbons are not detected in the air with their equipment sensitivity, respirable duct levels are under control and amount Carbon dioxide is acceptable (489ppm); however concertation of Volatile Organic Compounds(VOC) are recorded as 4ppm. Industrial acceptable limit is 0.1 ppm, while 0.3ppm to 1ppm considered as high concentration of VOC. Hence in this context workers are severely vulnerable due to high concentration of VOC. Due to long term exposure of VOC workers are susceptible for eye irritations, upper throat irritations chronic respiratory illness and headaches as mentioned in scientific literature.

Productivity of any company is itself the productivity of the workers who generates minutes; with concerning all these factors, it is obvious that combined effect of above poor environment attributes affect overall cutting department productivity. To overcome that proper ventilation process is much needed because combine effect of poor indoor air quality and heat stresses foster sick building Down syndrome (SBS) among workers(source: world health organization) which incur high rate of absenteeism future LTOs.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Productivity of Cutting department can be enhanced within +5%, by reducing inventories in numbering and bundling area and reducing downtimes due to management loopholes. Further it can be reached even more by generating more working minutes through monitoring and taking proactive measurements.

6.2 Recommendations

Table 9: Feasible Recommendations

Action	Productivity gain
Align cutting department layout with cutting department process flow	Time Saving ≥ 30mins (5% working minutes of a worker)
Reduce inventories in Numbering and bundling area by increasing working minutes.	Increase value added time percentage up to 16%(+4% increment)
Minimize downtime related to management errors.	Time Saving ≥ 272mins (45% working minutes of a worker)
Allocate high efficiency plotter machine. (4 head plotter machine)	Increase marker issue efficiency by 5 times.
Allocate adequate ventilation machines.	Reduce stressful environmental conditions and reduce potential absenteeism and LTOs
Supply standard illuminance levels for cut panel inspection areas.	Reduce potential cut panel quality issues
Train and develop workers' skills	Increase overall cutting department productivity by minimizing delays, reworks, random errors etc.

7. LIMITATIONS OF THE PROJECT

- Lack of expertise knowledge about Industry best practises regard to cutting department.
- Recorded data related to November and December in 2023 used as case study and generalized to the rest.
- Generated information through surveys would be biased.
- No long-term Recorded Data regarding inventories and other none –value added times.
- Time measurements may be with high uncertainties with real scenario.