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Process-loss Optimization through the Implementation of Kanban & Single-piece Flow: A Case Study in an Ethiopian Garment Factory

Sandeep Prasad, Monika Panghal
Lecturer, Apparel Production Department,
Bahir Dar University,
Ethiopia

ABSTRACT

Ethiopia is gearing up to challenge global apparel sourcing destinations like Myanmar, Kenya, Vietnam & Cambodia. To be more competitive in the global market and to achieve the GDP-II target of USD 2.7 billion, it must work hard to optimize the operational cost, standardize the quality, and increase the efficiency which is high when compared on a global level.

Case description:
Through this case study, the researchers addressed the macro issues of one of the export-oriented factories based out of Addis Ababa. The factory was a medium-scale shirt manufacturing unit with 208 state-of-art sewing machines. Still, they were struggling to make profits from the export market and were seriously contemplating diverting to the local market which was against the mandate of the Government which is struggling to increase the inflow of foreign currency through an increase of export in this sector. The explanation offered by the factory management was that the export market offered an abundance of orders but required the factories to be highly efficient in terms of cost, quality, and lead time. Somehow, they were not able to meet the requirements, which resulted in losing the orders.

After conducting an intensive Gap as well as Planning and Diagnostic (P&D) study, the researchers found out that high process loss in the cutting room, high factory operational cost, and low efficiency, poor quality, and low speed to market were the major cause of concern.

Discussion and Evaluation:
A bundle ticket generation tool based on advanced MS-Excel was developed. It would solve the issue of financial losses incurred in the cutting room due to the conventional method of preparing bundle tickets using fabric swatches. It would also be used to create Kanban cards. A unique amalgamation of Kanban, as well as single-piece flow (SPF), was implemented to take care of the process loss due to heavy WIP (work in progress), poor quality, fewer efficiencies and more throughput time in the sewing section, and missing pieces during packing which led to unnecessary delay in shipments. The WIP and throughput time were reduced by 48.5% and 80.3% respectively. The time to pack a carton was decreased by 65.3%. The problem of missing pieces was also diminished. The manufacturing unit greatly benefited from the solutions thus proposed and implemented by the researchers and is being used successfully.

Conclusions:
The study was an eye-opener for the factory management as well as for the researcher. It was realized that through proper observation, self-questioning about recurring problems, striving to explore low-cost solutions through concerted team efforts, process loss can certainly be optimized to a great level. It is proposed that further work can be taken up by researchers to explore the effectiveness of Kanban as well as single-piece flow system for different types of products.

Keywords: export market, Planning and Diagnostic, operational cost, efficiency

I. Introduction

A rapid increase in labor costs in major supplier countries viz. $550 - 600 in China, $ 160 - 180 in India, $ 170 - 190 in Vietnam, etc. has been forcing apparel sourcing giants to migrate to low-wage countries like Ethiopia where it is as low as $ 60-80 per month. Although, the price competitiveness card is not the only resort for Ethiopia to survive in the grueling competition with countries like Myanmar and Kenya, who are proving to be better off due to their optimized processes, lower operational costs, and shorter delivery times.

The major issues affecting the small and medium level Ethiopian-owned garment manufacturing industries are higher operational costs, higher lead times, high-quality costs, low skill level, and high operator turnover. These are the prime reasons why they still struggle to manufacture high-fashion products and export for high-end buyers like H&M & PVH. Apart from job-working (Cut - Make) for US buyers like Champro Sports and Superior Uniform Group, they are trying to compensate for their high operational costs by catering to the domestic market. Ethiopia is still struggling to meet the GTP-II (2016-2020) target of USD 2.7 billion. When the Government is heavily focusing on incentivizing and promoting exports, prioritizing the domestic market is certainly not a wise idea.

To survive in this rapidly demanding environment of shorter lead times, low operational cost, and quick response time, process optimization becomes imperative. Process loss optimization refers to the reduction of losses incurred due to lapses at different stages in the production process. Implementation of world-class principles i.e. Kanban and single-piece flow, which are the most popular Lean tools used in the readymade garment manufacturing industry today, definitively serves the purpose.

II. Background of the study

A case study was undertaken in one of the major sportswear and shirt manufacturing based out of Addis Ababa who had been doing job-work for a US buyer along with catering to the domestic market. It employs 299 workers, out of which 297 are locals and two are foreigners. The factory has 208 sewing machines, 18 of which were not operational.

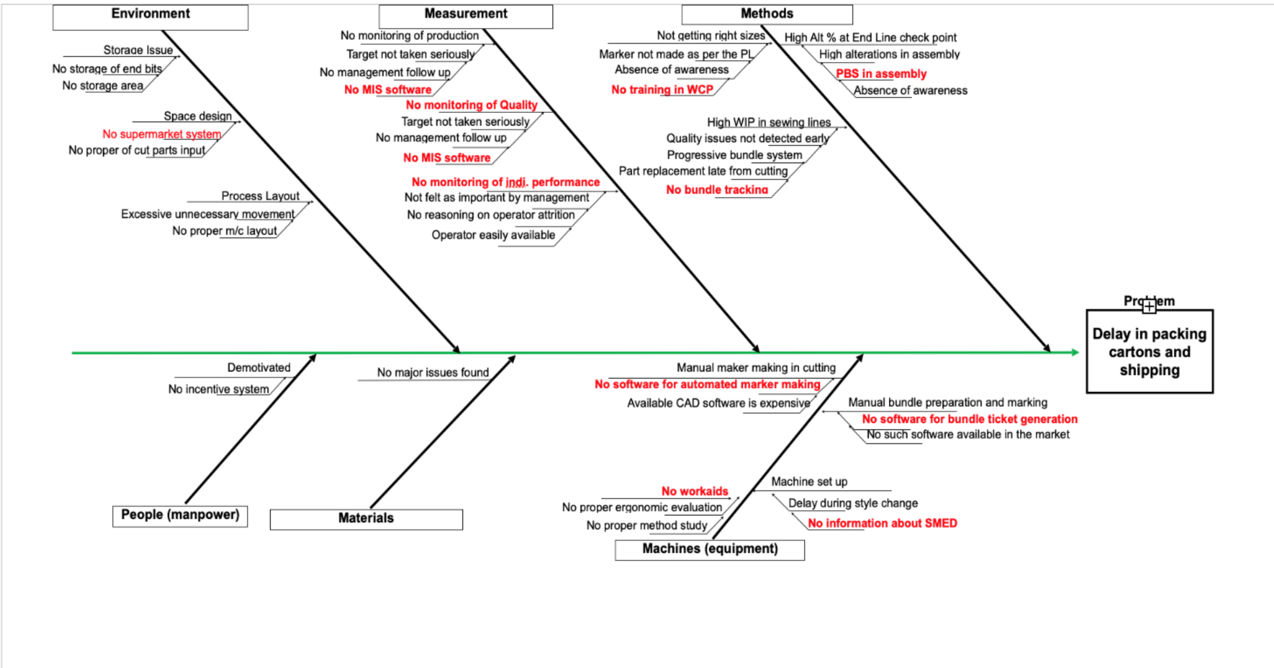

Figure 1: Department wise root cause analysis

i. ***Cutting Department***

a. Manual bundle ticket preparation using fabric swatches as shown in Figure 2 which alone resulted in a projected annual loss of ETB 3,08,752 against a planned cutting capacity of 30,000 pieces per month. This could be solved by the development of software that could create ready-to-print bundle tickets.

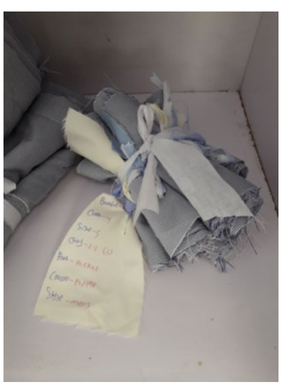

Figure 2: Manual bundle ticketing

b. No system of bundle tracking and end bit storage, which resulted in difficulty, time loss, and errors in searching for the fabric for panel replacement. This could be solved by allotting space for end-bit storage and proper training to the cutting staff on how to record and its retrieval.

ii. ***Sewing Department***

a. High WIP in lines, 400-425% of the daily output, which could easily be reduced by change of production system to single-piece flow and use of Kanban system (Ahad Ali, Mohammad Anwar Rahman, 2012).

b. Line working at an extremely low efficiency of 17% in comparison to the global average of 62% (Bheda, 2003), due to no strict follow up of targets by the management. The reason was they often not aware of the day-to-day development in the absence of an ERP system. They did not invest in an ERP system as it was thought as not important and expensive.

c. Low motivated and stressed operators due to no incentive scheme and ergonomically uncomfortable workplace which could be solved by:

- Proper division of work to eligible workers
- Job rotation
- Monitoring of worker performance
- Continuous training of hard, soft skills and world-class principles to the operators as well as the middle managerial staff
- Development of incentive system,
- Development of ergonomically work aids

d. High throughput time of more than 5 days for an order of 1500 pieces which could be reduced by:

- Change of production system into a one-piece flow
- Implementation of SMED (Single Minute Exchange of Die) for quick style change over time.

e. No properly designated work responsibility and evaluation mechanism for the middle to the upper-level managerial staff. This could be solved by:

- Development of an SOP (Standard Operating Procedure) for the factory
- Development of an HR manual for the factory with job description and evaluation criteria

iii. ***Finishing and Packing Department***

Only 35% of the Finishing and Packing Capacity was utilized. This was due to a delay in packing cartons due to the unavailability of the right sizes at the right time.

III. Objective

It could be observed from the results of the Gap and P&D analysis that the factory required a lot of interventions in different areas. This kind of action-based research focused on the implementation of Kanban and Single piece flow in a garment industry was one of its kind in Ethiopia. The objectives of this study were:

i. To study the effect of Kanban and single-piece flow on the optimization of process loss.

ii. Development of bundle ticket generation tool which could be used to create Kanban cards.

The researchers tried to answer the following research questions through the case study:

i. Can packing time and WIP be reduced by the implementation of Kanban & SPF?

ii. Do throughput time and production change by the implementation of Kanban & SPF?

IV. Literature Review

The major challenges which the garment industries, especially Small and Medium Scale Enterprises (SMEs) are facing recently are shorter lead times and highly demanding markets in terms of quick response (Bruce, Daly, & Towers, 2004). Nowadays to sustain themselves in the highly volatile market, the garment industry has to be highly flexible in terms of volume and style change (Singh & Sharma, 2009). According to (Womack & Jones, 1997), Lean is the most powerful tool available for creating value while eliminating waste in any organization. It provides flexibility and saves a lot of money by reducing production lead time, reducing the inventory, increasing productivity, improving quality, training operators for multiple works, and reducing rework (Drew, McCallum, & Roggenhofer, 2016; B, 2012).

Unfortunately, the SMEs struggle to adopt the Lean approach as neither they have the resource nor the expertise to follow them

(Little, McKinna, A, 2005; Kaya, 2012).

High WIP (Work in Process) in a traditional type of batch production is another major issue faced by industries. Due to high WIP, the throughput time and the rework level is very high, and the quality produced is poor. The flexibility towards the style change over cannot be achieved easily giving rise to longer lead times, which is the current demand of the garment industry to produce small orders (Kumar & Thavaraj, 2015). WIP can be reduced by the implementation of Kanban (Chethan Kumar C S, 2012).

Kanban

'Kanban', a technique for work and inventory release, is a major component of Just in Time and Lean Manufacturing philosophy. It was originally developed at Toyota in the 1950s as a way of managing material flow on the assembly line. Kanban means 'visual card', 'signboard' or 'billboard'. Mainly two types of Kanban cards are used in the manufacturing industry: withdrawal Kanban and production Kanban (Price, Gravel, M. and Nsakanda, A.L., 1994).

Kanban cards are used to limit the amount of inventory tied up in "Work in Progress" on a Manufacturing Floor. The essence of the Kanban concept is that a supplier, the warehouse, or manufacturing should only deliver components as and when they are needed so that there is no excess inventory (Charron, Harrington, Voehl, & Wiggin, 2014). Kanban is not an inventory control system, but a scheduling system that dictates what to produce, when to produce it, and how much to produce. Jobs are 'pulled' through production processes according to the demand of final products, rather than 'pushed' along process routings by keeping to a planned schedule in the push system (Li, 2011). The flow of parts throughout the product line is controlled by Kanban cards (Hemamalini, Rajendran, C, 2000). Within this system, workstations located along production lines only produce/deliver desired components when they receive a card and an empty container, indicating that more parts will be needed in production. In case of line interruptions, each workstation will only produce enough components to fill the container and then stop. As per (Chethan Kumar C S, 2012), the implementation of the Kanban system resulted in reduced inventory, minimum damage to materials, and higher clarity to material flow.

V. Methodology

Selection of lines

Two pilot lines were selected which would produce shirts. Out of the total order of 24000 pieces, 50% was planned to be run in each line. One of the lines (Line 1) was allowed to run in the existing progressive bundle system (PBS) and the other (Line 2) was taken up as the intervention line where Kanban & SPF was planned to be implemented. It needs to be noted that both the lines had a preparatory section for the preparation of parts before they came to the final assembly. The only difference followed was that in Line 1, the assembly followed PBS and Line 2 followed Kanban & SPF.

Development of bundle ticket generation tool

An excel-based bundle ticket generation tool was developed (Figure 3) which could be used to create Kanbans. Figure 4a & 4b demonstrates the output which was generated from the tool and carries with it all the details of the bundle to be created. These tickets could be directly pasted on the Kanban cards (Figure 5).

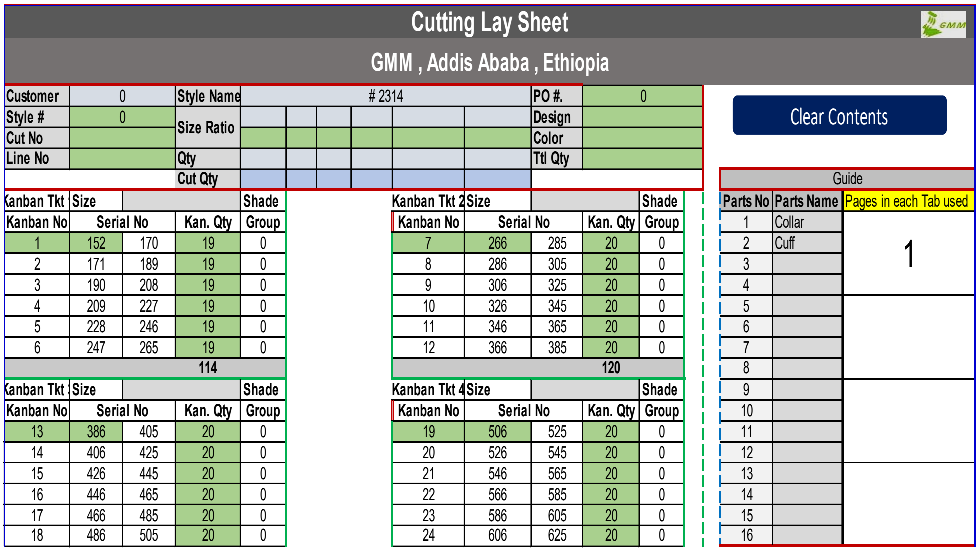

Figure 3: Bundle ticket generation tool: dashboard (screenshot)

Figure 4a: Bundle ticket output (screenshot); 4b: Bundle ticket pasted on bundles

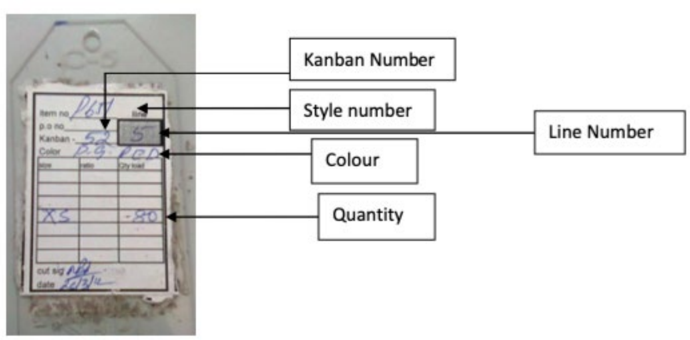

Figure 5: Kanban card

Development of SOP on Kanban process flow and training

An SOP (Standard Operating Procedure) manual on the Kanban and single-piece flow implementation process was developed and training was provided to the key production personnel (Figure 6 & 7):

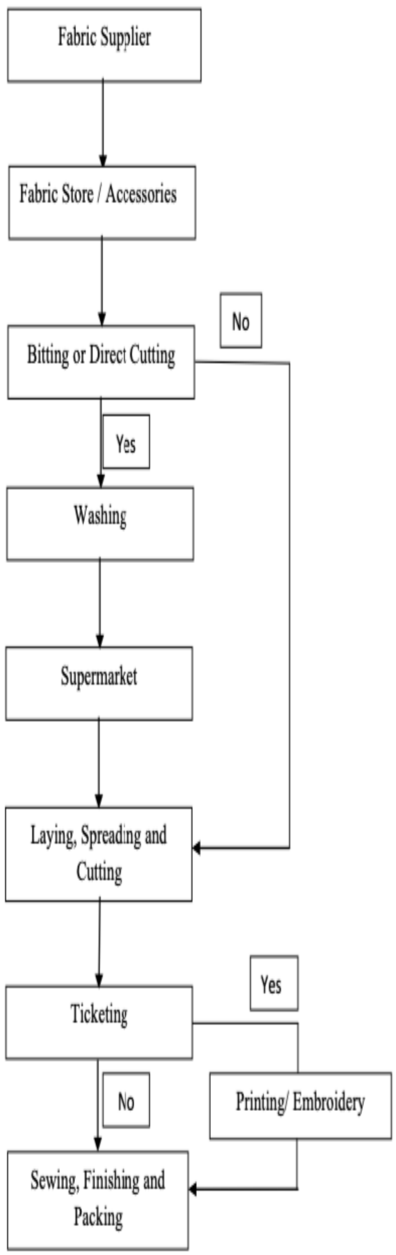

Figure 6: Kanban process flow -1

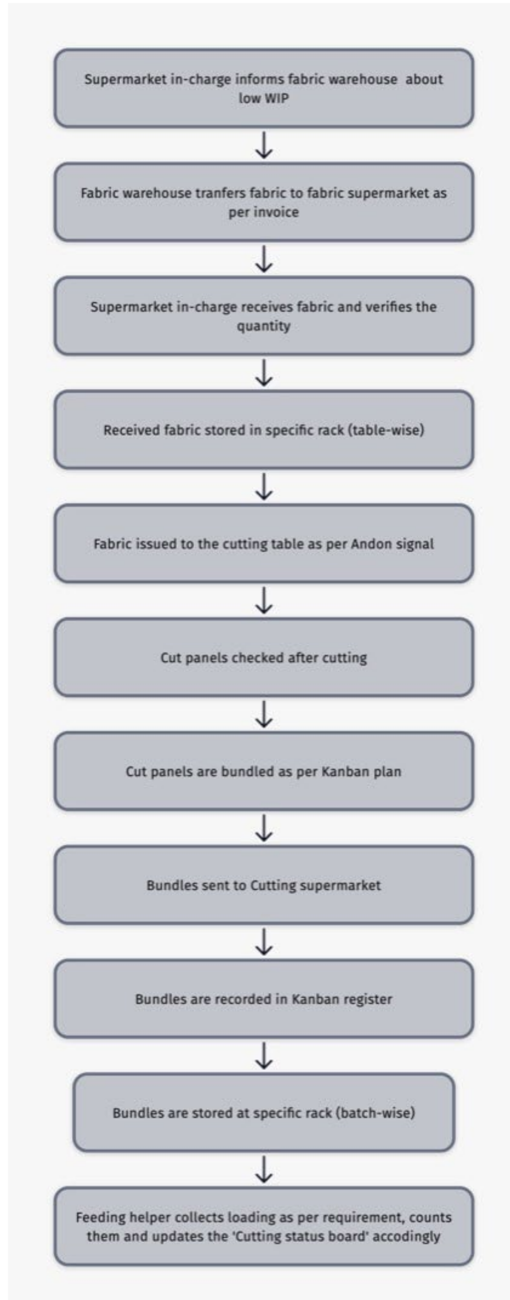

Figure 7: Kanban process flow: 2

Implementation of Kanban

a. Kanban card was prepared from colored paper, which went together through the production line from cutting supermarket till packing the garments to cartons.

b. There were four kinds of color Kanban cards that represent different flows of information from one process to the other as shown in

Figure 8.

c. Kanban cards traveled with the production item and identified the style number, Line number, Kanban number, color, and quantity issued.

d. Kanban cards served as both a transaction and communication device.

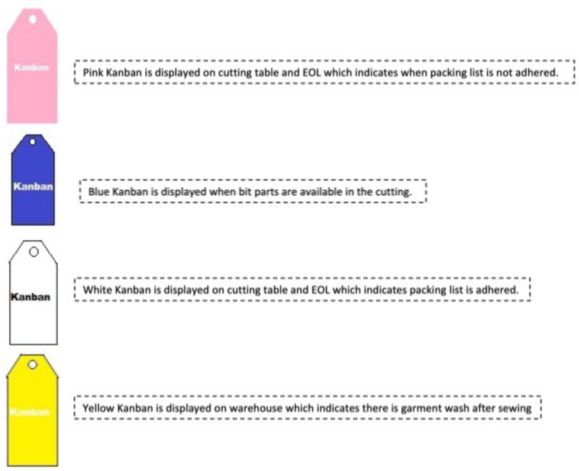

Figure 8: Colored Kanban cards

e. A card was displayed on the Kanban dashboard which means availability of bits in the supermarket (Figure 9).

f. The bits were moved from supermarket to cutting table along with the blue Kanban card.

g. The cutting of bits took place according to the micro-cut plan and a white Kanban card was then displayed on the Kanban post of the cutting table, to await to load back to the production line.

h. The white Kanban card returned to the Kanban post at the end of the production line that has been set up to provide a visual signal for the operation of the line.

i. The Kanban card was displayed till the finishing of the garment along with the packing of garments in the cartons.

j. The sticker attached to the Kanban card was stuck to the Kanban input book after accepting those cartons in the packing area.

k. Kanban loading, and Input Book serve as an assistant tool for Kanban cards which keeps the record of loading Kanban to the batch and completion of that Kanban (Figure 10).

l. The feeding helper maintained the record of those two books, and it was her/his responsibility to watch the daily loading and completion of Kanban.

m. By observing the two books anyone could find the loaded quantity, WIP of the line, which Kanban is taking much time to operate.

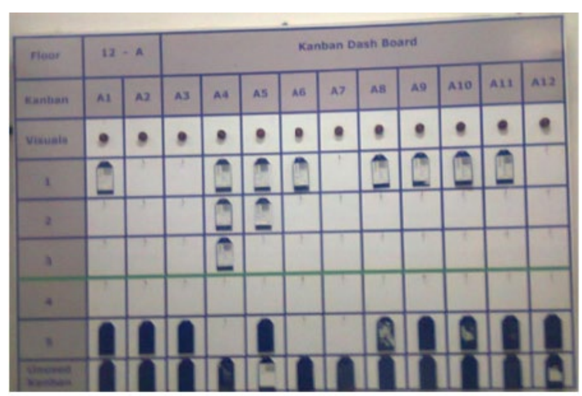

Figure 9: Kanban dashboard

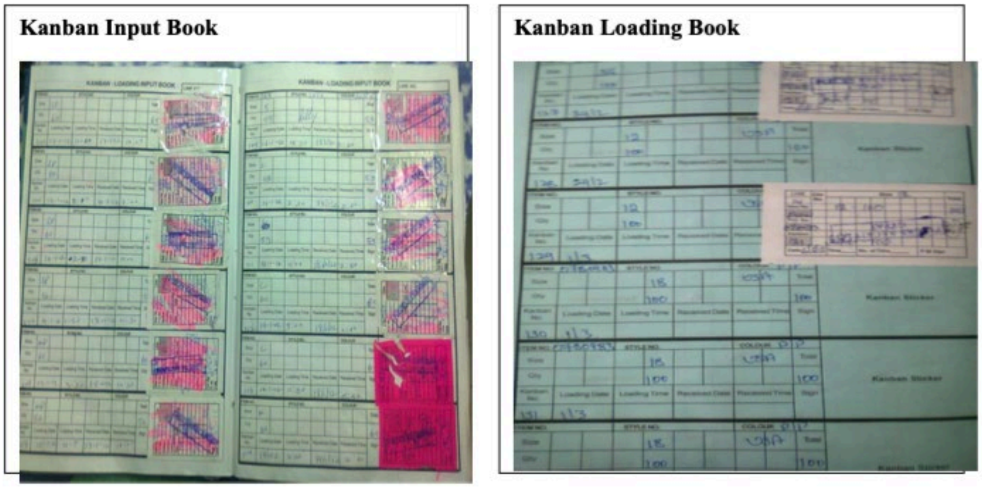

Figure 10: Kanban loading and input book

Calculation of Kanban size

a. Although the formula for calculating Kanban size as developed by Toyota production system has been used in different other industries (Chethan Kumar C S, 2012; Hemamalini, 2000; Li, 2011), it becomes a challenge to use indirectly for the garment manufacturing industry as there are many variables which are not easy to obtain.

b. Therefore, based on their own practical experience of implementing Kanban successfully in other factories across the globe, the researchers developed a simpler formula for calculating Kanban size based on the packing list and takt time output.

c. For implementing the Kanban method, the most important decision is the number of Kanbans that are to be used, which depends on the size of the order, carton capacity, and takt time.

d. A Kanban Loading plan was made before loading the Kanban card to the batch. This was made as per the packing list (Table 1). As it can be seen from the packing list that per carton capacity was 20 units.

Table 1: Packing list

Packing list								
Buyer Name	Local		**Order Quantity**	24000				
Style Name	Mens shirt							
Sizes	**S**	**M**	**L**	**XL**				
Ratio	**1**	**2**	**1**	**1**	**5**			
White	2400	4800	2400	2400	12000			
Blue	2400	4800	2400	2400	12000			
Carton Number	**Total Cartons**	**Color**	**Size**					
			S	**M**	**L**	**XL**	**Pieces per carton**	**Total Pieces**
1-600	600	White	4	8	4	4	20	12000
601-1200	600	Blue	4	8	4	4	20	12000

e. The target sewing production based on the lead time was fixed at 462 pieces per day.
f. Based on the available working hours per day of 7.5, the takt time output was 63 units.
g. The number of units calculated was of takt time equivalent to one hour and multiplies of carton size.
h. Kanban calculation for the pilot Shirt line undertaken for the study:

    1 Kanban + (Number of Workstation x 3 Units) + 1 Kanban
    48 Workstations x 3 Units = 144 Units
    Kanban Size = Takt Time Output = 63 Units
    Ratio = 20 Units/Carton
    Therefore, 63 Units/20 = 3(Approx.)
    Kanban Size = 3 Cartons x 20 = 60
    Therefore, 60 + 144 + 60 = 264/60 = 5(Approx.)
    Kanban = 300 units of WIP
    Total number of Kanbans for 12000 pieces order quantity = Order quantity/Kanban size
    = 12000/60 = 200

A minimum of 3 Kanbans was kept in cutting ready to load. The cutting section displayed WIP Kanban on the cutting table. Every Kanban was completed as per loading quantity and was offered for quality specifications and carton audit.

During the implementation of the Single-Piece flow system in the assembly line, bundles were replaced by single pieces. The bundle system continued as it is in the preparatory sections. A feeder was trained to clip the individual components i.e., sleeve, cuff, front, back, collar and cuff, etc., and make it ready to feed into the assembly section as per the Kanban. The line output was again bundled as per the Kanban at the end of the assembly line and issued to the Finishing Section.

After the implementation of Kanban and SPF, the following variables i.e., throughput time, output, WIP, and time to pack was monitored, evaluated, and compared between the two lines.

VI. Data Analysis

The production status of both Lines 1 & 2 was monitored for 6 (six) weeks. Although during the period the full order quantity could not be completed, the researchers had collected enough data which could enable them to conduct thorough analysis pre and post-intervention.

Line output, WIP, and Throughput time

Daily output was monitored at the end of the day for both lines. Figure 11 shows the comparison of week-wise average line output data collected during the period for both lines. As it can be seen the PBS system (Line 1) had lesser output in comparison to Line 2 in which Kanban & SPF was implemented. The maximum achieved by the Line 1 and 2 were 290 and 450 respectively at the end of week 6. The reason behind more output in Line 2 could be that WIP and waiting time between operators was lesser which resulted in higher output.

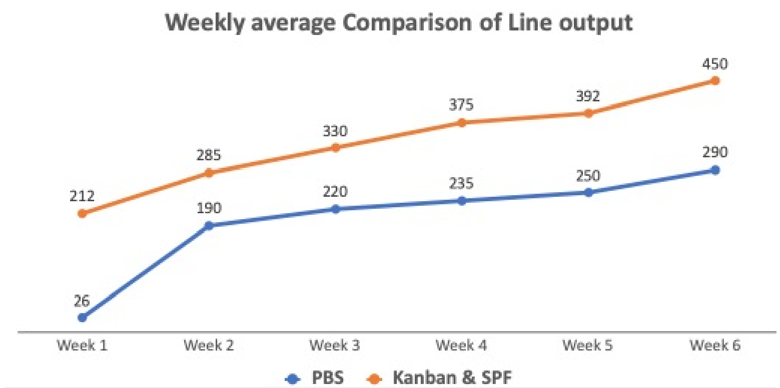

Figure 11: Weekly average line output

Hypothesis Test

A Hypothesis test was conducted to test the significance between the weekly outputs of the 2 (two) lines.

H_o: There is no difference between the output from the lines employing two different production systems

H_a: There is a significant difference between the output from the lines employing two different production systems

ka2 samples t-test (95% confidence interval) for testing the significance between the weekly line outputs from both the lines was conducted as shown in table 2. Since the p-value = T.DIST.2T(t,df) = T.DIST.2T(-2.72,10) = 0.02 < 0.05 (Table 2), the null hypothesis was rejected, concluding that there is a significant difference between the outputs of the two lines employing different production systems.

Table 2: 2-sample t-test (weekly average Line output)

t-Test: Two-Sample Assuming Unequal Variances		
	PBS	*Kanban & SPF*
Mean	201.83	340.67
Variance	8516.17	7107.07
Observations	6.00	6.00
Hypothesized Mean Difference	0.00	
df	10.00	
t Stat	-2.72	
P(T<=t) one-tail	0.01	
t Critical one-tail	1.81	
P(T<=t) two-tail	0.02	
t Critical two-tail	2.23	

Since Work in Progress (WIP) is one of the major KPI (Key Performance Indicators) of Lean methodology, it was monitored to study the impact. The average WIP for each of the lines has been listed below in Table 3. It can be noticed that there was a marked decrease of 48.5% in average WIP in Line 2 (Intervention line).

Table 3: Average WIP

	Average WIP		
	PBS	Kanban & SPF	Decrease %
Week 1	1237	637	48.5%

Throughput time was monitored in both lines. A unique result of the intervention was that the Throughput time was drastically reduced by 80.3% (Table 4).

Table 4: Throughput time

Throughput time (Hrs)		
PBS	Kanban & SPF	Decrease %
40.6	8	80.3%

Cut - Sew - Pack ratio analysis

In this KPI the ratio of the standard time (SAM) of Cutting, Sewing, and Finishing-Packing was derived. Hossain et al. 2018 studied the standard ratio of Cut-Sew-Pack based on SAM for a basic T-shirt as 7.1: 1: 28.7. This KPI is critical in analyzing the standard time for finishing and packing concerning cutting and sewing and helps to establish a benchmark for total lead time.

The researchers tried to derive the standard ratio for Men’s' Shirt being studied as 5.4: 1: 15.8 as shown in Table 5. Thereafter, the ratio was analyzed for Line 1 as well as for Line 2. The ratio of Line 1 was 15.6: 1: 118.8, which indicated excess time in finishing and packing. In contrast comparison, Line 2 scored a ratio of 5.6: 1: 70.5. Although it was way more to the standard required ratio of 5.4: 1: 15.8, still it showed a marked improvement in comparison to Line 1.

The Packing time for 12000 pieces was reduced by 65.3% in Line 2 in comparison to Line 1. This demonstrated the benefit of the implementation of Kanban as well as Single-Piece Flow in this study.

Table 5: Comparison of Cut-sew-pack time

Order Qty	12000							
Time Distribution	**Manpower Line 1**	**Manpower Line 2**	**Standard Ratio**	**Standard Ratio**	**Time Taken(Days)_Line 1**	**Ratio Line 1**	**Time Taken(Days)_Line**	**Ratio Line 2**
Cutting Time	24	20	7.1%	5.4%	7.88	15.6%	1.64	**5.6%**
Sewing Time	72	66	1	1	50.5	1.00	29.6	1.00
Finishing and Pack Time	12	10	28.7%	15.8%	60.0	118.8%	20.8	**70.5%**
			T - shirt	Shirt	**118.4**		**52.0**	

VII. Conclusion

The study conducted in one of the major garment manufacturing factories based out of Ethiopia demonstrated the fact that Kanban when wisely combined with a single piece flow system, can produce significantly fruitful results. Reduction in the throughput time and WIP, as well as an increase in the line output, were clear indicators for the above statement. Kanban, specifically, has been comparatively more popular amongst the automotive industries. The reason for its low popularity in the garment manufacturing industry can be associated with the fact that not enough literature is available related to its implementation in this industry. The authors have tried to demonstrate its successful implementation by simplifying the calculation of Kanban bundle quantity and by developing an SOP for the process flow of the Kanban system modified for the garment manufacturing industry. They have also demonstrated that single-piece flow can be successfully implemented in the assembly section. The development of an Excel-based bundle ticket generation tool replaced the manual work which used to result in loss of a huge amount of money and time and thus directly or indirectly helped in-process loss optimization. Since the Kanban cards were prepared as per the packing list, it greatly contributed to the reduction of time lost previously in searching for missing pieces, which contributed to the unnecessary increase of packing time. There is a great scope for other researchers to work further in this area by implementing Kanban and single-piece flow systems during the production of other product categories.

Abbreviation

SPF: Single-piece flow
WIP: Work in process
SAM: Standard allowed minute
SOP: Standard operating procedure
KPI: Key performance indicator
ERP: Enterprise resource planning
P&D: Planning and Diagnostic

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