

CASE STUDY

Applying value stream management to improve packaging processes in cosmetics industry – a case study

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The company under study is a company specializing in producing cosmetics. Sales of the company have declined sharply in recent years due to failure to deliver on time. After analyzing, the root causes of the problem of low on-time delivery rate are high production lead time and high cycle time in the packaging processes. The study applied value stream management, VSM, to improve packaging production process of the company. The primary objectives were to reduce the production lead time and reduce production cycle time to meet the takt time, thereby improving the on-time delivery rate and the company's sales. The results had shown that the lead time had been reduced by 46.23% from 42.4 to 22.8 h, the cycle time had been reduced 31.25% from 32 to 22 s, meeting the takt time.

Keywords: value stream management, single minute exchange of die (SMED), Job Design, Line Balancing, Kanban, first in first out (FIFO)

Introduction

The company under study is producing cosmetics. Its sales have dropped recently. The main reason for this is the failure to deliver on time. Recognizing the issue, the company is determined to enhance its on-time delivery rate as a strategic initiative to subsequently boost sales.

The problem lay in excessive waste in the packaging process. This led to increasing lead time and cycle time, which resulted in low productivity, affecting the on-time delivery rate and sales of the company. Therefore, the company sought to reduce both cycle and lead time in order to improve on-time delivery rate.

Value stream management (VSM), a well-structured methodology, has been used to solve the problems with the objective of reducing waste, thus reducing production lead time, reducing production cycle time to meet takt time.

The current state value stream map (CSM) was constructed, and the current performance indexes were assessed. Lean tools, including single minute exchange of die (SMED), Job Design, Line Balancing, Kanban, and first in

first out (FIFO), were used to construct the future state value stream map (FSM), and the future performance indexes were assessed. Comparing the CSM and the FSM, both the lead time and cycle time were reduced, and the cycle time met the takt time.

Literature review

VSM was used to improve the production processes in LED manufacturing (1), in PCB manufacturing (2), and in trolley-bag manufacturing (3), in production processes (4), and in warehouse operation processes (5) by using tools, including SMED, Work Design, Line Balancing, Kanban, and FIFO.

SMED is a tool developed by Shigeo Shingo for changeover reduction (6). Job Design is a lean tool used for reducing workstation cycle time (7). The two-hands method is often used to remove non-value-added operations and arrange value-added operations properly. In addition, some physical tools are designed to reduce operation times. Line Balancing is a lean tool that evenly distributes the work elements within a value stream to meet takt time (7). The main objective

of line balancing is to distribute the task evenly over the workstations so that the idle time of man of machine can be minimized (8).

Kanban is a lean tool that performs pull principle of lean thinking to control in-process inventory by using supermarket concept and pull signal (7). The Kanban system is an inventory stock control system that triggers signal for production of product based on actual customer requirement (9). FIFO is also a lean tool for control in-process inventory (7). FIFO is simpler than Kanban: inventory is brought in at one end and removed from the other end of FIFO lanes.

Research methodology

In this paper, the research methodology includes the following steps:

1. Choose the value stream
2. Map the current state
3. Map the future state

The step of choosing the value stream includes the following sub-steps:

1. Collect data on the number of products consumed
2. Use Pareto chart to identify the product to be researched
3. Use suppliers inputs process outputs customers (SIPOC) to define the process to be researched

The step for mapping the current state includes the following sub-steps:

1. Identify all workstations of the value stream
2. Collect data on the workstation attributes
3. Collect data on the available production time, customer daily demand
4. Collect data on the inventories of the value stream
5. Calculate times in process of the inventories
6. Map the current state value stream
7. Assess the current performance indexes

The step for mapping the future state includes the following sub-steps:

1. Draw the current balanced chart
2. Use SMED to increase the workstation takt times
3. Use Job Design to reduce the workstation cycle times
4. Use Line balancing to balance the line and meet workstation takt times
5. Use Kanban and FIFO to control inventories in the value stream

6. Map the future state value stream
7. Assess the future performance indexes
8. Assess the lean improvement

With review from (7), the SMED procedure used in this research includes the following steps:

1. Identify and classify internal and external activities
2. Separate internal from external activities
3. Convert internal activities to external activities
4. Eliminate internal waste to minimize internal activities time

The Job Design procedure (7) used in this research includes the following steps:

1. Identify and classify left- and right-hand operations
2. Eliminate all waste in left- and right-hand operations
3. Design physical tools to reduce operations time
4. Allocating operations evenly to left and right hands

Line balancing evenly distributes the work elements among workstations within the value stream to meet workstation takt time by the following sub-steps:

1. Identify work elements and workers of the current workstations
2. rearrange work elements and workers to future workstations

The work elements and workers are rearranged to balance the work between stations so that the new workstation cycle times do not exceed workstation takt times.

The Kanban and FIFO systems are constructed by the following sub-steps:

1. Define the positions of the Kanban and FIFO systems
2. Collect data and calculate the numbers of Kanban cards
3. Collect data and calculate the sizes of the FIFO lane

After collecting data to estimate daily demand D of back workstation, lead time L of front workstations, safety parameter α , and container size Q , the numbers of Kanban cards N are calculated by the following model.

$$N = DL \frac{1 + \alpha}{Q}$$

After collecting data to estimate of cycle time mean M , and standard deviation SD of front and back workstations, and station down time DT of front workstations, the sizes S of the FIFO lanes are calculated by the Christoph Roser model in (10).

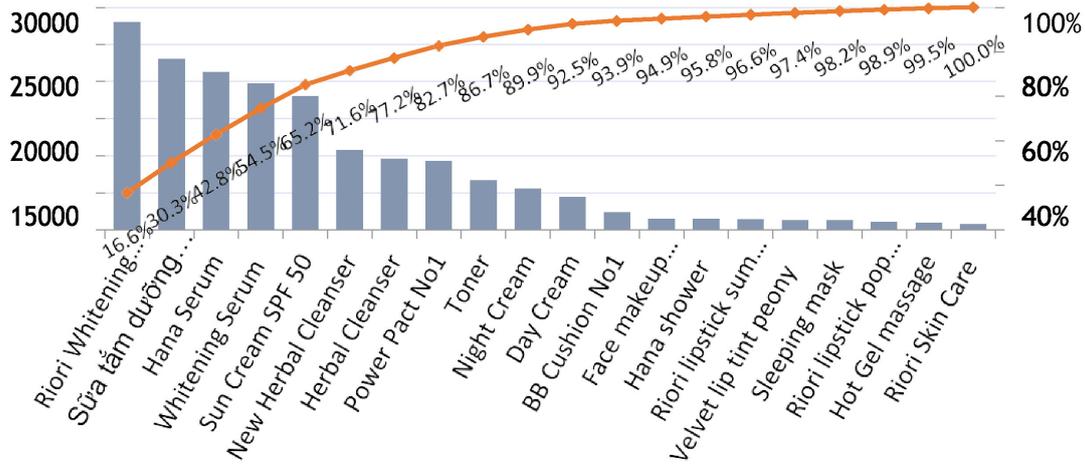


FIGURE 1 | The Pareto chart of products sale in 6 months.

Choosing the value stream

The company produced many products. The data for the number of products consumed in 6 months were collected. The pareto chart for the number of products sold in 6 months is shown in **Figure 1**.

From the Pareto chart, the product of Riori Whitening Body Lotion was selected for further research. The SIPOC diagram of the chosen product is shown in **Figure 2**, in which, the packaging process included 7 workstations.

Current state mapping

All the workstations in the stream are shown in **Table 1**.

The workstation attributes including cycle time CT, lead time LT, change over time COT were collected and shown in **Table 2**.

The company worked 1 shift per day, 8 h per shift. The total break time per day was 90 min. The available production time was calculated as follows.

$$APT = (8 - 1.5) = 6.5 \text{ (hour/day)}$$

$$APT = 6.5 \times 3600 = 23400 \text{ (sec/day)}$$

TABLE 1 | Workstations in the value stream of Riori Whitening Body Lotion.

Station	Name
W1	Transferring
W2	Cover
W3	Stamp
W4	Packed into paper box
W5	Print date
W6	Shrinking
W7	Crating
W8	Transferring

The customer average daily demand DD was collected as follows.

$$DD = 1000 \text{ (units/day)}$$

The process takt time was calculated as follows.

$$PIT = \frac{APT}{DD} = 23.4 \text{ (sec/unit)}$$

The number of inventories I of raw materials (RM), work in process (WIP) between workstations and finish good (FG) were collected and are shown in **Table 3**. The corresponding times in process (TIP) were calculated from the number of inventories I and the above daily demand (DD) and are also shown in **Table 3**.

$$TIP = \frac{WIP}{DD}$$

From all the above data, the CSM was drawn from the supplier to the customer as shown in **Figure 3**. with inventory I (units), number of workers N, cycle time CT (sec), changeover time (COT) (sec), value added time VAT (sec), non-value added time NVAT (day).

From the map, the current performance indexes, including process lead time LT, and process cycle time CT were as follows.

$$LT = 42.4 \text{ h}$$

$$CT = 32 \text{ s}$$

TABLE 2 | The workstations' attributes.

	W1	W2	W3	W4	W5	W6	W7
CT (s)	20	24	12	32	11	26	24
LT(s)	20	24	12	32	11	26	24
COT(s)	2400	420	0	300	2010	1080	0

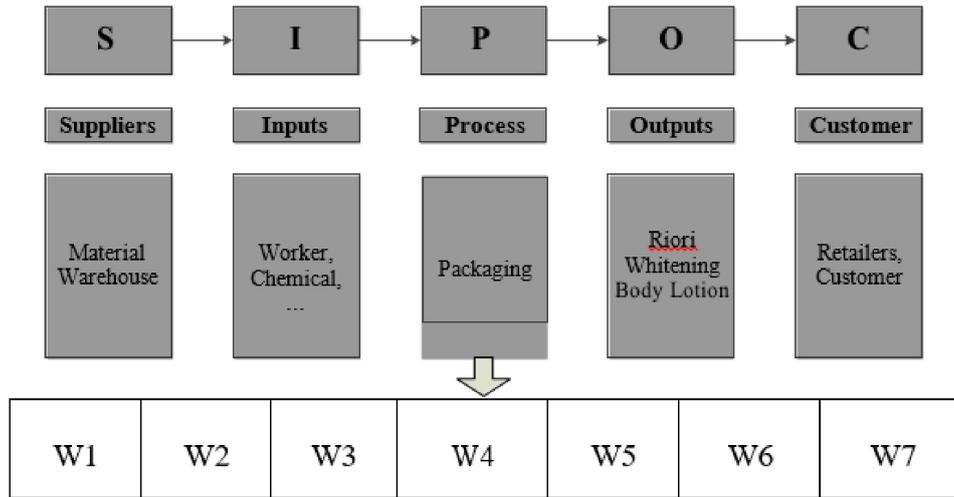


FIGURE 2 | The SIPOC diagram of Riori whitening body lotion.

Sup.	W1	W2	W3	W4	W5	W6	W7	Cust.
I	6000	2	0	4	0	10	3	500
N	1	1	1	1	1	1	1	
CT	20	24	12	32	11	26	24	
COT	2400	420	0	300	2010	1080	0	
VAT	20	24	12	32	11	26	24	
NVAT	6	0.002	0	0.004	0	0.01	0.003	0.5

FIGURE 3 | The current state map CSM.

The lead time LT of 42.4 h was much longer than value added time VAT of 149 s. Besides that, the process cycle time (32 s), did not meet the process takt time (23.4 s). Lean tools needed to be applied to reduce lead time and reduce cycle time to meet takt time.

Future state mapping

With the available production time APT of 23400 (s), the daily demand DD of 1000 products, workstation takt times TT were calculated from changeover time COT and are

shown in Table 4.

$$AOP = APT - COT$$

$$TT = \frac{AOP}{DD}$$

The balance chart with workstation cycle time CT and workstation takt time TT is shown in Figure 4.

Some workstation cycle times exceeded the corresponding workstation takt times. SMED should be used to reduce workstation changeover times to lift up workstation takt time TT. After using SMED, the workstation COTs were reduced, then workstation TT were changed as in Table 5.

The balance chart after using SMED is shown in Figure 5.

TABLE 3 | Inventories and time in process.

Inventory	I (units)	TIP (day)
RM	6000	6
WIP (W1-W2)	2	0.002
WIP (W2-W3)	0	0
WIP (W3-W4)	4	0.004
WIP (W4-W5)	0	0
WIP (W5-W6)	10	0.01
WIP (W6-W7)	3	0.003
FG	500	0.5

TABLE 4 | Workstation takt times.

Workstations	COT (s)	AOP (s)	TT (s)
W1	2400	21000	21
W2	420	22980	22.98
W3	0	23400	23.4
W4	300	23100	23.1
W5	2010	21390	21.39
W6	1080	22320	22.32
W7	0	23400	23.4



FIGURE 4 | The balance chart of the value stream.



FIGURE 5 | The balance chart after SMED.

After using SMED, some workstation cycle times still exceeded workstation takt times. Job Design was used to reduce workstation cycle times CTs. The results are shown in Table 6.

The balance chart after using Job design is shown in Figure 6.

Looking at the chart, the cycle times of workstations 4 and 6 still exceeded takt times. On the other hand, the value stream was unbalanced. Line balancing needed to be applied to balance the stream and to meet takt time. After using Line Balancing, there were 6 news stations in the value stream with cycle times CT, changeover time COT, takt time TT shown in Table 7.

The balance chart after using Line Balancing is shown in Figure 7.

TABLE 5 | Workstation takt times after SMED.

Station	COT (s)	AOP (s)	TT(s)
W1	1470	21930	21.93
W2	0	23400	23.4
W3	0	23400	23.4
W4	0	23400	23.4
W5	990	22410	22.41
W6	840	22560	22.56
W7	0	23400	23.4

TABLE 6 | Workstation CTs after Job Design.

	W1	W2	W3	W4	W5	W6	W7
CT (s)	15	15	10	26	11	24	19
TT(s)	21.93	23.4	23.4	23.4	22.41	22.56	23.4



FIGURE 6 | The balance chart after Job Design.



FIGURE 7 | The balance chart after Line Balancing.

The number of workers was reduced from 7 to 6. All the workstations then met their takt times, but the value stream was still unbalanced. In order to reduce lead time, inventories needed to be reduced and controlled. Raw materials would be reduced to 3000 and finished goods would be kept at the level of 500. Kanban and FIFO systems needed to be installed to control WIP inventories.

With review from (7), dual kanban systems were placed between stations 1 and 2, stations 4 and 5, as shown in Figure 8.

After collecting data, daily demand D of back workstation, front workstation lead time L (day), safety parameter α and container size Q were estimated and are shown in Table 8. The numbers of Kanban cards N were calculated and are also shown in Table 8. There were 3 cards in the supermarket between W1 and W2, and 2 cards in the supermarket between W4 and W5.

TABLE 7 | The cycle times CTs of the 6 news stations after using Line Balancing.

	W1	W2	W3	W4	W5	W6
CT (sec)	20	22	19	18	20	13
COT (min)	24.5	0	0	16.5	14	0
TT (sec)	21.9	23.4	23.4	22.4	22.6	23.4

TABLE 8 | The calculation of number of Kanban cards between stations.

Between stations	D (u)	LT (d)	α (%)	Q (u)	N
W1 – W2	1000	0.020	10	10	2.196
W4 – W5	1000	0.014	10	10	1.569

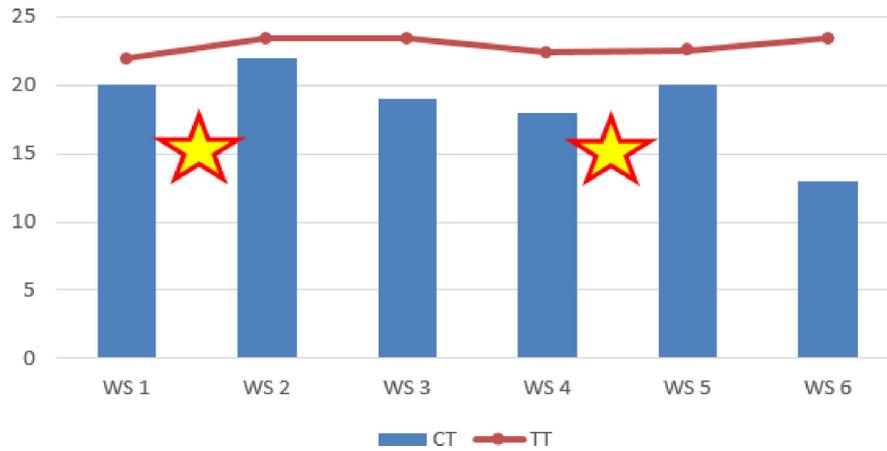


FIGURE 8 | The positions of Kanban systems.

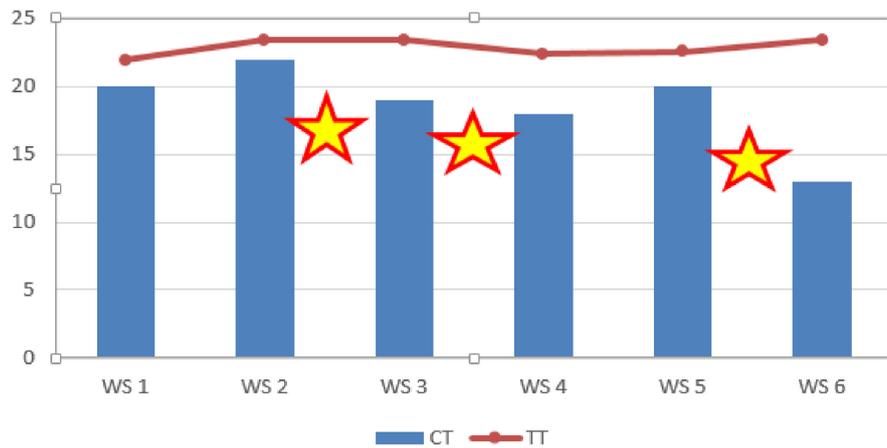


FIGURE 9 | The positions of FIFO lanes.

FIFO lanes would be placed between stations 2 and 3, stations 3 and 4, stations 5 and 6 as shown in Figure 9.

After collecting data, the cycle time means M , and standard deviations SD of front and back workstations, and station down time DT of front workstations were estimated and are shown in Table 9. The sizes S of the corresponding FIFO lanes were calculated by the supporting software provided by Christoph Roser in (10) and the results are shown in Table 9.

From all the above data, the FSM from the supplier to the customer was drawn and shown in Figure 10, with inventory I (units), number of workers N , cycle time CT (sec),

TABLE 9 | The calculation of FIFO lane size.

FIFO		M (sec)	SD (sec)	DT (sec)	S
W2-W3	W2	22	2.3	210	10
	W3	19	1.5		
W3-W4	W3	19	1.5	120	7
	W4	18	3		
W5-W6	W5	20	4	150	8
	W6	13	3		

TABLE 10 | The results of the implementation.

	CSM	FSM
Lead time LT (hours)	42.4	22.8
Cycle time CT (sec)	32s	22s
Number of worker N	7	6

changeover time COT (hours), value added time VAT (sec), non-value added time $NVAT$ (hours).

From the map, the future performance indexes, including process lead time LT , and process cycle time CT were as follows.

$$LT = 22.8 \text{ h}$$

$$CT = 22 \text{ s}$$

In order to assess the lean improvement, the critical performance indexes of the maps CSM and FSM are shown in Table 10.

From the table, we see that the number of workers was decreased from 7 to 6, the process lead time was reduced

Sup.	🚚	W1	🏢	W2	FIFO	W3	FIFO	W4	🏢	W5	FIFO	W6	🚚	Cust.
I	3000		30		10		7		20		8		500	
N		1		1		1		1		1		1		
CT		20		22		19		18		20		13		
COT		24.5		0		0		16.5		14		0		
VAT		20		22		19		16		20		13		
NVAT	19.5		0.195		0.065		0.045		0.13		0.052		3.25	

FIGURE 10 | The future state map FSM.

by 46.23% from 42.4 to 22.8 h, the process cycle time was reduced 31.25% from 32 to 22 s, meeting the TT.

Conclusion

The paper applied the VSM methodology to improve the production process of the company with the objective of reducing process lead time and process cycle time to meet takt time. The current state map (CSM) was constructed, and the current performance indexes were assessed. The future state map (FSM) was constructed using lean tools of SMED, Job Design, Line Balancing, Kanban, and FIFO systems. From the map, the future performance indexes were assessed.

The results showed that the objectives were achieved. The process lead time was reduced by 46.23% from 42.4 to 22.8 h, the process cycle time was reduced 31.25% from 32 to 22 s, meeting the TT. These positive results would lead to an improvement of on-time delivery rate. On the other hand, the number of workers was decreased from 7 to 6.

However, the paper also has some limitations. The data were collected in a short duration, not enough for better parameter estimations to make better results. The future state map hasn't been experimented to validate the real improvement. Future research would have new vistas that overcome these limitations.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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