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Car Assembly Line Efficiency Improvement by Lean Principle

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Abstract: This research aimed to increase the efficiency of actual working time to compare to design standard time ratio (DSTR) as per analysing process of Lean System of the assembly line in a car manufacturer in Thailand. Currently, the case study factory and its group of factories, which have many branches all over the world, have competed with each other on quality, delivered time and production cost. The production cost which can reduce without affecting quality and acceptable by clients is the manpower cost. The index of competition is DSTR. The factory now has DSTR of 6.13 and DSTR of the assembly department is 4.24 which is very high comparing to other departments. The low DSTR indicates that the factory has good quality. The ways to solve the problem are to apply the following tools, i.e. Lean principle, Value Stream Mapping (VSM), Waste Analysis and ECRS. After implementing the above tools, the results showed that DSTR decreased from 4.24 to 4.06 or 4.25%.

1. Introduction

The case study factory is one of the top-three Japanese car assembly plants in Thailand that produces products as passenger car, sedan, SUV, etc. The production process consists of five steps (Fig.1). Due to the sluggish of world economy, the purchasing power of consumers tends to decrease substantially causing reduced production volume in all plants. As a result, the factories in the group start to benchmark and compete with each other about quality, delivered time and production cost so that they could be able to accept more demand since they are more efficient than the others. However, the policy of the group mentions that reduction in the production cost has to be done without affecting quality. Therefore, the group decides to focus on improving the cost of manpower. The index that the group used to indicate the manpower cost of factories is the Design Standard Time Ratio (DSTR). It is an index to show the ratio of value-added in all operations and can be used to compare productivity of the company at the global level. Refer to the ranking of DSTR, it was found that the factory has DSTR of 6.13 (Fig. 2). When considering the DSTR index, several production aspects could not be compared. Therefore, the factory re-computes the index based on the cars with the same sizes. The DSTR index can be calculated as follows.

$$DSTR = \frac{Actual\ Working\ Time\ x\ Man\ Power}{Design\ Standard\ Time\ x\ Production\ Volumn} \quad (1)$$

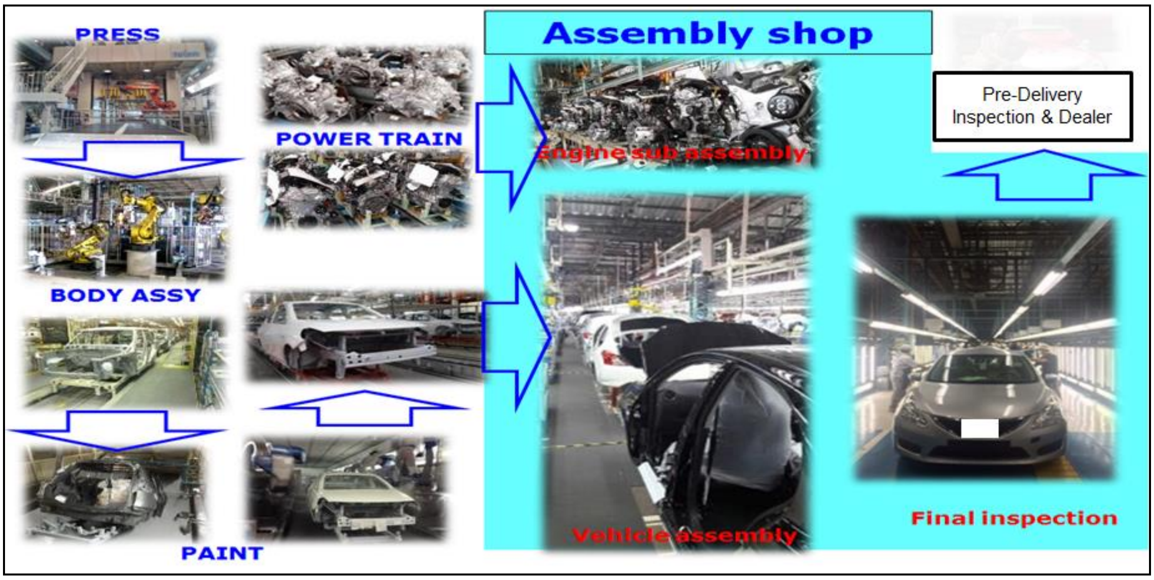

Figure 1. Production Process

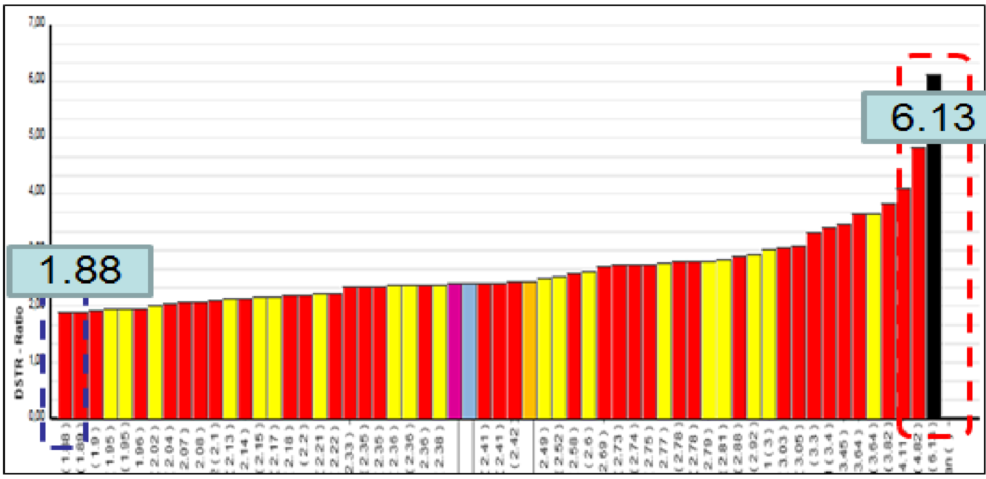

Figure 2. DSTR Plant Ranking

The other index that directly affects DSTR is the efficiency of the production line, namely the percentage of job balance (%JB). This index is depended on the percentage of work balancing efficiency that is used as a main factor and it can be calculated as follows.

$$\%Job\ balance = \frac{Total\ Actual\ Time\ x\ 100}{Tact\ Time\ x\ Manpower} \quad (2)$$

The relation between the equations (1) and (2) shows that the main factor is manpower. If we have more manpower, it will increase DSTR and decrease %JB.

From five steps of the production process, the processes that is used to calculate DSTR consisting of the body shop, paint shop and assembly shop. Historical data shows that the process which has highest DSTR is the assembly shop (DSTR = 4.24 and %JB = 73%) which is lowest compared to the other processes. The factor that affects DSTR of the assembly shop is that the assembly shop mainly uses manpower while the other processes mostly used machines to produce parts as shown in Table 1.

Table 1. Percentage of job balance for each shop

Dept	Body Shop	Trim&Chassis	Paint Shop						
			PBS	Seal	Sursand	Surfacer	Top Coat	Touch up	Under Coat
Actual time	722.95	360.5	13.6	41.51	18.88	19.21	23.86	18.92	18.45
Tact Time	2.48	2.28	2.45	2.5	2.6	2.72	1.66	2.59	2.5
Man Power	325	216	6	18	8	8	16	8	8
Job Balancing Ratio	89.7	73.2	92.51	92.24	90.76	88.28	89.83	91.31	92.25
			91.03						
DSTR	1.08	4.24	0.81						

The Lean Principle, that is create the manufacturing operation focused on continuous improvement [1], was considered by using Value Stream Mappings that is all actions (bolt value added and non-value added) currently required to bring a product through the main flows essential to every product. Therefore value stream map support people to see waste in process [2-3], it is found that the current value stream mapping of the production process has DSTR of 4.24 (Fig. 3)

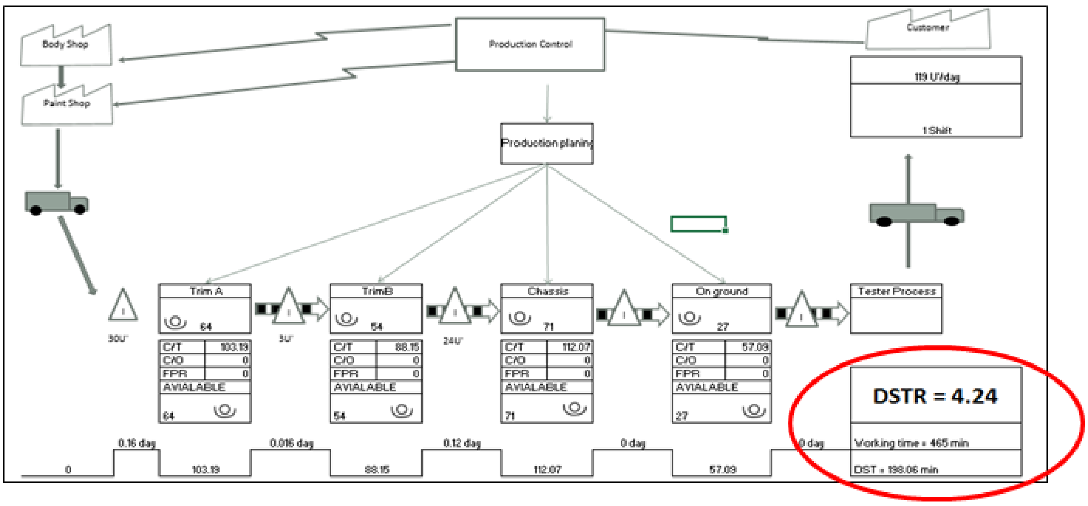

Figure 3. Current Value Stream Mapping of Assembly Shop

From the above problem, the factory decides to increase the actual working time of DSTR by using the following tools, i.e. Lean principle, Value Stream Mapping (VSM), Eliminate, Combine, Rearrange, Simplify (ECRS) and Waste Analysis (Seven types of wastes include Overproduction, Defects, Unnecessary Inventory, Inappropriate Processing, Excessive Transportation, Waiting and Unnecessary Motion) [4-6].

2. Problem Analysis

From the Current VSM, it is found that the assembly shop had DSTR of 4.24. From the production process time analysis, the bottlenecks include Set FR STRUT, Set RR SUSP, Set RR Shock and Mounting Engine. The flow process chart is analyzed and found that the waste comes from duplicated works between operators and in-line quality assurance officer (IQA), who is check man for recheck torque wrench. The duplicated process is the Tightening Torque which the worker needs to do it twice; therefore, these processes is the bottleneck and affects the next process since parts could not be sent according to the Takt time which is 2.28 minutes. For example, the station Set RR brakes Assembly RH and found that the assembly point has duplicated works between operators and IQA (Fig.4). The cycle time and man power of the bottleneck stations are summarized was shown in Table 2.

Item	Set RR brake Ass'y RH	Operation	Transportation	Inspection	Delay	Storage	VA	NVA
1	Check spec RR SUSP			●				0.05
2	Picking RR SUSP to jig fixture		●					0.15
3	Picking RR brake RH, LH to jig fixture		●					0.05
4	Assembly spindle to RR brake RH	●					0.44	
6	Temporary tightening SCR to PKB CABLE and PKB BRK'T RH (4 pcs)	●					0.16	
7	Tightening SCR (4 pcs)	●					0.1	
8	Assembly SENSANTISKID RR LH to RR brake ass'y RH	●					0.2	
9	Temporary tighten bolt to SENSANTISKID	●					0.15	
10	Tightening bolt to SENSANTISKID	●					0.1	
11	Assembly INSUL brake tube and press grommet to brake hose sensor harn BRK'T LH	●					0.15	
12	Assembly HSG RR AXEL to RR SUSP	●					0.2	
13	Assembly brake ass'y LH and HUB BRG wheel to RR SUSP	●					0.2	
14	Torque bolt FIX FLG to brake (4 pcs)	●					0.3	
15	Torque bolt SENSANTISKID	●					0.05	
16	Wiring brake tube to RR SUSP	●					0.05	
17	Check mark			●			0.05	
	Total	12	2	2	0	0	2.15	0.25
	Total C/T	2.4						

Item	Re-check torque RR brake RH	Operation	Transportation	Inspection	Delay	Storage	VA	NVA
1	Torque bolt FIX FLG to brake (4 pcs)	●					0.3	
2	Torque bolt SENSANTISKID	●					0.05	
3	Check mark			●			0.05	
	Total	2	0	1	0	0	0.4	
	Total C/T	0.4						

Figure 4. Flow Process Chart of RR SUSP (Set RR brake Ass'y)

Table 2. Cycle time and manpower for each process

Process	C/T *Remak Takt Time = 2.28 min	Man Power Operator	IQA
1.RR SUSP			
1.1 Set RR brake ass'y RH	2.8	1	1
1.2 Set RR brake ass'y LH	2.8	1	1
1.3 Set RR Drum brake RH	2.8	1	1
1.4 Set RR Drum brake LH	2.8	1	1
2. Sub assembly FR STRUT			
2.1 Sub FR STRUT RH	2.3	1	1
2.2 Sub FR STRUT LH	2.3	1	1
3. RR Shock			
3.1 Set RR shock RH	2.6	1	1
3.2 Set RR shock LH	2.6	1	1
4. Mounting Engine			
4.1 Set mounting engine LH	2.38	1	
4.2 Set mounting engine RH	2.38	1	
4.3 Fix FR STRUT to FR Axel I	2.38	1	1
4.4 Fix FR STRUT to FR Axel I	2.38	1	1
4.5 Fix FR SUSP MBR	2.38	1	

3. Process Improvement

The standard quality assurance system of the factory has three levels of checking for tightening was shown in Table 3.

1) Alfa (α) level was a high level, i.e. checking without IQA but needs to bring the system wrench that records torque and the line stop system to help.

2) Beta (β) level was a medium level, i.e. checking by bringing shut-off wrench to help and needs to have IQA to check by touching.

3) Gamma (γ) level was a low level checking, i.e. system wrench or shut-off wrench are not used to help, but needs to be rechecked by operators and IQA.

Table 3. Standard assurance system

		Imp AB(tightening)	Imp C(tightening)
α	Built-in	HCT & Line stop	Shut-off wrench & Control the number of tightening
	Outflow prevention		
β	Built-in	HCT & Control the number of tightening	Shut-off wrench
	Outflow prevention	check by touching	check by touching (Same operator is possible for low JPH)
γ	Built-in	Torque wrench	Torque wrench
	Outflow prevention	Torque recheck	check by touching

Currently, the process of work of the factory has to check at the Grammar (γ) level; therefore, it should be improved the process by decreasing the waste from duplicated working of operators and IQA by bringing the system wrench which records torque point to help in α level as shown in Table 3. It will help to reduce in-line quality assurance as well (Fig.5)

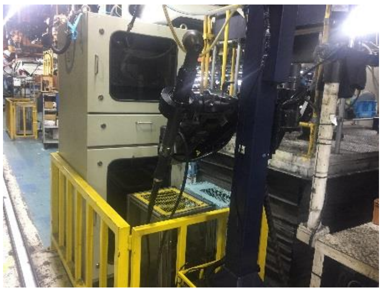

Figure 5. System Wrench Nut Runner and Line Stop

4. Result and Discussion

After the improvement by adding the system wrench nut runner and line stop, it could decrease the waste from duplicated works between operators and IQA that needs to torque (Fig. 6) and reduce the bottleneck of the process as shown in Table 4.

Item	Set RR brake Ass'y RH	Operation	Transportation	Inspection	Delay	Storage	VA	NVA
1	Check spec RR SUSP			●				0.05
2	Picking RR SUSP to jig fixture		●					0.15
3	Picking RR brake RH, LH to jig fixture		●					0.05
4	Assembly spindle to RR brake RH	●					0.44	
6	Temporary tightening SCR to PKB CABLE and PKB BRK'T RH (4 pcs)	●					0.16	
7	Tightening SCR and torque(4 pcs)	●					0.2	
8	Assembly SENSANTISKID RR LH to RR brake ass'y RH	●					0.2	
9	Temporary tighten bolt to SENSANTISKID	●					0.15	
10	Tightening bolt to SENSANTISKID and torque	●					0.2	
11	Assembly INSUL brake tube and press grommet to brake hose sensor harn BRK'T LH	●					0.15	
12	Assembly HSG RR AXEL to RR SUSP	●					0.2	
13	Assembly brake ass'y LH and HUB BRG wheel to RR SUSP	●					0.2	
16	Wiring brake tube to RR SUSP	●					0.05	
17	Check mark			●			0.05	
	Total	12	2	2	0	0	2	0.25
	Total C/T	2.25						

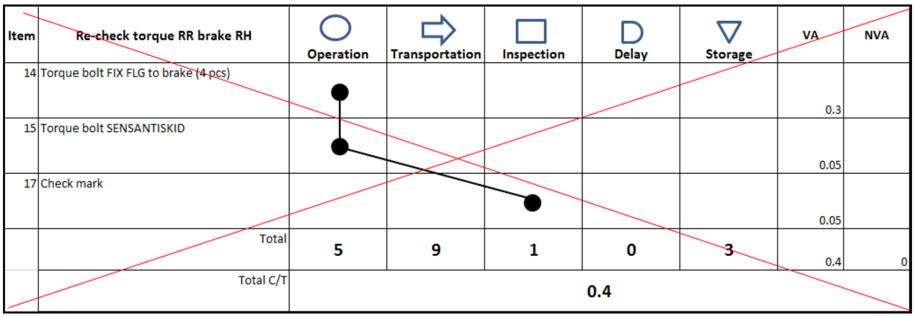

Figure 6. Flow Process Chart after Improvement

Moreover, it could reduce the number of IQA for 10 persons, from 216 persons to 206 persons, or 4.63% and the %JB increases from 73.20 to 75.57 or 3.24% as shown in Table 5. In addition, DSTR is reduced from 4.24 to 4.06 or 4.25%. Table 4 shows the new cycle time and manpower requirement after the improvement. The new Value Stream Mapping after improvement is shown in Fig. 7.

Table 4. Cycle time and manpower after improvement

Process	C/T	Man Power	
	*Remak Takt Time = 2.28 min	Operator	IQA
1.RR SUSP			
1.1 Set RR brake ass'y RH	2.25	1	
1.2 Set RR brake ass'y LH	2.25	1	
1.3 Set RR Drum brake RH	2.25	1	
1.4 Set RR Drum brake LH	2.25	1	
2. Sub assembly FR STRUT			
2.1 Sub FR STRUT RH	1.74	1	
2.2 Sub FR STRUT LH	1.74	1	
3. RR Shock			
3.1 Set RR shock RH	2.15	1	
3.2 Set RR shock LH	2.15	1	
4. Mounting Engine			
4.1 Set mounting engine LH	2.08	1	
4.2 Set mounting engine RH	2.08	1	
4.3 Fix FR STRUT to FR Axel L	2.08	1	
4.4 Fix FR STRUT to FR Axel L	2.08	1	
4.5 Fix FR SUSP MBR	2.08	1	

Table 5. Percentage of job balance of assembly shop after improvement

Dept	Body Shop	Trim&Chassis	Paint Shop						
			PBS	Seal	Sursand	Surfacer	Top Coat	Touch up	Under Coat
Actual time	722.95	354.94	13.6	41.51	18.88	19.21	23.86	18.92	18.45
Tact Time	2.48	2.28	2.45	2.5	2.6	2.72	1.66	2.59	2.5
Man Power	325	206	6	18	8	8	16	8	8
Job Balancing Ratio	89.7	75.57	92.51	92.24	90.76	88.28	89.83	91.31	92.25
			91.03						
DSTR	1.08	4.06	0.81						

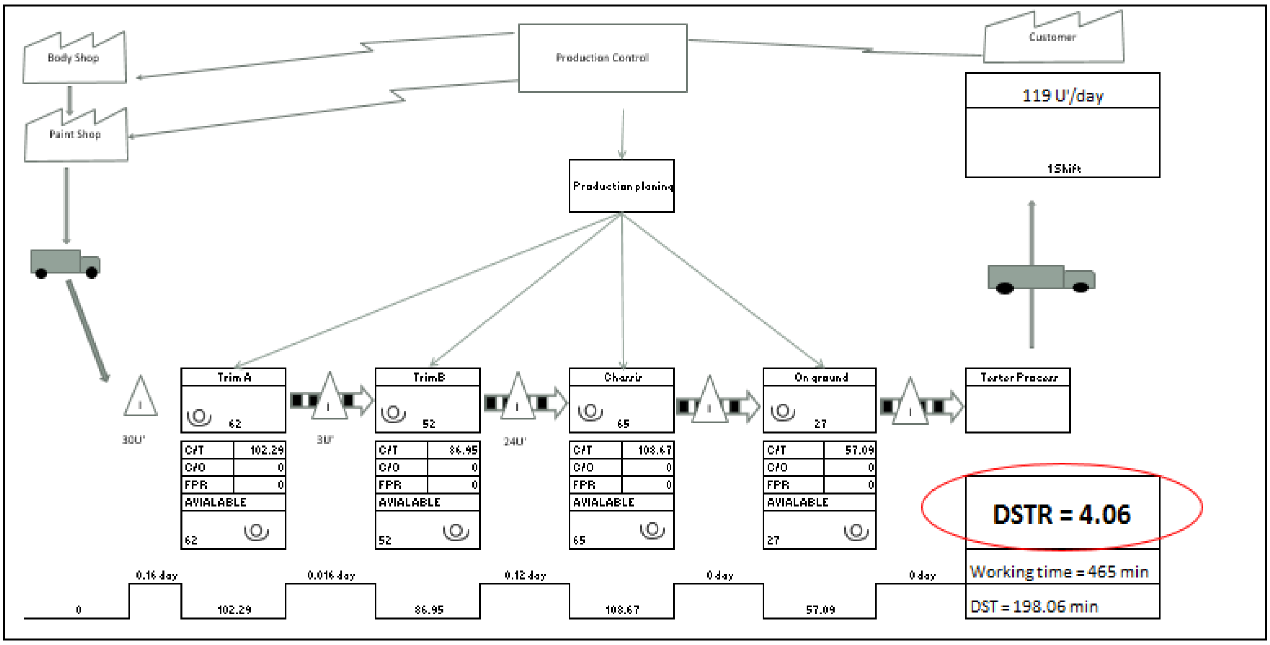

Figure 7. Value Stream Mapping of Assembly Shop after Improvement

From Figure 7, the value of DSTR is calculated as follows.

$$DSTR = \frac{Actual\ Working\ Time\ x\ \text{Man Power}}{\text{Design Standard Time}\ x\ \text{Production Volumn}}$$

$$DSRT = \frac{465\ x\ 206}{198.06\ x\ 119} = 4.06$$

5. Conclusion

This research aimed to use the Lean principle as a tool to improve the wasted process. The information is gathered from the Flow Process Chart to analyze jobs and classified them as valuable, wasted and duplicated jobs. The jobs are improved by adding the System Wrench Nut Runner and Line Stop. After the improvement, the waste from duplicated jobs between the operators and IQA is reduced. As a result, the value of DSRT is reduced significantly (i.e. 10 operators are removed from the assembly line) and the workload balance is improved.

References

[1] Feld, W.M. 2001 Lean Manufacturing : Tools, Techniques and How to them. Florida : St.Lucie.
[2] Markus L.Stamm, Thomas Noitzert. School of Engineering AUT University Auckland, New Zealand
[3] Sullivan, W.G., Mcdonold, T.N., Eileen, M. and Aken, V. 2002 Equipment Replacement Decision and Lean Manufacturing Elsevier Science Ltd.
[4] Hines, P. and Taylor, D. 2000 Going Lean. UK : Lean Enterprise Research Centre Cardiff Bussiness School.
[5] Ohno, T. 2002 Toyota Production System : Beyond Large Scale Production. Oregon : Productivity.
[6] Liker, J.K. 2004 The Toyota Way. New York : McGraw-Hill.