IMPROVEMENT OF KANBAN SYSTEM BASED ON THEORY OF CONSTRAINT

Rahmi Maulidya, Iveline Anne Marie, Kevin Wijaya

Industrial Engineering Department, Trisakti University, Jakarta, Indonesia
E-mail : rachmi@trisakti.ac.id, ivelineannemarie@yahoo.com

ABSTRACT

In order to synchronizing the shop floor, theory of constraint can identify the bottleneck machines. For company that has already use kanban system, there is posibility that the number of kanban is larger than it should be. It also gives impact to the shop floor. Kanban is an instruction for doing the production. But when kanban in the system is more larger, it will effect the shop floor from the number of work in process. The evaluation is recommended to decide the right number of kanban in the system and the right kanban system used. After focusing on the bottleneck machine and determine time buffer adding to the system, we use three scenarios for simulating the right kanban system. The scenarios are Kanban by product with time buffer, Kanban by process, and kanban by process with time buffer.

Key words : *Kanban, Theory of constraint, WIP, simulation*

1. INTRODUCTION

Theory of Constraint is an effort to increase shop floor performance. It can help to synchronize the production flow.

For some company that has implemented the kanban, it is necessary to evaluate the number of kanban in the system periodically. Sometimes, the number of kanban in the system is larger than it should be, and vice versa. The effect of so many kanban in the system is in the number of work in process. Every machines has different capacity, it also can cause various number of work in process.

Problem occurs is the accumulation of intermediate products (WIP) on the production floor. Stacking is impacting on the number of semi-finished products are to be rust due to the length of storage on the production floor, so that the necessary additional processes such as cleaning the rust that affects the company's increasing operational costs.

2. THEORETICAL BACKGROUND

2.1. Theory of constraint

Theory of constraints (TOC) is a phylosofi management developed by Eliyahu M Goldratt. TOC state that company's performance is sorrounded with constraint. This theory is admited that every company is limited by constraint, then we should develop an approach for the objective of continuous improvement.

According to Blocler et.al (2000), this theory helps company to effectively increase the important key success that is waiting time which indicate the period of time to transform product from raw material. TOC is focused on the speed of raw material being produced, buying the component, processing the finished product and customer delivery. TOC focus on improvement of throughput by eliminating waste. menekankan perbaikan *throughput* dengan cara mengubah atau menurunkan pemborosan dalam proses produksi yang mengurangi tingkat *output* yang dihasilkan.

According to Fogarty (1991), TOC accept the unbalance of factory when one of resource have unequal capacity than other resource. According to Tersine (1994), TOC is a phylosofi of continuous improvement which focus on identification on the constraint to achieve company's target. According to TOC, if you want to increase the whole company's profitability, so you should identify the constraint, exploite the constraint in short term and in the long term to find the way out of handling the constraint.

2.2. Time Buffer

Every resource has different capacity and the resource that become a constraint for others is called *bottleneck*. Resource has to be protected from statistically fluktuation and constraint from the previous resource. To cut the idle from constraint resource as an effect of previous resource, buffer is put in front of constraint buffer. This buffer has also a function to synchronizing the production and also known as protective buffer.

There are two types of Buffer (Umble dan Srikanth, 1996) :

1. Time buffer is adding more time as a buffer for protecting the throughput from constraint of the system
2. Stock buffer, is adding more finished goods or more work in process as a buffer to respon the demand, so production can be finished faster than usual.

Based on the two types of buffer, in this paper we use time buffer. Time buffer can protect the throughput from internal constraint. Inventory in the constraint resource seems like stock buffer, but the fact is inventory occur whenever we add time buffer to production.

Time buffer is time that needed to support the production and protect the throughput from constraint in the system. Equation for counting the time buffer is :

$$TB = K - Ki \qquad (1)$$

Where :
TB = Time Buffer (minute)
K = required time (minute)
Ki = available capacity (minute)

2.3. Kanban

Kanban is japanese means "*visual record or signal*". Just in time use information flow such as kanban in the form of card, flag or signal. Kanban is an information system use in many manufacturing company that harmonizely controlling the right number of producing a product in the right moment (Subagyo, 2010).

Production Kanban (P-Kanban) is an instruction card fro workstation to do the production of a component. And conveyance kanban (C-kanban) is an instruction card for asking the component from the previous workstation. Equation to know the number of kanban needed is :

$$Kp = \frac{D(P)(1+SF)}{Q} \qquad (2)$$

$$Kc = \frac{D(C)(1+SF)}{Q} \qquad (3)$$

Where :
Kp = number of P-Kanban
Kc = number of C-Kanban
D = demand per day (unit/day)
Q = container capacity (unit)
SF = Safety coeffisien (10 %)
P = lead time for using P-Kanban (minute)
C = lead time for using C-Kanban (minute)

3. RESEARCH METHOD

To increase the shop floor performance and to synchronize the production, we use theory of constraint. First step in TOC is to count the required and available capacity. Required Capacity is obtained from the total of processing time each type of product. Available capacity is obtained from the daily work hours. By comparing the available and required capacity, we can decide the bottleneck and CCR machines. Bottleneck is handled by adding time buffer. Time buffer is put in front of the bottleneck machine. After the flow is synchronous then the kanban system must be improved. The objective of improvement kanban system is to determine the right number of kanban in the shop floor.

4. RESULT AND DISCUSSION

This paper is using data of a manufacture of automobile parts like Oil Cooler. Oil Cooler products consist of four raw materials like outer pipe, inner pipe, fin w64.8 and fin w52.2. Oil Cooler product line is made in three mutually connected and respectively include assembly line, tig welding line and finish good line in Figure 1.

Number of machines for M1,...,M20 is 1. Setup time for M1,M2,M3 is 600 minute, for M4,...M19 is 300 minute and for M20 is 0.

Table 1. Required and Available Capacity in a week (minute)

Machine	Required capacity	Available capacity	Percentage	Note
M1	1801,63	4800	37,53%	Valid
M2	1799,26	4800	37,48%	Valid
M3	1808,91	4800	37,69%	Valid
M4	1378,32	4800	28,72%	Valid
M5	1375,31	4800	28,65%	Valid
M6	5320,19	4800	110,84%	Not Valid
M7	5639,42	4800	117,49%	Not Valid
M8	4882,50	4800	101,72%	Not Valid
M9	4852,11	4800	101,09%	Not Valid
M10	806,71	4800	16,81%	Valid
M11	817,98	4800	17,04%	Valid
M12	808,60	4800	16,85%	Valid
M13	810,72	4800	16,89%	Valid
M14	5566,84	4800	115,98%	Not Valid
M15	1132,28	4800	23,59%	Valid
M16	5589,42	4800	116,45%	Not Valid
M17	1149,07	4800	23,94%	Valid
M18	5590,23	4800	116,46%	Not Valid
M19	2559,27	4800	53,32%	Valid
M20	2556,72	4800	53,27%	Valid

Machines that have the required capacity over the available capacity are machine M6, M7, M8, M9, M14, M16, and M18. It is called bottleneck machines. Others are non bottleneck machines. Machine becomes a constraint, can be identified into Capacity Constraint Resource (CCR). CCR is a source for potential problem when it doesn't manage well and can cause a bottleneck. The machines are clasified into CCR-Bottleneck, CCR-non Bottleneck, non CCR-Bottleneck and non CCR-non Bottleneck (Table 2). M7 is a constraint because there is delay for the flow of material to the next machine. The capacity in M7 is higher than M8. Do the same for the other machines.

Table 2. Table Machines classification

	Bottleneck	Non Bottleneck
CCR	M7, M8, M9, M14, M16, M18	-
Non CCR	M6	M1, M2, M3, M4, M5, M10, M11, M12, M13, M15, M17, M19, M20

Time buffer will be given to the seven bottleneck machines. The objectives of adding time buffer is to give additional time for synchronizing shop floor to reach the target. The seven machine's time buffer is obtained using (1). Time buffer will be put in front of the bottleneck machines (Figure 2). *Time buffer* for M6 is 8,67 hour, M7 is 14 hour, M8 is 1,38 hour, M9 is 0,87 hour, M14 is 12,79 hour, M16 is 13,16 hour and M18 is 13,18 hour.

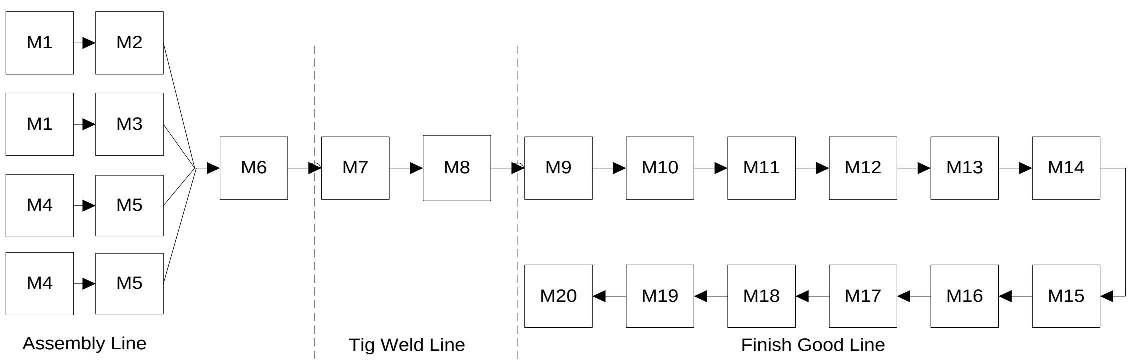

Figure 1. Production Flow

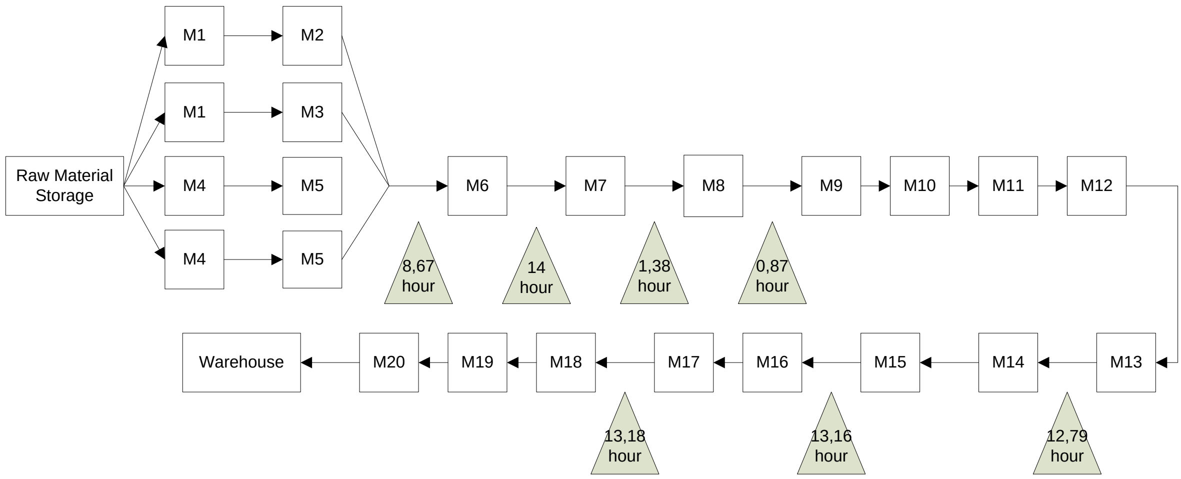

Figure 2. Production Flow with time buffer

Allocation for Time Buffer is 2 hour/day after shift#1 finished, from 16.30 untill 18.30 daily but more time buffer can be allocated in Saturday. Time Buffer will synchronizing the production. Kanban system that has been applied to the shop floor is kanban by product. The kanban card is too many in the shop floor. Safety Factor (SF) is 10%. Working day is 16,5 day. Demand (D) is 3.560 unit/month. Container quantity (Q) is 10% from Demand per day. Total time for production lead time in M7 is 0,07 minutes and Total time for conveyance lead time in M7 is 0,06 minutes. Production kanban and Conveyance Kanban by process is obtained using equation (2) and (3) :

$$Kp = \frac{D(P)(1+SF)}{Q} = \frac{216(0.07)(1+0.1)}{22} = 1\ kanban$$

$$Kc = \frac{D(C)(1+SF)}{Q} = \frac{216(0.06)(1+0.1)}{22} = 1\ kanban$$

Number of work in process in M7 is max [Kp,Kc]*Q = max[1,1]*22 = 22 unit

The number of kanban in each line is summarized in Table 3. Assembly line and Tig Welding line must decrease the number of kanban in shop floor whether the finish good line must increase the number of kanban in shop floor.

Table 3. The number of kanban in each line

	assembly line			Tig Welding line			Finish Good line		
Kp	101	48	-53	16	14	-2	89	132	+43
Kc	73	63	-10	17	16	-1	100	136	+36

For assembly line, work in process will decrease untill 48,65%. For Tig Welding line is 69,14% and Finish Good line is 33,51%.

The recent shop floor, use kanban by product, is simulated in Promodel 4.0.

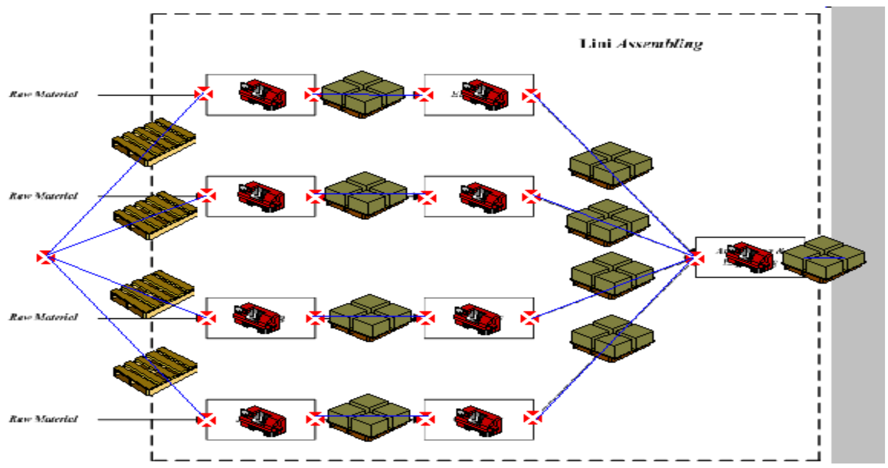

Figure 3. Layout in promodel For assembly line

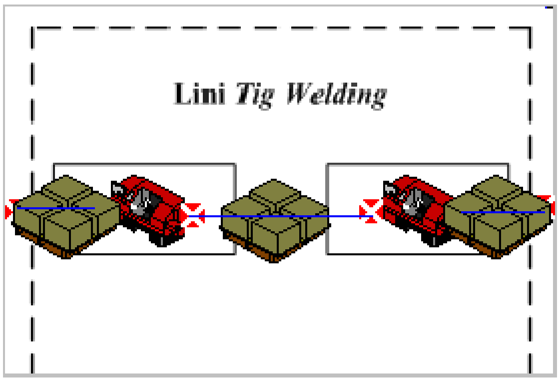

Figure 4. Layout in promodel For tig weldingline

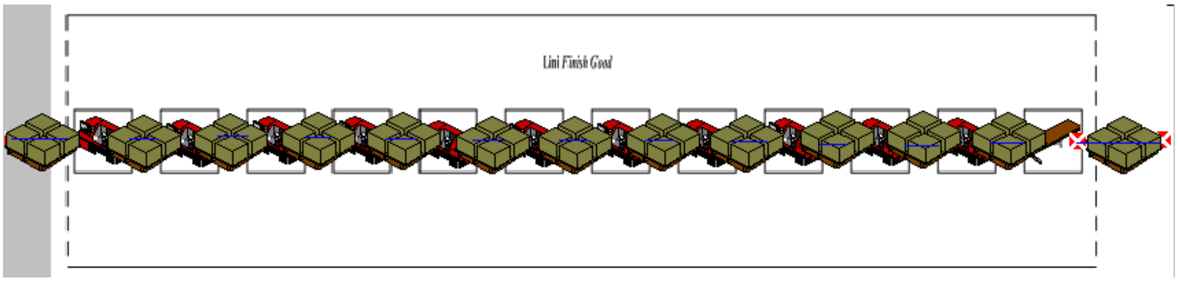

Figure 5. Layout in promodel For finish good line

Simulation is verified and it is valid, so we can continue to run the three scenario.
Scenario 1 : Kanban by product with time buffer

Report for assembling (Avg. of 10 replications)

General | Locations | Location States Multi | Location States Single/Tank | Resources | Resource States | Node Entries | Failed Arrivals | Entity Activity | Entity States | Variables | Location Costing

Entity Activity for assembling (Avg. of 10 replications)

Name	Total Exits	Current Qty In System	Avg Time In System (MIN)	Avg Time In Move Logic (MIN)	Avg Time Wait For Res (MIN)	Avg Time In Operation (MIN)	Avg Time Blocked (MIN)
Pipe Outer IMV CAMRY	0.00	647.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner IMV CAMRY	400.00	247.00	3183.45	141.84	460.93	23.65	2557.03
Pipe Outer P CAR	0.00	216.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner P CAR	0.00	216.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer CRV APV	0.00	259.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner CRV APV	0.00	259.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer 160P 390N	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner 160P 390N	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer YY6	0.00	20.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner YY6	0.00	20.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer B CAR	0.00	95.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner B CAR	0.00	95.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer KF60R	0.00	3.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner KF60R	0.00	3.00	0.00	0.00	0.00	0.00	0.00
Fin W648	0.00	4512.00	0.00	0.00	0.00	0.00	0.00
Fin W522	0.00	2483.00	0.00	0.00	0.00	0.00	0.00
Assy IMV CAMRY	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy P CAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy CRV APV	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy 160P 390N	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy YY6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy B CAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy KF60R	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 6. General Report for Scenario 1 in Assembling Line

Report for tig welding (Avg. of 10 replications)

General | Locations | Location States Multi | Location States Single/Tank | Resources | Resource States | Node Entries | Failed Arrivals | Entity Activity | Entity States | Variables | Location Co:

Entity Activity for tig welding (Avg. of 10 replications)

Name	Total Exits	Current Qty In System	Avg Time In System (MIN)	Avg Time In Move Logic (MIN)	Avg Time Wait For Res (MIN)	Avg Time In Operation (MIN)	Avg Time Blocked (MIN)
Assy IMV CAMRY	316.40	330.60	3759.23	35.63	1075.92	20.31	2627.38
Assy P CAR	0.00	216.00	0.00	0.00	0.00	0.00	0.00
Assy APV CRV	0.00	259.00	0.00	0.00	0.00	0.00	0.00
Assy YY6	0.00	20.00	0.00	0.00	0.00	0.00	0.00
Assy 160P 390N	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Assy B CAR	0.00	95.00	0.00	0.00	0.00	0.00	0.00
Assy KIJANG	0.00	3.00	0.00	0.00	0.00	0.00	0.00

Figure 7. General Report for Scenario 1 in Tig Welding Line

Report for finish good (Avg. of 10 replications)

General | Locations | Location States Multi | Location States Single/Tank | Resources | Resource States | Node Entries | Failed Arrivals | Entity Activity | Entity States | Variables | Location Costing

Entity Activity for finish good (Avg. of 10 replications)

Name	Total Exits	Current Qty In System	Avg Time In System (MIN)	Avg Time In Move Logic (MIN)	Avg Time Wait For Res (MIN)	Avg Time In Operation (MIN)	Avg Time Blocked (MIN)
Assy CAMRY	48.00	0.00	235.14	6.49	0.00	62.49	166.15
Assy IMV	185.00	0.00	1334.80	33.75	0.00	70.21	1230.83
Assy P CAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy B CAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy CRV	204.00	0.00	3012.69	79.25	0.00	64.49	2868.94
Assy APV Domestic	10.00	0.00	3816.71	104.29	0.00	63.70	3648.72
Assy YY6 Domestic	20.00	0.00	3925.58	107.80	0.00	63.21	3754.58
Assy IMV Domestic	145.00	669.00	4921.78	127.39	316.84	70.69	4406.86
Assy 160P390N Domestic	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Assy KF Domestic	0.00	3.00	0.00	0.00	0.00	0.00	0.00
Assy CRV Domestic	0.00	46.00	0.00	0.00	0.00	0.00	0.00

Figure 8. General Report for Scenario 1 in Finish Good Line

Scenario 2 : Kanban by process

Report for assembling (Avg. of 10 replications)

General | Locations | Location States Multi | Location States Single/Tank | Resources | Resource States | Node Entries | Failed Arrivals | Entity Activity | Entity States | Variables | Location Costing

Entity Activity for assembling (Avg. of 10 replications)

Name	Total Exits	Current Qty In System	Avg Time In System (MIN)	Avg Time In Move Logic (MIN)	Avg Time Wait For Res (MIN)	Avg Time In Operation (MIN)	Avg Time Blocked (MIN)
Pipe Outer IMV CAMRY	0.00	647.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner IMV CAMRY	400.00	247.00	2797.99	141.65	415.83	21.32	2219.19
Pipe Outer P CAR	0.00	216.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner P CAR	0.00	216.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer CRV APV	0.00	259.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner CRV APV	0.00	259.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer 160P 390N	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner 160P 390N	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer YY6	0.00	20.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner YY6	0.00	20.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer B CAR	0.00	95.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner B CAR	0.00	95.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer KF60R	0.00	3.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner KF60R	0.00	3.00	0.00	0.00	0.00	0.00	0.00
Fin W648	0.00	4512.00	0.00	0.00	0.00	0.00	0.00
Fin W522	0.00	2483.00	0.00	0.00	0.00	0.00	0.00
Assy IMV CAMRY	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy P CAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy CRV APV	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy 160P 390N	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy YY6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy B CAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy KF60R	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 9. General Report for Scenario 2 in Assembling Line

Report for tig welding (Avg. of 10 replications)

General | Locations | Location States Multi | Location States Single/Tank | Resources | Resource States | Node Entries | Failed Arrivals | Entity Activity | Entity States | Variables | Location Co:

Entity Activity for tig welding (Avg. of 10 replications)

Name	Total Exits	Current Qty In System	Avg Time In System (MIN)	Avg Time In Move Logic (MIN)	Avg Time Wait For Res (MIN)	Avg Time In Operation (MIN)	Avg Time Blocked (MIN)
Assy IMV CAMRY	477.90	169.10	2998.39	53.62	649.61	13.70	2281.47
Assy P CAR	0.00	216.00	0.00	0.00	0.00	0.00	0.00
Assy APV CRV	0.00	259.00	0.00	0.00	0.00	0.00	0.00
Assy YY6	0.00	20.00	0.00	0.00	0.00	0.00	0.00
Assy 160P 390N	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Assy B CAR	0.00	95.00	0.00	0.00	0.00	0.00	0.00
Assy KIJANG	0.00	3.00	0.00	0.00	0.00	0.00	0.00

Figure 10. General Report for Scenario 2 in Tig Welding Line

Report for finish good (Avg. of 10 replications)

General | Locations | Location States Multi | Location States Single/Tank | Resources | Resource States | Node Entries | Failed Arrivals | Entity Activity | Entity States | Variables | Location Costing

Entity Activity for finish good (Avg. of 10 replications)

Name	Total Exits	Current Qty In System	Avg Time In System (MIN)	Avg Time In Move Logic (MIN)	Avg Time Wait For Res (MIN)	Avg Time In Operation (MIN)	Avg Time Blocked (MIN)
Assy CAMRY	48.00	0.00	205.97	6.49	0.00	60.54	138.94
Assy IMV	185.00	0.00	927.08	33.75	0.00	60.62	832.71
Assy P CAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy B CAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy CRV	204.00	0.00	2123.84	79.25	0.00	60.66	1983.92
Assy APV Domestic	10.00	0.00	2782.20	104.29	0.00	60.53	2617.39
Assy YY6 Domestic	20.00	0.00	2873.57	107.80	0.00	60.53	2705.23
Assy IMV Domestic	216.00	598.00	4027.67	135.74	285.43	63.55	3542.96
Assy 160P390N Domestic	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Assy KF Domestic	0.00	3.00	0.00	0.00	0.00	0.00	0.00
Assy CRV Domestic	0.00	46.00	0.00	0.00	0.00	0.00	0.00

Figure 11. General Report for Scenario 2 in Finish Good Line

Scenario 3 : Kanban by process with time buffer.

Report for assembling (Avg. of 10 replications)

General | Locations | Location States Multi | Location States Single/Tank | Resources | Resource States | Node Entries | Failed Arrivals | Entity Activity | Entity States | Variables | Location Costing

Entity Activity for assembling (Avg. of 10 replications)

Name	Total Exits	Current Qty In System	Avg Time In System (MIN)	Avg Time In Move Logic (MIN)	Avg Time Wait For Res (MIN)	Avg Time In Operation (MIN)	Avg Time Blocked (MIN)
Pipe Outer IMV CAMRY	0.00	647.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner IMV CAMRY	480.00	167.00	3225.16	169.13	415.50	21.31	2619.22
Pipe Outer P CAR	0.00	216.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner P CAR	0.00	216.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer CRV APV	0.00	259.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner CRV APV	0.00	259.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer 160P 390N	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner 160P 390N	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer YY6	0.00	20.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner YY6	0.00	20.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer B CAR	0.00	95.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner B CAR	0.00	95.00	0.00	0.00	0.00	0.00	0.00
Pipe Outer KF60R	0.00	3.00	0.00	0.00	0.00	0.00	0.00
Pipe Inner KF60R	0.00	3.00	0.00	0.00	0.00	0.00	0.00
Fin W648	0.00	4512.00	0.00	0.00	0.00	0.00	0.00
Fin W522	0.00	2483.00	0.00	0.00	0.00	0.00	0.00
Assy IMV CAMRY	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy P CAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy CRV APV	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy 160P 390N	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy YY6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy B CAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy KF60R	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 12. General Report for Scenario 3 in Assembling Line

Report for tig welding (Avg. of 10 replications)

General | Locations | Location States Multi | Location States Single/Tank | Resources | Resource States | Node Entries | Failed Arrivals | Entity Activity | Entity States | Variables | Location Co:

Entity Activity for tig welding (Avg. of 10 replications)

Name	Total Exits	Current Qty In System	Avg Time In System (MIN)	Avg Time In Move Logic (MIN)	Avg Time Wait For Res (MIN)	Avg Time In Operation (MIN)	Avg Time Blocked (MIN)
Assy IMV CAMRY	578.90	68.10	3396.74	64.87	683.46	13.69	2634.71
Assy P CAR	0.00	216.00	0.00	0.00	0.00	0.00	0.00
Assy APV CRV	0.00	259.00	0.00	0.00	0.00	0.00	0.00
Assy YY6	0.00	20.00	0.00	0.00	0.00	0.00	0.00
Assy 160P 390N	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Assy B CAR	0.00	95.00	0.00	0.00	0.00	0.00	0.00
Assy KIJANG	0.00	3.00	0.00	0.00	0.00	0.00	0.00

Figure 13. General Report for Scenario 3 in Tig Welding Line

Report for finish good (Avg. of 10 replications)

General | Locations | Location States Multi | Location States Single/Tank | Resources | Resource States | Node Entries | Failed Arrivals | Entity Activity | Entity States | Variables | Location Costing

Entity Activity for finish good (Avg. of 10 replications)

Name	Total Exits	Current Qty In System	Avg Time In System (MIN)	Avg Time In Move Logic (MIN)	Avg Time Wait For Res (MIN)	Avg Time In Operation (MIN)	Avg Time Blocked (MIN)
Assy CAMRY	48.00	0.00	205.88	6.49	0.00	60.51	138.87
Assy IMV	185.00	0.00	925.53	33.75	0.00	60.53	831.25
Assy P CAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy B CAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Assy CRV	204.00	0.00	2122.14	79.25	0.00	60.63	1982.26
Assy APV Domestic	10.00	0.00	2780.75	104.29	0.00	60.52	2615.94
Assy YY6 Domestic	20.00	0.00	2872.11	107.80	0.00	60.53	2703.79
Assy IMV Domestic	327.00	487.00	4446.44	148.70	286.12	63.72	3947.89
Assy 160P390N Domestic	0.00	6.00	0.00	0.00	0.00	0.00	0.00
Assy KF Domestic	0.00	3.00	0.00	0.00	0.00	0.00	0.00
Assy CRV Domestic	0.00	46.00	0.00	0.00	0.00	0.00	0.00

Figure 14. General Report for Scenario 3 in Finish Good line

Table 4. Improvement in WIP for each scenario

Scenario	Assembly line		Tig Welding line		Finish Good line	
	WIP (unit)	Improvement	WIP (unit)	Improvement	WIP (unit)	Improvement
1	9087	0.86%	930	6.16%	724	9.95%
2	9087	0.86%	769	22.40%	653	18.78%
3	9007	1.74%	668	32.59%	542	32.59%

The results in table 4 show the number of work in process in the recent system when using kanban by product, the number of work in process for three scenarios and the percentage of improvement. The number of recent work in process in the assembly line is 9166 unit, in the Tig Welding line is 991 unit and in the Finish Good line is 804 unit.

ISSN : 1978-774X

5. CONCLUSION

This paper result that the performance of shop floor is depend on the number of WIP. Bottleneck machine can be exploited to reach maximum throughput. And time buffer act as a help for filling the demand. In order to minimizing WIP, we should control the number of kanban in the system. The more the kanban in system, the more the WIP will effect the system.
For the next reasearch, it needs more analysis of using kanban by product and kanban by process.

6. REFERENCES

(a) Harrel, Charles, Biman K. Ghosh, Royce O. Bowden. 2nd ed. (2004). *Simulation Using ProModel*. New York. Penerbit : Mc Graw Hill.
(b) Monden, Yasuhiro. (1995). *Sistem Produksi Toyota : Suatu Ancangan Terpadu Untuk Penerapan Just In Time, Buku Pertama,* Pustaka Binaman Pressindo, Jakarta.
(c) Nicholas, John M. (1998). *Competitive Manufacturing Management : Continuous Improvement, Lean Production, and Customer-Focused Quality,* Mc Graw Hill Inc, Singapore.
(d) Setiawan's blog. (2010). http://ariajach.blogspot.com/2010/05/teori-kendala.html (accessed on March 6th, 2012)
(e) Subagyo, Yayan. (2010). Artikel Sistem Kanban. Institut Sains & Teknologi. Yogyakarta, http://yayan-industri.blogspot.com/2010/03/sistem-kanban.html (accessed on March 5th, 2012)
(f) Sutalaksana, Iftikar Z., Ruhana Anggawisata, and Jann H. Tjakraarmadja. (2006). *Teknik Perancangan Sistem Kerja*. Laboratorium Tata Kerja & Ergonomi, Teknik Industri ITB, Bandung.
(g) Umble, M. Michael and Srikanth M.L.. (1996). *Synchronous Manufacturing.* Guilford, Connecticut. Penerbit : The Spectrum Publishing Company.
(h) Walpole, Ronald E. 1990. *Pengantar Statistika,* PT. Gramedia Pustaka Utama, Jakarta.
(i) Wiranata, Fahmi. 2011. Teori Kendala. Universitas Diponegoro. Semarang, http://dc344.4shared.com/doc/-vy6ShIX/preview.html (accessed on March 6th,2012)
(j) http://www.scribd.com/doc/25883551/Bab-IV-Sistem-Produksi-Tepat-Waktu-Just (accessed on March 5th, 2012).

AUTHOR BIOGRAPHIES

Rahmi Maulidya is a lecturer in the Industrial Engineering Department, Trisakti University, Jakarta. She received her Master degree in Industrial Engineering from Institut Technology Bandung in 2005. Her research interest are in the area of Production Planning & Control. She is a member of Production System Laboratory, Industrial Engineering Department, Trisakti University. She is also a member of the Society of Industrial Engineers and Indonesian Ergonomic Society. Her email address is rachmi@trisakti.ac.id.

Iveline Anne Marie is a lecturer in Department of Industrial Engineering, Faculty of Industrial Technology, Trisakti University, Jakarta. She obtained her doctoral degree from Agroindustrial Engineering Department, Bogor Agricultural Institute and master degree from Industrial Engineering Department, Bandung Institute Technology Her research interests are in the area of Production Planning & Control. Her email address is ivelineannemarie@yahoo.com.

Kevin Wijaya is an alumnus from undergraduate at Industrial Engineering Department, Trisakti University in 2012. His research area are in kanban system and theory of constraint.