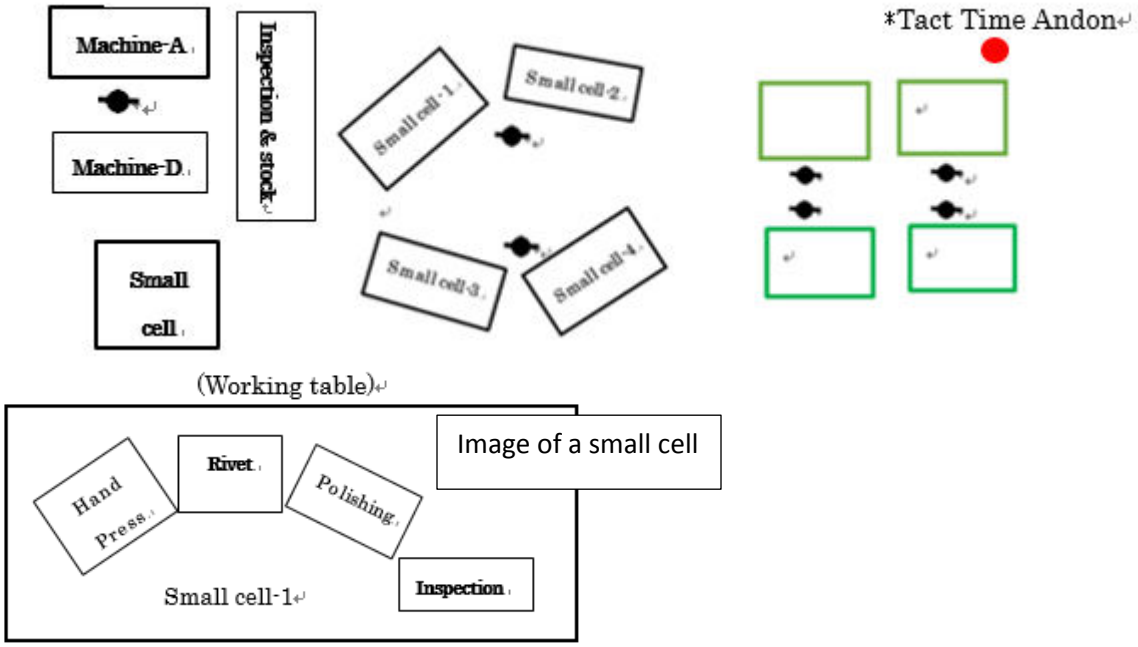
Making stream of production

-4. Tact Time.

Now we should go back to original theme “Making stream of production”.
I’m writing the TPS from the point of view of “Making stream of production”.
In the last description (Making Stream of Production-2) I presented the model and demonstration line with the product “8” which is a seasonal but continuous demand in 6 months and presented the effect and possibility of the reduction of LT, increase of throughput and cash-flow. In the last edition I promised to present the case of the product “7” which is very small lot and uses the furnace and large press.
But I need to write the case of the model line a little more (regarding the Takt Time).
Once again I would explain the model line and the method of the model line introduction.
The image of the model line is as follow.



The process of the introduction of “Making stream of production” is next 5 activities. Seeking the Takt Time, Investigate the net-working time (Time study, Standardized Work Chart & Standardized Work Combination Table, Process Capability Table), Calculation of head account, calculation of necessary machine capacity (Process Capability Table, Standardized Work Combination Table), Move machines and Layout and Teaching & start.
Let’s look individual process exactly.

1) Seeking the “Takt Time”.
   As you know Takt Time is one kind of production rhythm (baton in music). And is the speed how often the product should be produced to meet the customer requirements (the speed of sales). And the calculation form is
   Takt Time = Working hours (planned)/day ÷ Necessary (required)

production/day.

***** Working hours (planned) shouldn't be reduced in anticipating hours of machine down, material waiting, repair.

*****Necessary (required) production shouldn't be increased in anticipating numbers of defective products.

If anticipating these troubles in the takt time the sensitivity to the coping with the problems occurred becomes dull.

Many stocks (inventories) also obscure the problems which should be coped with quickly and kill the sensitivity.

The case of the model line.

Customer demand; 1.000/20 days = 50/day.

Net working hours; 8 hours = 8 x 60 min = 480 min.

9 hours 20minutes/ day. 5 minute for start meeting. 45 minutes for lunch time. 10 minutes for break (before noon). 10 minutes for break (after noon). 10 minutes for 5S before finishing.

Takt Time = 480 ÷ 50 = 9.6 min/product

Then the line should produce one product in each 9.6 min.

If.

If the demand is changed (for instance) from 1.000/20 to 1.200/20 the calculation is as follow.

Customer demand; 1.200/20 days = 60/ day.

Net working hours; 8 hours x 60 = 480 min

Takt Time = 480 ÷ 60 = 8.0 minutes/product.

2) Investigation of the net-working time.

Firstly I would advise that the job of making model line is never difficult, but is troublesome (for the preparation). Anyway troublesome.

Time study. In here I present the easiest way to implement.

The purpose of time study is to confirm the net time of total and individual process work. (After this job you need to make the job of confirming work element and standardized work. Therefore at the job of time study, it is necessary to consider these. It is as if the work of IE; Industrial Engineering.)

And based upon the result of time study and the takt time, the necessary head account is calculated.

The formula is

Head account (number of workers) = Net Time/product ÷ Takt Time.

When making time study (and investigation of work study, standardized work and simple Kaizen) it is necessary to make Time Study more than 10 times for one process.

But it is a little difficult to make Time Study and Work study with a stop watch for untrained persons. Then I recommend to use VTR which has the function of showing the time in the screen.

The step of time study is

-1. Nomination of a worker who has good skill for this process.

When asking to the worker please give the advice

No make peace sign to Video

Makeup if she (or he) wishes

Normal speed (which possible to keep the quality).

-2. 5S and simple Kaizen

Arrange necessary jigs & tools and materials, parts and working condition (height of working table, location, light and lux).

Consideration of 5S and better workability.

-3. VTR set up and trial video and confirm with the worker.

5S and Kaizen and confirming the best working condition with the worker.

-4. VTR start and shooting.

Let's look the time study exactly.

Following sheet is the Time Study Record sheet and the result.

When making the Time Study, the form below is used.

Time Study (Cell-1. Decimal)

Part No	12345-678910												Observation date: Jun. 29.06			
Process name		Time Study Record (sec)											Observer: TPS Project			
Process	Name	1	2	3	4	5	6	7	8	9	10	11	12	min	Max	M - n	Kai
1	Take one tray and walk 2 steps to shelf	2.6	2.4	2.3	3.1	3.1	2.9	3.7	2.5	2.2	3.3			2.2	3.7	1.5	
2	Gathering 8 parts in tray	10.9	11.8	12.7	10.4	10.7	13.1	13	10.6	10.6	10.4			10.4	13.1	2.7	
3	Walk 3 to cell-1 and put the tray	3.9	4.1	3.5	3.8	3.8	3.7	4.3	3.2	3.6	3.7			3.2	4.3	1.1	
4	Take K part and fit in press and press	2.4	3.1	2.7	2.8	2.5	3.1	3.6	2.3	3	3			2.3	3.6	1.3	
5	Take off from the press and check quality	2.5	2.6	2.9	2.7	2.7	2.8	2.4	2.6	2.5	2.7			2.4	2.9	0.5	
	and put the K part on the tray																
6	Take M part and fit in press and press	2.8	3.3	3.3	2.5	2.9	2.8	3.5	2.8	2.9	2.6			2.5	3.5	1	
7	Take off from the press and check quality	2.9	3.5	3.3	2.6	3.2	3.3	2.7	2.8	2.9	2.5			2.5	3.5	1	
8	Take one rivet and fit in the M part	1.8	2.1	2.2	1.9	1.9	1.9	1.8	1.8	2.7	1.7			1.8	2.7	0.9	
9	Take K part and fit to M in the rivet																
10	Fit in the riveting machine and rivet	1.7	1.5	1.8	1.9	2.3	2.1	1.7	2.5	2	1.6			1.5	2.5	1	
11	Take off and check quality	2.3	2.6	2.7	2.2	2.2	2.4	2.7	2.5	2.5	2.3			2.2	2.7	0.5	
12	Fit in polishing machine and polish	9.2	10	10.6	9.8	9.1	9.5	10.3	9.6	9.9	9.3			9.1	10.6	1.5	
13	Check and polishing	6.6	6.8	6.8	7.5	6.9	6.5	6.3	6.7	7.1	6.5			6.3	7.5	1.2	
14	Take inspection jig-1 and inspection	3.7	3.5	3.5	3.8	3.4	4	3.7	3.5	3.9	3.5			3.4	4	0.6	
	and put in the tray																
15	Take G part and fit in the polishing	7.8	8.1	8.6	7.9	7.9	8.3	8.6	8.2	7.7	7.5			7.5	8.6	1.1	
	machime and polish																
16	Take off and check quality and polish	6.7	6.5	6.2	7.2	7.1	6.8	6.5	6.3	6.7	6.3			6.2	7.2	1	
17	Take inspection jig-2 and inspection	3.7	3.3	3.5	3.8	3.5	4	3.8	3.5	3.9	3.3			3.3	4	0.7	
	and put in the tray																
18	Take the tray (K &M assembled and G)	5.7	5.3	6.3	5.2	5.3	6	6.4	5.7	5.4	6.1			5.2	6.4	1.2	
	and walk 3 to cell-2 and put the trays																
25																	
	total													72	90.8		

As an example of time study work, I present the case of sub-assembly-1.

And for getting your good understanding I explain the work of the Sub-assembly-1 worker in the next description and the Standardized Work Chart (below).

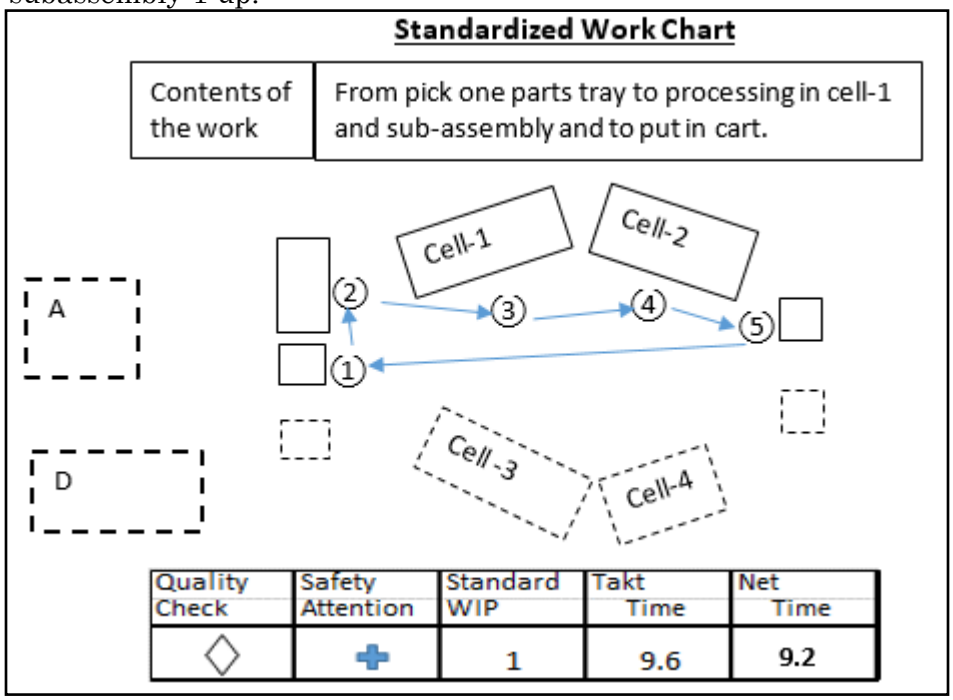
1 operator of Machine-A & D; Produce 12 parts (A: 8, D: 4.)

*Worker of the cell-1 and cell-2 produces Subassembly-1

With 7/12 and 8 commercially available parts (like rivet): uses total 15 parts.

Worker of the cell-3 and cell-4 produces Sub-assembly-2
With 5/12 and 3 commercially available parts: uses total 8 parts.
4 assembly workers assemble the product in the takt time
With 1 sub-assembly-1, 1 sub-assembly-2 and 6 plastic parts (from supplier) and
9 commercially available parts.
The example of above time study is the worker of sub-assembly-1
And just the work of cell-1.

The work of the Sub-assembly-1 worker. Starting position is ①.
The sub-assembly worker takes one tray in which 7 kinds of parts are prepared by the machine operator. The tray has also the frame for 8 commercially available parts.
The worker moves to the shelf ② and pick 8 kinds of parts up and put in the frames designated. (1 set preparation of the sub-assembly-1.)
The worker carries the tray to cell-1 ③ and put it on the standardized position.
The worker processes the part K and the part M. And combine K and M.
Then processes the part G. Put the K & M combined and G in the tray and carry them with other 4 parts and commercially available parts to cell-2 to make the subassembly-1 up.



The above time study example is just the movement of ①, ② and ③ in above Standardized Work Chart.
The result of the time study was 72sec (minimum) and 90.8sec (maximum).
And the time study activity should be made for individual work element.

3). Calculation of total time study and calculation of necessary workers.

Now please do not use the average, but use the shortest net-time of each process.

This work still has the variability. And the minimum net-time shows the possibility of best workability.

The meaning of having variability is that still this work (in cell-1) has some instability which is one of objective of Kaizen.

Regarding "Variability" once again I shall come back to this theme in next.

For this time study, the supervisor of this project team played the active part. Firstly he himself tried to work the process of sub-assembly and assembly (the record of assembly work was 41.3 minutes. Not bad.)

Based on the video measurement and record, the confirmation of work element (work study) and standardized work were made. (I describe these later.)

Then the summary of time study is as follow.

(About the machine work also I describe later.)

	Part No	12345-678910			
	Process name				
Time Study	Process	Name		Necessary	
	Process	min	Max	n of worker	
Sub-assembly-1	cell-1	1.2	1.5		
	cell-2	8	11.9		
	total	9.2	13.4	0.96	9.2÷9.6 = 0.96
Sub-assembly-2	cell-3	3.8	5.7		
	cell-4	4.3	4.8		
	Preparation	1.3	1.9		Other parts preparation for assembly.
	total	9.4	12.4	0.98	9.4÷9.6 = 0.98
Assembly	Preparation	0.9	1.3		6 plastic parts preparation.
Assembly	process-1	8.7	9.5		
	process-2	14	17.5		
	process-3	4.1	5.2		
	process-4	8.6	9.9		
	total	36.3	43.4	3.78	36.3 ÷9.6 = 3.78
	Total	54.9		5.7	

Calculation of necessary workers.

The case of the model line (product "8"). (For instance) The process of assembly.

Time study result (minimum net-work time); 36.3 min. Takt Time; 9.6 min.

Head account = 36.3 ÷ 9.6 = 3.8

Therefore 4 workers is necessary.

If

If the demand is changed (1.000 to 1.200) and the tact time is changed (9.6 to 8.0 min).

Head account = 36.3 ÷ 8.0 = 4.5

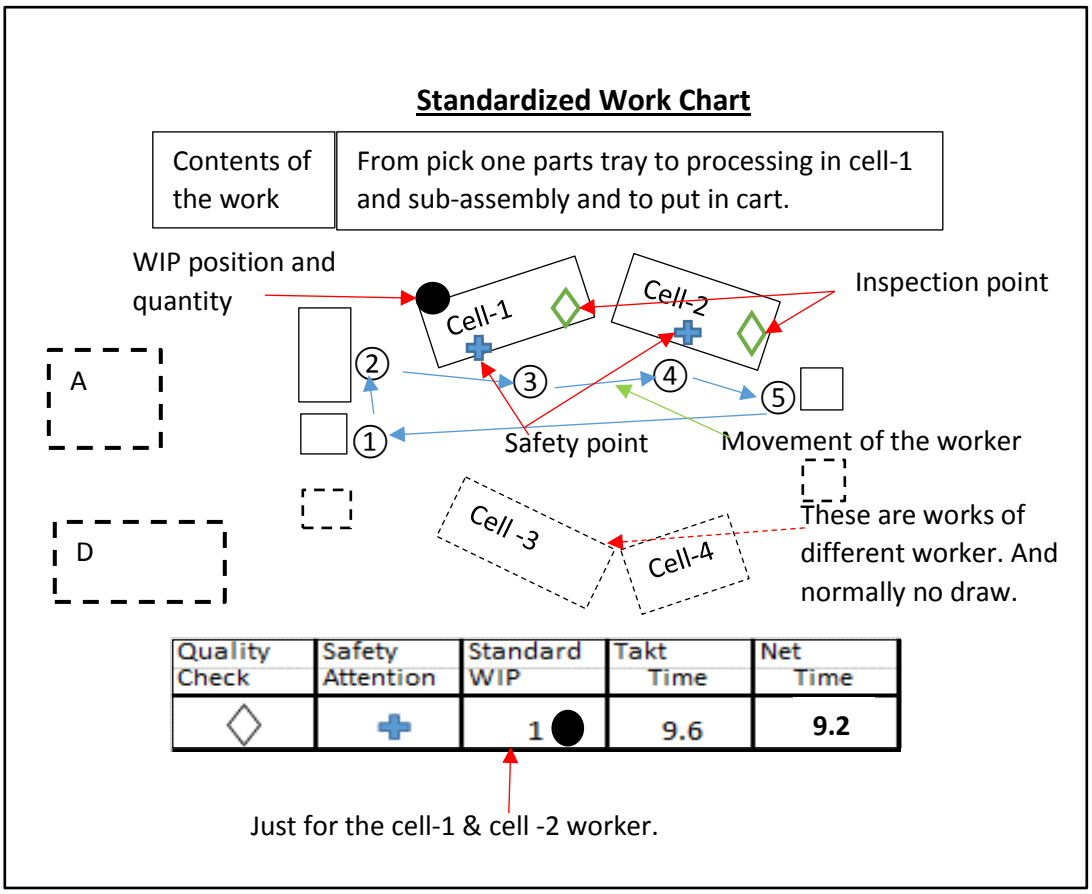
Actually there is no exist the 0.5 person. Therefore it is necessary to provide 5 persons for this tact time. (Or it is necessary to make Kaizen to reduce 0.5. Or

adjusting the work balance to reduce in total.)

Same calculation for the sub-assembly was made. And the result was 1.9 persons.
And the line was made with 2 sub-assembly and 4 assembly workers.
For making line in Takt Time it is essential to produce 3 diagrams which are Process Capability Table, Standardized Work Combination Table and Standardised Work Chart.

3) Standardized Work Chart.
I already showed this chart above. But once again.
The chart shows following matters.
-1. Working process and equipment. (From ① ~ ⑤)
-2. Takt time and net-time. (9.6 & 9.2 min)
-3. Standard WIP (work-in-progress); 1 set in process.
-4. Quality point.
-5. Safety point.

Let's look the complete chart.



This is a very simple chart and standard. And any process in Toyota has this standard with working standard.

By the way for whom are these standards necessary?
These standards are necessary for “the supervisors and managers” because they need to supervise and manage the gemba. (They need to let the workers keep the working procedures.) Therefore the standards need to be understandable very easily (by the supervisors and managers.).
For teaching the working method, the supervisor needs to make other material (Job instruction sheet).

4) Process Capability Table. Standardized Work Combination Table and Standardized Work Chart in machining process.

These tables and chart should be made for individual parts production. For instance the product “8” which uses the parts produced with machine–A and machine–D.
Machine-A produces 8 parts. And D produces 4 parts (by just one operator). In this case, for each part of 8 parts and 4 parts should be made these tables and chart which identify the takt time, machining process, manual process, inspection, and these time, operator movement, ----. And these are the base of the stream of production and continuous kaizen.
It is so troublesome to make these tables for individual part!
The job is never difficult, but easy. But it is so troublesome.
Firstly I present an example to gain your good understanding the Process Capability Table, Standardized Work Combination Table and Standardized Work Chart.
The case of the company B.
Now, before introducing the model line of product “8”, I made the practice for the project members to make these tables and chart which are one set.
For the practice we could get the chance to visit and look the company B who produces hinges.
Then I required to the project member to make the work element analysis and time study with “Stop watch”. (It was so difficult for them. But to take photo and video were prohibited.)
One part of the process of producing hinge is

1) Cut the parts from the material.
2) Making 3 different diameter holes.
3) Chamfer.
4) Second chamfer and finishing.
5) Inspection.

In this example 4 workers operate 4 machines (C-4, DR-K, Ch-1, Ch-2) individually and accomplish one part of hinge and make inspection with the jig designated.
And following Process Capability Table was made based on the time study and work element analysis by the project members.

Approval					Part number: 12345-678910					Type: RX-75		Plant: Machining	
Manager	Supervisor	**Process Capability Table**			Part name: Hinge-A					Articles	1	Process: Hinge chip out	
J.D	M.K										By	Project	
Process	Process name	Machine			Basic Time		Cutting Tool			Prod.		Remarks	
		No.	Manual T		Auto Feed T	Complete T	N of Change	Change T		Capacity			
1	Chip out from	C-4	3"		25"	28"	100	1'00"		966			
2	Make hole	DR-K	3"		21"	24"	1000	30"		1148			
3	Chamfer	Ch-1	3"		11"	14"	1000	30"		1967			
4	Finishing	Ch-2	6"		30"	36"	1000	30"		766			
5	Quality check	I-Hinge	5"		---	5"	---	---		5520			
						Working hour: 7h 40min = 460 min/day							
		total	20"										

Basic time; just manual time and auto feed time and total (Complete time) which not be included the walking time are measured and recorded.

Cutting tool; also this table is to identify the standard timing and time of cutting tool changeover.

For instance

N of Change (Number of Change) 100: after 100 pieces manufacturing, the jig, tool should be changed.

And the Change T (Changing time) is 1 min.

Prod capacity (Production Capability); 966 = (460 min/day – 9) x 60 ÷ 28 sec

Complete T (Complete Time): Manual Time + Auto Feed Time.

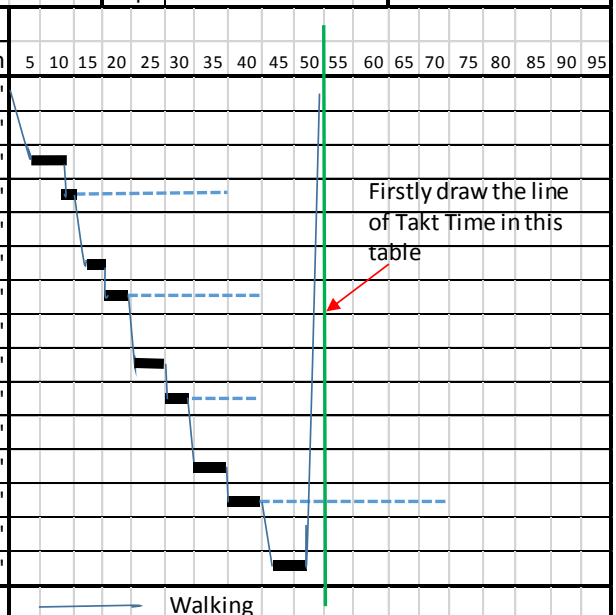
Production capacity =

(Available working hour – changeover time) ÷ Complete time.

Next I required them to make the Standardized Work Combination Table (Man-Machine Diagram) based on the above Process Capability Table.

Part No	12345-678910	Standardized Work Combination Table				Production Date	Ago. 06'	Quantity: 552
Process name; Machining						Dep.	Parts Production	Takt Time: 50"

Pro. No	Work Name; Chip out	Time			
		Manu	Auto	Walk	Cum
1	Take out 1material from pallet	1"			1"
				2"	3"
2	Take off from C-4 and check	4"			7"
3	Attach in C-4 and start-up	3"	25"		10"
				2"	12"
4	Take off from DR-K and check	4"			16"
5	Attach in DR-K and start-up	3"	21"		19"
				2"	21"
6	Take-off from Ch-1 and check	4"			25"
7	Attach in Ch-1 and start-up	3"	11"		28"
				2"	30"
8	Take off from Ch-2 and check	4"			34"
9	Attach in Ch-2 and start-up	6"	30"		40"
				2"	42"
10	Quality check	5"			47"
		37"		10"	
	Net Working Hours/ day: 7 h 40 min: 27.600 sec				
	Takt Time = 27.600 ÷ 552 = 50"				



Quantity (Necessary production quantity/ day) 552 pieces/day.
Now the number of "Quantity; 552" is the virtual for the practice.
And true figure was 100pieces /day (2.000/month). Therefore true

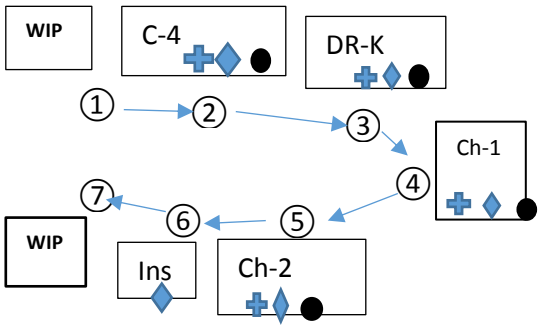
Takt Time = 460 x 60 ÷ 100 = 276 sec.

And the gap between 276 sec and 50 sec was used for other parts production.
At that time this company took the batch production style. And as I wrote above 4 operators handle 4 machines with many work-in-progress.
The project member showed one of possibility to reduce WIP (Work-in-progress) and LT.
Then my project member made following Standardized Work Table and made the suggestion to the company B.

1) Batch production to small lot production.
2) 4 operator to one for 4 kinds of machine.

Standardized Work Chart

Contents of the work	From pick one material and processing in C-4 to Ch-2 and Inspection .



Quality Check	Safety Attention	Standard WIP	Takt Time	Net Time
◇	✚	1 ●	50"	**47"**

4 machines and one operator.

But the suggestion was refused respectfully by the owner of the company B.

These are only the practice for making these tables and chart which are one set and should be shown in the process.
I made the comment for this result of diagrams as follow.

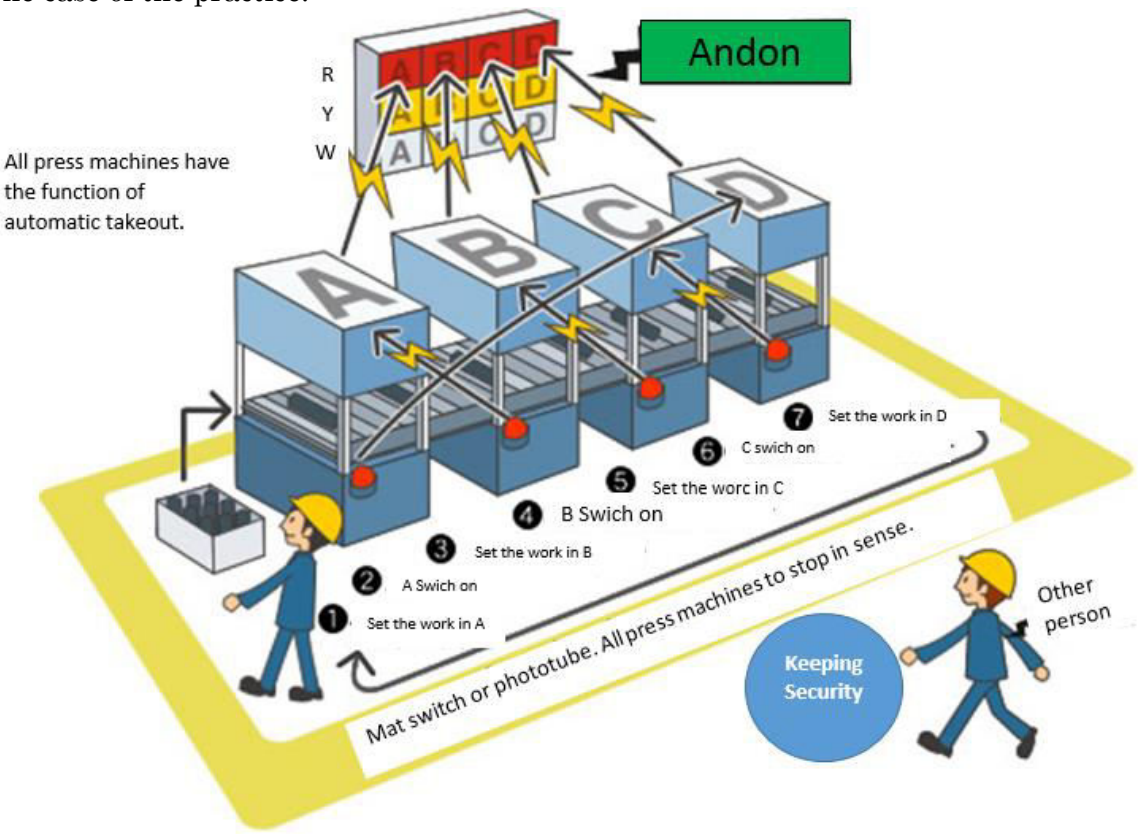
1) Net Time; 47 sec and Takt Time; 50. It is ideal balance, but is difficult to implement and keep.
   Because if the net time is less than 49 sec, the worker can't keep the working rhythm physiologically in all day. (I have never seen such speed line.)
2) Again machine performance down.
   As I wrote before when making cell and fixing the usage of the machines to be limited in the cell, the performance of the machines are down.
   In this case and (for instance machine) C-4, the operation ratio is 56% (28 ÷ 50). The case of machine Ch-1 is only 28%.

Therefore (also as I wrote) Toyota never like to use expensive machine and like to use the machine which is already finished the depreciation with good maintenance and simple machine which is cheap and easy maintenance.

In reality as a normal company, it is difficult to change the production style because the machines were prepared on the promise of batch style production which gives the

importance to the machine (investment) performance rather than labour performance, LT, WIP reduction.
(In reality the company B also doesn't know the importance of LT and Cash-flow. Might be----.)

The case of the practice.



The case of the practice in the company B is above type which is
One part is processed in several machines in order.
And the process is continuous.
(If this company B can introduce this hinge line as Toyota, the picture is as above.)
Now a little more we shall look back the Toyota's do which is above picture (which is from a text book of Toyota System).
Assumption; New parts production line is required. The process of the introduction of the new production line is
-1. Investigate the function and quality point of the new part.
Decide which process should be with machine or manual.
*The purposes of machine use are production capacity, safety, difficult work, accuracy, combination of man-machine and the making stream of production in the takt time.
-2. Making prototype of machine for individual process and make up the machines.
(Please image the example of hinge production.)
-3. Assumption of output requirement (Takt Time) and net-time.

For instance Demand; 1.000 pieces/day. 2 shifts (480 min x 2). One shift; 500.
Takt Time 480 ÷ 500 = 0.96 min (58 sec).
If the manual work net-time is less than 1 minute, the necessary worker is 1.
Net-time ÷ Takt Time = Number of worker.

-4. Making the line which the job of the worker is supply material, start button, take off
the finished piece, inspection (if and in the inspection point).

∗Of course for kaizen, there is the case of introducing new machine which is combined (for instance) first and second machines to reduce one process. And at this time important point is the possibility of reducing a worker (in total balance).
Toyota consists the way of JIT (which is necessary articles in necessary quantity and at the necessary timing). And as the result, the process of parts production in Toyota is like as above picture.
The way of other company.
He wishes to buy a new machine which is high speed and multi-functional as much as possible. And this style gives several problems.
-1. No consideration of the work in Takt Time.
The demand; 1.000. But the capacity; more than 10.000 (for instance).
And necessary capacity is calculated in total and in batch style production.
-2. The issue -1. creates the Muda of excess WIP and inventory easily.
-3. For seeking better machine (investment) performance, the gemba wishes to use the excess capacity for other job which is never bad, but to be easy to create the Muda of excess stock.
-4. Then the process flow is too difficult to see which means the difficulty of gemba control. Of course it is too far from the one by one production and short LT.
-5. A high speed and multi-functional machine is expensive and difficult to keep maintenance (in both technical issue and cost).
Though saying above, a common company doesn't have the capacity of developing machines by himself, and needs to buy the commercially available machine.
All of my clients are common companies and already have good (?) machines. This company which I'm presenting the model line of product "8" also same.

Back to the model line "8".
The machinery process (Machine-A and D) of this line is not possible to use the image of above picture because of following differences.
The differences are
One part is processed and completed in one machine. (single process)
Lot production. One kind of part production is repeated 5 times (5pieces/lot).
(At the start the lot size was 10. But was improved to 5.)
The operator needs to operate 2 machines for 2 groups of parts (A; 8. D; 4).
Therefore the characteristic of the process is quite different.
(However for understanding of the Process Capability Table, Standardized Work Combination Table and Standardized Work Chart, I taught the simple and easy case with the practice in the company B).

Based on the practice, the project members made these tables for the machine process of the model line product “8” as follow.

This model line with product “8” was very easy case because of not so many parts.

Please accept to postpone the Standardized Work Chart and Standardized Work Combination Table to the next description.

> For me it is so troublesome to draw the data from my notebook to Excel.
> (I’m now tired of drawing the chart and table in Excel and drawing soft.)

Sorry.

Chat
DNA of Toyota
I described “troublesome, troublesome, troublesome----”.
There is a company which implement such troublesome matter completely.
And this company is Toyota.
And this thing is one of DNA of Toyota.
When I was in UK, I have questioned to a Toyota person (Mr. Shuhei Toyoda; Current president of Toyota Boshoku.).

> “Essentially the method or system of production is one kind of confidential matter as a company. Why does Toyota open such information?”
> His answer was
> “We have no concern of the open of the information because I think nobody of foreign factory who hasn’t the DNA of Toyota can’t introduce TPS sufficiently”.

DNA of Toyota?
I thought what is DNA.
Then I reached the thought which is to implement such matter of troublesome completely.
Another story of DNA. The origin of JIT (Just In Time).
I got a simple question what is the origin of JIT and when it was begun to use? And would replay this.
The origin of “just in time” is not Taiichi Ohno and his system TPS. The word and the concept existed in Toyota before Taiichi Ohno and TPS.
The founder of Toyota group is Sakichi Toyoda. And the founder of Toyota (motor industry company) is his son Kiichiro Toyoda (who is the grandfather of Akio Toyoda; the present president).
The origin of JIT is Kiichiro Toyoda. And this concept was taken over by Eiji Toyoda and Tiichi Ohno.
At 1933 Kiichiro Toyoda decided to establish a new car manufacturing plant in KOROMO (Current Toyota city). And when establishing the plant he made a very unique requirement which is to consider “no warehouse” to the engineers. In those days the common sense of production was of course batch production and stock in a warehouse. However he required to consider “no warehouse”. His aim was to seek the smooth flow of materials. At the plant opening ceremony at 1938 he responded and declared his policy to the interview and told as follow.

"I believe following matters are important.

1) There is no Muda and Excess.
2) Each parts and materials don't let any work wait in the flow.
3) It is important to be prepared the each parts and materials in "just in time."

This was the first appearance of JIT in Toyota.

(From the book of Toyota 75 history)

But this concept was not accomplished during his period and wasn't see the light of day until Taiichi Ohno (because of the World War Second which brought the extreme supply shortages.)

Saying Toyota Production System, the guru is of course Taiichi Ohno. However if there was no support of Eiji Toyoda, TPS also didn't see the light of day. And Eiji Toyoda told the meaning of JIT of Kiichiro in his book "The decision" as follow.

> "Make just necessary things in necessary quantity every day. And the timing when is to meet the production flow is enough and never produce excessively. If it is possible to fix this concept, even the working capital becomes to be unnecessary because it is possible to sell a car before the payment of the materials."

The concept of to regard that a stock (inventory, work-in-progress) is the worst Muda and the worst cause of Muda is one of Toyota DNA since Kiichiro.

The day of opening of this plant 1938 November 3rd is the Day of anniversary of the founding.

Toyota and Toyoda.

In Kanji (Japanese character) both Toyoda and Toyota are same.

But when Kiichiro establishing the motor manufacturing company he chose ToyoTA (which is of course company name) than ToyoDA (which is family name), because of the company image from the pronunciation.

Next I write the Standardized Work Chart and Standardized Work Combination Table of the machine process of the model line "8" and write the case of the product "7".