Making stream of production

-2. LT.

Before going to the main theme, I would introduce the questions which were raised by my students.

-Jidoka in all machine and 100% inspection in Toyota?

The answer is “No”. Recently I haven’t visited the Toyota factory, but Toyota also uses commercially available machines. Of course Toyota makes his effort to install the automatic stop device in these machines, but never all.

Also the 100% inspection is not implemented in all process, but sampling inspection is applied. However the basic concept is 100% inspection and 100% guarantee the quality in individual process. Now how does Toyota do in the process which not implement 100% inspection? The step is as follow.

1) Regular sampling inspection. The lot of sampling inspection is decided (for instance 20).
2) 20 parts proceed to the conveyor which has a limit switch to identify the number and indicate in Andon and call the inspector.
3) The inspector makes the inspection of the final number of 20.
4) And if finding quality problem in the final number, all of the lot of this 20 are inspected.
5) Inspection in individual cellular line. When I visited Toyota (Tahara plant; currently Lexus and others and these engines), this plant has the assembly line with 11 sub-lines. And each line has the inspection.

(When looking this system, it is quite commonplace and never unique. But.)

This system is applied for the defects caused in time course, for instance the machine work of drill reamer tapping or press which uses die and tool.

These cases never repeat non-defective and defective products.

On the other hand, the process of manual work by workers applies the 100% inspection in “Self-Check inspection, Inspection by next process and Poka-Yoke”

The word of Taiichi Ohno. “Even though 1% of defect in total production, this is the meaning of 100% of defect as the customer who bought this defective car”. Therefore the attitude of 100% inspection and guarantee the quality in individual process is essential.

-LTE uses Net Time and not includes Preparation Time?

About the concept of LTE, many questions are proposed and it is very much appreciated for me. I believe you can understand the importance of this efficiency

which shows the managerial efficiency from the point of view of the “Time”. Yes there are many indexes based on the time like as Labour efficiency, Machine efficiency. However LTE is the index which mentions the efficiency of the “Time” itself with using the scale of “Time”.

Now have you heard the word of “Time efficiency”? Probably you may not.

When I made a class of TPS, I gave the task of group discussion to my students. (To say that students, they are professional consultants and respectable managers of industries.) And the theme was “Is time one of the managerial (business) resource?” And required to summarize the idea of each group in KJ method.

(Of course “Time” is not one of managerial resource.)

※Managerial resource: Tangible resources are 4M--- Man, Machine, Material and Money.

Intangible resources are Intellectual property (for instance patent, trademark, copyright), Technical capacity (including Technical Know How, Managerial capacity), Information.

Managerial resource is the generic name of aggregate of the capacity which supports the continuous and growing business.

And time is one of fundamental measure of management and the indexes based on “Time” and should be in Managerial capacity.

Therefore “Time” shouldn’t be included in the intangible resource. But it deserves to listen the student’s opinion.

For the efficiency of labour there is the index of Labour efficiency. For machine, there are indexes of machine performance, machine brake down ---. For the efficiency of material there are indexes of loss ratio, inventory turnover ratio.

On the other hand “Time control” also is very important and it is quite true that there are some indexes which are the themes of time and are “Opportunity loss, LT, Delivery time ---“. And it is quite natural to seek the proper tool of measuring efficiency for the time its self.

And their conclusion was that “Time” also should be calculated the efficiency. Then our proposal is the concept of Time Efficiency. And for controlling this, I propose the concept of LTE.

Now respond to the question of “LTE uses Net Time and not includes Preparation Time?”

In the last description I described the reason that the preparation time in standard time also the objective of the reduction activity.

※Standard Time = (Net Time + Preparation Time) x (1 + Allowance ratio)

When looking the case of this company, the net time of the press process for 15 products was only 30 seconds, but the preparation time was 58 minutes. The changeover time of 58 minutes also is targeted to reduce and were reduced to 17 minutes in the activity of SMED. Again the preparation time also the target objective of the reduction activity. (Net Time also is the target objective. But as the first step, the preparation time should be targeted sufficiently.)

A little more I describe the meaning of LTE.

The meaning of "Making stream of production (Flowing production)" is to make the flow in the production process (reduce and eliminate the stagnation).

And when starting the introduction of TPS or Lean concept, first of all "making stream of production" is effective.

Is bad LTE (for instance this company was 10.5%) bad managerial level?

When I taught this concept, there was an objection. If it is not use the labour capacity during the waiting time, there is no MUDA of the labour capacity even though there are many waiting times.

And it is quite true if the company can use the labour capacity effectively, there is no loss in the "Labour capacity" even though many waiting times. Once again let us look the figure of the company below.

Article	Net time	Actual time
Receiving and processing order	3 minutes	2 days
Waiting production start in schedule	0	10 days
Total LT of production in 5 processes	4 days y 4 hours	30 days
Stock in warehouse	0	1 day
Preparation and shipping	30 minutes	4 hours
Total	4 days and 4,5 hours	43 days and 4 hours

For instance "Waiting production start in schedule 10 days".

During 10days, this company was providing the raw materials, commercially available parts, procuring parts from the suppliers and which means spending moneys and fixing moneys.

As I wrote, when saying efficiency, It is necessary to consider not only the labour efficiency (and machine efficiency), but also material efficiency and money efficiency (cash flow). And also it is necessary to consider maximizing the throughput. In a word "Change to the money quickly after getting the order in very short LT" for improving the cash-flow and the profit ratio. And I'm telling you that even the gemba (workers), it is necessary to contribute to improve not only the labour efficiency, machine efficiency, but also the material efficiency and cash-flow (money

efficiency) and is necessary to look LTE. “Bad LTE means bad material efficiency, bad cash-flow and bad throughput”. How the gemba to contribute to improve material efficiency and money efficiency (cash-flow)?

The improvement of the material efficiency is controlled in the reduction of scrap (scrap rate) and betterment of yield rate, reduction of scrap in quality improvement and of obsolescence, of inventory, and reduction of work-in-progress.

For instance the case of this company, during (30days – 4days and 4hours = 25 days and 4hours), the materials plus labour cost spent were fixed (as the work-in-progress and finished goods). This situation causes not only the bad cash-flow, but also others Muda of inventory which are additional handling, control cost, space, defects & damages, lot defects and increase of procurement of raw materials (the raw materials are used to other products) and increase the inventory.

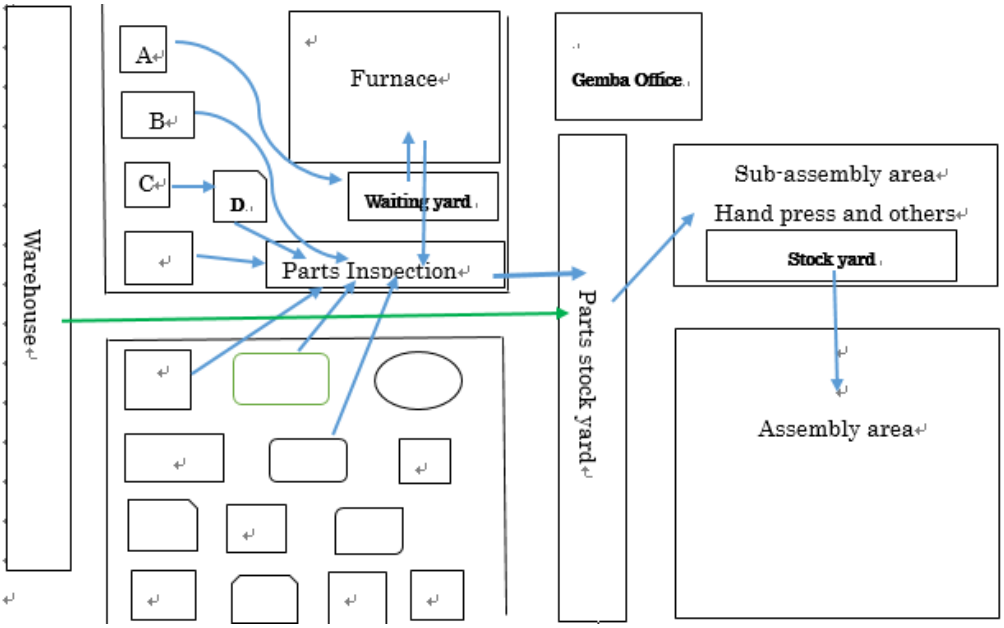
The improvement of cash-flow is managed in the inventory turnover ratio which is easier and quicker than the accountant index in the gemba. And to look these CS, Throughput, Efficiencies of Space, Materials and Cash-flow comprehensively, I teach this LTE in TPS.

Now backing to the main theme “Making the stream of production”.

The meaning of making stream of production is

a) To rectify the production flow which not having back water and complicate flow (as much as possible).
b) Elimination of the stagnation in the flow.
c) One by one or small lot production.

Again let us look the case of this company. The factory of this company has following lay-out (image).



For this product (No.7) the production plan assigned the machines of A, B, C and D and the Press, Furnace for producing 50 kinds of parts. And other machines when have no load were used arbitrarily.

After the work of machine A, the part is carried to the waiting yard of furnace and carried to the Parts Inspection yard.

The parts produced with B and C via D are also carried to the Parts Inspection.

After the inspection, the parts are stocked in the Parts Stock yard. Then the parts are given to the Sub-assembly area and assembled.

Now. How can we rectify (making stream) the production flow? Shall we re-layout the machines in the demonstration method of Shingijutsu? No, it is not realistic. Singijutsu also chooses the area and the case which are possible and easy to re-layout for Seiryuka (rectification; stream of production flow) for the demonstration. However in fact most of the industrial companies take the style of batch production layout (job shop) which collecting machines in the machine work area (grouping) and assembly area like as above image.

Establishment of project team.

For reforming this company, a project which were consisted of production engineers, supervisor of the gemba, accountant, production planner, quality assurance and inventory controller was established. (And we called this team “7 Samurais”)

My style of teaching and guiding project is always “Teach and Draw (their ideas)”.

After the lecture of the meaning of TPS and Basic Factory Management for all directors, managers and this project members, I taught to this members following matters.

ABC and Machine-Products analysis. Cellular production. SMED. Kanban system. (In parallel I taught TPM; Total Preventive Maintenance, TQM, Inspection system to the relevant departments and sections staffs.)

First of all this team made following Machine-Products analysis for seeking the possibility of "one model and demonstration line of stream of production".

(The results of 6 months of 2009)

	Products									
Machine	1	2	3	4	5	6	7	8	9	10
Large Press				○	○		○			○
A x 5	○	○	○	○	○	○	○	○	○	○
B x 1	○	○	○							
C x 2	○		○	○	○				○	○
D x 3		○		○		○	○	○		
E x 5		○	○	○			○			○
F x 1	○	○								○
Furnace x 1							○			
Production/month	100	500	—	10	—	—	—	1000	200	—

(A, B, ---; Machine. x 5; Number of the machines. 1, 2 ----; Product.
–; Intermittent order)

Model line installation.

The ideal formation of making stream is to install the machines and works in the process order of the production. But one difficulty is the balance of the machine capacity and the production volume. Then they chose the product "8" as the candidate of the model and demonstration line of "Making stream of production".

But in early, the objection was made from a manager and the department of production planning who concerned the down of the Machine Performance. Particularly the machine A is used to all products.

According to the preliminary survey of the factory,

the machine operation ratio of A = 45% and

the machine down ratio = 20%.

Based on these data and additional investigation, the project team discussed with managers, production planning department, gemba and maintenance engineer to improve other 4 machines A operation ratio up to more than 75% which figure was possible to cover the necessary capacity for the production of other products.

※ Machine down ratio =

∑Break down and Stop hours x 100/Total Working Hours planed

※ Machine operation ratio =

∑Operation hours x 100/Total Working Hours planned

The conventional situation of machine A (5 machines)

Average (of 5 machines) of operation hour result: 73 hours/month & machine.

Machine operation ratio = (73h ÷ 160h) x100 = 45%

※ Total working hours/month:

160hours/month = 20working days/month x 8hours/day.

Investigation.

The causes of so low machine operation ratio was investigated in the collection of monthly record and Man-Machine chart analysis.

Then the reason of machine stop was.

Machine down and stop hours: 32h.

(Machine down ratio: 32 x 100 ÷ 160 = 20%)

Changeover time total: 42.5h

(Changeover frequency: 98times/month. machine ≃ 5times/machine. day)

(Changeover time = 42.5h x 60 ÷ 98 = 26minutes/time)

Other machine stop (paperwork): 10h (30minutes/day)

Available machine operation hours: 160- (32 + 42.5+ 10) = 75.5h

Countermeasure of improvement

1) Changeover time reduction: 26 to 7minutes/time in the activity of SMED.
2) Improvement of Machine down ratio: 20% to 5% in the activity of TPM.

And improved available machine operation time was

160 – (11 + 8 +10) = 131h.

Changeover time total: 98times x 7min. = 686min. = 11h

Machine down time: 8h

Other machine stop: 10h

(Available Machine operation ratio = 131 x 100 ÷ 160 = 82%.)

The machines of D have sufficient capacity even though one machine is used in the model line.

With this condition which to be improved the operation ratio of machine A, this company allowed to use A and D machines in the model line.

Model line installation (with product "8")

-Product "8"

Monthly demand: 1.000/month

Delivery date: Aug.23rd.

Necessary machine: A and D.

Kinds of parts: Internal machine works; 12 (A: 8parts. D: 4parts).

From supplier (plastic parts); 6.

Production process: Machine work, sub-assembly and assembly.

Previous LT of this product: 21days.

The previous production lot size: 1.000/lot.

New lot size changed: 10/lot.

-Machine work process (A and D machine)

1.000/20days = 50/day. 50products x 8parts = 400p.

400p/10/lot =40times changeover/day.

At this timing we didn't target one piece production flow in the machine work process because of the increase of change over, but targeted to minimize the lot size (10/lot).

And it was easy to produce in these machine capacity.

The machine operators hated the trouble which to increase the changeover frequency. Anyway these operators were accustomed to the situation that after setting once, they didn't need to work without the watch and inspection. Then the supervisor taught the primary job and task of machine operator.

-The doubt of a member. (Heijunka of receiving order and) Heijunka of delivery.

Now I introduce an interesting story which was the doubt of a project member.

Once again what is the purpose or merit to introduce the "Making stream of production"?

The purpose or merit of this system are to reduce "LT, Inventory" and improve the "space efficiency, quality" and (as the results of these) improve the cash-flow.

(The members of this project were very much excellent and persistent.)

And one member who is an accountant questioned that it is not possible to ship the products until finishing the all order number and is necessary to stock in the warehouse even though making one by one. This question was on the essence.

If it is not understood this point, it is not possible to be understood the essence of the theme of "making stream of production".

In just making stream of production, is it possible to gain above merits?

1) Reduction of LT: Yes very dramatically.
2) Quality improvement: Yes but in the condition of installing the system of guarantee the quality in individual process.
3) Space efficiency improvement: Yes in the production site dramatically.
4) Inventory reduction: Work-in-progress--- yes very dramatically.

Inventory of raw material in warehouse---No, and it is necessary to introduce the system of “Heijunka of procurement”.

Inventory of finished goods--- No, and it is necessary to introduce the “Heijunka of delivery”.

As you understand even though introducing the system of “Making stream of production” it is not possible to reduce the inventory.

5) Improvement of cash-flow: Yes, but it is necessary to introduce the system of above (Heijunka of procurement and delivery”).

This accountant had the doubt of the effect of the cash-flow improvement in the model line. I taught the importance of increasing throughput for increasing profit and cash-flow. And the first step of introduction of TPS is to make the flowing production process (Making stream of production). But in just making stream of production, the effect of improving cash-flow in reduction of inventory is never sufficient.

Let’s look more exactly in this model line.

Monthly demand: 1.000/month

Delivery date: Aug.23rd. (One and half month later.)

Date of start production: Jul. 13th.

Promise of delivery: Delivery at once. Up to Aug. 23rd.

Delivery at once.

If delivery at once, it is necessary to stock the finished good which will be produced by Aug. 22nd. Therefore even though very short LT in small lot production is achieved, the finished good are stocked in the warehouse up to the delivery date. If these situation, the cash-flow is never improved.

And this team made a discussion with the “observer & advisor team” (all departmental manager are nominated and participated) to find the solutions.

(The solutions had already been made in the project team, but needed to gain the decision and agreement of the department managers of sales, production, production planning and procurement.)

Then as the result of the discussion,

Production start: Jul.13th. (Same to the plan)

Delivery lot: 50/delivery and 20 times.

Machine production lot: 10/lot.

Sub-assembly and assembly: One piece flow.

Delivery start: Jul.15th. (13th: start. 14th: allowance. 15th: first delivery.)

From Jul.16th to 19days: daily delivery. Final delivery: Aug.11th.

Accounts receivable: From the first delivery and not in bulk.

The most intense dissent was from the sales department manager. And saying

"Yes, it is possible to start production from Jul.13th, but impossible to deliver from the Jul.15th because of only 2 days LT. I can't believe this dream plan because our sales department always had the troubles of delivery delay and the claim of customers. We can't take the responsibility. -----"

"Also the requirement of the client is to deliver 1.000 at once."

Then we made the presentation of the model line which produce the product "8" 50 daily. And also the importance of the improvement of cash-flow and throughput and asked to investigate the wish of the customer when and how many the customer wishes to receive the product. Does really the customer wish to receive 1.000 at once?

As the result our offer was very much welcomed by the customer who uses the product "8" for his seasonal product.

The procurement department needed to negotiate to his supplier who makes the 6 plastic parts and required smaller lot delivery. And in following condition the requirement was accepted.

1) Guarantee the dealings of 1.000.
2) (But the accounts payable is made in each 50.)
3) The increase of delivery cost is paid by the company.

(As the result this supplier made this injection moulding parts in the 1.000 in bulk and stocked in his warehouse.)

The sales department manager strictly required us and said that "please never hesitate to inform if the line couldn't achieve the challenge and delay".

Now as you understand that only the making stream of production, it is not sufficient to achieve the target of Cash-flow and Throughput improvement in reduction of LT and inventory and is required the Heijunka of procurement and Heijunka of delivery.

Then the model line was started at the Jul.13th and was very smooth (because the workers are familiar with the product.)

The achievement results of this model line.

Labour efficiency: 20% increase.

Machine operation ratio A: 18% (Other A machines; 82% but 18%)

Machine operation ratio D: 20% (available operation hours: 5.2h, but 1.4h)

Production Turnover ratio: 10turns (*From average ratio total: 0.1turn.)

LT (just production LT): 2days (From 21days.)

※Production Turnover Ratio: Sales of the month/Stock (inventory) of the month.

I recommend to use the Production Turnover ratio (or Inventory Turnover ratio) as a gemba and as the index of Cash-Flow improvement. Of course we know that there is the Accounting Standard to calculate the cash-flow. However for the management in gemba, easier index is required.

※LT: 2 days for just first delivery. Previously 21days were needed for the start of shipping.

∗From average ratio total: 0.1turn--- Average of all of the factory.

Machine operation ratio was worsen to 18% and 20% (Other A machines: 82%).

But it is quite natural because it wasn't necessary to use these machine to produce more out-put in the model line.

Let's look the result of the machine operation ratio in the model line.

Total working hours planed = 8 hours/day; 480 minutes.

1.000/month. 20 working days. 50products/day.

Preparation of materials, tools were made by the supervisor.

Lot size: 10/lot

(Machine A. 8parts worked.)

Changeover time: 7min/changeover x 5 x 8 kinds/day = 280min. = 4.7h

No break down time recorded: 0

(Because of sufficient maintenance in advance)

Other machine stop: 30min/day (10h/month.)

Total machine stop result: 4.7 + 0 + 0.5 = 5.2h.

Therefore

(Available) machine operation hours/day = (8-5.2h) = 2.8h.

On the other hand total machine operation hour result was 1.4h.

Machine operation ratio = 1.4h ÷ 8h = 18%

This machine A has the capacity of machine operation 2.8h, but was used only 1.4h.

(Machine D. 4parts worked.)

Changeover time: 7 minutes/changeover x 20 times/day = 140min = 2.3h.

No break down time recorded (because of sufficient maintenance in advance)

Other machine stop: 30 minutes/day.

Machine operation ratio = (8h – 2.3 – 0.5 = 5.2h) x100 ÷ 8h = 65%

(Available)

On the other hand total machine operation hour result was 1.6h (96 min).

Machine operation ratio = 96 minutes ÷ 480 = 20%

This machine D has the capacity of machine operation 5.2h, but was used only 96min = 1.6h

Again machine operation ratio or machine performance or machine investment performance falls when fixing machines to a line.

Therefore TOYOTA doesn't like to use multifunctional and high speed machine which is very expensive, but likes simple and cheap one also doesn't like to fix.

In the case of this company and the model line, there was no necessity to produce more in machine A. If produces, it is Muda of production. Even though it is expensive, it is better to stop rather than making unnecessary stock.

In the process of making stream of production model there were many troubles.

1) Getting understanding of managers and gemba.

In the review of this model line still there was the dissent because the machine performance down.

Machine A: (Available) Machine operation hour and ratio;

2.8h (35%) but 1.4h (18%)

Machine D: (Available) machine operation hour and ratio:

5.2h (65%) but 1.6h (20%)

The opinion of the manager was

"By so low machine operation ratio (18% and 20%) it is not possible to recover the investment".

And I taught them and told that

"As you said one of cause of low machine operation ratio is the lot size"

"However even though use the original lot size (1.000/lot) or 1/lot, the depreciation amount is same. Even though no use or use in low operation ratio the depreciation amount is also same".

"The purpose of the company is to increase and improve profit and cash-flow, and not the increase of investment recovery".

"Our team could achieved the LT, improvement of labour efficiency, cash-flow improvement and could show the possibility and direction of this company". Now you can decide that shall we expand TPS to all or shall we stop this project?"

(Of course this company chose to continue this project and introduction of TPS.)

2) Labour union.

For the accomplishment of TPS installation, not only the mind of managers, but

also the change of worker's is essential.

Changing mind from the individual personal work to team work.

Multi-skill required and evaluated in the Skill training and Evaluation chart.

5S &4R and Kaizen in gemba. QC circle and Kaizen suggestion.

Self-check inspection and quality responsibility.

Machine check and maintenance (in the case of small problem) by the operator.

Most of the workers were very much cooperative. But some operators appealed to the union for increasing salary.

3) Cross training for multi-skilled worker.

The task of training was required to Human-resource department. But this department hadn't the experience of Training and training facility, Evaluation and the system.

Therefore our TPS team needed to establish the base of training with the members of the department.

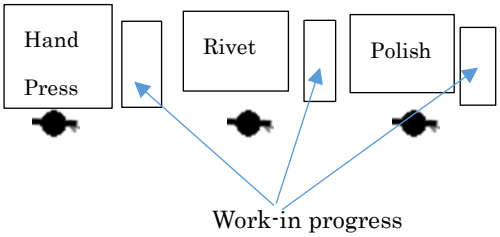
So far I described the making stream of production from the situation of machine work.

Then I describe the sub-assembly and assembly lines which were used the "Cellular Production system"

Cellular production.

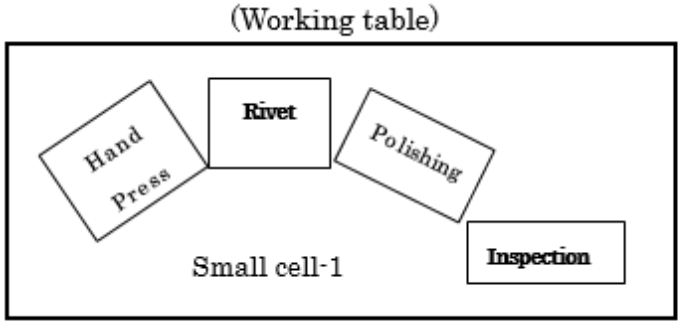
For making stream of the product and the model line, we used the technique of cellular production in sub-assembly and assembly.

The image of previous production line was as follow.



Typical batch production.
And each process has the work-in-progress (WIP).

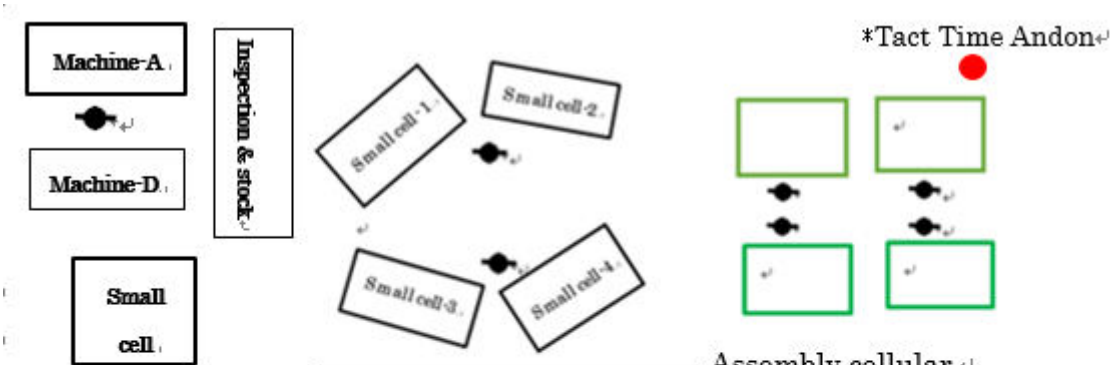
And following is the image of the sub-assembly cell in the model line.



Originally these processes were placed in individual working tables and the works. And this team collected the works in the consideration of working balance. (Stand work style)

This is an example of very small cell. And collected the works for making small cellular production. Of course the work load and number of workers were considered in the condition of 50/day production required.

And the project team made one cellular production line with total 4 small consecutive cells as following image. And next they made the assembly cell which linked to the sub-assembly cells. (●; worker)



Machine work cell.
1 operator and 2 machines.

Sub-assembly cellular.
2 workers. Also depending upon the production volume it is possible to adjust.

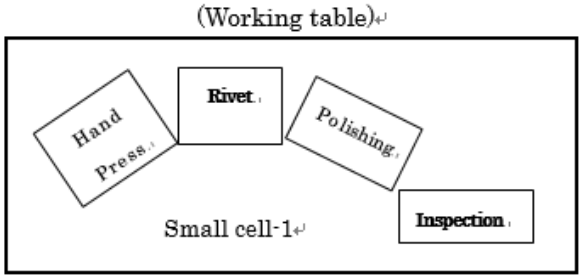
Assembly cellular.
4 workers; Depending upon the production schedule it is possible to reduce and adjust. 4 carts but *human conveyor system. Final inspection in each working cart.

※Human conveyor system: General assembly system in conveyor is that the conveyor moves and conveys the works. But human conveyor system is not use a conveyor, but the workers move clockwise rotation in the tact time which is signalled by the Tact Time Andon.

Small cellular. (In fact I prefer to use the cellular production system.)

For the formation of this stream of production, Machine cell, Sub-assembly cell and Assembly cell were made.

Once again this picture.

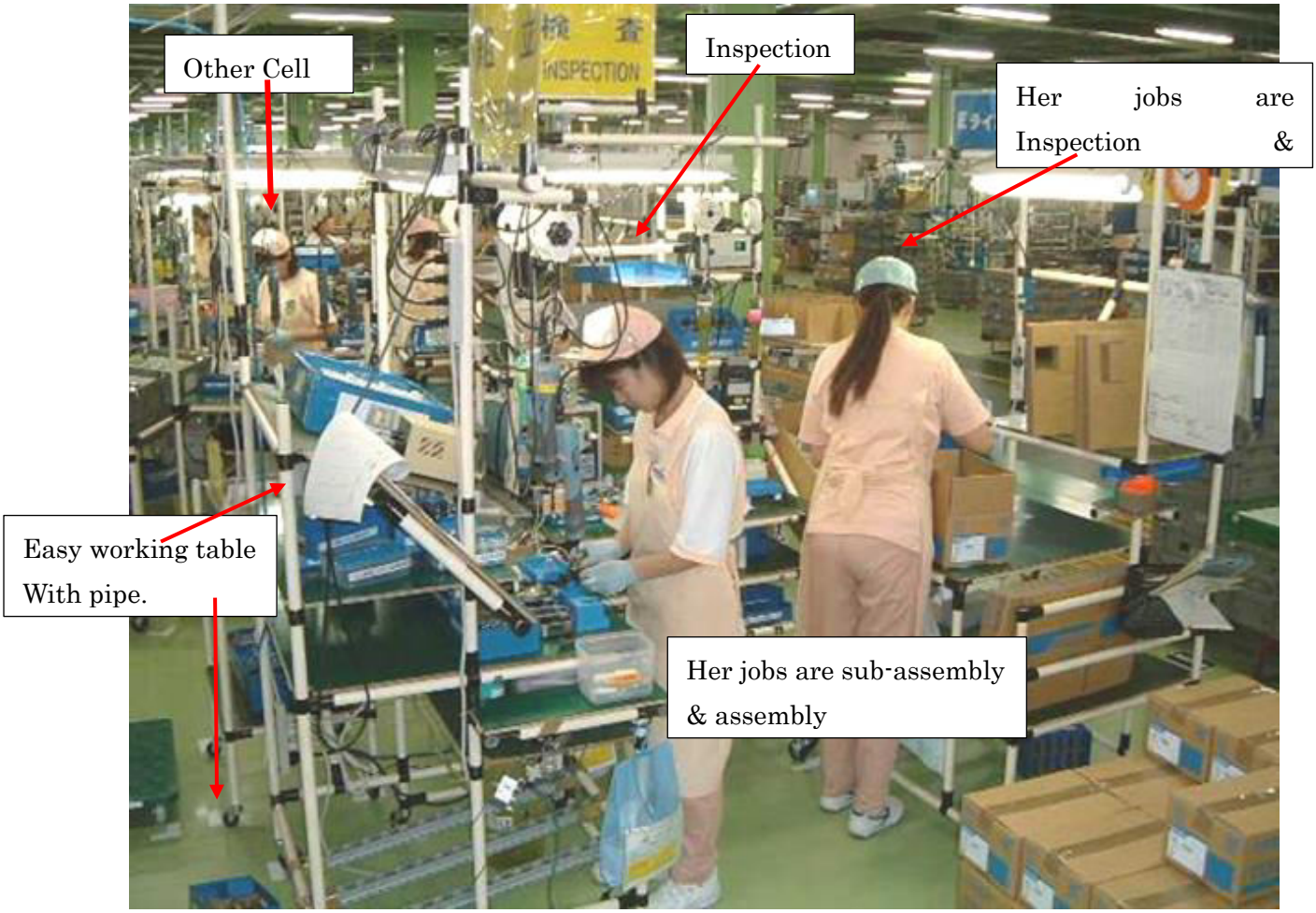


Originally Hand press, Rivet, Polishing machines were installed in individual working table like as independent process. (Inspection wasn't)
Our team collected these small machines in one working table.
This method is very effective for not only to simplify the process, but also to improve the efficiency.

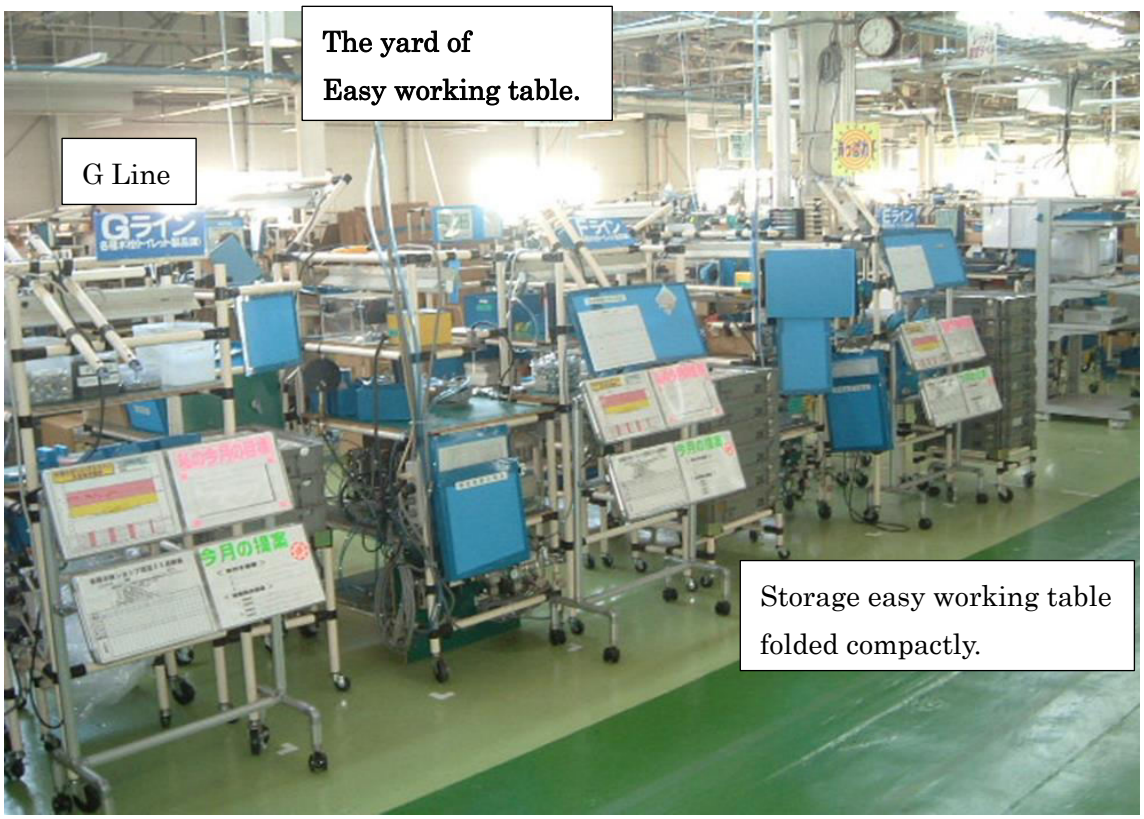
Example of cellular production (Japanese industrial company)

U-Line.

2 workers: Processing & Sub-Assembly & Assembly. Inspection and Packaging.



Same line and same product to above. But the demand of the product decreased.
Then the line formation also changed to 1 worker cell.



The advantage of this system is

-1. Possible to reduce LT. -2. Reduction of work-in-progress. -3. Quality improvement by the inspection in individual process and responsibility. -4. Quick response to customer demand in easy production control and the flexibility. -5. Reduction of conveyance between cells. -6. Reduction of changeover time. -7. Reduction of inventory (finished goods). -8. Improve the efficiency. And -9. Improve the motivation of workers.

On the other hand there are demerits which are following human factors.
-1. Multi-skilled worker is required. (Training and skill control are required.) -2. Variability of production out-put and quality between the workers. -3. Long term employment required (because of the multi skilled worker required),
(However if you desire to introduce TPS, the requirement of multi-skilled workers and multi-process working are essential.)
And the technique of Cellular Production is one of most effective system for eliminating the stagnation. “Stagnation” this is a cause of MUDA and a result.
Again the purpose of “Making stream of production” is to reduce the LT and avoid the stagnation.
But why does the phenomenon of stagnation (in production process) occur?
There are rough classifications in 2 causes.
One is the technical causes which are the job shop style and batch production, high speed and multi-functional machine, line balance, production order to gemba and one batch delivery. (One batch delivery; I will describe in “Heijunka of receiving order”.)
Another one classification is the causes of the variable condition of factory.

Human causes: Accident, work but out of standard, excess production, production error, production delay, capacity shortage, skill level, absence, corner-cutting and sabotage.
Material causes: Defective, shortage, mixed, supply delay, supply excess.
Machine causes: Break down, frequent stop, functional error, variability of speed, capacity shortage, defective die or tool.
Work environment causes: Variability of air, temperature, humidity, lux, variability of electricity, variability of pressure, stench, dirt, danger.

When starting the introduction of TPS, I taught the basic factory management in parallel to reduce the causes of factory condition.
And for the technical causes (the job shop style and batch production, high speed and multi-functional machine, line balance, production order to gemba and one batch delivery), we proved the effect and possibility in the model line.
After this success the team challenged to making stream line of the product 7 which requires to use the “furnace” and has 50 kinds of parts (I introduced in the description of LTE).

Next I describe the case of this product “7” and how we could make the “stream of production”.