Making Stream of Production

-10. Making Stream of Production for “small demand and constraint process”

Is “push” bad and is “pull” good?

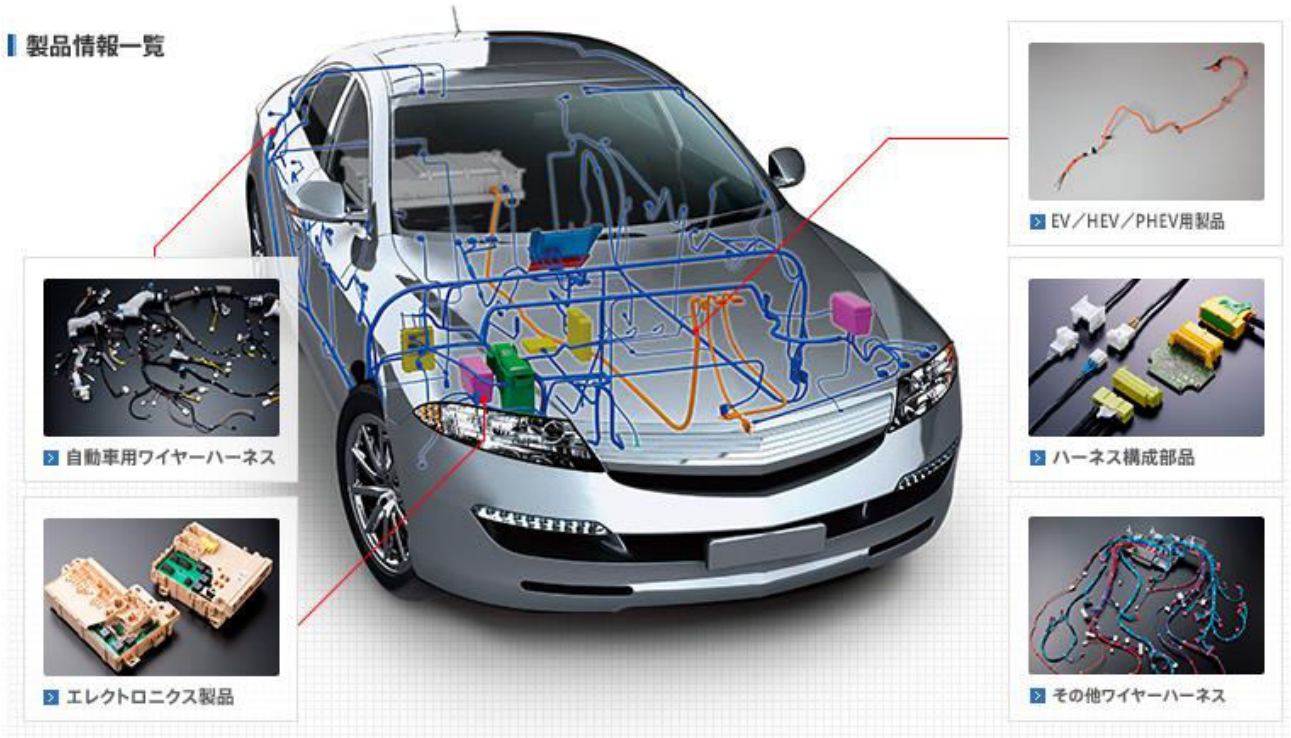
In the last description I wrote and explained the pull system.
And I explained the 2 types of pull system in SUSHI story.

One is the sushi process of traditional restaurant or high speed carrier.
This style realize the ideal pull which is no necessary to have stock.

Another one is the conveyor style sushi restaurant which is necessary to have the stock in the conveyor and has the risk of sushi scrap because of 45 minutes rule.

Basically the pull system is necessary to have WIP and minimum inventory to maintain the production stream.
And this student company was trying to introduce the production control system in their parts fabrication factory.
Their difficult task was to find the control methods for the parts fabrication process.
Firstly they believed that the furnace process is one of “constraint” process. But they realized that the constraint (which is so called) doesn’t exist, but mere missing control process exists.
Then the project team understood the key activity, which is the process control in Te-ban, Takt Time, reduction of LT and Heijunka in the Visual control.
But my students had the doubt of the use of push system in Te-ban because still one of their favourite was the lean book in which introduces the lean concept and pull and pull and pull. It is possible to say that these students (project member) were the devotees of this lean book. And they wished to introduce the pull system in their parts fabrication factory and wished to find the solution in the lean book. (But in fact this lean book doesn’t describe the parts preparation process.)
So I needed them to understand “pull and push” and “visual control”.
Now. Is push bad and is pull good?
As I have described pull is very good system in the condition of continuous demand to be able to expect and to be not many kinds of parts preparation in one unit of factory.
In the case of “not continuous and next demand unknown” and “many kinds of parts preparation”, the push system should not be denied.
For getting your good understanding I write one of example which is my experience in my previous company SUMITOMO.
Wiring Harness.
Firstly I need to explain the “Wiring Harness” which is one of main products of my previous company.

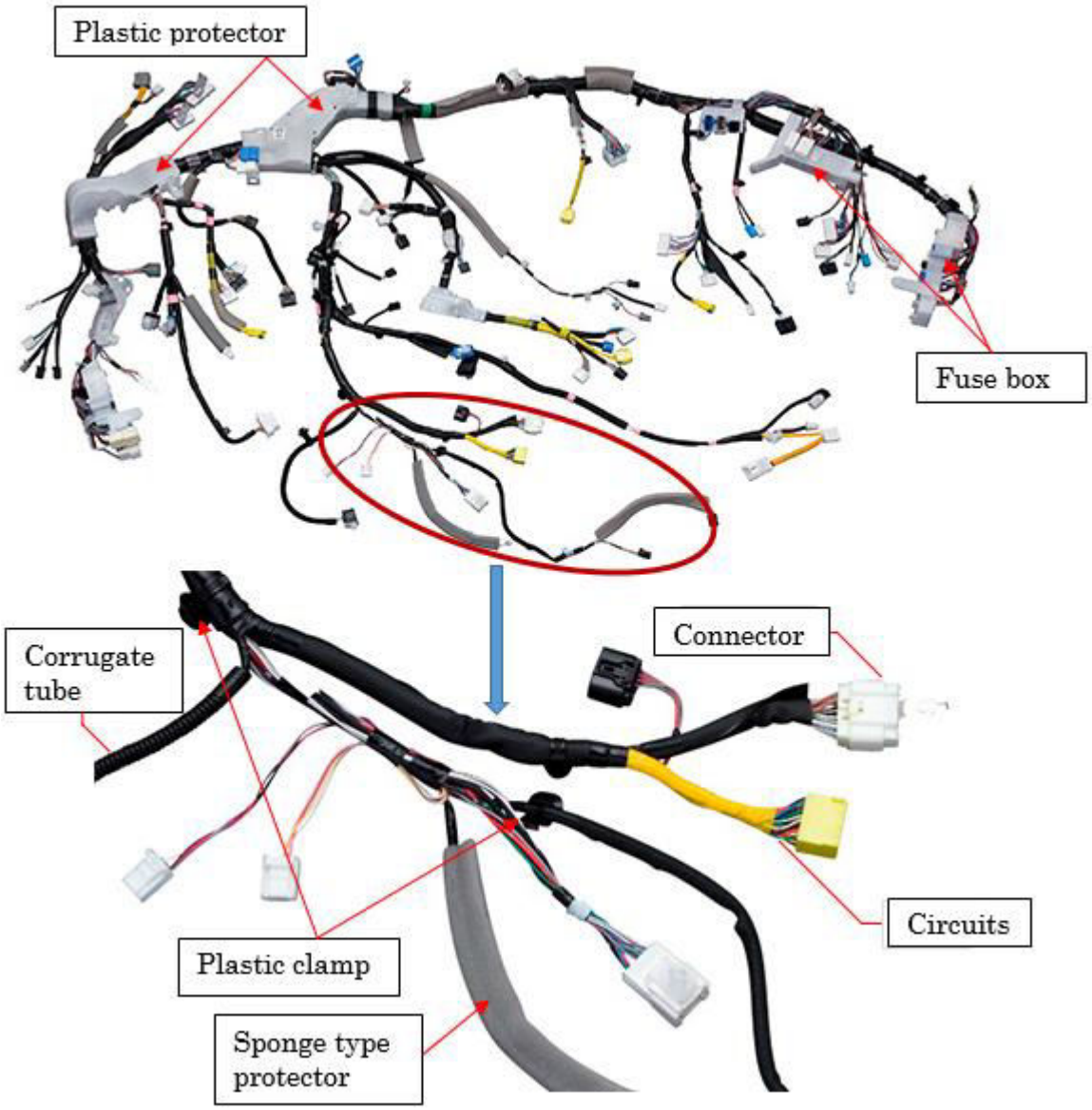
(Images from the web site of Sumitomo Wiring Harness Co. LTD.)



In one car there are 1,500 electrical circuits (depending upon the car type it is different).

Harness type.

The electrical circuits surrounded are cut in 12 kinds (also depending upon the cutting position, it is different.) and 1,500 total.
Cowl wiring harness, Engine, Instrumental, Door, roof----- etc.
Following is the cowl wiring harness which is biggest in all and has more than 300 circuits and more than 4 metres long.



Common materials.

One of difficult thing is that all circuit which constitute of the wiring harness is like as unique parts.

But the cables are the common materials for “all customer”.

The types of cables are general types (11 types), heat resistance (10 types), sealed & heat resistance (8 types) and tubed wire (1 type) total 30 types of cables.

The electric cables are colour coded (Extruding plastic insulation materials.).

For instance.

AVSS 0.5sqmm R-Y

AVSS; Type of electric cable.

0.5sqmm; cable size.

R-Y; Colour of insulation. Red-Yellow.

Then the total kinds of cables are (types x size x colour =) more than 800.
Connectors, terminals (which are crimped at the tip of circuits) are the common parts, but different in the individual customer (Toyota, Honda, Nissan---.).

Of course the functions of each type connector are same. And it is quite ridiculous that each car maker requires his unique connectors and terminals. But it is the reality.

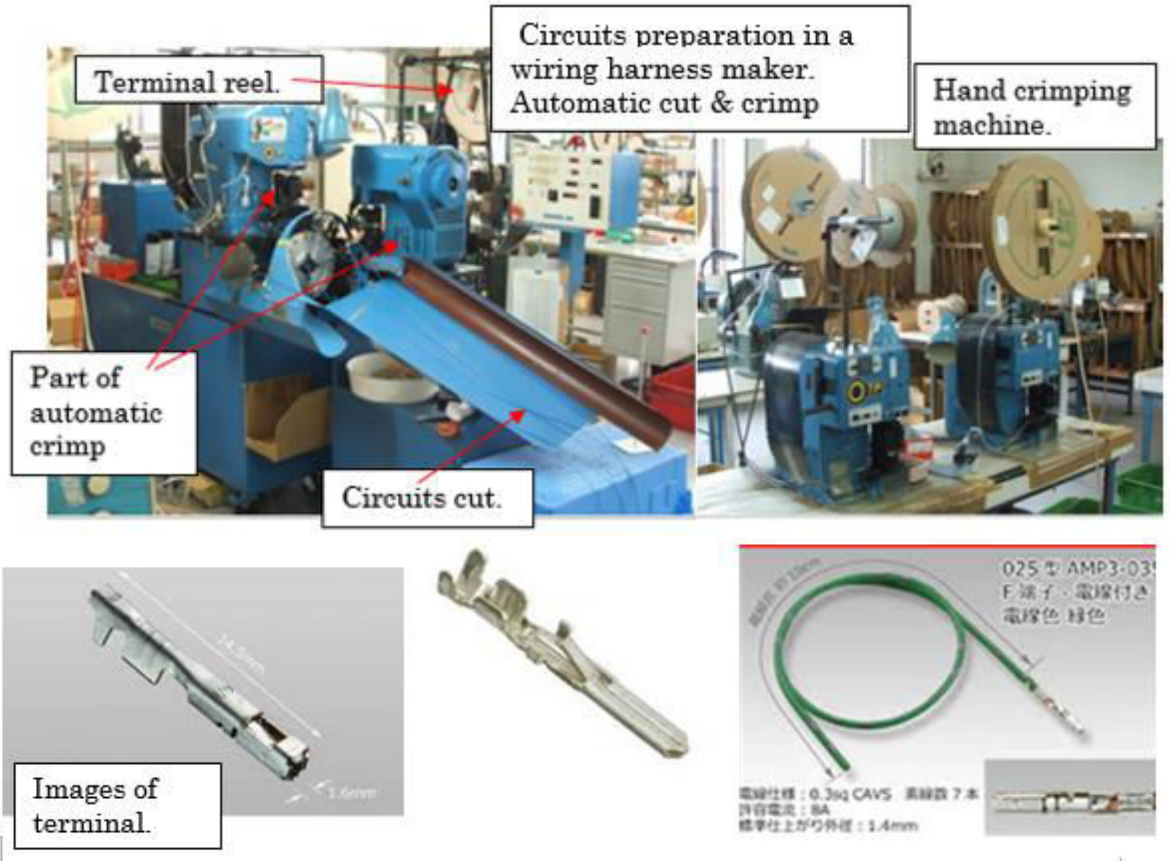
Exterior parts.

PVC Tape, Corrugate tube, pvc tube---. These are common for all customers.
But the plastic protectors are unique for just one car model.

Wiring harness process.

Circuit fabrication.

① (Measuring length and) Cable cutting, ② (insulation of cable) stripping (for crimping), ③ crimping (terminal), ④ Crimping inspection, ⑤ Soldering (in the part of crimp), ⑥ Insulation tube fitting (in the part of crimp), ⑦ Joint (middle strip, joint crimping, crimping inspection and insulation taping).
These processes are the circuits (unique parts) preparation process.
The figures below are the image of automatic cut and crimping machine and crimping machine.



In these machines ① ~ ③ processes are made.
After these, continuing the processes of Sub-assembly.

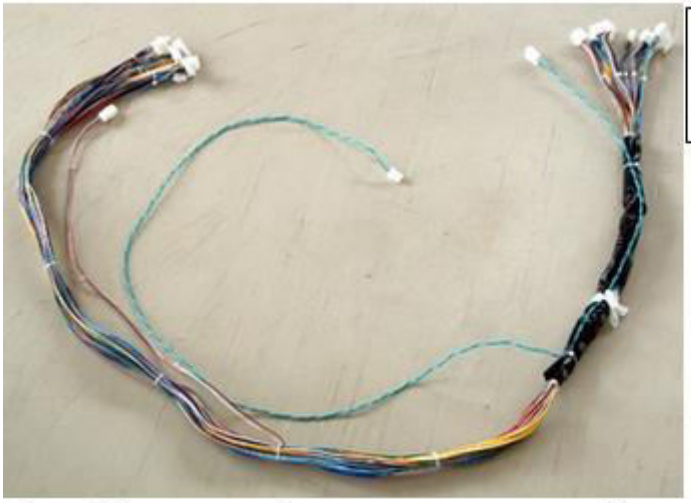


Image of sub-assembly.
The purpose is to realize easier assembly bob.

Assembly process (A wiring harness maker)

Wiring sub-assembly and circuits on the assembly board, Bundling with pvc tape, taping, putting protection parts (plastic protectors, corrugate tubes, pvc tubes---), putting clips and others exterior parts, visual inspection and electrical inspection. (And packaging.)
These are the general process of wiring harness.
Now the circuit fabrication of ①~③ are automated in 80% of circuits.

Wiring harness putting in the car body.
Let's look at how to be put in the car body or (for instance) instrumental panel.

Following photos are the process of Toyota MIRAI which is the FCV (Fuel Cell Vehicle) and was begun to sale.

FCV (Fuel Cell Vehicle); With hydrogen generate the electricity and drive the motor. The most gentle to the environment.

MIRAI; The meaning of future in Japanese.

His car manufacturing is still not in mass production, but has started to sale from the low volume.

After putting the wiring harnesses and other component parts, these are connected with the connectors to make the electrical circuits.

The wiring harness has unavoidable destiny which are

The design is decided at the last. (after deciding designs of other parts and layout, the wiring harness design is decided.)

And the harness layout is used the clearance of car body and other component parts.

Therefore the wiring harness business is bantered with "Niche business". And it is used at the most first of the car assembly.

Therefore if a defect occurred, all of the parts and component (of relevant range) should be taken off.

Now main theme.

The circuit preparation in JIT.

One of important know-how of this manufacturing is to prepare the circuits in JIT.
As I wrote above, one car has 1,500 circuits, which are all and completely unique.
Because of

Cable type x cable size x cable colour x terminal x "cutting length".

The cutting length is specific to just one car model circuits.

Therefore (for example) the wiring harness of corolla can be used just for corolla.
For making one corolla, 1,500 unique parts should be prepared in JIT.

Introduction of Kanban system in the circuit (parts) preparation process.

K. Suzumura and his team (Production Research Office) came to our company.

K. Suzumura is an evangelist of TPS and first disciple of Taiichi Ohno.

Production Research Office was established by T. Ohno to expand TPS in the suppliers.

After looking around the production processes, K. Suzumura decided and told us to introduce the kanban system in the circuit preparation process.
The introduction of kanban was decided by the team.

"There is no point talking now!" And "No more discussion and just do!"

I have already described his haughty attitude before and omit more description.

There was no way to open the business with Toyota. And it was like as the purification ceremony and was the strong will of T. Ohno who desired to expand the TPS in the suppliers.

However it is quite true that we learned many things from them. Yes many.

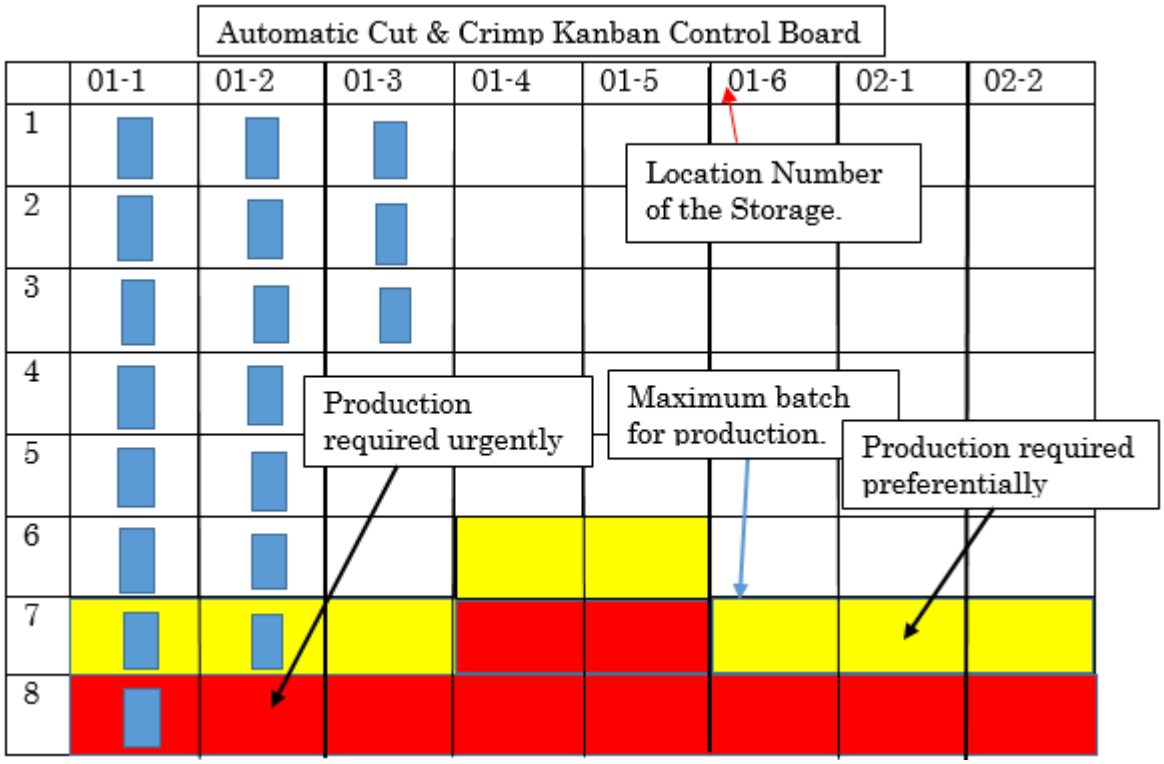
Now kanban introduction in the parts (circuits) fabrication factory.
The steps to introduce the kanban was as follow.

1. Making the circuits kanban list.

   Calculation of the number of kanban based on the demand.

   The rule of kanban (number) maintenance based on the demand change.
2. Kanban design.
3. Store space and stock method.
4. Material handling method.
5. Kanban transaction standard and education.
6. Kanban (visual) control board and transaction standard and education.

Once again I will write the kanban system more exactly. And here I introduce just kanban design and the control board.
Firstly kanban control board.



Above figure is the example of kanban control board for automatic cut & crimping machines. (And Hand crimping, Joint process were provided as well.)
The use of this board.
For example the location number 01-1.

One card requires to cut and crimp 10 circuits.
The production start timing (maximum batch for production) should be the 6.
But the kanban card is reached in the 8 (red zone) which shows the situation of no stock in the storage location (01-1).
Therefore the supervisor himself is required to take the immediate action. If not, the next process (sub-assembly line) will stop soon (or already stopped).

For example 01-2.

One card is in the yellow zone (Production required immediately).
The team leader or the material handler should take the action to produce the circuits as high priority.

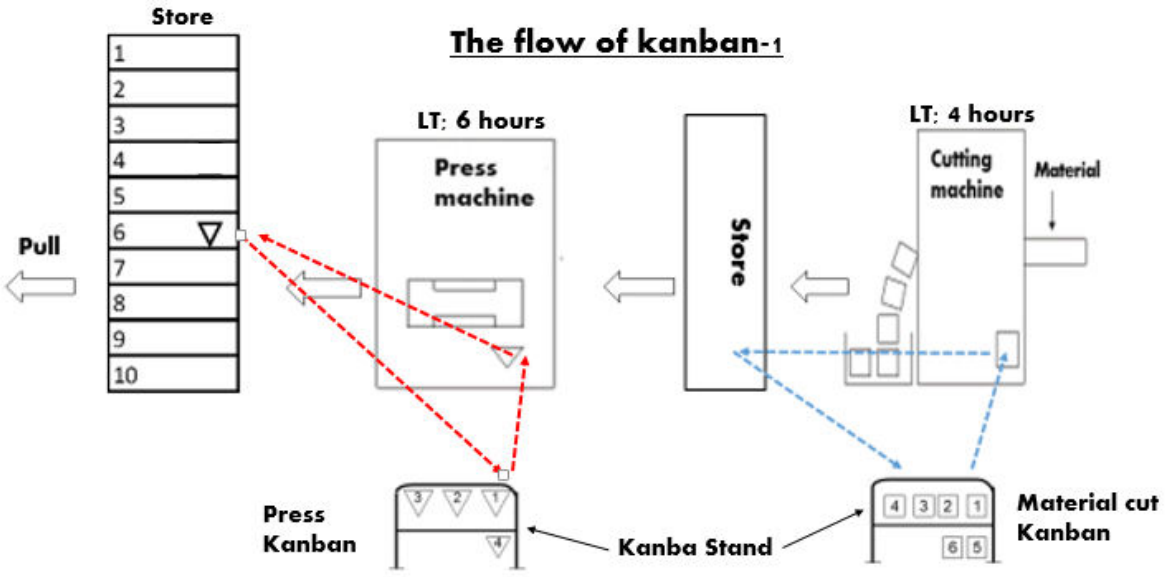
The normal transaction by the material handler is to transact before the level of the level of yellow zone.).

Material handler; At that moment we didn't use the call name of "Mizusumasi", but call name of DANDORI-man (material handler).
The role of DANDORI-man (Mizusumasi) is
Deciding the working order priority in out-put date (of circuits preparation) which is based on the Te-ban.
Providing materials (cable coils, reel of terminals, cut circuits which are

waiting next circuits preparation process such as crimp, joint).
Providing tools (crimping dies) and return these in designated location.
Carrying the circuits which are already finished to cut & crimp to the next process (sub-assembly.).
So the most important job of the Mizusumasi was (and is) to make the stream of production in deciding the work order priority and operate the cables, circuits with no idle time of the next process workers also with no timing delay (to the out-put date and delivery date.).

K Suzumura and his team firstly taught us the theory of Kanban system and then gave us the task to consider and create the idea of using the system in the parts fabrication (circuit preparation) factory.
Then we created above kanban control system based on the delta kanban of the press process in Toyota.

Note) Kanban system
With next figure, I explain the basic move of kanban.
(Just an example for better understanding.)
In the figure, there are 2 machine which are
Material cut machine; LT 4 hours.
Press machine; LT 6 hours.
Production lot size of 1 (Press) delta kanban; 10 containers/lot.
And there is the Store between the press process and material cut.



These processes use 2 different kanbans.
One is for material cut process (Material cut Kanban).
One is delta kanban for press process (Press Kanban).
Both are the production indication kanbans. (Same characteristics.)
Now in the store there are 10 containers.

The move of the press kanban (red line).

1) The containers are used (pulled) up to 6.
2) The press kanban is taken off and carried and hanged in the stand.
   Now in the stand there are 1 ~ 4 kanbans.
   The production turn must be kept, because the production order contents is not necessarily to be same.
3) The press machine produces the parts which are required in the press kanban (10 containers = 1 lot).
   For producing 10 containers, the operator pulls the necessary cut materials from the [Store] and produces the parts of 10 containers.
4) Put the press kanban at the position which is No. 6 turn from 10.
   The No. 6 is the position of 6 hours LT.

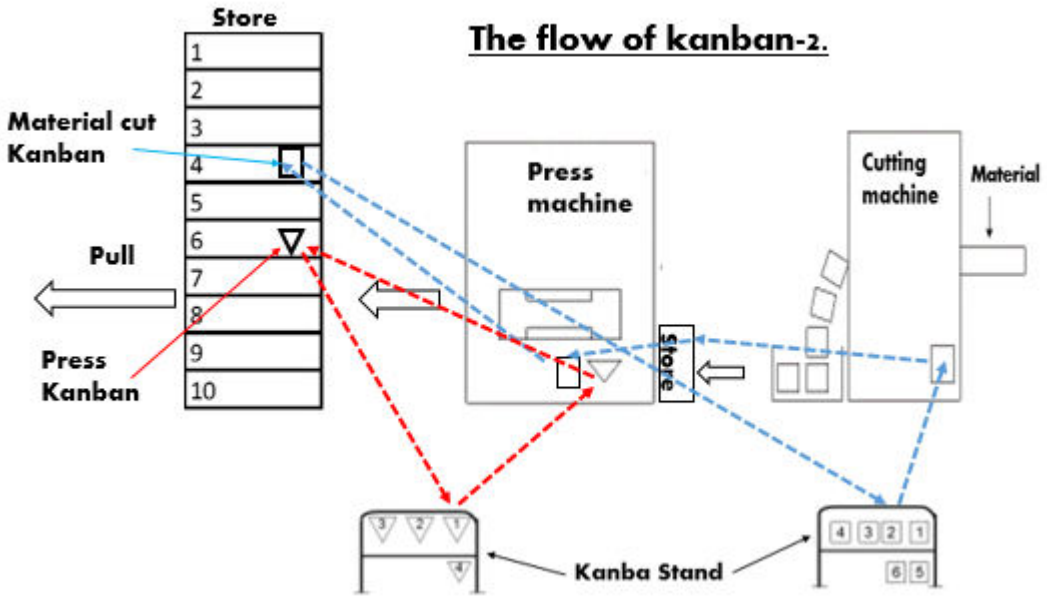
The move of the material cut kanban (blue line).

1) The cut materials in the [Store] are pulled (by the next process; press process). And the cutting order kanban (Material cut Kanban) which was put in the cut material container in the [Store] is taken off and hanged in the stand by the operator. Now there are 1 ~ 6 kanban.
   When hanging the kanban, the turn is never changed or jumped.
2) The material cut operator picks one kanban and start the production in order to the kanban.
   The lot size is not necessarily to be same to the press kanban (10/lot) and should be smaller because of the difference of LT (6 and 4 hours).
3) At finishing the production the kanban is put in the container and carried in the Store.

These are the very basic move and use of Kanban.
And the rule of Kanban system is

1) Don't send the defective parts to next process.
2) Fabricate just the contents and quantity which are mentioned in the kanban.
3) The turn (in the kanban stand) never be changed.
4) For keeping the system, Heijunka production is important.

Kanban system is very useful as the autonomic nerves for the process control.
※ But the essential condition is that the demand of the product should be continuous.
Now based on the understanding of basic move of kanban, I introduce the application of kanban.
Look at following figure.



It is same production flow to "The flow of kanban-1". But there is no [Store]. If the press machines and the cutting machine are very close, above kanban move is recommendable.

The purpose is to eliminate large [Store] and reduce space and the operators.

The move of the material cut kanban.

1) The containers are used up to 4.
2) The material cut kanban is taken off and carried and hanged in the stand.
3) The cutting machine produces the parts which are required in the Material cut kanban.

The move of the press kanban is same to the flow of kanban-1. But

4) Put the press kanban at the position which is No. 6 turn from 10.
The No. 6 is the position of 6 hours LT.
And put the material cut kanban at the position which is No. 4 turn from 10.
<u>The No. 4 is the position of 4 hours LT.</u>

(Again I'm writing the kanban system more exactly.)

(Now go back to the main theme)

Based on these understanding we created the idea of the "Automatic Cut & Crimp Kanban Control Board" for the batch production process (automatic cut & crimp process).

(For instance 01-1)

Minimum batch size; 10/kanban.
Maximum batch size; 10 x 6 = 60.

We began from the simple and small wiring harness (Door harness; about 20 circuits) as the initial stage. (The main circuits and almost are common in the model.)

And we were pleased with the success of the process control in kanban system.

(But the delight was broken very soon.)
The causes of the troubles were

1) Huge numbers of the unique circuit (which is the meaning of huge number of kanban).
2) The appearance of vast forest (huge number of circuit stands)
3) Defect occurrence.
4) Handling increase. And
5) Increase of Scrap loss.

At that timing in the factory there were 1,300 wiring harness part number (design number) in a month. And 800 wiring harness part number were fabricated at all times.

1,300 part number is mentioned the necessity of more than 13,000 storage locations.

1), 2) It was necessary to make the storage location in the kanban control board and the "Circuit storage stands", regardless of which there was the demand or not in the month.

Vast forest. We call the circuit stock stand which is like a tree and possible to provide 4 locations (2 in both side of left and right).

And soon all of the walls were jammed with the kanban control board. And the spaces were flooded with the trees.

As the result we stopped the plan of "tree" and discussed with Toyota.

At that timing we still believed that the problems were not in the kanban system, but were in the method of storage (circuits).

Then as the suggestion of K. Suzumura team, we decided the use of storage rack with containers.

4) 3) But the Mizusumasi workers (material handler) disagreed severely with the decision because of the very much increase of handling.

(not only the rack with containers, but also tree type)

But anyway we persuaded them with the condition of increase Mizusumasi person.

But the result of handling increase caused the circuit damage increase.

Also there was another defect cause which was the deterioration of the circuit end (in the part terminal and insulation stripped).

The electric circuits are so delicate particularly at the point of crimping terminal.

5) Why scrap loss increase?

The causes are the obsolescence because of the design change, damage circuits and the deterioration and unknown demand. The major problem was the design change and unknown demand.

① Design change.

Which happens quite frequently.

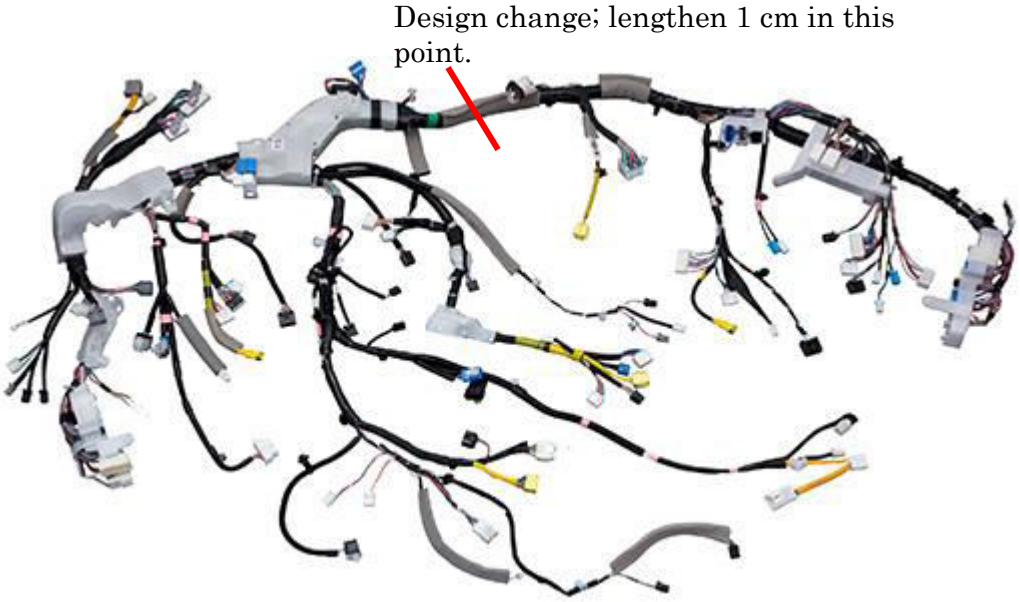
As you know, the kaizen activity is quite popular in Japan. And if an assembly worker of the line has a trouble or difficulty, he makes the suggestion of kaizen.

For instance.

If it is assumed a trouble which a pipe (for instance) touch to the wiring harness, it is suggested to take action. And the action is reflected to the wiring harness design change. In the car maker it is thought that rather the design change of pipe which requires the die tool modification is easier (low cost) than the design change of wiring harness. The design change happens quite often even though after the start of mass production.

The influence of design change.

Again this picture. And in this picture, I explain the worst case of design change.



Design change which is related to the circuit length in the parts of trunk is worst case because all of the relevant circuits are required to change the length. As I wrote before all circuits are unique to just one part number or the car model. Of course this casual kaizen idea by the line worker relates to the cause of circuit obsolescence.

This threat happens in the conventional production control method. But one of difference is that it is possible to gain the compensation in the conventional method from the car maker because the method was completely “make to order” style.

On the other hand it isn’t possible to gain the compensation in the kanban system which is needed to have the minimum stock by our own risk.

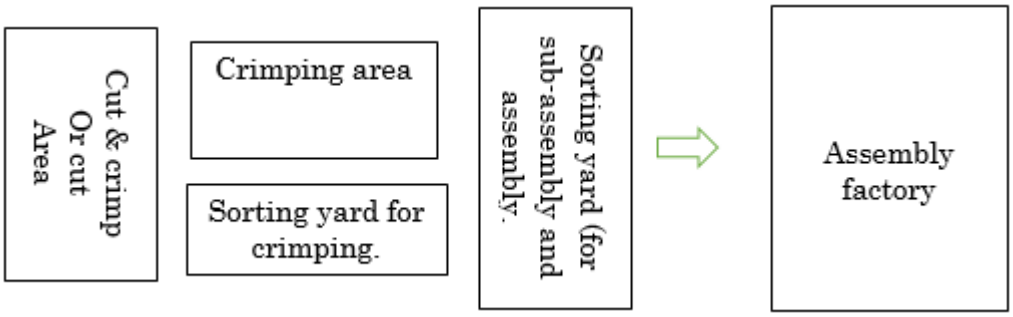
② Circuit damage because of the material handling increase.

The conventional production control method is the te-ban control with push system.

Making order to the process.

In the back calculation from the delivery date in te-ban, the making

order to the process is made.
The work of Mizusumasi person (material handler).
Following figure is the image of circuit fabrication factory.



After cut & strip (insulation) & crimp if necessary to crimp in other end, the circuit is put in "sorting yard for crimp. And the circuits which finished the fabrication are put in the sorting yard (for sub-assembly and assembly).

The carts are developed for the handling. The shape of the cart is like a "horse (but with no parts of neck and head)".
The Mizusumasi sorts the cut circuit and decide the priority of (for instance crimping) based on the out-put date.
Also the Mizusumasi arranges the necessary circuits for assembly based on the te-ban and the delivery date.
Of course these works are done in the use of the carts.
The most important job of Mizusumasi is to make the flow of production (Making stream of production).
The Mizusumasi persons required us to return from the "stock forest and/or rack" to the conventional method.
One of reason was the increase of damage circuits because of the increase of handling.

③ Deterioration and unknown demand.

Why deteriorate? So long term the circuits were kept in the trees.
In the last description I explained the pull system in the story of SUSHI.
The life cycle of SUSHI (in the conveyor) is 45 minutes. The case of the circuits are not so short, but about 2 months. The circuits deteriorate within 2 months. The identity of the deterioration is the rust (particularly in the part of stripped insulation).
Why does it occur the case of keeping so long term?
Because the timing of demand is unknown.
(At that timing we didn't manufacture the wiring harness of Corolla. But as the example.)
Corolla has many variations such as sedan, van, hardtop, lift back, for Southeast Asia, for China, different engine types -----.
And individual variation has the different wiring harness part number.
And it is required to prepare and stock the circuits for all variations.

Note) Unique circuits.

For instance Cowl wiring harness had more than 40 part numbers. And individual wiring harness was constituted of the common and unique circuits.
The common circuits were possible to use for all part numbers.
But the unique circuits were for just individual part number.
Of course the corolla wiring harness can't be used for other model (for instance Lexus).
These unique circuits were the unknown demand.

It is possible to gain the one month, 2 months and 3 months forecast. And the one month forecast has very high accuracy (error by less than 10%). But these are "forecast" and not the actual order. The actual order is made by just daily withdrawal kanban (at that era, kanban card was used. Now it has been changed to the electronic kanban.).
In the forecast, the information of detail variation which is possible to use for the production wasn't mentioned. Therefore actual demand timing is "unknown".
Anyway it was required to prepare all variations in stock for the kanban system. All circuits variation were used (it is quite true.). But Toyota can't so much as know the demand in the variations.
In the reason, many obsolete or deteriorated circuits occurred.

After K. Suzumura and his team retreated, we restored our conventional production control system. And the spectacular trial of pull in kanban system in the parts fabrication area was finished in failure.
We learned in this failure many things.

① Kanban is very excellent system, but not universal technique.

The essential condition for pull in kanban system is that the demand is continuous and shouldn't be unknown.

Note) After this project, I used the kanban system for (for instance) electric cable manufacturing (from Drawing ~ Bunching ~ Extruding) etc. in very successfully.
(I describe more detail use of kanban in the column of kanban system.)

② Pull system requires the minimum WIP or inventory for JIT to the next process or customer.

My students are almost devotees of the lean book. In this book, TPS is introduced in all example companies to explain the importance of lean thought. Therefore it is possible to say that this book is one of TPS book. And this book advocates lean pull lean pull----for the implementation of lean thought. It is ridiculous.
To seek for lean, TPS is mere one of tool, but not universal tool.
Pull system which requires minimum stock is also not the universal method.

③ It is not suitable for enormous kinds of unique parts production.

I introduced the case of my previous company.

Huge number of storage locations were necessary.

The most difficulty was the maintenance of kanban including the kanban board.

I know that it is possible to maintain "logically" even though the number is in vast.

But the maintenance of kanban card and the control boards in the frequent design changes wasn't easy in the actual work in the line and also in the office work.

Note) The situation of car manufacturer.

The car manufacturer (Toyota, Nissan, Honda whatever) is mere assembly maker and not manufacture many parts. One car uses about 100 thousands parts (. Including commercially available parts and component parts; 20 ~ 30 thousands). But most of these and the component parts are supplied by external supplier.

The exceptions are body line and engine manufacturing. The car manufacturers have their own body and engine plant. But they don't make all parts internally.

The outline of body line is

Press – Welding – Painting (Under coating, middle coating, over coating and Clearing) – Assembly and welding – Inspection.

In this process, door, roof, both side, floor, rear and bonnet are manufactured. And as you aware, there are not so many kinds.

A gasoline engine has 500 ~1,300 parts. And most of the parts are supplied by the suppliers. And some parts like as cylinder block and crankshaft are made internally.

However the number of internal parts production kind is double-digit.

The engine type also is not so many. For example, new corolla has 5 types of engine (1NZ-FEX, 2RN-FKE, 1NR-FE, 1NZ-FE), but uses common parts in 5.

Therefore it is possible to say that Toyota applies TPS for quite few internal parts.

④ Te-ban control for making stream was not perfect method and was still far from JIT but better than the pull system for this business model.

⑤ The importance of Mizusumasi job for making stream.

We learned the importance of the work of Mizusumasi for "Making Stream of Production"

⑥ The meaning of visual control.

One of big problem in our process was the insufficient level of the "visual control".

About this, I'm writing in next description.

Note) Toyota also uses “push” system in his line. (It is quite true.)

In an occasion, Toyota uses the push in his manufacturing line.
The occasion is the finishing of the model.
(Probably there is no description in your text book.)
As you know, car manufacturer does the model change regularly.
In the case of Japanese car maker,

Full model change; each 4 years. (This is for complete renewal of model).
Minor model change; each year. (This is for kaizen.)

In both case, the wiring harness has the new design or big modification.
In the final production, Toyota uses the push system to avoid the obsolescence.
UCHIKIRI Kanban.

UCHIKIRI; Finishing the current model.

In Toyota line
When it is identified the final production number for changing to new model,

this information is issued to all process (not just final assembly process.)
※ In normal production, the production information is informed to just final assembly process.

And all of the processes check the inventory.
Based on the inventory and WIP check, the production planning department

issues the UCHIKIRI kanban to individual process.
In this occasion, the production order is completely push.

In supplier (my previous company).
Getting UCHIKIRI kanban of individual necessary harness part number.
Inventory check.

Finished products. WIP of each process (Sub-assembly).
WIP in circuit storage location.

And unique parts (Exterior parts, plastic protector, connectors, terminals)

Then if it is necessary to produce or fabricate additional, make the number of

the difference.
Most of the circuits are in this case.

But if there is no demand or smaller number than the stock, the difference

becomes the obsolescence.
And many of “demand timing unknown” circuits become the obsolescence.

I wrote above the returning to the conventional method with te-ban.

It is same to use the UCHIKIRI kanban for individual demand.

Note) Famous manufacturer of machine tools.

(I believe you also know the name of this company which is so famous in the world.)
I have visited this famous manufacturer of machine tools.
And at the same timing one of Japanese consultant of TPS, visited the company and looked around the manufacturing process.

He engaged in Toyota long years and now works as a TPS consultant based upon his experience.

He expressed his impression regarding the use of TPS in such machine tool manufacturing process in his book published as follow.

I have visited a major manufacturing company of machine tool.
In this company, one machine tool is produced in each 8 hours.
In Toyota, one car is produced within 1 minute. Therefore in the parts fabrication factory, one parts is produced within 1 minutes and is sent to next machine.
The parts factory doesn't use the NC machine which is very expensive and multi-purpose, but use very simple and cheap machines because of the work of simple repetition.
And for making the dedicated lines, lot of cheap and reduced change die machines are required.
However this machine tool manufacturing company makes one product in 8 hours. And it is not possible to make the dedicated lines because of the huge variety kinds of parts.
After all, this company needs to produce the huge variety kinds of parts in NC machine. On the other hand the changeover time of NC is not easy to shorten like as Toyota. Then this company has lot of NC machines for the parts preparation area.

Such production model which is very small production quantity, it is not suitable or possible to use the TPS.

After all I recognize that TPS is useful and suitable for the mass production factory (at least it is possible to expect the continuous demand.)

I never agree with all of his point of views.
But it is quite true that it is not realistic to make the dedicated production line for small demand and many variety of parts kinds.

(The project of the model line.)
As the result, I could free my students from the spell of the lean book.
Again.

Push and pull. Depending upon the occasion, it is necessary to use both properly.
Pull in kanban is good tool for the case of continuous demand.
On the other hand it is not suitable for the demand of timing unknown.
Also it is not suitable for the process of huge kind of parts preparation.
For seeking lean, TPS is one of good tool, but it is not universal tool.
Te-ban control with visual control, Mizusumasi, reduction of LT and Heijunka is one of good method for seeking lean manufacturing.
In this meaning, not only TPS but also factory management is the good means.

Next I write the true “visual control”.

5Ss is one of basic tool for the visual control. But it is the base of the base of the base.
The purpose of visual control is to know everything of the situation of factory and the progress in the processes.