Asprova's "Pocket manual" series No.15

Theory of Constraints and Asprova

The theory of constraints is frequently discussed as a method for improving factory production capacity. Here we'll look at simple examples of the phenomena in partial optimization that is not based on the theory of constraints and important points in the use of Asprova that are based on TOC.

With data

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Introduction

Factories that operate non-stop and adopt many different measures but still cannot get the results they hope for are greatly troubled by frequent delays in delivery time, no increase in sales, frequent shortages of products and parts, needed personnel unavailable, lead-time much longer than theorized, plans for the future unreadable, building of too many products and/or high defect rate.

The plant might put together a table that shows results in manufacturing (for example number of parts processed) by each worker on each day and hang it up on the plant bulletin board so that it shows the calculated standard values, and will encourage all workers to increase manufacture performance as much as possible, These programs are based on the notion that the organization is made up of individuals and if the performance of the individual is raised, then the entire group's performance goes up. But in many instances such policies do not work well.

For example, a simple policy in which each employee increasing manufacturing performance is equal to decreasing leisure time, may lead to retention of goods-in-process inventory. You could also reduce setup time as much as possible by producing all the same items. You might also make only those products you know best and use only methods already known. Doing that could lead to low-profit manufacturing and perhaps to goods that no one needs. It could also increase defect occurrence.

Conducted according to instruction some of these seem good, but if the instructions are followed but data on sales, delivery date of each lot and manufacturing costs are ignored, they will be factors resulting in low profit, i.e., giving an excellent effort to each process may not lead to improved profits overall.

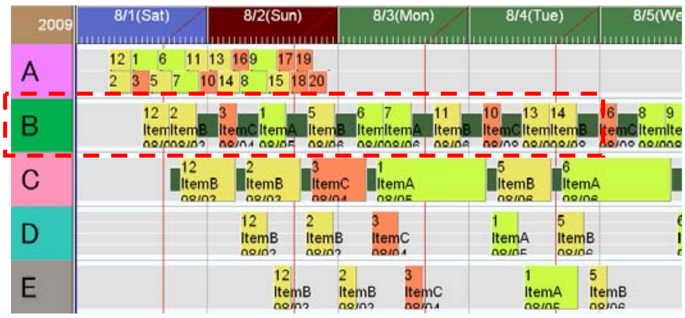
The above described optimization of each worker and each process is a partial optimization while, in contrast, looking over an entire factory and specifying what the restrictions are and then making use of those to the maximum is the theory of constraints (TOC) that looks to optimize the entire picture.

These pages will show you how you can use Asprova in regard to the theory of constraints. They will not explain the theory of constraints, for that, please refer to any number of the generally available texts.

Example 1 Bad influences of partial optimization Reducing setups is no good

First let's take a look at one example with Asprova in which bad effects appeared with the partial optimization mentioned above.

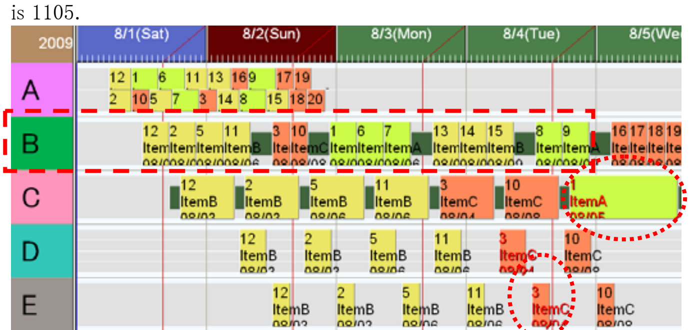
Fig. 1 shows the manufacturing plan for "ItemA", Item B" and "Item C", items which require five processes. Machines A, B, C, D and E, respectively, perform each process and the bar colors in the Gantt chart indicate the item. Machine B performs the second process and incurs a preparation time for switching the item. Fig. 2 is a manufacturing schedule table for calculating the number of manufactures per day scheduled by the plan. The total of production volume for a four-day period for items A, B and C is 1105 units. The plan for resource B shows a large number of item switches, and a large proportion of setup time in relation to manufacturing time.



▲ Fig. 1 A Gantt resource chart showing the manufacturing plan for the next four hours. A switching setup occurs (a total of 8 times) with Resource B in the second process.

	Reso	Mon	Item	Sum	1	2	3	4
1	B	8	ItemA-	300		100	200	
2			ItemB-	600	200	100	100	200
3			ItemC-	205		100		105
4		8		1105	200	300	300	305

▲ Fig. 2 Schedule table for manufacturing with Resource B. Total volume is 1105.



▲ Fig. 3 Results of adjustments in which the number of setup times is reduced. Two orders are delayed in delivery (a total of five times)

	Reso	Mon	Item	Sum	1	2	3	4
1	B	8	ItemA−	500		23.4	276.7	200
2			ItemB−	700	236.7	163.4	123.4	176.7
3			ItemC−	200		200		
4		8		1400	236.7	386.8	400.1	376.7

▲ Fig. 4 A Production Plan table for the planning in Fig. 3. Total volume is 1400.

If manufacture of the same item continues and the number of setups is decreased, per day manufacturing volume can increase and the resource B can be adjusted. Fig. 3 shows the result of doing that. The number of setup steps decreases. Fig. 3 shows the Production Plan table for this plan. Total manufacturing volume is 1400 and that allows an increase of 295 units manufacturing volume in a four-day period. However, the adjustments in order of manufacture cause two delays in delivery. Those are the orders in Fig. 3 bar for which the bar character string turns red.

Fig. 1 shows the use of a dispatching rule that merely requires the sequence of delivery date for orders to be fast and does not take number of setup steps into consideration.

However, just because items always arrive in delivery date order doesn't make it good. Quite naturally, decreasing the number of setup steps can avoid delays in delivery. The important point is that even though an increase in manufacturing volume was made in some processes, it did not lead to an improvement in overall results.

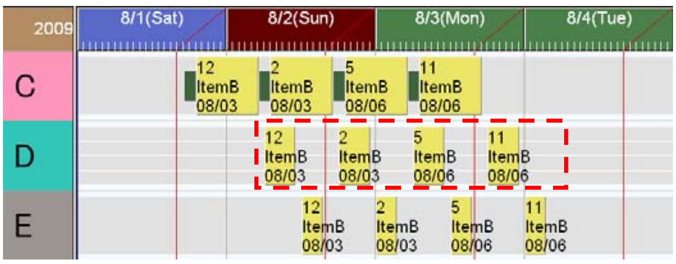
Help

"Production plan – purchase plan"(Help No. 706400)
"Grouping"(Help No. 740500)
"Specifying a setup time for changing an item"(Help No. 307000)

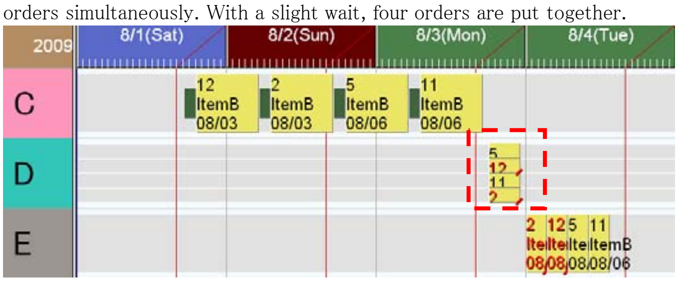
Example 2 Bad influences of partial optimization Large batch size is good

Next we turn to an example of "efficiency cost," which is frequently given as one of the indices for goals in improvement. This is an examination of the number of times a batch-type furnace is used.

The batch furnace is fixed in size and when efficiency is taken into consideration the goal becomes one of increasing the filling ratio in order to decrease the number of batches.



▲Fig. 5 Resource D is a furnace resource that can heat treat up to four orders simultaneously. With a slight wait, four orders are put together.



▲Fig. 6 However, if those items are all put together in one batch, a delay in delivery occurs.

Fig. 5 shows an example of waiting slightly for heat-treated parts at hand. The situation is one in which the parts are heat-treated at the same temperature then finish preprocessing and during that period of time are in wait status.

Decreasing the number of batch steps is seen as a way to increase efficiency, but the wait for heat treat processing creates a probability of delivery delay as shown in Fig. 6

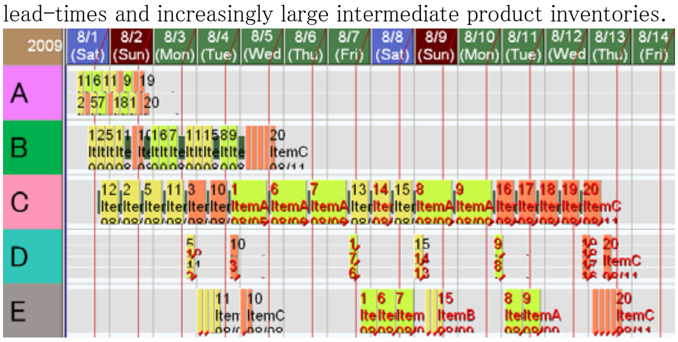
Help

"Furnace resource"(Help No. 747000)
"Sample I"(Help No. 914000)

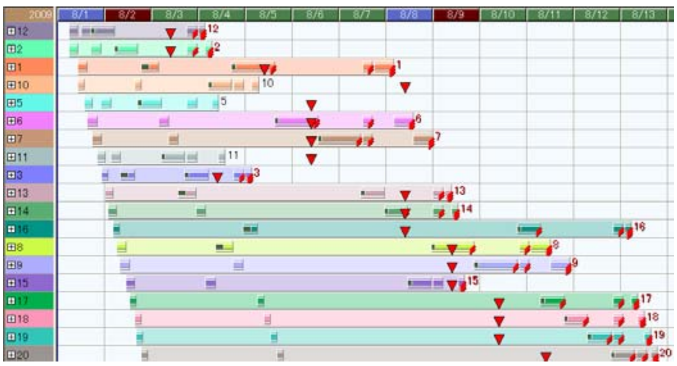
TOC step 1 Assign target and find constraint conditions

Now to return to the discussion of theory of constraints. Before getting partly involved in the process of the theory of constraints, we want to assign targets for the entire factory, and then look over the whole situation and determine what the conditions of constraint are for achieving those targets. In the following, we recommend increasing throughput as a target, and to do that, recommend targets of shrinking lead-time to decrease inventory, no matter whether it is intermediate product or finished items, and reducing delivery time.

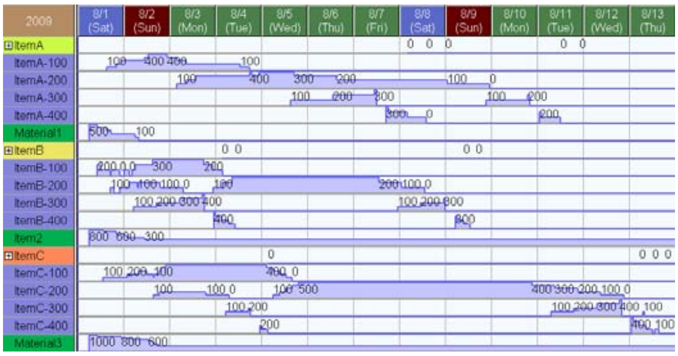
Figs. 7, 8 and 9 are, respectively, a Gantt resource chart, an inventory graph and a Gantt Order chart for the present plan. The diagrams show that there are frequent delays in delivery, long lead-times and increasingly large intermediate product inventories.



▲ Fig. 7 Resource Gantt chart for the present plan. It shows frequent occurrence of delivery delays.



▲ Fig. 8 This Gantt order chart shows that wait times are extremely long.

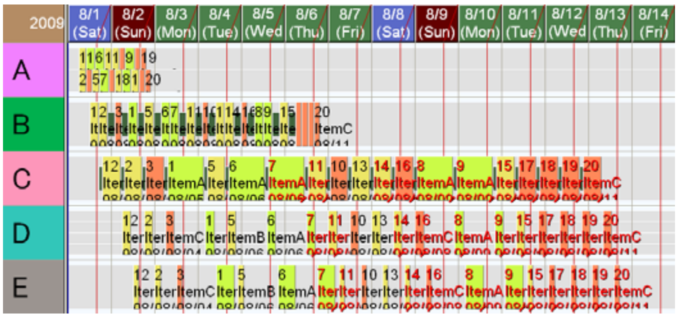


▲Fig. 9 Inventory graph. Item codes with titles in blue indicate intermediate products.

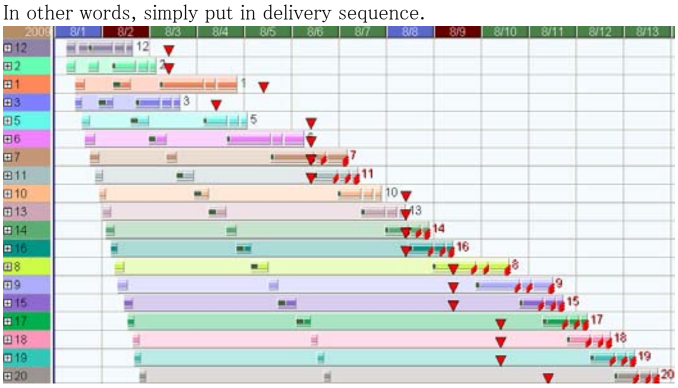
At the start rescheduling was done that gave absolutely no consideration to partial optimization as discussed in the previous chapter (see Figs. 10, 11 and 12). Decreasing wait time in some of the processes will shorten lead-time and reduce the number of goods in process but absolute lead-time remains long and there are still many delays in delivery time.

Seen from the perspective of the drum buffer rope (DBR) theory of lean-manufacturing, we search for the process with the largest effect on total lead-time.

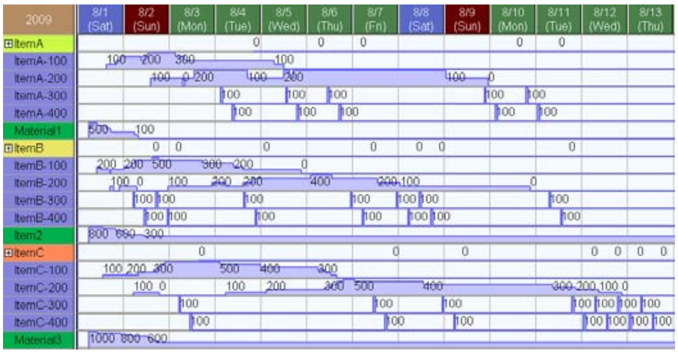
The Inventory graph in Fig. 12 shows a large goods-in-process inventory immediately before the second and third processes, the Gantt Order chart in Fig. 11 shows long wait times for the second and third processes. Fig. 10 shows a large resource load for resources B and C in the second and third processes and the load graph in Fig. 13 shows that the load for resource C is almost 100%.



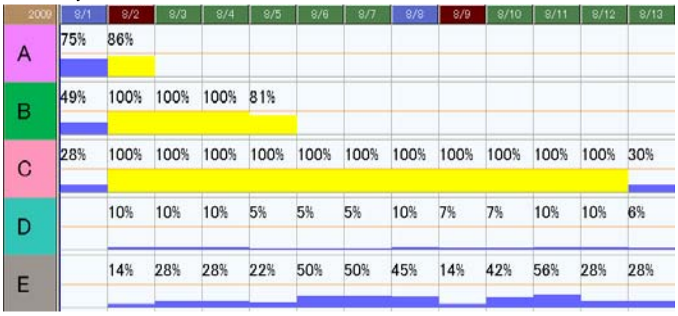
▲ Fig. 10 Planning results without highly processed partial optimization. In other words, simply put in delivery sequence.



▲ Fig. 11 Gantt Order chart. Processes one and two have long wait times; processes three and four have almost no wait time.



▲ Fig. 12 Inventory graph. Processes 1 and 2 have large goods-in-process inventories, and processes 3 and 4 have almost no goods-in-process inventory.



▲ Fig. 13 Load graph. Days with 80 percent or higher load ratio are in yellow. Setup time for resource B is not included in load.

Evaluating results from this perspective shows that the way in which resource C in the third process moves forward determines the forward motion for the entire plant. Constraint conditions can be seen with Process 2 as well but the Gantt resource chart and the Load graph show there is leeway in load. In other words, the operating conditions for resource C are determining overall throughput and resource C is a constraint condition. Thus, resources A, B, D and E are non-constraint conditions and even if partially optimized, contribute little to overall throughput.

Help

"Order Gantt chart"(Help No. 678000)
"Inventory graph"(Help No. 685000)
"Load graph"(Help No. 692000)

Theory of constraints step 2
Active use of constraint conditions

The next step after uncovering resource conditions is to actively use constraint conditions. The resource plan shows constant 100% operation so, theoretically, any level of use higher than that must be impossible. However, there are actual methods that can be used.

1) Actual operating conditions show the occurrence of idle time so we delineate the causes and devise ways to be operating at all times.

2) Place alternative resources in position.

3) The setup is internal, so, if possible, make it external.

4) Increase the number of personnel with the skills to run these processes.

The running costs for alternate resources in 2) are high and the plant and equipment (C) is old and takes more time in manufacturing. Using the old equipment definite increases speed of manufacturing but it increases running costs so that we have no way of knowing immediately whether results are profitable.

Asprova has a built-in function (the KPI option) for such situations to calculate Key Performance Indicators (KPI) such as cost, sales and profit. We can use that function to find out what profit is. To do that, we assign unit cost per item and time cost per resource (see Figs 14 and 15) and then use the KPI command to obtain the KPI evaluation results table shown in Fig. 16. This table finds the results of calculation when using and not using resource CX. Looking at this table, non-use of CX gives a sales order LET achievement of 21.2% and profit of $21,400. But when CX is used, sales order LET achievement is 84.2% and profit is $13,150. This is the way that we obtain a throughput simulation on the use of CX

	Item code	Unit price	Item type
1	ItemA	10	Finished item
2	ItemA-100	1	Intermediate item
3	ItemA-200	2	Intermediate item
4	ItemA-300	6	Intermediate item
5	ItemA-400	9	Intermediate item
6	Material1	0.8	Purchased part

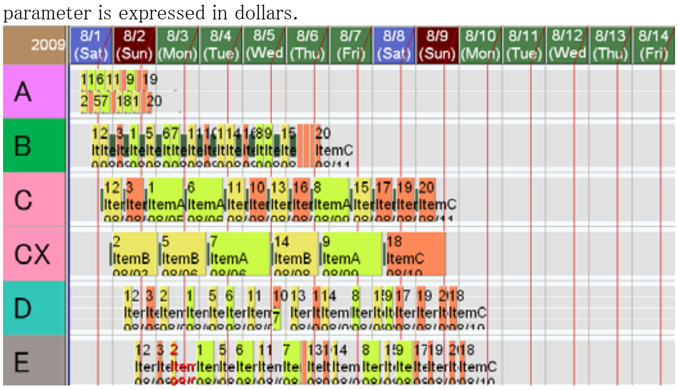
▲ Fig. 14 "Unit price" and "item type" in the Item table. Unit is in dollars.

	Resource code	Hourly cost
1	A	20
2	B	20
3	C	50
4	CX	70
5	D	30
8	E	20

▲ Fig. 15 "Time cost" in the resource table. Unit is in dollars.

	Code	Earnings	Material cost	Labor cost	Total cost	Profit	Profit ratio	Sales order LET achieveme
1	With CX	$47,000	$5,600	$28,250	$33,850	$13,150	28.0%	84.2%
2	Without CX	$47,000	$5,600	$20,000	$25,600	$21,400	45.5%	21.1%

▲ Fig. 16 KPI evaluation results table. The result of evaluating each parameter is expressed in dollars.



▲ Fig. 17 Assigned results when using resource CX (Gantt Resource chart)

Help

"Specifying an external setup"(Help No. 320000)

"Setup time"(Help No. 781000)

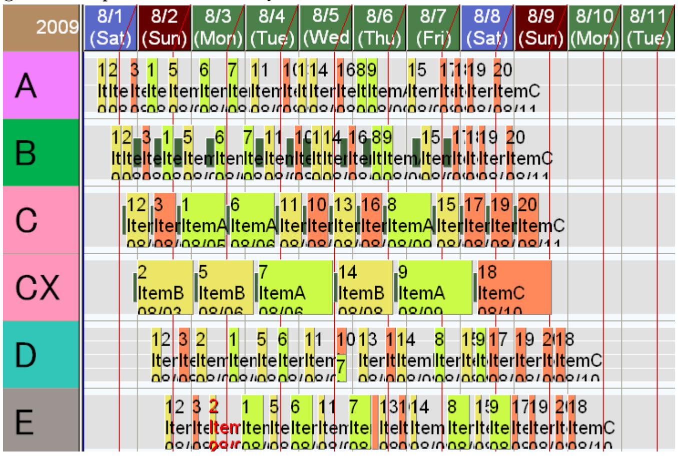
"Asprova KPI"(Help No. 3160)

"Skill map"(Help No. 749200)

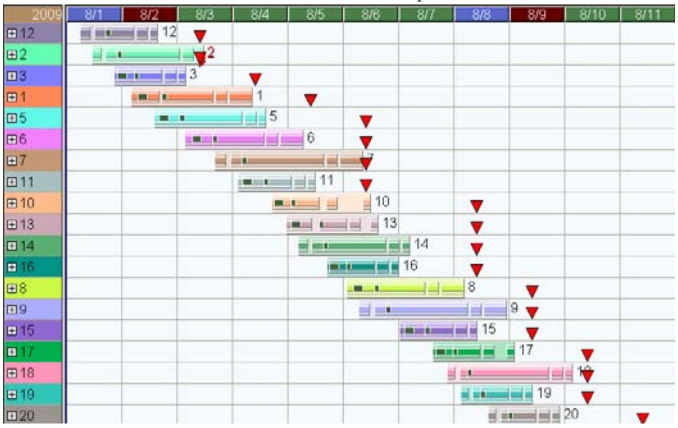
"Disabling a resource"(Help No. 247000)

Subordinating non-constraint conditions

The next step is to subordinate the non-constraint conditions to the constraint conditions. In other words, match the manufacturing speed of process 3 to the manufacturing speed of the other processes. Process 3 has the slowest speed in manufacturing as well and it becomes difficult to generate wait time for process 4 and 5. The problem is with processes 1 and 2 and because their process operations are subordinated to the operations of constraint conditions C, they are assigned backward. Fig. 18 shows the result of using and assigning the planning parameter "Forward+Assign first half process backward". Both the Gantt Order chart (Fig. 19) and the Inventory graph (Fig. 20) show a large decrease in lead-time and goods-in-process inventory.

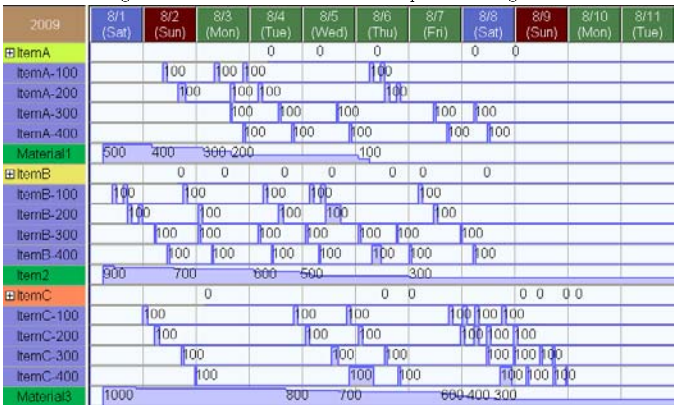


▲ Fig. 18 Assignment results when processes 1 and 2 are assigned backward (Gantt resource chart). The timing for placing the order in process is subordinated to the constraint conditions of process 3.



▲ Fig. 19 Gantt Order chart

It shows a large reduction in lead-time as compared to Fig. 11.

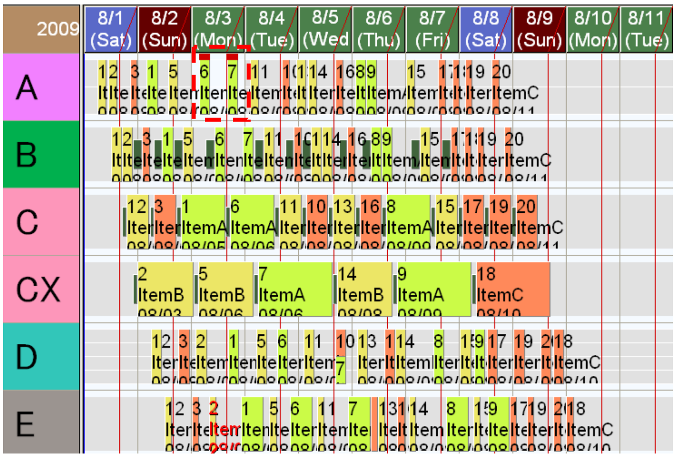


▲ Fig. 20 Inventory graph showing a large reduction in intermediate goods-in-process compared to Fig. 12.

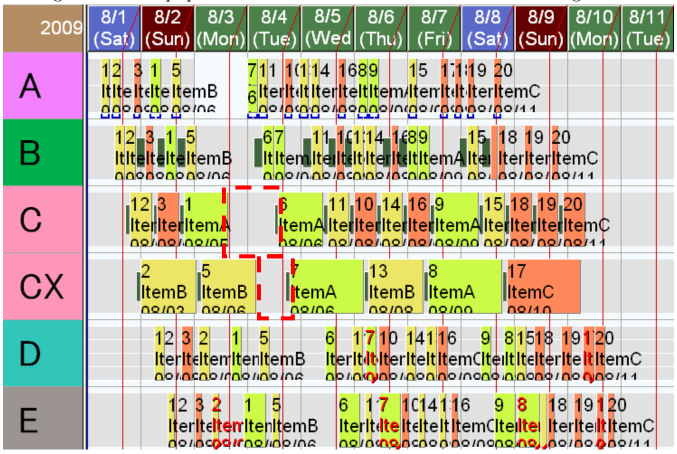
Decreases in lead-time and goods-in-process inventory have these advantages:

1) Reduces the cost of maintaining inventory
2) Strong protection from changes and cancellations in orders.

There are, however, disadvantages if an attempt is made to use it too much. Fig. 21 shows an example in which an unpredictable equipment accident has occurred. Because there is no goods-in-process inventory with resources C and CX, which are constraint conditions, the equipment accident also affects and stops resource C and CX (see Fig. 22). The stoppage of constraint condition resources has a direct effect on factory throughput so top priority must be placed on avoiding stoppages.

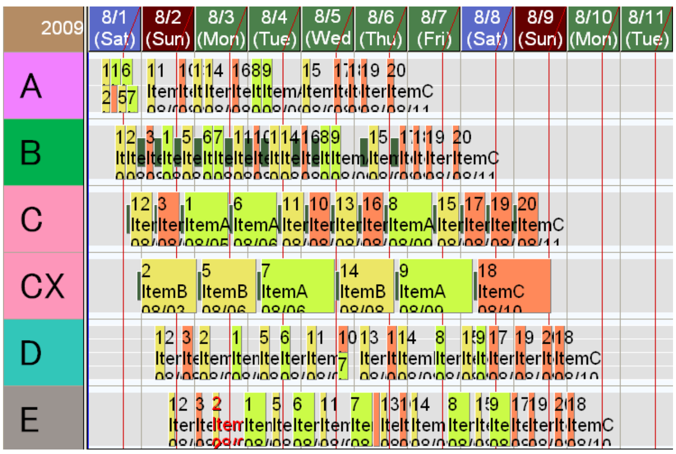


▲ Fig. 21 An equipment accident occurs to resource A on August 3

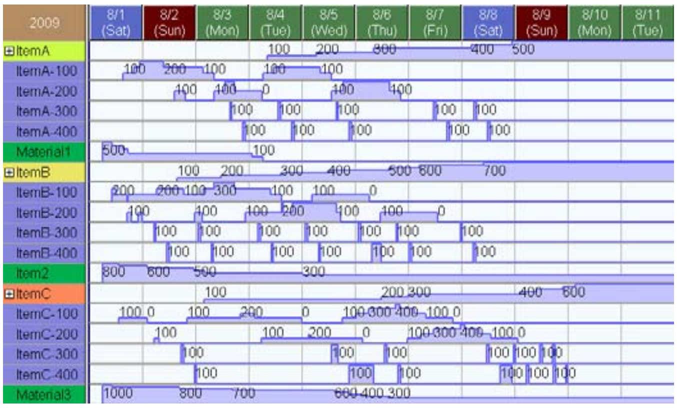


▲ Fig. 22 The plan changes when an equipment breakdown occurs to an area with no buffer and constraint conditions C and CX go into idle time.

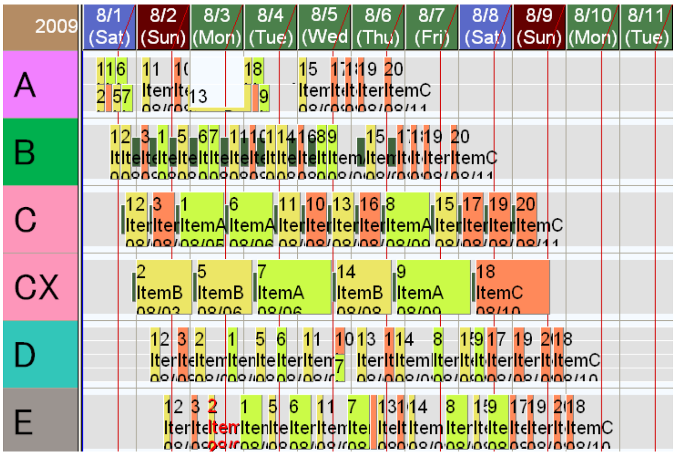
Fig. 23 shows a means of dealing with this situation, in which the plan calls for a certain degree of goods-in-process inventory to be retained immediately before the constraint-conditions process. The inventory graph for this plan (Fig. 24) shows that an appropriate degree of goods-in-process inventory is stored. When equipment malfunctions as above, this plant is like that shown in Fig. 25. Even when equipment in the previous process malfunctions, the goods-in-process inventory allows constraint-condition resources C and CX to continue to operate.



▲ Fig. 23 A plan that gives leeway in input timing to the first process so that a goods-in-process inventory can be stored just before resources C and CX, which are constraint conditions.



▲ Fig. 24 Inventory graph. An appropriate level of goods-in-process inventory is stored (for example, ItemA-100 and ItemA-200).

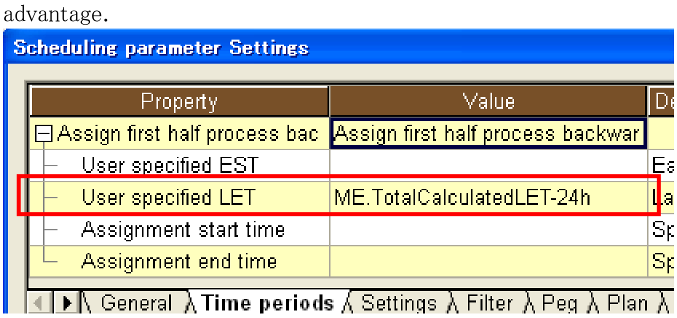


▲ Fig. 25 The goods-in-process inventory keeps resources C and CX, which are constraint conditions, from stopping and there is absolutely no subsequent effect on the process plan and no new delivery time.

This plan has established the planning parameter "Forward+Assign first half process backward with buffer", and the difference between that and "Forward+Assign first half process backward" is merely that "ME.'Total calculated LET'-24h" is assigned to the "Assign first half process backward with buffer" in the child planning parameter "Assign first half process backward with buffer" (see Fig 26).

When the first half of the process (resources A and B) is assigned backwards, the time will not be assigned just a few moments back, but by 24 hours, and a buffer will be set up.

Doing this makes non-constraint conditions subordinate to constraint conditions and gives resistance to trouble and problems. However, before that, using the production scheduler allows the calculation of input timing of Process 1 with the load in Process 3 as the reference yardstick and that use of the scheduler is a major advantage.



▲ Fig. 26 Assign a 24-hour buffer for storing the goods-in-process inventory.

Help
"User specified EST, User specified LET"(Help No. 779600)

In conclusion

This pocket manual has presented simple examples for verifying the theory of constraints and methods of actively using Asprova to make improvements based on that theory of constraints. In very few instances can we find constraint conditions as simply as we have here. An actual factory manufactures a much larger number of items and has a greater number of processes and resources. Because the resources are different depending on what the items are, there may be no limit on the constraint conditions for the resource with the biggest load and there may be many resources with a 100-percent load.
However, finding the constraint conditions and using them to the maximum is the very core of the theory of constraint conditions and Asprova is the tool for efficiently performing those operations.
The biggest advantage in using Asprova is that it is in a form in which anyone can see what the plans for the future are. Asprova makes the connections clear between series of processes, and allows a clear picture of when the order will be finished no matter what that order is. Another advantage is strategic use. With Asprova you can make simulations to find out where the emphasis should lie and what the best selection is of the paths available for improvement.

In many instances, the standard reasons for installing Asprova are limited to either making plan drafting more efficient or replacing the existing planning system. If, for example, the results of the draft planning parameters contain a lot of idle time, before making a judgment as to whether that idle time is good or bad, we should find out from people at the manufacturing plant what they dislike about the planning and, based on those reasons, adjust the planning parameters so that they become closer to existing production plans.

These are often the reasons many customers think they cannot use Asprova to its fullest potential. To those customers, I would say please make the attempt to use Asprova based on the theory of constraints.

For more Information

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