AUTOMATIC LINE BALANCING AND ORDER SEQUENCE OPTIMIZATION

BACKGROUND

The software company Solme AB develops the software suite AVIX that is used by hundreds of companies in different countries and industries. The software AVIX is used by production engineers and production planners to structure data and improve productivity. A typical customer is found in the automotive industry in a highly competitive market. Therefore, optimization of resource usage is very important.

An assembly line is a manufacturing process (often called a progressive assembly) in which parts are added as the semi-finished assembly moves from workstation to workstation where the parts are added in sequence until the final assembly is produced.

Takt time, or simply Takt, is a manufacturing term to describe the required product assembly duration that is needed to match the demand. For example, if the customer demand is 10 units per week, then, given a 40-hour workweek and steady flow through the production line, the average duration between production starts should be 4 hours, ideally. This interval is further reduced to account for things like machine downtime and scheduled employee breaks.

LINE BALANCING

An important factor to achieve high productivity of the assembly line is to distribute the assembly activities evenly between the workstations, this activity we call *Line Balancing.* An uneven distribution of the assembly activities results in that some operators (the persons performing the assembly activities) must wait or idle for other operators to complete their activities before being able to continue the assembly. The loss from uneven distribution of assembly activities is often referred to as *balancing loss*

+46(0) 31-711 52 20 – info@solme.se – Fabriksgatan 21, 412 50, Göteborg, Sweden – www.avix.eu
Org. Nr. 556555-1503 – Bankgiro 5065-3633 – Innehar F-skattebevis

(figure 1). One objective with *Line balancing* is to reduce the balancing loss. In a mixed model line, where different products with different amount of work is assembled the optimal line balancing solution is not trivial.

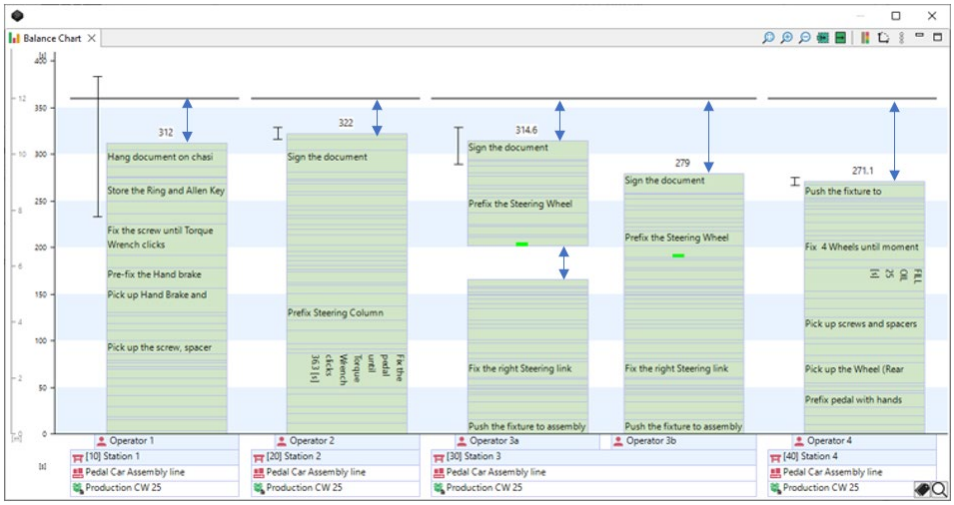


Figure1. The black line is the Takt. The blue arrows indicate the balancing loss.

LINE BALANCING CONSTRAINTS

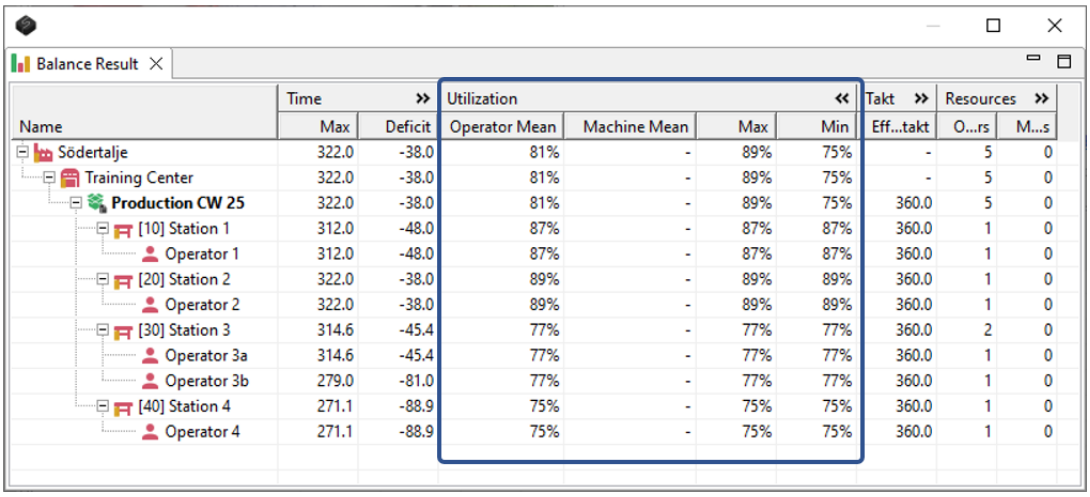
The components, that together constitutes the product, often have built-in restrictions in which order that may be assembled. For instance, the wheels on a car may not be assembled before the wheel axis has been assembled. Tools and machines may also be tied to a specific workstation, followingly assembly activities that require this tool or machine must therefore be carried out on that workstation.

LINE BALANCING IN AVIX

In AVIX, line balancing is done based on the engineer´s skills and experience and facts presented in a graphical interface in AVIX - the balancing graph (figure 1). The engineer manually distributes the assembly activities between the operators. The key

+46(0) 31-711 52 20 – info@solme.se – Fabriksgatan 21, 412 50, Göteborg, Sweden – www.avix.eu
Org. Nr. 556555-1503 – Bankgiro 5065-3633 – Innehar F-skattebevis

performance index to measure how well the engineer has succeeded with the line balancing is the operator utilization (figure 2), how much of the working time the operator is assigned with work.



Name	Time		Utilization				Takt	Resources	
	Max	Deficit	Operator Mean	Machine Mean	Max	Min	Eff...takt	O...rs	M...s
Södertalje	322.0	-38.0	81%	-	89%	75%	-	5	0
Training Center	322.0	-38.0	81%	-	89%	75%	-	5	0
Production CW 25	322.0	-38.0	81%	-	89%	75%	360.0	5	0
[10] Station 1	312.0	-48.0	87%	-	87%	87%	360.0	1	0
Operator 1	312.0	-48.0	87%	-	87%	87%	360.0	1	0
[20] Station 2	322.0	-38.0	89%	-	89%	89%	360.0	1	0
Operator 2	322.0	-38.0	89%	-	89%	89%	360.0	1	0
[30] Station 3	314.6	-45.4	77%	-	77%	77%	360.0	2	0
Operator 3a	314.6	-45.4	77%	-	77%	77%	360.0	1	0
Operator 3b	279.0	-81.0	77%	-	77%	77%	360.0	1	0
[40] Station 4	271.1	-88.9	75%	-	75%	75%	360.0	1	0
Operator 4	271.1	-88.9	75%	-	75%	75%	360.0	1	0

Figure 2. The KPI Utilization is shown in the blue box.

PRODUCTION ORDER SEQUENCING

A production order is ordering the production facility, in our case the assembly line, to produce a specific product. In a mixed model line the production orders are ordering different products with different work content. The sequence of production orders may add balancing loss to the system and reduce the operator utilization. However, an optimal order sequence is an opportunity to reduce the balancing loss and increase productivity by utilizing that the production orders imply different amount of work.

Typically, the order sequencing is done manually using defined rules. Rules that are used could be of type:

- Maximum every third order may be of variant A.
- After a variant A order must follow a variant B or variant C order.

With a large number of orders and a large number of types of orders the manually order sequencing will likely not be the optimal order sequence.

PRODUCTION ORDER SEQUENCING CONSTRAINTS

A production order often has a specific customer and there is an expected delivery date. The customer may accept that the delivery is delayed by 6 hours, 2 days or even a week, but she will likely not accept a delay of 1 year. So, there is a limitation for how much the order may be shifted later in the order queue.

+46(0) 31-711 52 20 – info@solme.se – Fabriksgatan 21, 412 50, Göteborg, Sweden – www.avix.eu
Org. Nr. 556555-1503 – Bankgiro 5065-3633 – Innehar F-skattebevis

A production order is dependent of components and those components are available with some margin before that are needed. So, there is a limitation for how much the order may be shifted earlier in the order queue.

PROJECT DESCRIPTION

The line balancing task and the order sequencing task are interdependent. The project therefore contains both tasks.

1. Develop algorithms that, with given constraints and an existing line balance, automatically suggests a line balance closer to the optimal one. The algorithms are to be implemented in the AVIX software. A user interface for the functionality is to be implemented.

2. Develop algorithms that, with given constraints and an existing order sequence, automatically suggests an order sequence closer to the optimal one. The algorithms are to be implemented in the AVIX software. A user interface for the functionality is to be implemented.

SUPPORT FROM SOLME AB

SOLME AB will provide support with relevant data structures, development environment set-up as well guidance to develop optimization algorithms.
The implementation is done in Eclipse RCP using Java.

LITERATURE

1. https://en.wikipedia.org/wiki/Assembly_line

TARGET GROUP

D, DV, IT and Z

PROJECT GROUP SIZE

A group of 4-6 persons. The project can be done partly at our office at Lindholmen Science park, it makes it easier for us to support the group and an opportunity to get to know each other.

+46(0) 31-711 52 20 – info@solme.se – Fabriksgatan 21, 412 50, Göteborg, Sweden – www.avix.eu
Org. Nr. 556555-1503 – Bankgiro 5065-3633 – Innehar F-skattebevis