Fully Automated Production Control with A+W SmartFactory

Fully Automated Production Control with A+W SmartFactory
Dr. Klaus Mühlhans – A+W Software GmbH

Keywords:

1. Production Control
2. Just In Time
3. Pull-Principle
4. Minimized Work in Progress
5. Lean Production

Abstract

A+W SmartFactory is a just-in-time control system based on "pull-principles" suited for highly complex flat glass manufacturing and pro-cessing environments.
So far, shopfloor control systems (PPS, MES ...) used in the flat glass industry are using JIT (just-in-time) backward capacity planning tools. Once planned, however, today's systems are used to group production into batches and push those batches through production starting, typically, with the cutting process.
As a result, there are lots of lot-size-conflicts limiting efficiency and larger challenges to cope with last-minute-changes.
A+W SmartFactory, however, is based on so called "Pull-Principles" being the core of an A+W patent originally es-tablished using an automated sorting system. This principle is extended to work in a complex manufacturing environment comprising of several sorters and fabrication cells.
This results in a minimized amount of WIP (Work-In-Progress) generating the batches as a result of production at the very end (dispatch) building intermediate lot dynamically based on the actual situation within the workflow.

Introduction

Flat glass processing is a make-to-order business each single workpiece differing at least in size. To cope with this, state of the art shopfloor organization is based on batches grouping a reasonable number of individual workpieces together. These batches are used as an orientation criterion for workers (base for paperwork, labels, sorting criteria...). In addition, those production units are processed together in several areas of the factory trying to improve processing yield within this defined amount of work. One severe consequence of this way of working is the so-called lot-size-conflict:
A larger batch allows better optimization of processes but results in less flexibility when change requests are coming up!
Mixing batches, however, results in much more workload for workers in terms of organization and, likely, additional search activities.

The lot-size-conflict

The best example to understand the lot-size-conflict within flat glass processing is the cutting area. There, all different kinds of glass and glass sizes have to be combined to compute individual cutting patterns. It is obvious that a large number of sheets having different sizes will easily result in a very good cutting yield if it is allowed to mix them chaotically.
Unfortunately, this is extremely limited:

- A complete chaotic optimization will result in a large sorting effort after cutting
- In case of late changes, it is exceedingly difficult to change production sequences within a batch. Consequently, complete batches are, typically, rescheduled. This is easy for a small batch but very difficult the larger it gets.
- For rare glass types within a batch there might be just a few sheets to do resulting in a large number of residues.

This conflict between flexibility and process yield is named the lot-size-conflict.

A+W DynOpt vs. lot-size-conflict

A+W successfully introduced A+W DynOpt into the market as a first step towards changing production paradigm by applying a pull-principle to the cutting area instead of the so far used push-principle. Using a sorting system in a dynamic way (not just dynamic optimization but a full dynamic process up to the output sequence of the buffer), batches are now viewed as an outcome (sequence) from the buffer and no longer as an input schema. This patented way of working proved to be a superior way of working. DynOpt principles are known to the market and will not be detailed within this paper. The paragraphs to follow will instead focus on the logical steps to extend those principles to the complete process chain of a flat glass processing plant.

Limiting rising complexity

The next logical step following the A+W DynOpt approach could have been an extended single production control system controlling all steps of a production in a backward (pull-mode) way. Getting all of this control into a single system will clearly result in an enormous complexity. Furthermore, it is known from other industry sectors that the idea of integrating all production steps into a single, controlled flow results in a substantial risk of adding many single points of failure into the process chain. As a result, segmented processing based on the idea of individual fabrication cells came up as a solution. This method is limiting complexity in the chain but results in a lot of communication needs between the production cells. Fortunately, there are elegant solutions to this conflict within state-of-the art development frameworks:
The concept of software agents controlling a segment or a cell and negotiating their needs automatically and permanently with the other software agents!

A+W SmartFactory as a system of software agents (also named services)

Within an A+W SmartFactory system, each workpiece, its process chain and its grouping (batches) are represented with its digital twin in the software layer. Batches, in this picture, represent groups of final products to be delivered together to a customer. They are organized in a planned production sequence. Based on the knowledge of the point in time and sequence a product is expected at the end of the chain, the software agents continuously negotiate their need to fulfil the respective requirement. Each agent has the freedom to do any combination of products he desires as long as the requested output sequence can be achieved. The agent passed his needs to fulfil this to the agent being the one before in the chain and so forth. Hence, the agents are working dynamically based on the pull principle.
As a result, the agents may apply any combination of work within a fabrication step or cell that is possible while keeping the final sequence in mind. This flexibility is achieved by continuously monitoring requests, sequences and buffer capabilities.
Compared to the traditional A+W DynOpt, the agent controlling cutting and the buffer after cutting may perform its selection for cutting not just based on the sequence primarily known for the exit of this first buffer but based on all kinds of last-minute decisions from all other agents located later in the chain.
This results in the utmost flexibility possible based on the available production capabilities

and buffers. Still, there is some independence between fabrication cells as there are individual software agents for each cell.

A+W SmartFactory interaction

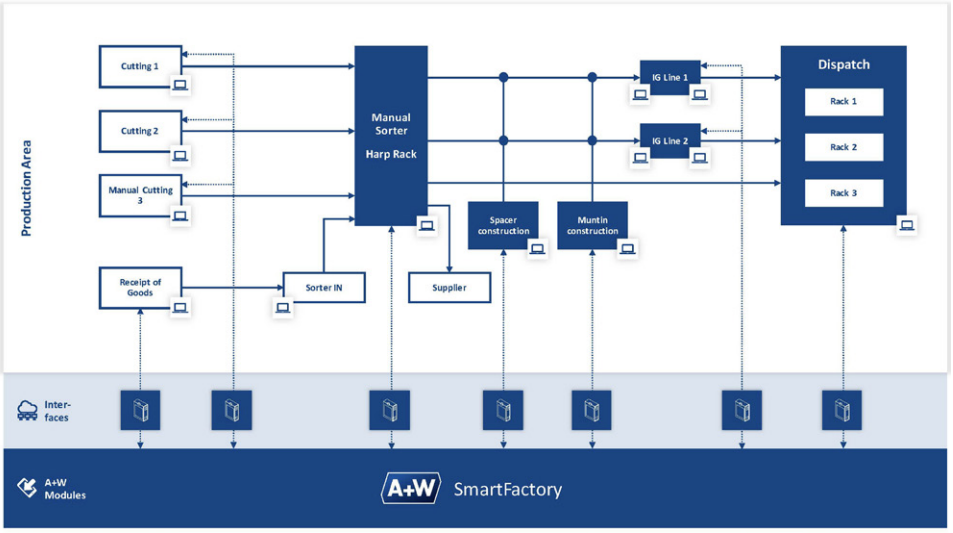
A+W SmartFactory maps the processing flow within a flat glass processing plant into a software layer. Each individual processing step may be defined using a separate agent. The agent has to ensure correct processing. To achieve this, however, there is no dedicated need to assign an agent to a machine. A+W SmartFactory is designed to interact with human workers as well. Instead of sending instructions to a machine, workstations, label printers and scanners may be used to organize the work of individual workers.

Instead of pre-printing batch-based paper-work for each workstation, the work-station will show the worker individual sequences of sheets to be worked on. Those may vary based on the requirements negotiated between the different software agents.

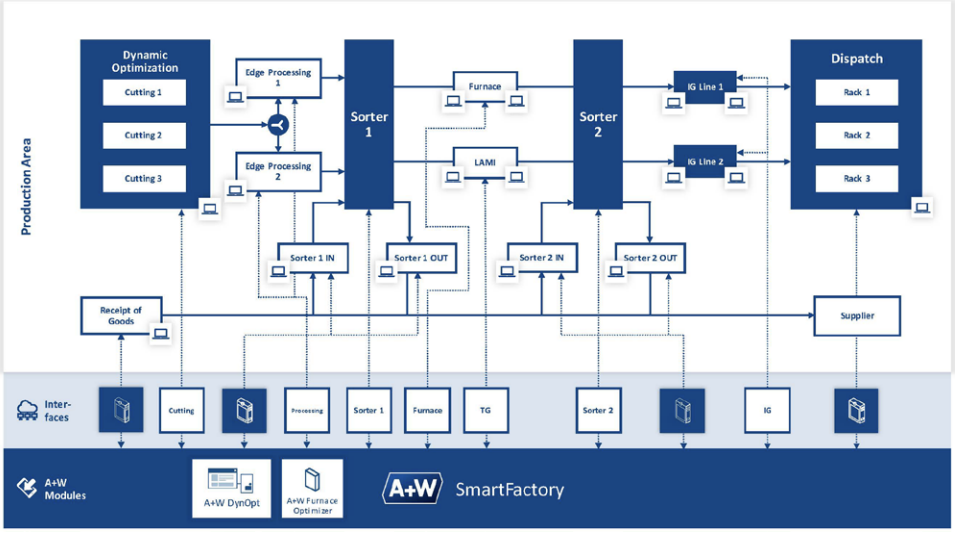
Using this way of working, A+W Smart-Factory may be used even without highly automated machinery equipment. Hence, it is possible to automate processing step by step replacing Workstation based interfaces for human workers by interfaces to processing machinery.

Summary

Traditionally, work in a flat glass processing company has been organized by a push-principle based on batches guiding the work throughout all processes in the chain. A+W SmartFactory offers a completely new way of organizing the process chain based on pull-principles. Software agents negotiate work do be done within a chain of separate fabrication cells resulting in batches to be presented as a result at the end of the chain but mixing them totally within the chain. A+W SmartFactory may be used based on interfaces to human workers as well as interfaces to all kinds of modern automated machinery.



Already implement automation processes when automation lines and machines are missing. Use A+W SmartFactory as a central system.



Multi-level automation system