

Product description

CIPHOS

„Automation and Optimization of cutting layouts and production planning in the converting industry“

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1 SCOPE

1.1 Project Background

Foil- / film- / paper- / laminates-, ... production is done in large rolls of typically multi-kilometers length and a width between one somewhat over 2 meters. These rolls (jumbos or tambours) represent the raw material for the next step, in which the formats are cut, that the customers have ordered.

Dividing a jumbo of e.g. 5km length and 200cm width into dozens of customer's orders which each have different formats is a challenge that wastes or saves substantial amounts of

- material
- slitting machine setup-times and
- jumbo/tambours handling effort.

Typically a foil- / film- paper- / ... producing company has experienced planning personnel, who handle the planning of how to cut the incoming customer's orders from the raw-material on jumbos/ tambours. In a market, that fully utilizes the production capacity, the quality of this planning fully hits the bottom line profit of the company.

CIPHOS was specified to mathematically optimize this planning process with the intention to support the planning personnel and ensure a steady highest possible quality (material utilization, waste reduction).

The production process of the raw material (foil, film, paper, ..) is not included into the process steps that CIPHOS automatic planning is covering and optimizing. The wording "production" in the following text refers to the cutting/slitting process.

1.2 CIPHOS Key Goals

CIPHOS key goals are

- optimization and automation the cutting/slitting process including the accompanying handling-, machine-setup-, stock-, and storage processes.
- Supporting a planning that is cycle short enough to re-run the planning any time e.g. in response to changes in equipment availability or short term urgent additional orders.
- Waste reduction and bottom line profit increase

1.2.1 Production Plans

CIPHOS's automated planning comes up with complete and realistically producible production plans and cutting plans.

These plans represent at time of their computation:

- The complete actual order pool
- Access to all available and usable raw material
- Access to the current status of storage and in-stock available express material
- Access to the production capacity and availabilities of the machine park (e.g. slicing equipment).

The cutting plans, that CIPHOS computes provide information about

- Cutting layouts and production scheduling for each layout
- Equipment selection and production schedule for each cutting plan.
- For each slicing machine: run-/stop times, setup process descriptions, setup-times, and setup process cost.
- Prognosis for machine run times and modes
- Selection of raw material from storage or from express article stock

1.2.2 Hierarchy of Priorities

CIPHOS assumes the following standard hierarchy of priorities:

1. In time fulfilment of customer order due date
2. Minimization of equipment setup-times
3. Minimization of waste
4. Optimization of stock material (Express availability of commonly requested products)

2 Planning Tool CIPHOS

2.1 The Interface / CIPHOS.API

CIPHOS is a cloud-based SaaS application, that can communicate with ERP-System via a RESTful-Service. The communication happens by an exchange of XML-files. The user generates exports from the company's ERP according to the CIPHOS API documentation and XML structure.

The API is composed of 3 information groups:

- Base data (machine/equipment data, material status, ..)
- Order info (meta data of customer orders)
- Planning board (that's the result of the CIPHOS computation).

2.1.1 Base Data - „Digital Twin“ of facility

The base data represent a „Digital Twin“ of the customer's production facility. Specifically these are realistic models for

- The equipment in the facility
- Equipment features / performance specifications,
- Raw material catalogue (input material)
- Articles catalogue (standard products that can be ordered).

The catalogues of raw material and articles are needed for referencing of the customer order data. The info from these catalogues support the handling of dimensions specifications (length, width, diameter, weight, ..) additional specifications such as the handling of defective areas on the raw material. Every raw material unit (jumbo, tamboure) has according specific info attached. Also has every raw material unit a price/m2 info attached.

Key element of the Digital Twin model of facility are the precise descriptions of the slitters and the definition of the limitations in regard to the handling of the custom-cut foil orders on pallets. The number of slitting machines and winders that CIPHOS can simultaneously handle is not specifically limited.

The digital model of a slitter is composed of 3 physical sub-components (wind-down unit, cutting unit, wind-up unit) and one performance component.

Wind-Down unit: The model for the wind-down unit contains the min/max physical dimensions info of the jumbo/tambour-size and the info for the sleeve anchor specifications.

Cutting Unit: The model of the cutting unit contains the relevant detail info on the cutting tools. The slitters are modeled with scissor cut style methods. Slitter models support various models and combinations of top- and bottom knife shafts, flexible number of knives, as well as separate cutting modules with fixed number of knives.

Wind-Up unit: The wind-up unit differentiates between a variety of drive modes. For each traverse multiple wind-up stations and slice patterns can be specified. The model even supports splitting rollers for support of very narrow rolls (disks). For the realistic modelling of the behavior of the facility operation, the static model information of the slitters is not sufficient.

Performance Component: The model, which describes the performance component of the slitters is used to assign to all relevant process steps accurate, sometimes variable (e.g. depending on what material is used) costs and time budgets; for example:

- Loading and unloading of the wind-down unit
- Setting and adjusting of the knife positions, depending on how many knives used
- Changing and cleaning of knives
- Loading and unloading of wind-up units
- Treatment of faulty areas on the raw material, setting of glue lines

Running times and -cost can be defined in dependency of the raw material. Also times / necessities for machine cleaning and knife wear can be specified depending on what raw material is in use.

2.1.2 Order Data

The order data involves 4 components:

- Production orders (derived from customer orders)
- In stock available express material (those are left over pieces from previous production runs, that were stored for potential re-use)
- Condition of the express article storage unit (e.g. location in storage, age of material, how good is the fit to current need, ..).
- Utilization of facility equipment (slitters, winders, ..)

Production orders are referenced to articles from the product catalogue (base data); based on that the specification for the production recipe is concluded; specifications of additional requirements are permissible and can be defined. These can be e.g. higher than normal quality requirements (glue lines, ..), reduced tolerances, production on specific jumbo rolls, Also the requirement to produce this specific order on one dedicated slitting machine is possible.

The production can heavily be depending on the material stock situation and the processes to access pre-fabricated material in storage.

The model of the jumbos/6tambours supports holding of jumbos specific info such as „age” or assignment of a dedicated space in storage. With that the storage logistics (raw material storage as well as express article storage) can be optimized in conjunction with the production.

Before production begins, the start condition of the facility is provided with a report, that contains for each equipment piece:

- the time slices of its availability
- the equipment current setting
- info of currently loaded raw material in the equipment

2.1.3 Planning Board

The planning board defines the time schedule for each piece of equipment. It hold information of equipment availability and the assignment of when each available piece of equipment is schedules which specific cutting layout.

2.1.4 Cutting Layout

The cutting layout represents the graphical design of how the raw material is cut such that the customer ordered material pieces are cut out. The challenge is good area utilization of the raw material.

2.2 The CIPHOS-Engine

2.2.1 Optimization and Automation

The CIPHOS engine computes planning boards and cutting layouts, that are cost optimized, support customers delivery time needs, and can be produced with the available facility. The planning board gives the instruction which cutting layout shall be produced at what time and sequence on which piece of equipment. The cutting layouts contain the location of each customer order on the raw material, the cutting instruction and the instruction about handling of left-over material as express-material that is put into stock for later use.

When computing, the CIPOS engine includes also the consideration of

- quality requirements for each order,
- feature availability for each piece of equipment incl. setup instruction,
- slitting equipment availabilities,
- storage transfer equipment and -handling availability
- storage location management
- conformance to machine operation guidelines

The CIPHOS engine tries to fulfil all requested product shipment dates/times (see also 1.2.2). There can be situations when not all production orders can be fulfilled as requested, in this case the engine focuses on timely fulfilment of near term orders, while orders with later due dates get lower priorities.

With consideration of the due date priority handling, the engine computes optimized cutting layouts and production schedules for the complete available order pool. The optimization decisions base on cost information that CIPHOS has for equipment, for changing equipment settings, for raw material, for left-over material in stock, CIPHOS identifies compatible orders and combines them into one cutting layout, even when orders are from different customers. CIPHOS

is able to identify cutting waste, that can potentially be used later and classifies that as express stock material.

The CIPHOS engine tries to efficiently use the raw material (jumbos/tambours). That requires sophisticated decisions in regard when to put a jumbo back into storage (how many meters remaining material on the jumbo) instead of using it to the extent that the left material may not be easily usable for future orders.

The engine analyzes defect positions in the jumbos in order to plan around them or for planning to cut them out when quality criteria allows for that. Stock and storage material is tracked with the info of its physical dimensions and age for optimization of storage logistics.

2.2.2 Performance & WorkFlow

Depending on the size of the order pool, CIPHOS engine compute times range from seconds to minutes. The algorithm is such, that adding compute cores will shorten the compute time accordingly.

CIPHOS is intended to support the person who does the planning in his/her work by providing reliable, according to all provided criteria and side criteria optimized cutting layouts, planning boards, left-over material handling (express stock products) and storage and material handling and management.

The workflow is such, that the planner computes with CIPHOS the production plan for the complete available order pool. This computation typically is done in minutes, the planner then reviews the result layout by layout releasing them into production.

Due to the extreme variability of parameters not always all parameters given to the CIPHOS engine reflect meaningful intents and therefore it occasionally happens that the planner rejects single layouts. In this case the planner either manually interacts or he re-computes the planning process with a new constellation.

Experience shows, that planners accept >90% of the computed layouts and therefore the overall efficiency of the production is greatly enhanced. At the same time the planner, who uses CIPHOS gains free capacity that can be used for enhancing the facility operation even more.

3 Key Performance Parameters / Limitations

CIPHOS 1.0 has been developed for a specific lead-customer application, which may or may not result in limitations to other similar deployments.

Key characteristics of CIPHOS 1.0 are

- Standard foil width is 1 meter to 2.5 meters
- Foil length is 2km to 8km
- Foil-/laminate weights between 100g/m² and 300g/m²
- Raw-material production is aligned with the known or expected order pool from customers (in order to e.g. minimize storage capacity needed)
- Customer orders typically range between 400m and 4km length at variable width.
- The planning process includes slitting machines, incl. their setup cost/times, raw material storage, interim storage, finished orders storage, pallet handling, time constraints, and quality constraints.
- CIPHOS can handle regular customer order articles and express articles, that do not base on a customer order.
- CIPHOS can handle known raw material defects by avoiding the areas when computing layout plans or by cutting them out if quality criteria allows for that.